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ANL-MGR-MD-000001 REV 03

September 2004

Inhalation Exposure Input Parameters for the Biosphere Model

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Inhalation Exposure Input Parameters for the Biosphere Model

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11. Remarks

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Change History

12. Revision/ICN No.	13. Description of Change
REV 00	Initial issue
REV 00 ICN 01	Changed verification status of climate data (Table 1 and DIRS); added data tracking numbers for data accepted since release of REV 00 (Table 1; pp. 1, 9, 10, 17, 20, 21, DIRS); used modified crop coefficients for turf grass, which resulted in different values for irrigation rate (Tables 1, 3, 4 and pp. 10, 20); modified justification for selecting climate and air quality data from site 9 (pp. 7, 9); replaced reference to unfinished AMR with reference to Census Bureau data (pp. 6, 9, 11, 12, 16); and used electronic DIRS.
REV 01	Added parameter values for analysis of volcanic eruption and climate change (throughout). Revised inputs and parameter values for mass loading to reflect a farming community and to base values on total suspended particles (Sections 4.1.1, 5.1.1, and 6.1.1). Added key technical issues and acceptance criteria (Section 4.2). Revised assumptions for time spent outdoors (Section 5.2.3) and parameter values for inhalation exposure time (Section 6.2) and external exposure time (Section 6.4). Corrected average annual precipitation value used in calculation of home irrigation rate (Section 6.5 and Appendix B). Updated format throughout.

Change History	
REV 02	Entire report revised. Reanalyzed all mass loading parameter distributions for use in biosphere model to be used in support of License Application. Added mass loading time function and associated decrease constant parameter. Removed parameters for chronic breathing rate, exposure times, home irrigation rate, and duration of home irrigation. Changed title
REV 03	Entire scientific analysis revised to modify classification of inputs to comply with current versions of procedures. Added to Section 4.1.1 qualification for intended use of airborne particle concentration. Provided additional justification that parameter distributions are consistent with conditions in the Yucca Mountain region. Updated references to project documents that have been revised. Added DIRS numbers for all references. Made editorial corrections.

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ACRONYMS AND ABBREVIATIONS

BDCF	biosphere dose conversion factor
DTN	data tracking number
EPA	U.S. Environmental Protection Agency
ERMYN	Environmental Radiation Model for Yucca Mountain, Nevada
FEP	feature, event, or process
$PM_{2.5}$	particles with an aerodynamic diameter less than or equal to 2.5 μm
PM_4	particles with an aerodynamic diameter less than or equal to 4 μm
PM_{10}	particles with an aerodynamic diameter less than or equal to 10 μm
RMEI	reasonably maximally exposed individual
SD	standard deviation
TSP	total suspended particles
TSPA	total system performance assessment

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1. PURPOSE

This analysis is one of 10 reports that support the Environmental Radiation Model for Yucca Mountain, Nevada (ERMYN) biosphere model. The *Biosphere Model Report* (BSC 2004 [DIRS 169460]) describes in detail the conceptual model as well as the mathematical model and its input parameters. This report documents development of input parameters for the biosphere model that are related to atmospheric mass loading and supports the use of the model to develop biosphere dose conversion factors (BDCFs). The biosphere model is one of a series of process models supporting the total system performance assessment (TSPA) for a Yucca Mountain repository.

Inhalation Exposure Input Parameters for the Biosphere Model is one of five reports that develop input parameters for the biosphere model. A graphical representation of the documentation hierarchy for the ERMYN is presented in Figure 1-1. This figure shows the interrelationships among the products (i.e., analysis and model reports) developed for biosphere modeling, and the plan for development of the biosphere abstraction products for TSPA, as identified in the *Technical Work Plan for Biosphere Modeling and Expert Support* (BSC 2004 [DIRS 169573]).

This analysis report defines and justifies values of mass loading for the biosphere model. Mass loading is the total mass concentration of resuspended particles (e.g., dust, ash) in a volume of air. Mass loading values are used in the air submodel of ERMYN to calculate concentrations of radionuclides in air inhaled by a receptor and concentrations in air surrounding crops. Concentrations in air to which the receptor is exposed are then used in the inhalation submodel to calculate the dose contribution to the receptor from inhalation of contaminated airborne particles. Concentrations in air surrounding plants are used in the plant submodel to calculate the concentrations of radionuclides in foodstuffs contributed from uptake by foliar interception.

Two sets of mass loading values are developed in this analysis. The first is representative of nominal, current and future concentrations of resuspended particles in the Yucca Mountain region. In this report, nominal refers to air-quality conditions in the reference biosphere not measurably affected by a volcanic eruption at Yucca Mountain. As displayed in Figure 1-1, this set of mass loading values is used in the analysis of the biosphere groundwater exposure scenario to calculate the dose caused by inhalation and crop interception of resuspended soil contaminated by irrigation water. These values also are used in the analysis of the biosphere volcanic ash exposure scenario to calculate the dose caused by inhalation and interception of nominal concentrations of resuspended, contaminated ash following a volcanic eruption. The second set of mass loading values is representative of the increase in mass loading expected after a volcanic eruption at Yucca Mountain and is used in the biosphere volcanic ash exposure scenario to calculate the inhalation and ingestion doses following an eruption. The biosphere exposure scenarios are not the same as scenario classes used in the TSPA.

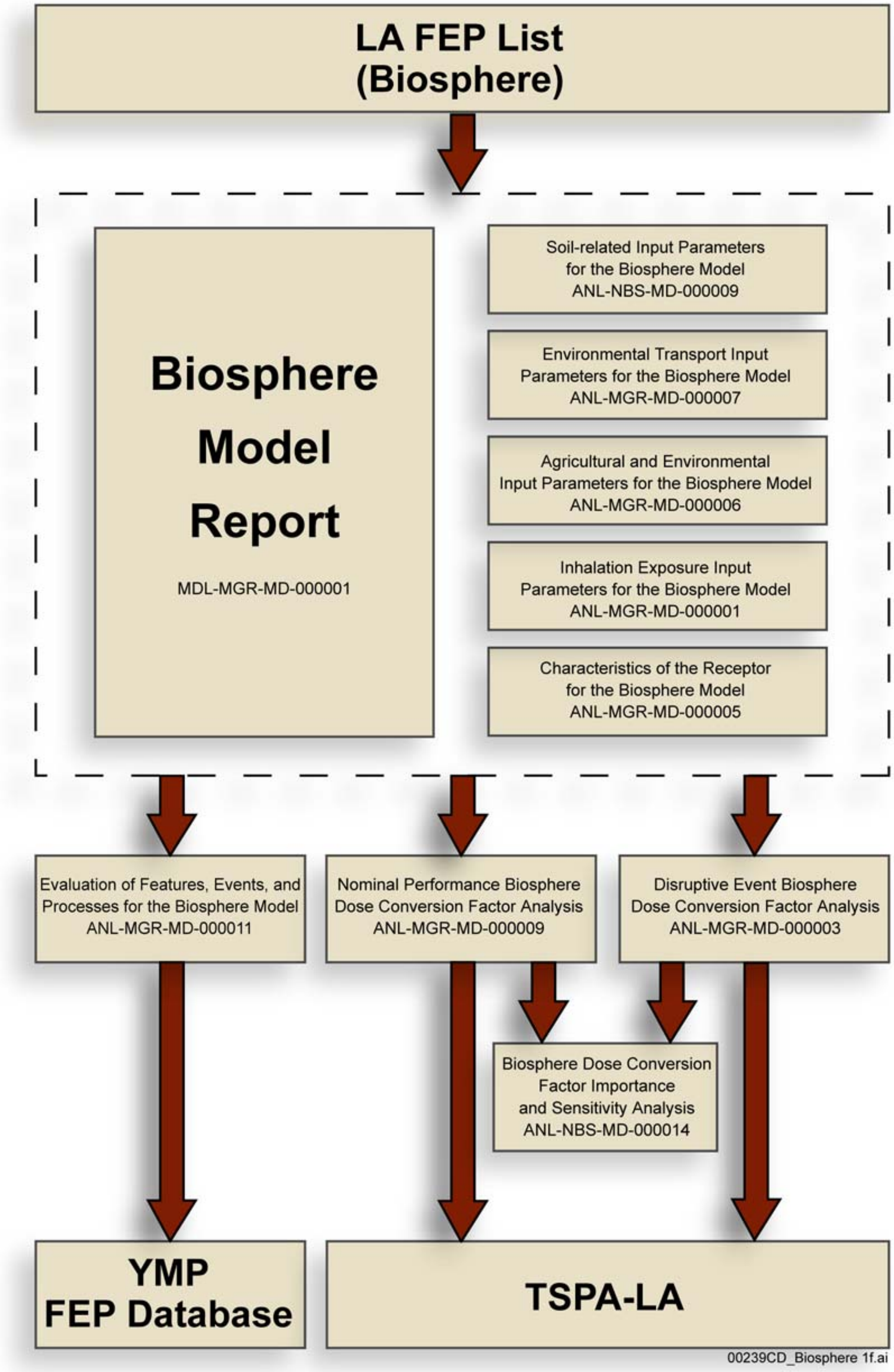

Figure 1-1. Documentation Hierarchy for the Environmental Radiation Model for Yucca Mountain, Nevada

In addition, the mass loading time function and the parameter mass loading decrease constant are developed in this analysis. This function describes how mass loading changes over time following a volcanic eruption. The decrease constant defines the rate of change in mass loading following an eruption. The time function and decrease constant are used directly in the TSPA model to account for changes in BDCFs caused by a decrease in mass loading through time following an eruption.

To summarize, the following parameters are developed in this report.

- **Mass loading–receptor environments**, S_n (mg/m^3)—The average annual mass concentration of suspended particles in n environments.
- **Mass loading–crops**, S (mg/m^3)—The average annual mass concentration of suspended particles in agricultural fields and gardens to which food and forage crops are exposed.
- **Mass loading decrease constant**, λ (1/year)—Proportion of resuspended particles present at the beginning of a year that are not readily resuspendable at the end of the year. This parameter and the associated mass loading time function are applicable only to the volcanic ash exposure scenario.

These parameters support treatment of the features, events, and processes (FEPs) listed in Table 1-1 that are applicable to biosphere modeling. See the *Biosphere Model Report* (BSC 2004 [DIRS 169460], Section 6.2) for information on the treatment of FEPs in the biosphere model. Consideration of the *LA FEPs List* (data tracking number [DTN] MO0407SEPFEPLA.000 [DIRS 170760]) constitutes a deviation from the technical work plan (BSC 2004 [DIRS 169573]), which referred to an earlier revision of the FEPs list.

This analysis was conducted according to AP-SIII.9Q, *Scientific Analyses*, and an approved technical work plan (BSC 2004 [DIRS 169573]).

Table 1-1. Relationship of Parameters and FEPs

Parameter	FEP Name	FEP Number	Biosphere Submodel	Summary of Disposition in TSPA[a]
Mass Loading – Receptor Environments	Ash fall	1.2.04.07.0A	Air	The treatment of this parameter is described in Sections 6.1 and 6.2 and summarized in Table 7-1.
	Human lifestyle	2.4.04.01.0A		
	Wild and natural land and water use	2.4.08.00.0A		
	Agricultural land use and irrigation	2.4.09.01.0B		
	Urban and industrial land and water use	2.4.10.00.0A		
	Atmospheric transport of contaminants	3.2.10.00.0A		
Mass Loading – Crops	Ash fall	1.2.04.07.0A	Plant	The treatment of this parameter is described in Sections 6.1.5 and 6.2.5 and summarized in Table 7-1.
	Agricultural land use and irrigation	2.4.09.01.0B		
	Atmospheric transport of contaminants	3.2.10.00.0A		
Mass Loading Time Function and Decrease Constant	Ash fall	1.2.04.07.0A	N/A[b]	The treatment of this parameter is described in Section 6.3 and summarized in Table 7-1.
	Soil and sediment transport in the biosphere	2.3.02.03.0A		
	Inhalation	3.3.04.02.0A		

Source: DTN MO0407SEPFEPLA.000 (DIRS 170760).

[a] The effects of these FEPs are included in the TSPA through the BDCFs. See the *Biosphere Model Report* (BSC 2004 [DIRS 169460], Section 6.2) for a complete description of the inclusion and treatment of FEPs in the biosphere model.

[b] This parameter is used directly in the TSPA, not in the biosphere model.

FEP=features, events, and processes; TSPA=total system performance assessment

2. QUALITY ASSURANCE

Development of this report involves analysis of data to support performance assessment, as described in the technical work plan (BSC 2004 [DIRS 169573]) and is a quality-affecting activity in accordance with AP-2.27Q, *Planning for Science Activities*. Approved quality assurance procedures identified in Section 4 of the technical work plan have been used to conduct and document the activities described in this report. Electronic data used in this analysis were controlled in accordance with the methods specified in Section 8 of the technical work plan.

The natural barriers and items identified in the *Q-list* (BSC 2004 [DIRS 168361]) are not pertinent to this analysis and a safety category per AP-2.22Q, *Classification Analyses and Maintenance of the Q List*, is not applicable.

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3. USE OF SOFTWARE

The only software used to manipulate or analyze data were the commercial off-the-shelf products Microsoft Access 97 SR-2 and Microsoft Excel 97 SR-2. All methods used within Access and Excel to manipulate or combine data, and associated formulas, inputs, and outputs, are described in the text or tables of this report. The average and standard deviation (SD) functions of Excel were used throughout this analysis to calculate summary statistics and Excel graphics functions were used to create figures.

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4. INPUTS

4.1 DIRECT INPUTS

The inputs directly used to develop parameter distributions are described and justified below and summarized in Table 4-1.

Table 4-1. Direct Inputs

Input	Source of Input	Description
Resuspended particle concentrations and ratios	Peer-reviewed publications listed in Table 4-2	External-source measurements of TSP or other airborne particulate concentrations taken in the environments considered in the biosphere model
Resuspended particle concentrations	EPA AIRdata database (MO0210SPATSP01.023 [DIRS 160426])	Annual average TSP concentrations at monitoring sites throughout the United States, 1970–2001
Resuspended particle concentrations	EPA AIRdata database (MO0008SPATSP00.013 [DIRS 151750])	24-hour concentrations of TSP at monitoring sites in Washington, 1979–1982
Resuspended particle concentration ratios	MO98PSDALOG111.000 (DIRS 119501) TM000000000001.039 (DIRS 121386) TM000000000001.041 (DIRS 121396) TM000000000001.042 (DIRS 121405) TM000000000001.079 (DIRS 121410) TM000000000001.082 (DIRS 121416) TM000000000001.084 (DIRS 121419) TM000000000001.096 (DIRS 121421) TM000000000001.097 (DIRS 121426) TM000000000001.098 (DIRS 121429) TM000000000001.099 (DIRS 121435) TM000000000001.105 (DIRS 121440) TM000000000001.108 (DIRS 121442)	24-hour concentrations of TSP and PM_{10} at two sites at Yucca Mountain, 1989–1997.
Climate	National Climatic Data Center (NCDC 1998 [DIRS 135900; DIRS 125325])	Average annual precipitation and snowfall, and other measurements of climate at weather stations in the western United States through 1997

EPA=U.S. Environmental Protection Agency; PM_{10}= particles with an aerodynamic diameter $\leq$10 μm; TSP=total suspended particles

4.1.1 Airborne Particle Concentrations

Measurements of airborne particle concentrations reported within the sources listed in Table 4-2 were used to develop distributions of mass loading. These measurements were taken in settings consistent with the conditions in the active outdoor, active indoor, and asleep indoor environments in Amargosa Valley and used in the biosphere model (the environments are described in Section 6). To ensure that the distributions of mass loading developed from these measurements were consistent with conditions in the Yucca Mountain region, uncertainty about the influence of climate, environment, activity patterns, and other factors were considered, as described in Section 6. Description of these measurements, their use in this analysis, and their applicability to conditions in the Yucca Mountain region, is further described in Sections 5.2, 6.1, 6.2, and 6.3. Applicable mean or other representative values from the publications included in this data set are presented in Tables 6-1, 6-3, 6-4, and 6-5.

Table 4-2. Sources of Published Measurements of Resuspended Particle Concentrations

Source	Source
Archer et al. 2002 (DIRS 168488)	Merchant et al. 1982 (DIRS 160102)
Baxter et al. 1999 (DIRS 150713)	Molocznik and Zagorski 1998 (DIRS 154281)
Brauer et al. 2000 (DIRS 159703)	Molocznik and Zagorski 2000 (DIRS 159587)
Brook et al. 1997 (DIRS 160254)	Monn et al. 1997 (DIRS 150888)
Buist et al. 1983 (DIRS 159738)	Mozzon et al. 1987 (DIRS 159585)
Buist et al. 1986 (DIRS 144632)	Nieuwenhuijsen and Schenker 1998 (DIRS 150854)
Buist et al. 1986 (DIRS 160308)	Nieuwenhuijsen et al. 1998 (DIRS 150855)
Clausnitzer and Singer 1997 (DIRS 160404)	Nieuwenhuijsen et al. 1999 (DIRS 150711)
Clayton et al. 1993 (DIRS 159599)	Pellizzari et al. 1999 (DIRS 159702)
Evans et al. 2000 (DIRS 159679)	Quackenboss et al. 1989 (DIRS 159682)
Howard-Reed et al. 2000 (DIRS 159680)	Rojas-Bracho et al. 2000 (DIRS 159678)
Janssen et al. 1998 (DIRS 159699)	Searl et al. 2002 (DIRS 160104)
Kullman et al. 1998 (DIRS 159586)	Thatcher and Layton 1995 (DIRS 159600)
Leaderer et al. 1999 (DIRS 160403)	Wheeler et al. 2000 (DIRS 159704)
Linn et al. 1999 (DIRS 159602)	Wigzell et al. 2000 (DIRS 159729)
Lioy et al. 1990 (DIRS 159655)	Williams et al. 2000 (DIRS 159735)
Long et al. 2000 (DIRS 159681)	Yano et al. 1990 (DIRS 160112)
Long et al. 2001 (DIRS 159733)	Yocom et al. 1971 (DIRS 159654)

To ensure that a comprehensive set of data was included in this analysis, online scientific journal and citation index searches were conducted and reference lists from related reports and publications were reviewed. The resulting data set includes original measurements of resuspended particle concentrations from all publications known to the author of this analysis that met the following requirements. The requirements were selected to ensure that the data are technically defensible and applicable to this analysis.

- The information was published in a peer-reviewed scientific journal. The location of publication of each data source is listed in Section 8.1.
- The methods used to measure particulate concentrations were sufficiently described to determine whether the methods and equipment used were applicable to this analysis and comparable to other studies.
- Measurements were made in a setting applicable to this analysis (e.g., outdoor settings during dust-disturbing activities, indoor settings with and without activity).

In addition, because mass loading is defined as the concentration of all resuspended particles, most of the sources included in this data set report concentrations of total suspended particles (TSP) or particles with an aerodynamic diameter less than or equal to 10 μm (PM_{10}). Because of the small number of measurements reported for the active outdoor environment, asleep indoor environment, and post-volcanic environments, sources that report concentrations of smaller particles (e.g., particles with an aerodynamic diameter less than or equal to 4 μm [PM_4] or less than or equal to 2.5 μm [$PM_{2.5}$]) in those environments also were included. Sources that report concentrations of $PM_{2.5}$ in the other environments considered in the biosphere model were not included because sufficient measurements of TSP and PM_{10} were available. Also, sources that report concentrations for environments not considered in the biosphere model were not included.

No requirement was included concerning the accuracy or precision of the data because the mass loading distributions developed in this analysis have a relatively large range and are therefore insensitive to the much smaller levels of error in measurement of airborne particle concentrations. For example, limits of detectability of equipment commonly used to measure mass loading are generally less than 0.01 mg/m^3 and sampling precision generally is less than 0.02 mg/m^3 (Howard-Reed et al. 2000 [DIRS 159680], p. 1127; Rojas-Brancho et al. 2000 [DIRS 159678], p. 297; Williams et al. 2000 [DIRS 159735], p. 523).

In accordance with AP-SIII.9Q, the following information was considered to evaluate whether the data was collected using acceptable methodology and to evaluate whether sufficient confidence in the acquisition and development of results is warranted to consider the data suitable for use in this analysis.

- **Reliability of Data Sources–**Because all data considered here came from peer-reviewed publications, and was thus judged to be appropriate for publication by experts in the associated fields of study, it is concluded that the data sources are reliable for use in this analysis. In addition, the methods used were described in sufficient detail to determine whether the results are applicable to this analysis. Four publications that report resuspended particle concentrations following the eruption of Mount St. Helens did not fully describe the methods used to measure and summarize concentrations (Buist et al. 1983 [DIRS 159738]; Buist et al. 1986 [DIRS 144632; DIRS 160308]; and Merchant et al. 1982 [DIRS 160102]). However, those methods were fully described in reports published by the National Institute for Occupational Safety and Health (Hewett 1980 [DIRS 168490; DIRS 168491]; Sanderson 1982 [DIRS 168492]).

- **Extent to Which the Data Demonstrates the Properties of Interest–**Measurements of resuspended particle concentrations are most applicable to this analysis if they are measurements of personal exposure to TSP taken in the environments considered in the biosphere model under conditions consistent with the conditions in the Yucca Mountain region. As described in Section 6, all measurements considered here were taken in settings that are consistent with the environments considered. In addition, most measurements were of personal exposure to particle concentrations. Measurements of ambient concentrations were not used for the active outdoor environment (Sections 6.1.1 and 6.2.1), and were used for the active indoor environment only if people were active indoors while the measurements were taken (Section 6.1.3 and 6.2.3). Ambient concentrations were included for the asleep indoor environment because they are representative of conditions while people are inactive (Sections 6.1.4 and 6.2.4). Because there were too few measurements of TSP for some environments, such as active indoors, measurements of PM_{10} and smaller particles also were considered. Because representative ratios of large to small particles specific to each environment were used when considering those concentrations, they are appropriate for use in this analysis. Additional discussion of the applicability of the data to the conditions in the Yucca Mountain region is included in Sections 5.1, 6.1, 6.2, and 6.3.

- **Availability of Corroborating Data**–Because all applicable data on resuspended particle concentrations were considered in this analysis, there is no corroborating data available. However, all data used were plotted and compared to evaluate the reasonableness of the results of each study and to understand variation and uncertainty of concentrations within each environment (Tables 6-1, 6-3, 6-4, and 6-5). Measurements for each environment are similar, especially for indoor environments (e.g., Table 6-3). These comparisons provide confidence that the data are reliable and do not contain invalid or inconsistent measurements.

Because the data considered here come from peer reviewed journals, have sufficiently described methods, and were from studies conducted in applicable environments, it is concluded that the data are suitable for the specific application in this analysis. Confidence in the reliability of the data is raised by corroborative comparisons. Thus, the data are considered qualified for the intended use in this analysis.

4.1.2 Total Suspended Particles – United States

Annual average concentrations of TSP measured at ambient monitoring stations located in rural, agricultural settings in arid to semi-arid environments in the western United States (DTN: MO0210SPATSP01.023 [DIRS 160426]) were used to determine mass loading in the outdoor inactive environment (Section 6.1.2). The data were obtained from the U.S. Environmental Protection Agency (EPA) Office of Air and Radiation AirData database (Ambrose 2002 [DIRS 160080; DIRS 160081]). This federal agency is responsible for developing programs, policies, and regulations for controlling air pollution. The AirData database contains measurements of air pollution concentrations collected by federal, state, and local air pollution control agencies to track compliance with emission standards. These data were collected and reported in accordance with EPA requirements for methodology and quality control and therefore were collected using consistent methods that meet federal quality control standards. These data therefore are appropriate for use in this analysis and are considered established fact. See Section 6.1.2 for additional information on the appropriateness of these data for their intended use and the applicability of the data to the conditions in the Yucca Mountain region. Selection of the subset of data used in this analysis is described in Section 6.1.2.1, and those data are displayed in Appendix B.

4.1.3 Total Suspended Particles – Washington

Twenty-four-hour concentrations of TSP during 1979–1982 from air quality monitoring sites in Washington with high ash fall from the eruption of Mount St. Helens (DTN: MO0008SPATSP00.013 [DIRS 151750]) were used in Sections 6.2.2 and 6.3 to predict changes in mass loading following a volcanic eruption. These data were obtained from the EPA AirData database and were collected using consistent methods that meet federal quality control standards. Selection of the subset of data used in this analysis is described in Section 6.2.2.1. See Section 6.2.2 and 6.3 for additional justification on the appropriateness of these data and for caveats about the interpretation of the data for their intended use. Data used in this analysis is displayed in Appendix D and are considered established fact.

4.1.4 Resuspended Particles – Yucca Mountain

All valid 24-hour concentrations of PM_{10} and TSP measured concurrently using co-located monitoring equipment at Yucca Mountain during 1989 through 1997 were used in Section 6.1.3.1 to calculate a ratio of TSP to PM_{10} for the Yucca Mountain region. See Table 4-1 for a list of DTNs containing these data. These data are appropriate because they were collected in areas with soils typical of those in Amargosa Valley (CRWMS M&O 1999 [DIRS 107736], Figure 1 on pp. 2 and 3) and therefore are consistent with relatively undisturbed conditions of the Yucca Mountain region. In addition, these measurements are comparable to data collected elsewhere in the United States because they were taken in accordance with EPA requirements for methodology and quality control. The data are displayed in Appendix E. Deletion of 24 invalid ratios with a TSP:PM_{10} ratio of less than or equal to 1 is discussed in Section 6.1.3.1.

4.1.5 Precipitation – United States

Measurements of average annual precipitation at weather stations in the western United States obtained from the National Oceanic and Atmospheric Administration, National Climatic Data Center (NCDC 1998 [DIRS 135900; DIRS 125325]) were used in Section 6.1.2 and Appendices B and C to aid in selecting analogue air quality monitoring sites representative of arid farming communities. This information also was used throughout Section 6 to describe the climate at weather stations analogous to future conditions predicted for Yucca Mountain. The National Climatic Data Center is responsible for archiving weather data obtained by the National Weather Service, Military Services, Federal Aviation Administration, Coast Guard, and voluntary cooperative observers. These measurements were collected using the standardized methods and equipment required by the National Climatic Data Center; therefore, they are valid for comparison among sites in the United States and are considered established fact. The data from the National Climatic Data Center used in this analysis are displayed in Appendix B.

4.2 CRITERIA

Table 4-3 lists the requirements from the *Project Requirements Document* (Canori and Leitner 2003 [DIRS 166275]) that are applicable to this analysis. These requirements are for compliance with applicable portions of 10 CFR Part 63 [DIRS 156605]. In addition to the requirements listed in Table 4-3, definitions of terms in 10 CFR 63.2 and description of concepts in 10 CFR 63.102 that are relevant to biosphere modeling are also applicable to this analysis.

Listed below are the acceptance criteria from the *Yucca Mountain Review Plan, Final Report* (NRC 2003 [DIRS 163274]) that are applicable to this analysis. The list is based on meeting the requirements of 10 CFR 63.114, 10 CFR 63.305, and 10 CFR 63.312 [DIRS 156605], that relate in whole or in part to this analysis. See Section 7.2 for a summary of where the criteria are addressed.

Table 4-3. Requirements Applicable to This Analysis

Requirement Number	Requirement Title	Related Regulation
PRD-002/T-015	Requirements for Performance Assessment	10 CFR 63.114 (DIRS 156605)
PRD-002/T-026	Required Characteristics of the Reference Biosphere	10 CFR 63.305 (DIRS 156605)
PRD-002/T-028	Required Characteristics of the Reasonably Maximally Exposed Individual	10 CFR 63.312 (DIRS 156605)

Source: From Canori and Leitner (2003 [DIRS 166275], Table 2-3).

Only the criteria from Section 2.2.1.3.14 (Biosphere Characteristics) of the *Yucca Mountain Review Plan, Final Report* (NRC 2003 [DIRS 163274]) apply to this analysis. The modeling of effects of wind erosion on the redistribution of radionuclides in soils, which is partially covered in Section 2.2.1.3.13 (Redistribution of Radionuclides in Soil) of the review plan, is discussed in other biosphere reports (e.g., BSC 2004 [DIRS 169459], Section 6.4; BSC 2004 [DIRS 169460], Sections 6.4.1 and 6.5.1). Section 2.2.1.3.11 (Airborne Transport of Radionuclides) of the review plan is interpreted to apply only to airborne transport of radionuclides to the biosphere following a volcanic eruption. Airborne transport of radionuclides within the biosphere is evaluated in the context of the review criteria in Section 2.2.1.3.14:

Acceptance Criteria from Section 2.2.1.3.14: Biosphere Characteristics

Acceptance Criterion 1: System Description and Model Integration are Adequate

> **(3)** Assumptions are consistent between the biosphere characteristics modeling and other abstractions. For example, the U.S. Department of Energy should ensure that the modeling of features, events, and processes, such as climate change, soil types, sorption coefficients, volcanic ash properties, and the physical and chemical properties of radionuclides are consistent with assumption in other total system performance assessment abstractions; and

Acceptance Criterion 2: Data are Sufficient for Model Justification

> **(1)** The parameter values used in the license application are adequately justified (e.g., behaviors and characteristics of the residents of the Town of Amargosa Valley, Nevada, characteristics of the reference biosphere, etc.) and consistent with the definition of the reasonably maximally exposed individual in 10 CFR Part 63. Adequate descriptions of how the data were used, interpreted, and appropriately synthesized into the parameters are provided.
>
> **(2)** Data are sufficient to assess the degree to which features, events, and processes related to biosphere characteristics modeling have been characterized and incorporated in the abstraction. As specified in 10 CFR Part 63, the U.S. Department of Energy should demonstrate that features, events, and processes, which describe the biosphere, are consistent with present knowledge of conditions in the region, surrounding Yucca Mountain. As appropriate, the U.S. Department of Energy sensitivity and uncertainty analyses (including consideration of alternative conceptual models) are adequate for determining additional data needs,

and evaluating whether additional data would provide new information that could invalidate prior modeling results and affect the sensitivity of the performance of the system to the parameter value or model.

Acceptance Criterion 3: Data Uncertainty is Characterized and Propagated Through the Model Abstraction

(1) Models use parameter values, assumed ranges, probability distributions, and bounding assumptions that are technically defensible, reasonably account for uncertainties and variabilities, do not result in an under-representation of the risk estimate, and are consistent with the definition of the reasonably maximally exposed individual in 10 CFR Part 63;

(2) The technical bases for the parameter values and ranges in the abstraction, such as consumption rates, plant and animal uptake factors, mass-loading factors, and biosphere dose conversion factors, are consistent with site characterization data, and are technically defensible;

(3) Process-level models used to determine parameter values for the biosphere characteristics modeling are consistent with site characterization data, laboratory experiments, field measurements, and natural analog research;

(4) Uncertainty is adequately represented in parameter development for conceptual models and process-level models considered in developing the biosphere characteristics modeling, either through sensitivity analyses, conservative limits, or bounding values supported by data, as necessary. Correlations between input values are appropriately established in the total system performance assessment, and the implementation of the abstraction does not inappropriately bias results to a significant degree.

4.3 CODES, STANDARDS, AND REGULATIONS

No codes, standards, or regulations other than those identified in the *Project Requirements Document* (Canori and Leitner 2003 [DIRS 166275], Table 2-3) and determined to be applicable (Table 4-3) were used in this analysis.

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5. ASSUMPTIONS

5.1 MASS LOADING–CROPS

The distribution of mass loading in fields where crops are growing is assumed to be similar to or higher than that in the inactive outdoor environment, with a minimum value equal to the minimum value of the inactive outdoor environment, and a modal and maximum value twice that of the inactive outdoor environment.

This assumption is used in Sections 6.1.5 and 6.2.5 to develop distributions of mass loading for crops for nominal and post-volcanic conditions.

Dust concentrations during the latter part of the growing season, rather than the entire season, must be considered for development of the mass loading distribution for crops, because dust deposited on the surface of plants quickly falls off, washes off, or is otherwise removed relatively rapidly (Till and Meyer 1983 [DIRS 101895], pp. 5-36 and 5-37; IAEA 2001 [DIRS 158519], p. 64), and because harvested foodstuffs and forage are not present early in the season. Therefore, planting, plowing, weeding, berming, and other soil-disturbing activities that occur early in growing seasons will have little influence on uptake of radionuclides into foodstuffs via dust deposition. Few soil-disturbing activities except harvesting usually occur during the latter part of growing seasons, especially for plants such as alfalfa, wheat, orchard crops, and garden vegetables commonly grown in Amargosa Valley and eastern Washington (the analogue site for consideration of the wettest and coolest future climatic conditions, BSC 2004 [DIRS 170002], Table 6-1). The increase in mass loading during harvesting will occur over a very short period relative to the remainder of the period for which radionuclide concentrations on plant surfaces are considered and much of the dust deposited during harvesting may be removed during field processing of crops. Because fields and gardens are infrequently disturbed and frequently irrigated during the latter part of the growing season, there should be few sources of resuspended particles in the immediate vicinity of plants and mass loading therefore will be influenced most by particle resuspension in the region surrounding the fields and gardens.

The mass loading distribution for the nominal, inactive outdoor environment was developed from measurements of airborne particulate concentrations at stationary monitors in rural, agricultural communities with less than 20 in. of rainfall in the western United States (Section 6.1.2). Those measurements were influenced by resuspended dust from agricultural fields and agricultural activities in the general vicinity of monitoring stations, but not necessarily at the station locations. Therefore, they are consistent with the climatic and rural, agricultural conditions in the Yucca Mountain region and generally match the conditions required to estimate mass loading concentrations for crops. See Section 6.1.2 for additional information on the consistency of these data with conditions in the Yucca Mountain region.

It is possible that mass loading concentrations in some fields are higher than measurements from stationary, community monitors. Crops may be located closer to sources of resuspended particles (e.g., dirt roads, recently plowed fields) than community monitors and some increase in airborne particle concentrations will occur during harvesting. Also, stationary monitors usually are located about 1.5 m above the ground surface, and therefore do not measure airborne particulate concentrations where most plants grow. Mass loading near the ground surface is expected to be higher than at 1.5 m because it takes less force (i.e., less wind) to resuspend a particle a short distance off the ground.

To account for uncertainty in these differences between the environment around crops and the locations where community monitors are located, it is assumed that the modal and maximum values of the distribution of mass loading for crops are twice that of the distribution for the inactive outdoor environment. A higher multiplier was not chosen for the following reasons. There are few soil disturbing activities, other than harvesting, that would occur late in the growing season. In addition, the crops commonly grown in Amargosa Valley, such as alfalfa and other hay, cover much of the soil surface when mature, and are irrigated regularly. The presence of vegetative cover and moist soil reduces soil resuspension. Also, mass loading rapidly returns to background levels after soil-disturbing activities cease (Pinnick et al. 1985 [DIRS 159577], p. 104) and the influence of soil disturbing activities on mass loading generally is limited to less than 0.75 km (Chow et al. 1999 [DIRS 145212], p. 652). Thus, for most of the time, there will be few or no soil-disturbing activities or sources of readily resuspendable soil that would cause an increase in mass loading near crops greater than that measured at community monitoring sites.

The minimum value of the distribution of mass loading for crops is assumed to be equal to the minimum value of the inactive outdoor environment, primarily because it is likely that some crops are located in situations very similar to community monitors. Therefore, concentrations measured by those monitors (and used to estimate mass loading in the inactive outdoor environment) will be similar to concentrations for those crops. In addition, some crops such as alfalfa cover almost the entire ground surface; therefore, there would be very little wind erosion in the immediate vicinity of the plants before harvesting.

5.2 POSTVOLCANIC INDOOR CONCENTRATIONS

It is assumed that changes in outdoor concentrations of mass loading following a volcanic eruption have a proportional affect on mass loading in indoor environments.

This assumption is used in Section 6.2.3 and 6.2.4 to develop distributions of mass loading in the active indoor and asleep indoor environments for the first year following a volcanic eruption.

This assumption is based on published comparisons of indoor and outdoor concentrations of particulate matter. The studies reviewed were selected as described in Section 4.1.1, and are the same as those described in Sections 6.1.3 to evaluate concentrations in the active indoor environments. See Section 6.1.3 for a description of the studies.

Eleven of the 17 studies reviewed in Section 6.1.3 included correlation and some regression coefficients of indoor and outdoor concentrations (Table 5-1). Those coefficients ranged from 0.08 to 0.96, and most were between 0.25 and 0.75. Five of seven studies that included statistical tests of correlation coefficients reported that the correlations were significant. Outdoor concentrations were relatively low in the two studies that reported no significant correlation (Leaderer et al. 1999 [DIRS 160403], Table 2; Rojas-Bracho et al. 2000 [DIRS 159678], Table 2). Factors such as amount of smoking, cooking, and personal activity were listed in many studies as explanations why correlations between indoor and outdoor concentrations were relatively low.

Seven studies reported the slope of the regression between indoor or personal and outdoor concentrations (Table 5-1). Eight of 10 slopes reported were between 0.39 and 0.55, indicating that in those studies, an increase in outdoor concentrations resulted in an increase of about half that amount in indoor concentrations. The only study reporting a slope greater than 1 (Quackenboss et al. 1989 [DIRS 159682]) included a substantial number of smokers. It is expected that concentrations inside the homes of smokers would be high relative to outdoor concentrations because smoking generates a large concentration of particles.

In summary, the results of these studies indicate that an increase in outdoor concentrations usually will result in an increase in indoor concentrations, although the magnitude of changes indoors likely will be less than those outdoors, and that other factors, such as the amount of smoking, cooking and other indoor activities also influence the relationship between indoor and outdoor concentrations.

There is some uncertainty in applying the results of these studies to post-volcanic conditions that may occur near Yucca Mountain. It is predicted that modal TSP concentrations in the inactive outdoor environment would double from 0.060 mg/m^3 to 0.120 mg/m^3 the first year after a volcanic eruption (Section 6.2.2). Few of the studies listed in Table 5-1 were conducted when outdoor concentrations were that high, and none were conducted during a period when concentrations remained high for long. It is possible that a large increase in TSP outdoors, or high concentrations outdoors for most of the year, would result in a larger change in indoor TSP than indicated by the regression slopes listed in Table 5-1. For example, air-filtering systems could become overwhelmed or larger amounts of dust could be tracked indoors, resulting in higher concentrations indoors. It contrast, people may dust and vacuum more often or keep their windows closed to reduce dust concentrations. To account for this uncertainty, and ensure that indoor concentrations following a volcanic eruption are not underestimated, it is assumed that indoor concentrations will increase proportionally to outdoor concentrations.

Table 5-1. Correlation Coefficients (R) of Indoor and Personal Versus Outdoor Concentrations of Airborne Particles

Reference	***R***	***P*[a]**	**Slope[b]**	**Comparison[c]**
Clayton et al. 1993 (DIRS 159599), Table 3	0.35	–	–	Personal: Ambient PM_{10}, day
	0.62	–	–	Personal: Ambient PM_{10}, night
	0.46	–	–	Indoor: Ambient $PM_{2.5}$, day
	0.65	–	–	Indoor: Ambient $PM_{2.5}$, night
Lioy et al. 1990 (DIRS 159655), p. 62	0.67	<0.01	0.50	Indoor: Ambient PM_{10}
Quackenboss et al. 1989 (DIRS 159682), Figure 2	0.42	–	1.14	Indoor: Ambient PM_{10}, includes smokers
Leaderer et al. 1999 (DIRS 160403), Table 2, Figure 2	0.29	>0.10	–	Indoor: Outdoor PM_{10}
	0.11	>0.10	–	Indoor: Ambient PM_{10}
	0.53	<0.01	0.43	Indoor: Outdoor $PM_{2.5}$
	0.08	>0.10	–	Indoor: Ambient $PM_{2.5}$
Long et al. 2000 (DIRS 159681), Figure 7	0.20	<0.001	–	Indoor: Outdoor $PM_{2.5\text{-}10}$, day
	0.65	<0.001	–	Indoor: Outdoor $PM_{2.5\text{-}10}$, night
Pellizzari et al. 1999 (DIRS 159702), Figure 3	0.23	<0.01	–	Personal: Outdoor $PM_{2.5}$
	0.19	<0.01	–	Personal: Ambient $PM_{2.5}$
	0.33	<0.01	–	Indoor: Outdoor $PM_{2.5}$
	0.21	<0.01	–	Indoor: Ambient $PM_{2.5}$
Janssen et al. 1998 (DIRS 159699), Table 3	0.71	<0.01	0.55	Personal: Ambient PM_{10}
	0.75	<0.01	0.47	Indoor: Outdoor PM_{10}
Evans et al. 2000 (DIRS 159679), Table 10	0.75	–	–	Indoor: Outdoor PM_{10}
	0.67	–	–	Indoor: Ambient PM_{10}
Williams et al. 2000 (DIRS 159735), Table 9	0.96	<0.001	0.39	Apartment: Outdoor $PM_{2.5}$
	0.96	<0.001	0.40	Apartment: Ambient $PM_{2.5}$
Linn et al. 1999 (DIRS 159602), Table 3 and p. 112	0.66	–	0.87	Personal: Outdoor PM_{10}
	0.54	–	0.22	Indoor: Ambient PM_{10}
Rojas-Bracho et al. 2000 (DIRS 159678), Table 5	0.41	>0.05	0.43	Personal: Ambient PM_{10}

[a] Probability of null hypothesis that there is no correlation between indoor and outdoor concentrations.

[b] Slope of regression of indoor/personal on outdoor concentrations.

[c] "Personal" concentrations were measured near head of subjects; "Apartment and Indoor" concentrations were measured at stationary indoor sites; Outdoor concentrations were measured at stationary sites outdoors near homes; and "Ambient" concentrations were measured at regional, stationary sites.

$PM_{2.5}$ =particles with an aerodynamic diameter ≤ 2.5 μm; PM_{10} =particles with an aerodynamic diameter ≤ 10 μm, dash indicates no data reported.

6. SCIENTIFIC ANALYSIS DISCUSSION

This section describes how mass loading distributions are used in the biosphere model to calculate radionuclide concentrations in air. The following sections then describe development of the mass loading parameters for the biosphere groundwater scenario (Section 6.1) and the volcanic ash scenario (Section 6.2). Use of the mass loading time function and decrease constant in the TSPA model, and development of that parameter, is described in Section 6.3.

In general, mass loading distributions were developed based on concentrations of resuspended particles measured in environments in which the relevant conditions were consistent with present knowledge of conditions in the region surrounding Yucca Mountain. Alternatively, mass loading distributions could have been developed using a soil resuspension model (Anspaugh et al. 1975 [DIRS 151548]). Although resuspension models were examined to select the shape of the mass load decay function for the volcanic eruption parameters, resuspension models were not used to calculate mass loading values because available models require numerous site- and situation-specific parameter values that are not available and the accuracy of the models is not well understood (Garger et al. 1997 [DIRS 124902]).

The mass loading distributions presented in this report are intended for use in modeling of all climate states considered in the TSPA (BSC 2003 [DIRS 166296], p. 79; BSC 2004 [DIRS 169674], Section 6.1.3). Average annual precipitation in northern Amargosa Valley currently is approximately 4–6 in. (CRWMS M&O 1999 [DIRS 102877], Appendix A) and snowfall is rare. It is forecasted that the wettest, coolest future climate that will occur at Yucca Mountain during next 10,000 years, the glacial transition climate, will be consistent with the climate in part of eastern Washington (BSC 2004 [DIRS 170002], Section 6.6.2 and Table 6-1). Analogue weather stations for the upper bound of the glacial transition climate are Spokane (average annual precipitation = 16.2 in., average annual snowfall = 42.1 in.), Rosalia (precipitation = 18.1 in., snowfall = 24.3 in.), and St. Johns (precipitation = 17.1 in., snowfall = 25.8 in.), Washington (BSC 2004 [DIRS 170002], Table 6-1). Climate data are from the National Climatic Data Center (NCDC 1998 [DIRS 125325]).

To evaluate the influence of a change from present-day to predicted future climatic conditions on mass loading, annual average concentrations of TSP at rural, agricultural sites with annual average precipitation ranging from 4.1 to 53.2 in. and snowfall ranging from zero to 43.8 in. were compared (Appendix C). Rural, agricultural sites were selected to ensure that the level of human activity and surface-disturbing conditions at the sites were consistent with the conditions in the Yucca Mountain region. Eleven sites included in this analysis had total annual precipitation of less than 10 in. Some of these arid sites are within or along the northern edge of the Mojave Desert and have vegetation consistent with that found in the Yucca Mountain region (e.g., Twentynine Palms, California [site number 06-071-1101, average annual precipitation 4.1 in.]; Moapa, Nevada [32-003-1003, 4.1 in.]; Bishop, California [06-027-0002, 5.3 in.]; Corcoran, California [06-031-1002, 7.2 in.]; see Table C-1). The remainder also are in areas with sparse native vegetation.

The average concentration of TSP for the 11 sites having less than 10 in. of precipitation was 0.055 mg/m^3. This is similar to the average of 0.056 mg/m^3 for 21 sites that have an annual precipitation of 10 to 20 in., and slightly higher than the average of 0.037 mg/m^3 for 10 sites with an annual precipitation of 21 to 53 in. (Table C-1). There also was little difference in TSP concentrations among 14 sites with less than 10 in. of snowfall (average = 0.058 mg/m^3), 7 sites with 10 to 20 in. of snowfall (average = 0.055 mg/m^3), and 11 sites with more than 20 in. of snowfall (average = 0.053 mg/m^3) (Table C-2).

Based on this comparison, it is concluded that annual average concentrations of resuspended particles are not affected by the range of precipitation and associated change in vegetation expected to occur at Yucca Mountain during the 10,000-year compliance period. Therefore, the mass loading distributions developed in this analysis are intended for the present-day and future climatic conditions considered in the TSPA.

Triangular distributions were selected for all parameters in this analysis for the following reasons.

- Although distributions of dust concentrations for single activities or locations generally are lognormal (Morandi et al. 1988 [DIRS 159866], Section 3.2; Nieuwenhuijsen and Schenker 1998 [DIRS 150854], p. 10; Nieuwenhuijsen et al. 1999 [DIRS 150711], p. 37), little information is available about the shape of mass loading distributions that are representative of annual average exposure for a large group of activities such as those typically conducted in the environments used in the biosphere model.

- Distributions for most environments were developed by examining all available, applicable measurements of mass loading taken in an environment. Because the measurements considered for an environment were not all equally applicable to the conditions in the reference biosphere, they could not be used to calculate averages and SDs for lognormal or normal distributions. There was, however, sufficient information to make informed judgments and select central tendencies and bounds for use in defining triangular distributions.

- Uniform distributions are not used because those distributions convey less information than triangular distributions and because the minimum and maximum values of the distributions were selected to be reasonable bounds that have a low probability of occurrence.

- Some distributions are developed based on changes in bounds or the central tendency relative to other environments (e.g., the upper bound of mass loading for crops is twice that for the inactive outdoor environment, Section 5.1). Moving one bound of a distribution without affecting the central tendency (i.e., mode or average) or other bound is possible for triangular and uniform distributions but is not possible for many other distributions (e.g., lognormal or normal).

Because dust concentrations for single activities generally are lognormal, geometric mean values of airborne particle concentrations presented in publications are reported in this analysis if available; otherwise, arithmetic mean values are reported.

Mass Loading – Receptor Environments–The radionuclide concentrations in air that are used to estimate inhalation doses for the groundwater exposure scenario are calculated in the ERMYN for a series of environments using the following equation (BSC 2004 [DIRS 169460], Section 6.4.2).

$$Ca_{h,i,n} = f_{enhance,n}\, Cs_{m,i}\, S_n \qquad \text{(Eq. 6-1)}$$

where:

$Ca_{h,i,n}$ = Activity concentration of radionuclide *i* in air from soil resuspension for the assessment of human inhalation exposure (*h*) in environment *n* (Bq/m^3).

$f_{enhance}$ = Enhancement factor for the activity concentration of suspended particulates (dimensionless), which accounts for differences between activity concentrations of soil and suspended particles caused by differential resuspension and activity concentrations on small versus large particles.

$Cs_{m,i}$ = Activity concentration of radionuclide *i* in the surface soil per unit of mass (m) (Bq/kg).

S_n = Average annual concentration of TSP in air (mass loading) for evaluation of inhalation exposure for environment *n* (kg/m^3).

n = Index of environments (see below).

The activity concentration is then combined in the inhalation submodel with environment-specific breathing rates, time spent in each environment by the receptor, and radionuclide-specific dose conversion factors to calculate an annual dose from inhalation exposure. Therefore, an increase in mass loading results in a proportional increase in the activity concentrations of radionuclides in the air, which results in an increase in the inhalation dose. The equation used for the volcanic ash scenario is the same except that S_n is calculated as a function of time (BSC 2004 [DIRS 169460], Section 6.5.2), as described in Section 6.2.

The following receptor environments are considered in the model. They are mutually exclusive and represent the various behavioral and environmental combinations for which a person would receive a substantially different rate of exposure via inhalation or external exposure.

1. **Active Outdoors**: This environment is representative of conditions that occur when a person is outdoors in the contaminated environment conducting dust-generating activities, for example while working (e.g., field preparation, excavating, livestock operations) or recreating (e.g., gardening, landscaping, riding horses or motorbikes). Because dust concentrations decrease rapidly after dust-disturbing activities cease (Pinnick et al. 1985 [DIRS 159577], pp. 103 and 104), this category is limited to conditions during and shortly after dust-generating activities.

2. **Inactive Outdoors**: Conditions outdoors in the contaminated area when dust-generating activities are not being conducted by the receptor. This category includes time spent commuting within contaminated areas and time spent outdoors in contaminated areas conducting activities that do not resuspend soil (e.g., sitting, swimming, walking on turf or compacted/covered surfaces, barbecuing, equipment maintenance). Commute time is included in this category because major roads in Amargosa Valley are paved, and commuting on those roads would not resuspend soil.

3. **Active Indoors**: Conditions indoors within the contaminated area when people are at home or at a place of business, including conditions when they are sedentary or active.

4. **Asleep indoors**: Conditions indoors within the contaminated area when people are asleep.

5. **Away from Potentially Contaminated Area**: This category is included to account for time spent away from the potentially contaminated agricultural area (groundwater scenario) or ash deposit (volcanic ash scenario). Because the concentration of radionuclides in this environment is zero, mass loading concentrations are not developed for this environment.

Calculations described in Appendix A were conducted to evaluate the sensitivity of estimates of the mass of resuspended particles inhaled to changes in mass loading and other input parameter values. Total mass of particles inhaled was influenced most by mass loading and time spent in the active outdoor environment. Mass loading in the active indoor environment had a moderate influence on the predicted mass of particles inhaled (Appendix A, Table A-1).

10 CFR 63.311 [DIRS 156605] expresses the dose limit for the individual protection standard as an annual limit and the biosphere model therefore calculates BDCFs as the annual dose to the reasonably maximally exposed individual (RMEI) per unit concentration of radionuclides in groundwater and volcanic ash. For each realization of the biosphere model, one value of each stochastically sampled parameter is selected and used to calculate a BDCF per radionuclide. These BDCFs are then used in individual TSPA realizations to calculate a predicted annual dose. Therefore, each stochastically sampled value used in the ERMYN model must be representative of average annual conditions.

To correctly calculate the annual inhalation dose, distributions of mass loading per environment developed in this analysis must be representative of average annual concentrations of resuspended particles while the RMEI would be in the environment. Distributions of average annual concentrations do not include infrequent or unusually high or low concentrations, which could occur over short periods because such concentrations are episodic at unpredictable times and amounts.

Mass Load–Crops–The equation used to calculate radionuclide concentrations in air from which resuspended particles are intercepted by crops is similar to that used for human inhalation (Eq. 6-1), but does not include an enhancement factor and only considers one environment (i.e., immediately around the crops). Radionuclide concentrations are combined in the plant submodel of ERMYN with the deposition velocity of airborne particulates, radionuclide concentrations in soil, crop yield, and other variables to estimate the concentration of radionuclides in the edible portion of crops resulting from foliar interception of particles (BSC 2004 [DIRS 169460], Sections 6.4.2 and 6.5.2). In contrast to receptor environments (for which mass loading following a volcanic eruption is treated as a function of time), radionuclide concentrations in the environment surrounding crops are not treated as a function of time for either exposure scenario.

6.1 MASS LOADING–NOMINAL CONDITIONS

This section describes the development of mass loading distributions within the five environments (four receptor environments and the environment around crops) for nominal conditions; i.e., air quality conditions in the reference biosphere not measurably influenced by a volcanic eruption at Yucca Mountain. These values are intended for use in the groundwater exposure scenario. They also are intended for use in the volcanic ash exposure scenario for calculation of BDCFs representative of the period after mass loading concentrations have returned to pre-eruption conditions. See Section 6.2 for a description of that scenario.

For the groundwater exposure scenario, the reference biosphere is a rural community with conditions consistent with the Yucca Mountain region and a population with a living style representative of the people residing in the Town of Amargosa Valley (based on requirements in 10 CFR 63.305 and 312 [DIRS 156605]). The only common potential sources of contaminated, resuspended soil particles for this scenario would be agricultural fields, gardens, and landscapes irrigated with contaminated well water.

For the volcanic ash exposure scenario during nominal conditions, the sources of contaminated resuspended particles would be ash/waste particles initially deposited during the eruption, ash/waste particles washed into the valley from Fortymile Wash, and ash/waste particles blown into the valley. By definition of the mass loading time function, the tephra deposit will have been stabilized by the time nominal conditions occur (see Section 6.2). Thus, resuspension on undisturbed sites will be similar to that before the eruption, and the main source of resuspended particles will be agricultural fields and other disturbed sites.

The number and size of agricultural and other disturbed sites in Amargosa Valley is small relative to the size of the inhabited area. The inhabited portion of Amargosa Valley extends south and west of Highway 373 from the Lathrop Wells Junction of Highway 95 to the California border. Most people in Amargosa Valley live in the southern portion of the valley in a triangular area approximately 17 x 17 x 24 km (about 150 km^2) in size (BSC 2003 [DIRS 168723], Figure 1). This area, known as the farming triangle, is also where most agriculture in the valley occurs (CRWMS M&O 1999 [DIRS 107736], pp. 1 to 3). The U.S. Census Bureau estimated that only 26 of 449 employed Amargosa Valley residents 16 years old or older worked in agriculture (Bureau of the Census 2002 [DIRS 159728], Table P49). During 1998, there were about 8.9 km^2 (2,199 acres) of commercial agriculture in Amargosa Valley, 8.4 km^2 (2,072 acres) of which were planted at the time agricultural acreage was measured. About 87 percent of all acreage was planted in alfalfa and other hay (92 percent of planted acreage) and about 6 percent was orchards or vineyards (YMP 1999 [DIRS 158212], Table 10). During 1999, there were 8.2 km^2 (2,015 acres), 7.3 km^2 (1,798 acres) of which were planted at the time of the survey. Eighty-three percent was planted in alfalfa and other hay (93 percent of planted acreage) and 6 percent was orchards or vineyards (YMP 1999 [DIRS 158212], Table 11). In spring 2004, about 85 percent of the agricultural acreage identified in the valley in 1998 was re-surveyed (Rasmuson 2004 [DIRS 169506]). About 8 km^2 (2,000 acres) were planted for commercial agriculture; over 95 percent of that was planted in alfalfa and other hay. An additional approximately 4 km^2 (1,000 acres) had recently been planted in pine trees (Rasmuson 2004 [DIRS 169506]). Thus, only a small portion of the valley (about eight percent of the farming triangle and a much smaller portion of the entire inhabited valley) is planted in agriculture, and most of that is planted in hay, orchards, tree farms, and vineyards. Those crops require infrequent land preparation or other soil disturbances that would resuspend contaminated soil particles. There also is one large dairy near the south end of the agricultural region in Amargosa Valley that had about 5,000 cows (YMP 1999 [DIRS 158212], Tables 8 and 9; Rasmuson 2004 [DIRS 169506]). About 46 percent of 195 Amargosa Valley households surveyed during 1997 had a garden (DOE 1997 [DIRS 100332], Tables 2.4.2 and 3.5.1). In summary, Amargosa Valley has a small agricultural industry and most fields are planted in crops that require infrequent soil disturbances. Within the valley, large disturbed sites occupy only a small portion of the landscape, although small sites (e.g., gardens) may be found near about 50 percent of residences.

Resuspended particle concentrations measurement in northern Amargosa Valley and elsewhere in the Yucca Mountain region are very low. Average annual concentrations of TSP at Yucca Mountain monitoring site 1, which was near the Yucca Mountain Exploratory Studies Facility and surrounded by numerous unpaved roads and other disturbed sites, had annual average concentrations of TSP ranging from 0.022 to 0.027 mg/m^3 during 1992 to 1997 (CRWMS M&O 1999 [DIRS 102877], Table 2-3), the years when most construction was occurring at Yucca Mountain. Average concentrations of PM_{10} there ranged from 0.009 to 0.012 mg/m^3. Average annual concentrations of PM_{10} at a monitoring site in northern Amargosa Valley (Yucca Mountain monitoring site 9 at the southern boundary of the Nevada Test Site) ranged from 0.007 to 0.010 mg/m^3 during 1993 through 1997 (TSP was not measured at that site). Maximum 24-hour concentrations of PM_{10} per year at that site ranged from 0.015 to 0.057 mg/m^3. Concentrations in the farming and residential community farther south in Amargosa Valley probably are higher. However, concentrations there would not be substantially greater because the only large sources of resuspended particles in that area are about 2,000 acres of agricultural fields, most of which have perennial crops such as alfalfa that cover the ground surface and require infrequent soil-disturbing activities.

6.1.1 Active Outdoor Environment

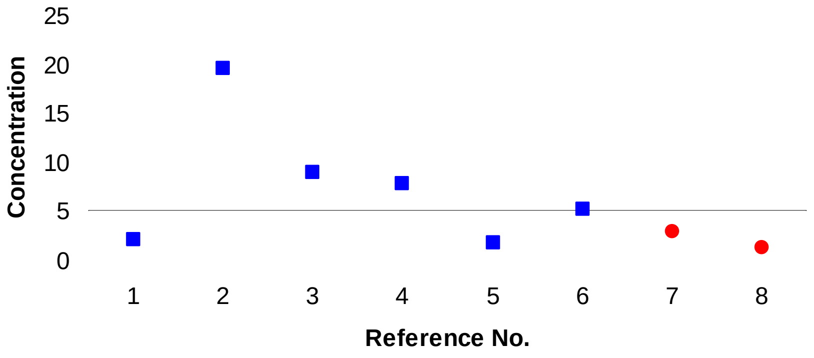
Applicable literature (see Section 4.1.1) was reviewed to determine the range of average concentrations of particles resuspended while soil disturbing activities were being conducted. The relevant factors considered in evaluating the whether the conditions under which those studies were conducted were consistent with the present conditions in the Yucca Mountain region included the types of activities conducted, aridity, and soil texture.

Applicable studies are presented below, with the most applicable results presented first. Studies were considered most applicable if they (1) reported particulate concentrations resulting from behaviors that are consistent with those conducted outdoors in Amargosa Valley while soil is being disturbed, (2) were conducted in arid to semi-arid environments, and (3) measured and reported concentrations of TSP. Only measurements of personal exposure were considered applicable for analysis of this environment. Unless otherwise stated, personal exposure was measured by placing the inlet device of a dust sampler near the head of the person performing the activity (e.g., on a shirt collar); thus, measurements of personal exposure are representative of the concentration of resuspended particles inhaled by a person while conducting an activity. A summary of this review is in Table 6-1.

Table 6-1. Particulate Concentrations–Nominal Outdoor Active Environment

	Reference	**Concentration, mg/m^3**		**Comments**
		$\bar{x}$	**Range**	
1	Nieuwenhuijsen et al. 1999 (DIRS 150711), Table 2	2.19	0.30–7.93	TSP, Farming-California, one extreme value excluded
2	Nieuwenhuijsen et al. 1998 (DIRS 150855), Table 2	19.6	0.7–98.6	TSP, Farming-California, many activities in open cab
3	Molocznik and Zagorski 1998 (DIRS 154281), Figure 2	9	3.5–19	TSP, Farming-Poland, midpoint of ranges for 6 applicable activities
4	Molocznik and Zagorski 2000 (DIRS 159587), p. 47	7.8	2.5–14.4	TSP, Farming-Poland, midpoint of ranges for 6 applicable activities
5	Kullman et al. 1998 (DIRS 159586), p. 3	1.78	GSD = 2.9	TSP, Dairy barns-Wisconsin
6	Mozzon et al. 1987 (DIRS 159585), p. 115	5.3	0.44–22.8	TSP, Landfill operators–Ontario
7	Clausnitzer and Singer 1997 (DIRS 160404, Table 1)	2.9	0.2–13.6	PM$_4$, Farming-California, respirable concentrations only
8	Archer et al 2002 (DIRS 168488), Table I	1.31	SD = 2.87	PM$_4$, Farming-North Carolina, respirable concentrations only

$\bar{x}$ = mean or other value representative of the central tendency (see text), GSD = geometric standard deviation; PM$_4$=particles with an aerodynamic diameter ≤4 μm; SD = standard deviation



Squares = TSP, circles = PM$_4$

6.1.1.1 Literature Review

Nieuwenhuijsen et al. (1999 [DIRS 150711]) recorded 142 measurements of personal exposure to TSP during farming activities at 10 farms near Davis and Sacramento, California over 15 months. Cultivated soils in that area generally are silty clay loams to clays and loams, and annual rainfall ranges from 16 to 24 in. (Andrews 1972 [DIRS 170526]). The mean TSP concentrations of 23 farming activities ranged from 0.30 (scraping cattle stalls) to 45.14 mg/m^3 (machine harvesting of nut trees from an open tractor cab); the average was 4.14 mg/m^3 (Nieuwenhuijsen et al. 1999 [DIRS 150711], Table 2). The dustiest activity would be conducted infrequently in Amargosa Valley, in part because nut orchards occur on less than 5 percent of fields in Amargosa Valley (YMP 1999, [DIRS 158212] Tables 10 and 11) and because harvesting only occurs for a short time each year. Only three other activities (machine harvesting vegetables from an open cab, 7.93 mg/m^3; scraping poultry houses, 6.67 mg/m^3; mowing weeds from an open cab, 5.11 mg/m^3) had geometric mean values greater than 5 mg/m^3. The average of all activities excluding nut harvesting was 2.19 mg/m^3.

Nieuwenhuijsen et al. (1998 [DIRS 150855]) measured higher levels of personal exposure to TSP during a smaller-scale study of farming operations at three experimental farms near Davis, California, during April through November. The soils in this region have a loam to silty loam texture and no rainfall occurred during the study (Nieuwenhuijsen and Schenker 1998 [DIRS 150854], p. 10). The mean TSP concentrations of 18 farming activities ranged from 0.7 (milking) to 98.6 mg/m^3 (disking from an open cab); the average was 19.6 mg/m^3 (Nieuwenhuijsen et al. 1998 [DIRS 150855], Table 2). Ten activities had geometric mean values greater than 10 mg/m^3; all except cattle feeding and nut harvesting were field preparation or similar activities conducted from an open tractor cab. Concentrations measured during this study may be higher than those reported in the Sacramento study (Nieuwenhuijsen et al. 1999 [DIRS 150711]), because the Davis study was conducted only during the dry season and because 10 of the 18 activities were conducted in an open cab. Nieuwenhuijsen and Schenker (1998 [DIRS 150854], p. 11) reanalyzed data from the Davis study and concluded that the presence of an enclosed cab had a very large influence on exposure levels (e.g., exposure during disking was 50 times lower when conducted from an enclosed cab). Molocznik and Zagorski (1998 [DIRS 154281]) measured personal exposure to TSP during seven activities conducted by tractor drivers on large farms and by farmers on small, private farms in Poland. Figure 2 of the Molocznik and Zagorski report presents the results as the minimum and maximum average concentrations for seven types of activities (concentrations per activity are reported here as approximated whole numbers because the chart does not present more precise results). The activity with the highest concentrations, 2 to 58 mg/m^3 (indoor occupations, including threshing of wheat indoors), does not apply to this analysis, because indoor threshing of wheat probably is not conducted in Amargosa Valley and because that activity would not result in exposure to a substantial amount of contaminated soil (i.e., only that remaining on the plant surface). The activity with the second highest concentrations was plant harvesting, ranging from about 3 to 35 mg/m^3. The activity with the lowest concentrations was plant protection, ranging from about 2 to 5 mg/m^3. The average of the midpoints of the six applicable values was about 9 mg/m^3, with a range of 3.5 to 19 mg/m^3. Activity budgets per farmer were also recorded and used to calculate average annual exposure to TSP per eight hours of work, which ranged 5.3 to 10.8 mg/m^3 for 10 tractor drivers and 3.6 to 10.7 mg/m^3 for 7 private farmers.

In a similar study of 10 females working on private farms in Poland, average personal exposure to TSP during six applicable activities (excluding household occupations) ranged from 1.3 to 23.6 mg/m^3. The average of the six midpoints was 7.8 mg/m^3 (range 2.5 to 14.4). Average personal exposure while working ranged from 3.5 to 9.3 mg/m^3 (Molocznik and Zagorski 2000 [DIRS 159587], p. 47 and 48).

Personal exposure to TSP during routine work in 85 dairy barns in Wisconsin averaged 1.78 mg/m^3 (geometric SD = 2.9). Area concentrations within barns averaged 0.74 mg/m^3 (geometric SD = 3.05) (Kullman et al. 1998 [DIRS 159586], third page).

Personal exposure to TSP of bulldozer operators and other workers at three landfills in Ontario averaged 5.3 mg/m^3 and ranged from 0.44 to 22.8 mg/m^3. Only one measurement was greater than 10 mg/m^3 (Mozzon et al. 1987 [DIRS 159585], p. 115).

Clausnitzer and Singer (1997 [DIRS 160404]) measured exposure to PM_4 during farming activities conducted in Davis, California. Sampler inlets were placed directly on farm implements; therefore, dust concentrations may have been higher than those experienced by equipment operators if the inlets were located closer to the source of dust than operators or if operators were within enclosed cabs. The texture of the surface soil was clay loam. Average (arithmetic) concentrations of respirable dust during 29 farming activities ranged from 0.2 to 13.6 mg/m^3. The average of those 29 activities was 2.9 mg/m^3. Eighteen of the activities had average concentrations of equal to or less than 2 mg/m^3. Only one activity (land planing, 13.6 mg/m^3) had an average concentration more than 10 mg/m^3, and four others had concentrations greater than 5 mg/m^3 (Clausnitzer and Singer 1997 [DIRS 160404], Table 1).

Archer et al. (2002 [DIRS 168488], Table I) measured personal exposure to PM_4 during farming activities in North Carolina. The soils there had a loamy sand to sandy loam texture (Archer et al. (2002 [DIRS 168488], p. 754). The arithmetic mean concentration of 37 measurements was 1.31 mg/m^3 (SD = 2.87). The only activity having an average concentration of more than 1.3 mg/m^3 was planting of sweet potatoes (average = 7.62). The average of all activities except planting of sweet potatoes was 0.32 mg/m^3.

6.1.1.2 Parameter Distribution

The distribution recommended for use in the biosphere model must be representative of the average annual concentration that would be experienced by the RMEI within this environment (see introduction to Section 6). Therefore, extremely high or low values associated with activities that are conducted infrequently would be outside of the range of the distribution of the annual average concentration.

Based primarily on the results of Nieuwenhuijsen et al. (1999 [DIRS 150711]), a triangular distribution with a mode of 5 mg/m^3, minimum of 1 mg/m^3, and maximum of 10 mg/m^3 is selected. The mode is higher than the average of activities monitored by Nieuwenhuijsen et al. but lower than the average or midpoint of some of the other studies (Table 6-1). The minimum value was selected to bound possible minimum concentrations in this environment in the Yucca Mountain region, where there are few outdoor workers and where many soil-disturbing activities likely do not involve the use of farm implements or other mechanical devices. The upper bound was selected to bound uncertainty in the consistency of precipitation, soil texture, and other conditions at the analogue study sites with the conditions in the Yucca Mountain region.

Numerous factors, including the type of activity or operation, use of an enclosed tractor cab, relative humidity and other climatic factors, and soil texture have been identified that influence the concentrations of resuspended particles during farming activities (Clausnitzer and Singer 1997 [[DIRS 160404]; Niewenhuijsen et al. 1998 [DIRS 150855]; Nieuwenhuijsen and Schenker 1998 [DIRS 150854]; Archer et al. 2002 [DIRS 168488]). Based on these studies, the important factors identified that are relevant to evaluating uncertainty in the use of the analogue measurements and the consistency of the selected distributions of mass loading with the conditions in the Yucca Mountain region are the types of activities conducted during the studies and the climate and soil texture at the study sites.

Dust concentrations were measured during a wide variety of farming activities. Activities with the highest dust concentrations generally were soil preparation, planting, and other activities that required direct disturbance of the soil and that were conducted from an open tractor cab or other farm implement. Activities that were conducted in an enclosed cab or did not involve intensive soil disturbance had much lower dust concentrations. Typical dust-generating activities conducted by people while working outdoors in Amargosa Valley include field preparation, harvesting, and other activities required to grow field crops; livestock feeding and management; and excavating. Because most crops grown in Amargosa Valley are perennials such as alfalfa and fruit and nut trees, disking, plowing, and other soil disturbing activities that generate very high concentrations of dust are conducted infrequently. People in Amargosa Valley would also generate dust while gardening, landscaping, walking on loose soil, or participating in other recreational activities outdoors. There are no published measurements of particulate concentrations associated with these activities. Gardening, home landscaping, and similar activities would generate less dust than the soil-disturbing agricultural activities included in the studies reviewed above, because large mechanical equipment usually is not used. It is estimated that local outdoor workers comprise 5.5 percent of the Amargosa Valley population and spend 3.1 hours per day in the active outdoor environment. The remainder of the population is estimated to spend 0.3 hours active outdoors (BSC 2004 [DIRS 169671], Sections 6.3.1 and 6.3.2). Thus, about 62 percent of the time spent outdoors by this population is spent by people not employed in farming or other local, outdoor occupations ([0.945 x 0.3 hours] / [0.945 x 0.3 hours + 0.055 x 3.1 hours]). Because soil disturbing activities are conducted infrequently on agricultural fields in Amargosa Valley, and because much of the time spent in this environment by the population is during recreational and other non-occupational activities, the average concentration in this environment in the Yucca Mountain region will be lower than that that reported in the studies reviewed. The lower bound of the distribution was selected as a reasonable minimum estimate of conditions in the Yucca Mountain region for the population. This value is similar to the lower concentrations measured during farming and other activities in the reviewed studies.

Soil moisture, relative humidity, wind speed, and other climate-related factors may affect mass loading concentrations during soil disturbing activities. Two of the analogue studies (Nieuwenhuijsen et al. 1998 [DIRS 150855]; Nieuwenhuijsen et al. 1999 [DIRS 150711]) were conducted in a semi-arid environment, but the other studies were conducted in more mesic regions. The lower precipitation and relative humidity (and possibly other differences such as wind speed) could result in higher concentrations of resuspended particles than those measured in the studies reviewed. However, soil moisture during the growing and harvesting season likely was similar among studies because soil moisture must be maintained within the tolerance limits of crops. An upper bound of 10 mg/m^3 was selected to account for uncertainty in differences in climate between the studies reviewed and the conditions in the Yucca Mountain region. This bound includes average concentrations from all but one activity measured by Nieuwenhuijsen et al. (1999 [DIRS 150711]) and all average measurements made in the other studies except those from cultivating, plowing, disking, or similar activities conducted from an open cab. A higher bound was not selected because the types of activities that would result in concentrations greater than 10 mg/m^3 would be conducted infrequently by the population in the Yucca Mountain region and therefore a higher value would not be representative of average annual conditions in the region.

The proportion of resuspendable material in soil (i.e., soil texture) may also influence mass loading during soil disturbing activities. Soils in northern Amargosa Valley are sandy to sandy loams and have a low proportion of readily resuspendable material in the surface layer. For example, the surface layer of the Shamock gravelly fine sandy loam soil type found along Fortymile Wash north of Highway 95 has a soil texture of more than 80 percent sand and 3 to 8 percent clay, with 50 to 70 percent coarse fragments larger than 2 mm (CRWMS M&O 1999 [DIRS 107736], Table 2 and Appendix B). The four studies reviewed above for which soil texture could be determined were conducted on soils having a similar or higher proportion of smaller particles (i.e., clay and silt) than those in northern Amargosa Valley. Thus, the measurements from those studies should bound uncertainty in the influence of soil texture on mass loading.

The selected distribution of mass loading for the active outdoor environment ranges over an order of magnitude. This distribution was selected to bound uncertainty about the influence of relevant conditions in the studies reviewed to the current conditions in the Yucca Mountain region. Therefore, this distribution is consistent with the applicable current conditions in the Yucca Mountain region. This consistency supports a conclusion that the FEPs associated with this parameter (Table 1-1) are also consistent with the present knowledge of the conditions in the region surrounding the Yucca Mountain site, as required by 10 CFR 63.305(a) [DIRS 156605].

6.1.2 Inactive Outdoor Environment

Averages of TSP concentrations measured over 24-hour periods at stationary, outdoor sites in arid to semi-arid, rural, agricultural settings in the western United States were used to develop a distribution of mass loading for the inactive outdoor environment. These data were selected because measurements taken at stationary, outdoor sites are consistent with the conditions that would be experienced by a person in the rural, agricultural setting of the Yucca Mountain region who is outdoors and not conducting activities that resuspend dust.

Average concentrations calculated from measurements taken over 24-hour periods are appropriate for use in this analysis because they are representative of average conditions within an environment. Measurements taken over shorter periods would have greater variation because they would include short-term peaks in concentrations of resuspended particles. Including those short-term peaks in the distribution of mass loading would be invalid because they are not representative of average annual concentrations. As described in the introduction to Section 6, distributions representative of average annual conditions are required in the biosphere model to calculate an annual dose to the RMEI for evaluation of compliance with the annual dose limit specified in 10 CFR 63.311 [DIRS 156605].

6.1.2.1 Selection of Data

A database of average annual concentrations of TSP for the United States and territories for 1970 through 2001 was obtained from the AirData database managed by the EPA Office of Air and Radiation (DTN MO0210SPATSP01.023 [DIRS 160426], see Section 4.1.2). All correspondence and data files associated with this set of data are located in the Records Information System and can be accessed via the link on the Automatic Technical Data Information Form for this DTN in the Technical Data Management System. The data were obtained via e-mail, rather than from the EPA AirData internet database, because that internet database does not provide access to TSP data.

Two datasets received from the EPA were used in this analysis:

1. KR450TSP.TXT, obtained from the EPA on September 6, 2002 (Ambrose 2002 [DIRS 160080]). This dataset contains 76,220 records. Each record includes an annual average concentration of TSP at a monitoring site.

2. KR380.NATION.TXT, obtained from the EPA on September 17, 2002 (Ambrose 2002 [DIRS 160081]). This dataset contains 11,763 records. Each record contains site description information (e.g., address, setting, years active) for TSP monitoring sites.

Information from these two datasets were imported into an ACCESS database and parsed according to the report manual (AQ1.WPD) provided by the EPA (Ambrose 2002 [DIRS 160080]). The two files were then merged by station number to create a database labeled COMBINEDTSP that contains all the TSP data (from KR450TSP.TXT) for each station as well as the site description data (from KR380.NATION.TXT).

The following was done to select data from sites having conditions that are consistent with the current conditions in the Yucca Mountain region. The database COMBINEDTSP was queried to obtain all records having a land use classification of agricultural (EPA code = 4), and a location setting of rural (EPA code = 3) for the following eight states: Arizona, California, Idaho, Nevada, New Mexico, Oregon, Utah, Washington. These states were selected to ensure that a large sample of analogue sites with a climate consistent with present-day and predicted future conditions for Yucca Mountain would be selected. The rural, agricultural location and land use classifications were selected to match the setting, land use, and range of surface disturbing conditions in Amargosa Valley. That query resulted in a list of 486 valid annual measurements. Fifty-nine of those measurements from sites located west of the Cascade Range in Oregon were eliminated from further consideration because the climate in that region is not consistent with Yucca Mountain conditions. An additional 32 duplicate annual averages (included by EPA to present annual averages with and without unusually high 24-hour measurements) were deleted; the lower of the values for a year were deleted. The remaining 395 records for 68 sites are listed in Appendix B, Table B-1.

To identify which sites have an arid or semi-arid climate, representative data on average annual precipitation and snowfall were obtained for the 68 sites from National Climatic Data Center reports (NCDC 1998 [DIRS 135900; DIRS 125325]) (Table B-2). Information for each site was then examined to select those that are appropriate analogue sites for Amargosa Valley. Sites were deleted or selected for the following reasons.

- Two sites (35-006-0007 and 35-061-0007) were combined because they were in the same location but had different New Mexico county codes, resulting in a total of 67 sites.

- Ten sites were deleted because average annual precipitation exceeded 20 in. (Table B-2). The average TSP concentration of those sites was 0.036 mg/m^3 (SD = 0.009). An additional 11 sites were deleted because average annual snowfall exceeded 20 in. (arithmetic mean concentration = 0.053 mg/m^3, SD = 0.026) (Table B-2). This was done to ensure that only sites with a climate that is consistent with present-day and potential future conditions at Yucca Mountain were included. Arid sites generally are considered to have less than about 10 in. of precipitation per year (Brady and Weil 1999 [DIRS 160019], p. 830) and the future climate for the next 10,000 years is predicted to have a maximum precipitation of 16 to 18 in. per year (BSC 2004 [DIRS 170002], Section 6.6.2; NCDC 1998 [DIRS 125325]). The results of this analysis show little sensitivity to these cutoff values. The average TSP concentration for the 20 sites with less than 10 in. of precipitation (mean = 0.060 mg/m^3, SD = 0.036) was similar to that for 57 sites with less than 20 in. (mean = 0.056 mg/m^3, SD = 0.029), and to all 67 sites (mean = 0.053 mg/m^3, SD = 0.028). Likewise, the average concentration for the 42 sites with less than 10 in. of snowfall (mean = 0.056 mg/m^3, SD = 0.031) was similar to that for 52 sites with less than 20 in. (mean = 0.054 mg/m^3, SD = 0.030) and to all 67 sites (mean = 0.053 mg/m^3, SD = 0.028).

- Based on the site description information in the file KRNATIONRPT.WPD, one site (04-019-0009) was deleted because it was near an electrical power plant, and a second (04-013-0008) was deleted because it had abnormal readings "due to substantial updraft." These two sites had average TSP concentrations of 0.081 and 0.131 mg/m^3, respectively.

- Twenty-three sites were deleted because there was more than one monitoring site within a county (Table B-2). The average concentration at those sites was 0.051 mg/m^3 (SD = 0.035). For counties with more than one monitoring station, the site with the greatest number of years of data was selected. If sites within a county had the same number of years of data, the site with the highest average TSP was chosen (because a higher TSP will result in a higher predicted inhalation dose, see Equation 6-1).

The remaining 21 sites had an average TSP concentration of 0.057 mg/m^3 (SD = 0.019) (Table 6-2). The minimum and maximum annual average concentrations were 0.025 and 0.089 mg/m^3, respectively.

Table 6-2. Average Concentration of TSP at 21 Selected Monitoring Sites

EPA Site ID[a]	State	City	County	Average TSP (mg/m^3)	N Years
04-007-1902	Arizona	Miami	Gila	0.030	8
04-019-0010	Arizona	Tucson	Pima	0.089	2
06-013-1002	California	Bethel Island	Contra Costa	0.041	6
06-019-1002	California	Five Points	Fresno	0.078	13
06-027-0002	California	Bishop	Inyo	0.025	8
06-031-1002	California	Kettleman City	Kings	0.086	9
06-071-1101	California	Twentynine Palms	San Bernardino	0.049	11
06-083-1011	California	Jalama	Santa Barbara	0.045	7
06-111-3001	California	El Rio	Ventura	0.064	13
06-113-4001	California	Dunnigan	Yolo	0.044	13
32-003-1003	Nevada	Moapa	Clark	0.061	1
32-031-1004	Nevada	Sparks	Washoe	0.054	12
35-013-0004	New Mexico	Sunland Park	Dona Ana	0.080	17
35-017-0002	New Mexico	Hurley	Grant	0.085	3
35-045-0014	New Mexico	Kirtland	San Juan	0.044	14
35-061-0007	New Mexico	Bluewater	Cibola/Valencia	0.071	6
41-059-1001	Oregon	Pendleton	Umatilla	0.040	5
49-015-0002	Utah	Huntington	Emery	0.030	4
53-039-0002	Washington	Bingen	Klickitat	0.056	4
53-071-1001	Washington	Wallula Junction	Walla Walla	0.066	9
53-077-0003	Washington	Sunnyside	Yakima	0.062	10
			Average =	0.057	
			SD =	0.019	

Source: DTN: MO0210SPATSP01.023 (DIRS 160426). Note that site ID numbers are not presented with leading zeros or dashes in the database.

[a] See Appendix B for additional descriptions of these sites and annual average measurements.

Average TSP=average of annual average concentrations; SD=standard deviation

6.1.2.2 Parameter Distribution

The TSP concentrations in Table 6-2 do not appear to be symmetrically distributed because there are more values near the high end of the distribution (5 values from 0.078 to 0.089 mg/m^3) than at the low end (3 values from 0.025 to 0.036 mg/m^3). Therefore, a triangular distribution is selected for the nominal inactive outdoor environment with a mode of 0.060 mg/m^3, minimum of 0.025 mg/m^3, and maximum of 0.100 mg/m^3. The mode and maximum are slightly higher than the average and maximum in Table 6-2 to account for the cluster of high values. This distribution encompasses most annual average values from rural agricultural sites in the entire set of EPA data. Of 426 annual average concentrations reported for rural agricultural sites in eight western states (range = 0.012 to 0.173 mg/m^3), only 18 were less than 0.025 mg/m^3 and 17 were greater than 0.100 mg/m^3; thus, the distribution encompasses or is greater than all but about 4 percent of the measurements from all rural, agricultural sites.

The modal value is much higher than concentrations measured at relatively undisturbed, non-agricultural sites at Yucca Mountain (minimum and maximum annual TSP concentrations = 0.019 and 0.030 mg/m^3, respectively) (CRWMS M&O 1999 [DIRS 102877], Table 2-3). This confirms that the measurements selected are influenced to some extent by dust-disturbing activities, such as those encountered in agricultural settings or by some other sources of resuspended particles.

The important factors considered to evaluate uncertainty in the use of measurements from the stationary monitoring sites to predict the conditions in the Yucca Mountain region are the types and level of soil-disturbing activities, climate, vegetation, and soil.

The measurements considered in this analysis were taken in rural, agricultural settings. This setting matches the land use conditions and level of soil disturbing activities in the occupied portion of the Yucca Mountain region (i.e., Amargosa Valley). Because the Yucca Mountain region has no unique sources of resuspended particles, and because the common sources of readily resuspendable particles there (gardens and cultivated land) would be common in rural agricultural monitoring settings elsewhere, the types and levels of soil-disturbing activities at the monitoring sites considered in this analysis are consistent with the conditions in the occupied portions of the Yucca Mountain region.

Precipitation and presence of vegetation may affect the resuspendability of soil particles. However, there is no difference in average ambient mass loading over the range of precipitation predicted to occur at Yucca Mountain over the next 10,000 years (Appendix C), and, as described above, the results of this analysis are insensitive to the precipitation limits used to select data for this analysis. As a further example, the four sites listed in Appendix B, which have less than or equal to 6 in. of precipitation (i.e., consistent with present-day precipitation in northern Amargosa Valley), have an average ambient concentration of 0.053 mg/m^3 (SD = 0.022, range = 0.025 to 0.078). The sites are Twentynine Palms, Moapa, Bishop, and Five Points; precipitation is listed in Table B-2. This is similar to the distribution of the values listed in Table 6-2 for all selected sites with less than 20 in. of precipitation. Those four sites also have sparse desert vegetation consistent with that in the Yucca Mountain region. Thus, precipitation and native vegetation at the analogue sites are sufficiently consistent with the conditions in the Yucca Mountain region and using one distribution for all climate states will not underestimate mass loading for the present-day climate.

Soil characteristics at the air-quality monitoring sites may affect mass loading but were not considered in the selection of data for use in this analysis for the following reason: Soils in northern Amargosa Valley are sandy to sandy loams and have a low proportion of readily resuspendable material in the surface layer and a well-developed, indurated layer of pebbles and cobble on the surface of most undisturbed areas. For example, the surface layer of the Shamock gravelly fine sandy loam soil type found along Fortymile Wash north of Highway 95 has a soil texture of more than 80 percent sand and 3–8 percent clay. Those soils also have 50–70 percent coarse fragments larger than 2 mm (CRWMS M&O 1999 [DIRS 107736], Table 2 and Appendix B). Soils with a loam, silty loam, and other textures commonly found in farming areas have a higher percentage of readily resuspendable material than those found in northern Amargosa Valley (Brady and Weil 1999 [DIRS 160019], Figure 4.8). Thus, measurements of mass loading taken at monitoring sites on other soils bound the soil conditions in the Yucca Mountain region.

Other factors such average annual wind speed, topography, and diurnal patterns of wind speed, that could have an influence mass loading in the inactive outdoor environment were not considered, because calculations of the amount of dust inhaled in the biosphere model are not sensitive to changes in mass loading in the inactive outdoor environment (Appendix A). For example, tripling the average mass loading in this environment from 0.06 to 0.18 mg/m^3 would increase the predicted amount of dust inhaled by about 4 percent (calculated using the methods described in Appendix A). This would have a similar effect on the calculation of BDCFs and predicted dose for those radionuclides for which inhalation is the dominant pathway (^{237}Np, ^{239}Pu) (BSC 2004 [DIRS 169674], Table 6.2-10) because of the linear equations used in those calculations (BSC 2004 [DIRS 169460], Sections 6.4.10 and 6.5.8). It would have a smaller effect on the BDCFs and predicted dose of radionuclides for which inhalation is not a dominant pathway (e.g., ^{99}Tc, ^{129}I) (BSC 2004 [DIRS 169674], Table 6.2-10). Thus, differences in conditions between the monitoring sites and the Yucca Mountain region not considered here would not affect the results of the biosphere model or result in underestimation of risk in the TSPA calculations.

Because the most important conditions under which the analogue measurements were taken are consistent with the current conditions in the Yucca Mountain region, and because the biosphere model is not sensitive to changes that may result from other conditions not considered here, the distribution of mass loading in the inactive outdoor environment is consistent with the applicable conditions in the Yucca Mountain region. This consistency supports a conclusion that the FEPs associated with this parameter (Table 1-1) are also consistent with the present knowledge of the conditions in the region surrounding the Yucca Mountain site, as required by 10 CFR 63.305(a) [DIRS 156605].

6.1.3 Active Indoor Environment

A review of applicable literature (see Section 4.1.1) was conducted to identify average concentrations of resuspended particles measured indoors while people were present and awake. The results are summarized in Table 6-3. The relevant factors considered in evaluating whether the conditions under which those studies were taken are consistent with the present conditions in the Yucca Mountain region included the types of activities conducted, the types of dwellings or buildings within which the studies were conducted, and the ambient outdoor particle concentrations while the studies were being conducted.

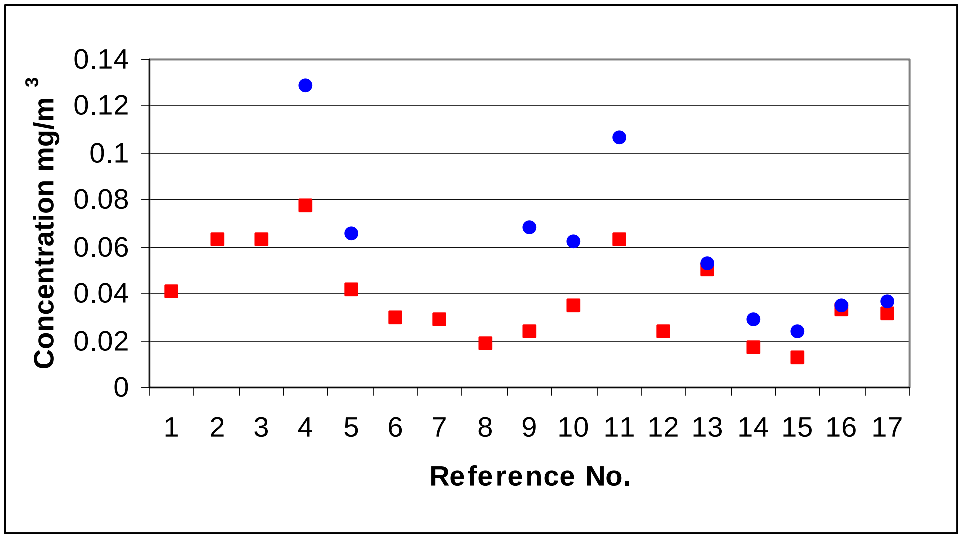
Studies were considered applicable to the conditions in the active indoor environment in the Yucca Mountain region if measurements of indoor concentrations were taken while people were home and active or if personal exposure (i.e., inlet of the monitoring device was located on a person) was measured while people were indoors and active. Because there are few public buildings in Amargosa Valley, and because about 40 percent of the population there does not work (Bureau of the Census 2002, Table P43), measurements taken in homes were considered more applicable than those taken in public buildings. Because concentrations of TSP were measured in only three of the studies reviewed, studies that measured PM$_{10}$ were also included.

Table 6-3. Particulate Concentrations–Nominal Indoor Active Environment

	Reference	Personal Exposure, mg/m^3		Concentration Indoors, mg/m^3		Comments
		$\bar{x}$	Range	$\bar{x}$	Range	
1	Wigzell et al. 2000 (DIRS 159729), Table 3	–	–	0.041	0.026-0.118	TSP, 10 homes, England
2	Thatcher and Layton 1995 (DIRS 159600), Table 3	–	–	0.063	–	TSP, 1 home, California
3	Yocom et al. 1971 (DIRS 159654), Table 1	–	–	0.063	0.049-0.076	TSP, 2 homes, Connecticut
4	Clayton et al. 1993 (DIRS 159599), Table 2	0.129	0.060-0.263	0.078	0.031-0.181	PM$_{10}$, 178 people, California
5	Lioy et al. 1990 (DIRS 159655), Figures 4, 5, and 6	0.066	0.030-0.130	0.042	0.028-0.058	PM$_{10}$, 14 people, New Jersey
6	Quackenboss et al. 1989 (DIRS 159682), Table 3	–	–	0.03	SD = 0.020	PM$_{10}$, 43 homes, Arizona
7	Leaderer et al. 1999 (DIRS 160403), Table 1	–	–	0.029	0.005-0.098	PM$_{10}$, 49 homes, Connecticut and Virginia, summer, with A/C
8	Long et al. 2000 (DIRS 159681), Table 2	–	–	0.019	0.003-0.095	PM$_{10}$, 9 homes, Massachusetts
9	Pellizzari et al. 1999 (DIRS 159702), Figure 2	0.068	0.025-0.104	0.024	0.009-0.065	PM$_{10}$, 881 people, Toronto
10	Janssen et al. 1998 (DIRS 159699), Table 1	0.062	0.038-0.113	0.034	0.019-0.065	PM$_{10}$, 37 people, Amsterdam
11	Brauer et al. 2000 (DIRS 159703), Table 4	0.107	SD = 0.002	0.063	SD = 0.002	PM$_{10}$, 49 people, Slovakia, summer
12	Monn et al. 1997 (DIRS 150888), Table 2	–	–	0.024	0.011-0.033	PM$_{10}$, 17 homes, Switzerland
13	Wheeler et al. 2000 (DIRS 159704), Table 2	0.053	–	0.05	–	PM$_{10}$, 10 children, London
14	Howard-Reed et al. 2000, (DIRS 159680), Table 2; Evans et al. 2000 (DIRS 159679), Table 8	0.029	0.003-0.221	0.017	0.012-0.023	PM$_{10}$, 51 people, retirement facility, California
15	Howard-Reed et al. 2000 (DIRS 159680), Table 2; Williams et al. 2000 (DIRS 159735), Table 4	0.024	<0.001-0.249	0.013	0.007-0.030	PM$_{10}$, 21 people, retirement facility, Maryland
16	Linn et al. 1999 (DIRS 159602), Table 2	0.035	0.005-0.085	0.033	0.009-0.105	PM$_{10}$, 30 people with lung disease, California
17	Rojas-Bracho et al. 2000 (DIRS 159678), Table 2	0.037	0.009-0.211	0.032	0.002-0.329	PM$_{10}$, 18 people with pulmonary disease, Massachusetts

$\bar{x}$ = mean or other value representative of the central tendency (see text); PM$_{10}$ = Particles with an aerodynamic diameter $\leq$10 μm; SD = standard deviation; TSP= total suspended particles, dash indicates no data reported.

Table 6-3. Particulate Concentrations–Nominal Indoor Active Environment (Continued)



Studies 1, 2, and 3 measured TSP, all others measured PM_{10}

Squares = average indoor concentrations, circles = average personal exposure concentrations

For use in this analysis, PM10 concentrations must be converted to TSP, so applicable measurements of the ratio of TSP to PM10 also were reviewed.

For many of the following studies, both personal exposure and stationary indoor concentrations (i.e., measured using a stationary monitor placed in a central location in the house) were reported. Measurements of personal exposure are most applicable to this environment if the people monitored spent their time indoors conducting a variety of typical activities. Measurements of personal exposure during indoor dust-generating activities (e.g., during housework and cooking) are useful for understanding maximum indoor concentrations, but are not representative of average concentrations while indoors. Static measurements are most applicable if they were taken while people were present and active. Outdoor concentrations measured at regional monitoring sites were also reported in most studies and are included here to compare levels of dustiness outdoors during the studies to those in the Yucca Mountain region (see Section 6.1.2).

The only source of indoor contaminated particulates for the biosphere model is soil or ash that is tracked or blown indoors. Other sources of indoor, airborne particles may have contributed substantially to mass load concentrations in some studies. For example, smoking resulted in a 37 percent increase in average daytime PM_{10} concentrations in homes in Riverside California (Clayton et al. 1993 [DIRS 159599], Table 6) and concentrations in homes in Tucson with smokers were more than twice as high as those without (Quackenboss et al. 1989 [DIRS 159682], Table 3). Cooking, use of household cleaning products, and other activities also generate resuspended particles that would not be contaminated in the scenarios considered in this analysis (e.g., Long et al. 2000 [DIRS 159681], pp. 1242 to 1245). Therefore, the most applicable studies are those that omitted homes with smokers or that present data separately for homes with and without smokers.

6.1.3.1 Literature Review

Indoor and Personal Exposure Concentrations—Wigzell et al. (2000 [DIRS 159729]) measured TSP and $PM_{2.5}$ concentrations over 48-hour periods in the kitchens and living rooms of 10 homes in Oxford England. Sampling devices in the living rooms were on only when residents were home. The average TSP concentration in living rooms was 0.041 mg/m^3 (range = 0.026 to 0.118). The average in nine homes where smoking did not occur was 0.036 mg/m^3. Outdoor PM_{10} concentrations averaged 0.019 mg/m^3 (Wigzell et al. 2000 [DIRS 159729], Table 3).

Thatcher and Layton (1995 [DIRS 159600]) measured TSP and PM_{10} concentrations in one home in California during normal and staged activities. The TSP concentration while five residents (2 adults and 3 children) were present “performing normal activities” was 0.063 mg/m^3. Outdoor PM_{10} concentrations at that time were 0.014 mg/m^3. In one experiment, TSP concentrations after vigorous cleaning was about 0.2 mg/m^3, and decreased to about 0.05 within 60 minutes. Walking into a room that previously had no activity caused concentrations of particles with an average aerodynamic diameter equal to or more than 5 μm to more than double. Cleaning caused an 11.4-times increase in the concentration of particles 5 to 10 μm and a 29.5-times increase in the concentration of particles equal to or greater than 10 μm (Thatcher and Layton 1995 [DIRS 159600], Table 3, Figures 3 and 7).

Yocom et al. (1971 [DIRS 159654]) measured TSP concentrations in two homes, two office buildings, and two public buildings over three seasons in Hartford Connecticut. The average daytime concentration in the homes was 0.063 mg/m^3 (range = 0.049 to 0.076). Average daytime concentrations in office and public buildings were 0.073 mg/m^3 (range = 0.057 to 0.087) and 0.046 mg/m^3 (range = 0.036 to 0.060), respectively. Outdoor concentrations in the area averaged 0.089 mg/m^3 (Yocom et al. 1971 [DIRS 159654], Table 1).

Clayton et al. (1993 [DIRS 159599]) summarized the results of a study conducted by the EPA to estimate population levels of exposure to particulates in Riverside California. Indoor, outdoor, and personal exposure concentrations of PM_{10} were measured for a probability-based sample of 178 nonsmokers 10 years old or older. Daytime personal exposure averaged 0.129 mg/m^3 (10th and 90th percentiles = 0.060 and 0.263, respectively) (Clayton et al. 1993 [DIRS 159599], Table 2). Nighttime personal exposure averaged 0.068 mg/m^3 (10th to 90th percentiles = 0.037 to 0.135). The people monitored spent an average of about 50 percent of their daytime hours out of their house; therefore, measurements of personal exposure may not be as applicable to this analysis as indoor measurements. Daytime and nighttime concentrations measured at a stationary indoor monitor averaged 0.078 mg/m^3 (0.031 to 0.181) and 0.053 mg/m^3 (0.025 to 0.117), respectively. Average indoor concentrations were 37 precent higher in homes on days when housework occurred (0.091 mg/m^3 compared to 0.057 mg/m^3 on days with no housework). The average indoor concentration (0.078 mg/m^3) is between those values and therefore appears to be a reasonable estimate of homes with and without substantial dust-generating activities. PM_{10} concentrations at outdoor, regional monitoring sites averaged 0.079 mg/m^3 (Clayton et al. 1993 [DIRS 159599], Table 2).

Personal exposure to PM_{10} for 14 people in Phillipsburg, New Jersey, averaged 0.066 mg/m^3 (range approximately 0.030 to 0.130 mg/m^3). Most personal exposure concentrations were between 0.040 and 0.080. Concentrations inside fourteen homes averaged 0.042 mg/m^3 (range approximately 0.028 to 0.058 mg/m^3). Outdoor concentrations averaged 0.048 mg/m^3. There were no smokers living in the homes and all measurements lasted 24 hours (Lioy et al. 1990 [DIRS 159655], Figures 4, 5, and 6).

PM_{10} concentrations in 43 homes in Tucson, Arizona, without smokers averaged 0.030 mg/m^3 (SD = 0.020, 24-hour measurements). Homes with evaporative coolers had lower concentrations (average = 0.021) than those without (average = 0.038). Homes with smokers had much higher concentrations (average = 0.075) (Quackenboss et al. 1989 [DIRS 159682], Table 3). Outdoor concentrations were not reported.

PM_{10} concentrations during summer in 49 homes in Connecticut and Virginia with air conditioning was 0.029 mg/m^3 (range = 0.005 to 0.098, 24-hour measurements). Concentrations in 8 homes without air conditioning averaged 0.033 mg/m^3 (range = 0.018 to 0.60). Concentrations during winter in 84 homes without kerosene heaters averaged 0.026 mg/m^3 (range = 0.003 to 0.182). Concentrations outside of homes averaged 0.028 and 0.024 mg/m^3 during summer and winter, respectively (Leaderer et al. 1999 [DIRS 160403], Tables 1 and 4).

Concentrations of PM_{10} in nine homes without smokers in Boston, Massachusetts, averaged 0.019 mg/m^3 (range = 0.003 to 0.095, 24-hour measurements). Peak concentrations during dusting and vigorous walking were 0.105 and 0.041 mg/m^3, respectively. Outdoor PM_{10} concentrations averaged 0.013 mg/m^3, lower than other studies reviewed here (Long et al. 2000 [DIRS 159681], Tables 2 and 3).

Personal exposure to PM_{10} in a stratified sample of the population in Toronto, Canada, averaged 0.068 mg/m^3 (10th and 90th percentiles approximately 0.025 and 0.104, 24-hour measurements). Indoor concentrations averaged 0.024 mg/m^3 (10th and 90th percentiles approximately 0.009 and 0.065). Outdoor concentrations averaged 0.024 mg/m^3 (Pellizzari et al. 1999 [DIRS 159702], Figure 2).

Personal exposure to PM_{10} for 37 nonsmokers (50–70 years old) in Amsterdam, Netherlands, averaged 0.062 mg/m^3 (range = 0.038 to 0.113). Indoor exposure averaged 0.034 mg/m^3 (range = 0.019 to 0.065) and outdoor concentrations averaged 0.042 mg/m^3. On the days they were monitored, subjects spent an average of 1.3 hours outdoors and 20.5 hours at home; therefore, personal exposure concentrations reported here likely are a good measure of concentrations in the active indoor environment of this sample (Janssen et al. 1998 [DIRS 159699], Table 1).

Brauer et al. (2000 [DIRS 159703], Table 4) measured personal exposure and PM_{10} concentrations in homes of 18 office workers, 15 high school students, and 16 industrial workers in Slovakia. Personal exposure (24-hour) during summer and winter averaged 0.107 mg/m^3 (geometric SD = 1.7) and 0.105 mg/m^3 (geometric SD = 1.7), respectively. Twenty-four hour average concentrations in homes during summer and winter were 0.063 (geometric SD = 2.0) and 0.060 mg/m3 (geometric SD = 1.6), respectively. Outdoor PM_{10} concentrations averaged 0.033 and 0.040 mg/m^3 during summer and winter. Participants of this study spent an average of 71 percent of their time at home (Brauer et al. 2000 [DIRS 159703], Table 1).

PM_{10} concentrations in 17 homes in Switzerland averaged 0.024 mg/m^3 (range 0.011 to 0.033). Homes where substantial activity occurred (home groups A and C) had average concentrations of 0.029 mg/m^3. Outdoor concentrations averaged 0.022 mg/m^3 (Monn et al. 1997 [DIRS 150888], Table 2).

Personal exposure to PM_{10} for 10 children in London, England, during daytime averaged 0.053 mg/m^3 (no range presented). Concentrations in homes while children were present averaged 0.050; smokers were present in some homes. Average concentrations in gardens, classrooms, and at a regional outdoor monitoring site were 0.022, 0.079, and 0.024 mg/m^3, respectively (Wheeler et al. 2000 [DIRS 159704], Table 2).

The lifestyles, physical conditions, and similarity between personal and indoor concentrations indicate that the subjects of the following studies were sedentary and therefore did not resuspend substantial concentrations of particles. These results therefore are applicable only for identifying a lower bound of the average mass loading concentration for the Amargosa Valley population.

Personal exposure to PM_{10} was measured in retirement facilities in Fresno, California, and Baltimore, Maryland. Average exposure while awake at home indoors was 0.029 (range = 0.003 to 0.221) and 0.024 mg/m^3 (range = <0.001 to 0.249) in Fresno and Baltimore, respectively (Howard-Reed et al. 2000 [DIRS 159680], Table 2). Concentrations in apartments at the Fresno facility averaged 0.017 mg/m^3 (range = 0.012 to 0.023), and outdoor ambient concentrations there averaged 0.021 mg/m^3 (Evans et al. 2000 [DIRS 159679], Table 8). Concentrations in apartments in Baltimore averaged 0.013 mg/m^3 (range = 0.007 to 0.030) and outdoor concentrations averaged 0.028 mg/m^3 (Williams et al. 2000 [DIRS 159735], Table 4).

Personal exposure to PM_{10} for 30 people in Los Angeles, California, with severe lung disease averaged 0.035 mg/m^3 (range = 0.005 to 0.085). Concentrations in their homes averaged 0.033 mg/m^3 (range = 0.009 to 0.105). Outdoor concentrations averaged 0.033 mg/m^3 (Linn et al. 1999 [DIRS 159602], Tables 1 and 2).

Personal exposure to PM_{10} for 18 people in Boston, Massachusetts, with chronic obstructive pulmonary disease averaged 0.037 mg/m^3 (range = 0.009 to 0.211, winter and summer, daytime measurements). Concentrations in their homes averaged 0.032 mg/m^3 (range = 0.002 to 0.329, 24-hour measurements). Outdoor concentrations averaged 0.022 mg/m^3 (Rojas-Bracho et al. 2000 [DIRS 159678], Table 2).

TSP: PM_{10} Ratios–The following are summaries of applicable measurements of the ratio of TSP to PM_{10} and TSP:$PM_{2.5}$. The ratios measured by Brook et al. (1997 [DIRS 160254]) and at Yucca Mountain (Appendix E) were derived from stationary outdoor monitors and are not as applicable as ratios from the other studies, which were based on indoor measurements. However, results of the latter studies are useful for corroborating the other results.

Thatcher and Layton (1995 [DIRS 159600], Table 3 and Figure 3) measured a TSP:PM_{10} ratio of 2.7:1 during normal indoor activities, 3.2:1 immediately after vigorous cleaning, and 1.6:1, one hour after cleaning had ended.

The ratio of TSP:PM_{10} in homes following the eruption of Mount St. Helens was 3:1 (Buist et al. 1986 [DIRS 144632], Table 2).

The average ratio of TSP to $PM_{2.5}$ measured in nine homes in England was 2.7:1 (Wigzell et al. 2000 [DIRS 159729], Table 3, comparison of arithmetic mean of concentrations in living rooms). The TSP:PM_{10} ratio would have been lower because the concentration of fragments from 2.5 to 10 μm would be included in the denominator of the ratio.

Average TSP:PM_{10} ratios for 19 locations in Canada was 1.8 to 2.0:1. Tenth and 90th percentiles were 3.3:1 and 1:1. These measurements were taken at stationary outdoor monitors (Brook et al. 1997 [DIRS 160254], Table 3).

The ratio of TSP to PM_{10} outdoors at Yucca Mountain averaged about 2.5. This value is based on 1,276 simultaneously collected measurements of TSP and PM_{10} taken during 1989 through 1997. This data and the associated DTNs are displayed in Appendix E. Twenty-four ratios of less or equal to 1.0 (i.e., PM_{10} concentrations the same as or higher than TSP, which is very unlikely or not possible) were omitted from consideration. Six of these ratios had PM_{10} values of zero and 15 others had very low values of TSP and PM_{10} (<10 μg/m^3) or very small differences between TSP and PM_{10} (≤2 μg/m^3). Thus, most of these incorrect ratios likely were the result of normal measurement error for the equipment used. The average TSP:PM_{10} ratio for the remaining 1,276 measurements was 2.49:1 (SD = 1.03). The median value was 2.22 and the ratios ranged from 1.0 to 12.57. The data were skewed toward small values; 84 percent of ratios were less than 4.0 and 94.3 percent were less than 5.0.

6.1.3.2 Parameter Distribution

Average personal exposure to PM_{10} in the studies reviewed ranged from 0.024 to 0.129 mg/m^3. Average indoor concentrations of TSP and PM_{10} while people were active ranged from 0.041 to 0.063 mg/m^3 and from 0.013 to 0.078 mg/m^3, respectively (Table 6-3). As discussed below, it is reasonable to conclude that these ranges include the average annual conditions in the Yucca Mountain region because the studies were conducted over a variety of applicable conditions, including some with relatively high outdoor concentrations (Clayton et al. 1993 [DIRS 159599]; Lioy et al. 1990 [DIRS 159655]), and because results did not vary much among studies.

A triangular distribution with a mode of 0.100 mg/m^3, minimum of 0.060 mg/m^3, and maximum of 0.175 mg/m^3 is selected for the active indoor environment. The minimum value is based on the three studies that measured TSP indoors (references 1, 2, and 3 in Table 6-3). The upper bound is based on a high PM_{10} concentration of 0.070 mg/m^3 and a TSP:PM_{10} ratio of 2.5:1. The PM_{10} concentration of 0.070 mg/m^3 is similar to the maximum of the average indoor concentrations measured in the studies reviewed (Table 6-3) and higher than all but two of the average personal exposure concentrations measured. It was selected to bound uncertainty in conditions such as types of dwellings that may differ between the analogue studies and the conditions in the Yucca Mountain region. The subjects of the two studies that had higher average levels of personal exposure (Clayton et al. 1993 [DIRS 159599]; Brauer et al. 2000 [DIRS 159703]) spent a substantial amount of time away from their homes and therefore may have been exposed to excess sources of particulates or to particulates that would not be contaminated in the biosphere analysis scenarios (e.g., car exhaust, industrial pollutants). The

TSP:PM_{10} ratio is based on the range of 1.6:1 to 3:1 measured indoors in three studies, and confirmed by outdoor ratios. The modal value selected is less than the midpoint between the minimum and maximum, because all three applicable measurements of TSP are at the minimum end of the distribution. This indicates that the true average for the Amargosa Valley population likely is closer to the minimum than the maximum value. As shown in Appendix A, a change in the average mass loading from the modal to the maximum values of this distribution would increase the predicted amount of dust inhaled by the receptor by about 17 percent. This change is small relative to the approximately order-of-magnitude variation in BDCFs calculated by the ERMYN model (BSC 2004 [DIRS 169674], Section 6.2.3; BSC 2004 [DIRS 167287], Section 6.2.3).

The important factors relevant to evaluating uncertainty in the use of the analogue measurements and the consistency of the selected distribution of mass loading to the conditions in the Yucca Mountain region are the types of indoor activities, types of dwellings, and outdoor ambient concentrations. Outdoor ambient concentrations would be influenced by outdoor conditions such as precipitation, vegetation, sources of outdoor particles, and types of outdoor activities; therefore, those outdoor conditions are not discussed separately.

The types of activities that were conducted during the studies reviewed are typical of those expected to occur in dwellings in the Yucca Mountain region (e.g., walking, cleaning, cooking, sitting). Because there are no unique industries, occupations, or other conditions in the Yucca Mountain region (see the introduction to Section 6.1 and BSC 2004 [DIRS 169671], Section 6.3), there is no reason to expect that people in the region would conduct indoor activities that differ substantially from people elsewhere or result in higher concentrations of resuspended particles. Conditions during some of the studies that measured the lowest concentrations (e.g., Linn et al. 1999 [DIRS 159602]) may not be representative of average annual conditions in the Yucca Mountain region, because the subjects had medical conditions that would cause them to be less active than other people. The studies with the highest concentrations of PM_{10} included measurements of subjects that spent a substantial amount of time away from their homes (Clayton et al. 1993 [DIRS 159599]; Brauer et al. 2000 [DIRS 159703]). The results of those studies were considered less applicable in the selection of the distribution of mass loading for this environment. Some of the studies took place while subjects were conducting activities that cause high concentrations of resuspended particles that would not be contaminated with radionuclides by the use of groundwater, such as smoking and cooking. Measurements from those studies would be higher than concentrations of contaminated, resuspended particles applicable to this analysis.

The reviewed studies were conducted in a variety of dwellings and concentrations varied little among the studies. However, no measurements were reported to have been taken in mobile homes, the type of dwelling lived in by most people in Amargosa Valley (Bureau of the Census 2002 [DIRS 159728], Tables H30 and H31). It is possible that more resuspended dust from outdoors would be transferred into mobile homes than into dwellings constructed of brick or other building materials. The upper bound for this distribution is similar to or greater than all applicable measurements of indoor and personal exposure concentrations and was selected to account for this source of uncertainty. A higher value was not selected because no higher applicable average measurement was reported, indoor concentrations varied little among different types of dwellings, and because a small increase in this value would have little effect on the predicted amount of dust inhaled by the receptor (Appendix A).

Changes in outdoor concentrations of resuspended particles have been shown to influence indoor concentrations (see the studies listed in Table 5-1). Thus, differences in outdoor concentrations resulting from differences in the outdoor sources of resuspended particles, precipitation, vegetation, and other factors could affect the applicability of the studies reviewed. Average outdoor concentrations of PM_{10} at regional monitoring sites ranged from 0.013 to 0.079 in those studies. That range is similar to the range of concentrations in rural, agricultural sites in arid to semi-arid settings (Table 6-2) and similar to or higher than that measured in the Yucca Mountain region (see the introduction to Section 6.1 and CRWMS M&O 1999 [DIRS 102877], Table 2-3). Because almost all analogue studies were conducted in areas having higher outdoor concentrations than those expected for a rural, agricultural setting in the Yucca Mountain region, the distribution for this environment, which was based on the results of those studies, bounds conditions in the region.

Because most relevant conditions under which the analogue measurements were taken are consistent with the current conditions in the Yucca Mountain region, and because the range of the distribution was selected to bound uncertainty in other relevant conditions that may have differed (e.g., type of dwelling), the distribution of mass loading in the active indoor environment is consistent with the applicable current conditions in the Yucca Mountain region. This consistency supports a conclusion that the FEPs associated with this parameter (Table 1-1) are also consistent with the present knowledge of the conditions in the region surrounding the Yucca Mountain site, as required by 10 CFR 63.305(a) [DIRS 156605].

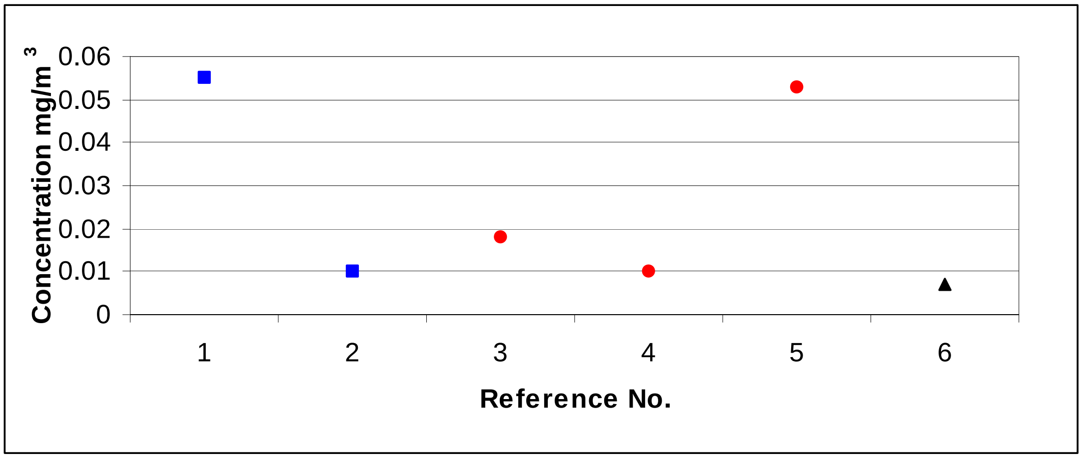
6.1.4 Asleep Indoor Environment

A review of applicable literature (see Section 4.1.1) was conducted to determine the range of average concentrations of resuspended particles measured while people were asleep indoors. The results are summarized in Table 6-4. Studies were considered most applicable if concentrations were measured while people were sleeping. Studies were also considered applicable if indoor concentrations were measured while subjects were inactive or absent. Because most applicable studies measured concentrations of PM_{10}, a review of applicable $TSP:PM_{10}$ ratios also was conducted.

6.1.4.1 Literature Review

Thatcher and Layton (1995 [DIRS 159600], Figure 3) reported a TSP concentration of about 0.055 mg/m^3 in a home in California one hour after all resuspension activities were stopped. The $TSP:PM_{10}$ ratio at that time was about 1.6:1. This measurement is analogous to one hour after people became inactive or went to bed.

Table 6-4. Particulate Concentrations–Nominal Asleep Indoor Environment

	Reference	Concentration, mg/m3		Comments
		$\bar{x}$	Range	
1	Thatcher and Layton 1995 (DIRS 159600), Figure 3	0.055	–	TSP, one hour after activities stopped, California
2	Buist et al. 1983 (DIRS 159738), p. 717	<0.01	–	TSP, summer camp, Oregon, while sleeping
3	Howard-Reed et al. 2000 (DIRS 159680), Table 2	0.018	0.005-0.040	PM_{10}, retirement facility, California, while sleeping
4	Howard-Reed et al. 2000 (DIRS 159680), Table 2	0.010	0.001-0.159	PM_{10}, retirement facility, Maryland, while sleeping
5	Clayton et al. 1993 (DIRS 159599), Table 2	0.053	0.025-0.117	PM_{10}, 178 people, California, 12-hr measurements, 40–50% of concentration from vehicles and secondary sulfites
6	Long et al. 2001 (DIRS 159733), Table 2	0.007	0.001-0.021	$PM_{2.5}$, nine homes, Boston, while sleeping
 Squares = TSP, circles = PM_{10}, triangle = $PM_{2.5}$.				

$\bar{x}$ = mean or other value representative of the central tendency (see text); PM_{10} = particles with an aerodynamic diameter ≤10 µm; $PM_{2.5}$ = particles with an aerodynamic diameter ≤2.5 µm; TSP = total suspended particles, dash indicates no data reported.

Buist et al. (1983 [DIRS 159738]) measured personal TSP exposure concentrations of children ages 8 to 13 that were attending a summer camp in Oregon shortly after 1.2 cm of ash had fallen from the eruption of Mount St. Helens. The methods used for that study are more fully described in Hewett (1980 [DIRS 168491]). Nighttime TSP concentrations were at or below the 0.01-mg/m^3 limit of detection of sampling equipment (Buist et al. 1983 [DIRS 159738], p. 717). Although the results of this study are most applicable to analysis of the volcanic ash scenario, they are listed here to demonstrate that dust concentrations in the asleep indoor environment can be very low even when conditions outdoors are very dusty.

PM_{10} concentrations in retirement apartments in Fresno, California, and Baltimore, Maryland, while residents were asleep averaged 0.018 mg/m^3 (range = 0.005 to 0.040) and 0.010 mg/m^3 (range = 0.001 to 0.159) (Howard-Reed et al. 2000 [DIRS 159680], Table 2). Concentrations varied little while residents were asleep (Howard-Reed et al. 2000 [DIRS 159680], Figures 1 and 2).

Indoor concentrations of PM_{10} at night (7:00 pm to 7:00 am) in homes of 178 people monitored in Riverside, California averaged 0.053 mg/m^3 (10th and 90th percentiles = 0.025 and 0.117) (Clayton et al. 1993 [DIRS 159599], Table 2). These measurements are overestimates of concentrations of soil particles experienced while subjects were sleeping for two reasons. First, the measurement period includes times when people where active during the evening and early morning. Second, a portion of the mass loading concentration consists of particles that would not be contaminated in the groundwater or volcanic ash scenarios. Yakovleva et al. (1999 [DIRS 159730], Figure 7) examined the source contributions in this study and concluded that about 40 to 50 percent of particulate concentrations at night were from motor vehicles and secondary sulfates.

Long et al. (2001 [DIRS 159733]) measured $PM_{2.5}$ concentrations and volume of $PM_{2.5}$ and PM_{10} particles in nine homes of nonsmokers in Boston at night while people were asleep and/or inactive. The average $PM_{2.5}$ concentration was 0.007 mg/m^3 (5th and 95th percentiles = <0.001 to 0.021). Less than 10 percent of the PM_{10} particle volume consisted of particles 2.5 to 10 μm in diameter (Long et al. 2001 [DIRS 159733]; Table 2). Because few of the resuspended particles were larger than 2.5 μm, concentrations measured during this study are comparable to PM_{10} concentrations reported in other studies.

6.1.4.2 Parameter Distribution

A triangular distribution with a mode of 0.030 mg/m^3, minimum of 0.010 mg/m^3, and maximum of 0.050 mg/m^3, is selected for the asleep indoor environment. The minimum and maximum are based on the two measurements of TSP concentrations reported (Table 6-4). All but one applicable measurement of PM_{10} and $PM_{2.5}$ (Table 6-4), if multiplied by a TSP:PM_{10} ratio of 1.6:1 (Thatcher and Layton 1995 [DIRS 159600], Figure 3), are within this range. As discussed above, the average value of 0.053 mg/m^3 measured by Clayton et al. (1993 [DIRS 159599]) is an overestimate of applicable concentrations by a factor of at least two because it includes secondary sulfates and particles generated by motor vehicles (Yakovleva et al. 1999 [DIRS 159730]). Thus, this distribution encompasses the range of variation and uncertainty in measurements of mass loads in the asleep indoor environment.

As shown in Appendix A, estimates of the amount of dust inhaled are insensitive to changes in dust concentrations in the asleep indoor environment. Because of the insensitivity of the biosphere model to changes in this distribution, and because there is very little variation in mass loading indoors while people are asleep, the only factor considered in evaluating whether the conditions in the studies reviewed were consistent with the conditions in the Yucca Mountain region was the type or level of human activity. All studies were conducted when people were asleep or inactive and it is therefore concluded that the distribution developed based on those studies is consistent with the applicable current conditions in the Yucca Mountain region. This consistency supports a conclusion that the FEPs associated with this parameter (Table 1-1) are also consistent with the present knowledge of the conditions in the region surrounding the Yucca Mountain site, as required by 10 CFR 63.305(a) [DIRS 156605].

6.1.5 Mass Loading–Crops

As described and justified in Section 5.1, it is assumed that the distribution of mass loading in fields and gardens where crops are growing is similar to or higher than that in the inactive outdoor environment, with a minimum value equal to the minimum value of the inactive outdoor environment, and a modal and maximum value twice that of the inactive outdoor environment. That assumption is based on the crops grown and farming practices in Amargosa Valley and therefore is consistent with the current conditions in the Yucca Mountain region.

The distribution of mass loading in the inactive outdoor environment is triangular with a mode of 0.060 mg/m^3, and a range of 0.025 to 0.100 mg/m^3. Based on the above assumption, the distribution of mass loading for crops is predicted to have a mode of 0.120 mg/m^3, and a range of 0.025 to 0.200 mg/m^3.

6.2 MASS LOADING–VOLCANIC ASH SCENARIO

This section describes the development of mass loading distributions within the five environments (four receptor environments and the environment around crops) for the volcanic ash exposure scenario. The representative biosphere for this scenario is the same as for the groundwater scenario: a rural community in an arid to semi-arid environment with conditions consistent with those in the Yucca Mountain region and a population with living style representative of the residents of the Town of Amargosa Valley today (based on requirements in 10 CFR Part 63 [DIRS 156605], Sections 305 and 312; also, see Section 4.3). However, the source of radionuclides differs. For the volcanic ash scenario, the source of radionuclides is contaminated ash from a volcanic eruption at Yucca Mountain. Ash depths 18 km downwind from Yucca Mountain were predicted to range from 0.07 to 55 cm (based on 100 realizations of the ASHPLUME model). About 35 percent of predicted depths were less than 1 cm, 75 percent were less than 5 cm, and 90 percent were less than 15 cm (BSC 2004 [DIRS 170026], Table 6-4). Ash depths at the location of the RMEI (18 km south of Yucca Mountain) would be about 2 orders of magnitude or more lower under normal, variable wind conditions (CRWMS M&O 2000 [DIRS 153246], Section 3.10.5.1 and Figure 3.10-14) because the wind at Yucca Mountain blows to the south infrequently (BSC 2004 [DIRS 170026], Figure 8-1).

Observations at volcanic sites (e.g., see Section 6.3.1 and 6.3.2) indicate that tephra is more readily suspended than the soil upon which it was deposited, which would result in higher mass loading concentrations than experienced under nominal conditions (i.e., prior to the eruption). Through time the ash would erode, become mixed into the soil, become buried, or otherwise become stabilized. That erosion or stabilization would result in a decrease in mass loading, with concentrations eventually returning to conditions similar to those considered in the groundwater scenario (i.e., nominal concentrations). Because of this change in mass loading through time, dose resulting from a volcanic eruption must be calculated as a function of time, as described in the following equation (BSC 2004 [DIRS 169460], Section 6.5.8).

$$D_{all,i}(d_a,t) = D_{ext,ing,Rn,i} + D_{inh,v,i}\,g(d_a)\,f(t) + D_{inh,p,i}\,g(d_a) \qquad \text{(Eq. 6.2-1)}$$

where:

$D_{all,i}(d_a,t)$ = All-pathway annual dose from internal and external exposure to radionuclide i for an ash deposition thickness d_a at time t following a volcanic eruption (Sv/year).

$D_{ext,ing,Rn,i}$ = Annual dose from external exposure, radon inhalation, and ingestion of radionuclide i following a volcanic eruption (Sv/year).

$D_{inh,p,i}$ = Annual dose from inhalation exposure to radionuclide i resulting from exposure to nominal (p) mass loading following a volcanic eruption (Sv/year).

$D_{inh,v,i}$ = Annual dose from inhalation exposure to radionuclide i resulting from exposure to elevated, post-volcanic (v) mass loading in addition to nominal concentrations (Sv/year).

d_a = Thickness of the contaminated ash/soil layer (meters).

$g(d_a)$ = Function of ash thickness, representing the fraction of total activity that is available for resuspension

t = Time (year)

$f(t)$ = Decay function describing reduction of mass loading with time.

Three components of the BDCFs are required by this model, as shown in equation 6.2-2 (BSC 2004 [DIRS 169460], Section 6.5.8).

$$BDCF_i(d_a,t) = BDCF_{ext,ing,Rn,i} + \left(BDCF_{inh,v,i}\,f(t) + BDCF_{inh,p,i}\right)g(d_a) \qquad \text{(Eq. 6.2-2)}$$

where:

$BDCF_i(d_a,t)$ = BDCF of radionuclide i for an ash deposition depth d_a at time t following a volcanic eruption (Sv/year per Bq/m^2).

$BDCF_{ext,ing,Rn,i}$ = BDCF of radionuclide i for external exposure, radon inhalation, and ingestion following a volcanic eruption (Sv/year per Bq/m^2).

$BDCF_{inh,p,i}$ = BDCF of radionuclide i for inhalation of resuspended particles at nominal mass loading following a volcanic eruption (Sv/year per Bq/m^2).

$BDCF_{inh,v,i}$ = BDCF of radionuclide i for inhalation of resuspended particles at concentrations in addition to nominal mass loading following a volcanic eruption (Sv/year per Bq/m^2).

The component $BDCF_{ext,ing,Rn,i}$ accounts for the consequences of all exposure pathways except inhalation of particulate matter. This component of BDCFs is not a function of time or ash depth. The parameter mass loading for crops is not treated as a function of time in the volcanic ash scenario because it is used in the calculation of the ingestion dose. Therefore, the equation in the biosphere model for the volcanic ash scenario that uses mass loading for crops is the same as that described in Section 6.

The component $BDCF_{inh,p,i}$ accounts for the consequences of inhalation of resuspended particles at concentrations to be expected at some time following a volcanic eruption when mass loading has stabilized. Because concentrations of resuspended particles at that time will be influenced by the same factors considered when developing distributions for nominal conditions, the mass loading distributions for receptor environments developed in Section 6.1 are intended for use in calculating $BDCF_{inh,p,i}$. This BDCF component is a function of ash depth, because the dose contribution may change as ash depth decreases, but is not a function of time.

The component $BDCF_{inh,v,i}$ accounts for the additional dose contribution resulting from inhalation of elevated concentrations of resuspended contaminants following a volcanic eruption. This component contributes to the total dose (i.e., is greater than zero) only for the period starting at the end of the volcanic eruption (i.e., time = t_0, which starts after the initial ash fall has ceased) and ending when the ash blanket has eroded or stabilized and airborne concentrations are equal to predisturbance, nominal conditions.

Concentrations of resuspended particles decrease following a volcanic eruption, and therefore the total mass loading in receptor environments following a volcanic eruption must be calculated as a function of time, as shown in the following equation (BSC 2004 [DIRS 169460], Section 6.5.2).

$$S_n(t) = S_n + S_{v,n} f(t) \qquad \text{(Eq. 6.2-3)}$$

where:

$S_n(t)$ = Total average annual mass loading in receptor environment n at time t following a volcanic eruption (mg/m^3).

S_n = Nominal average annual mass loading in receptor environment n (mg/m^3)

$S_{v,n}$ = Elevated, post-volcanic (v) average annual mass loading in receptor environment n (i.e., in addition to or greater than $S_{v,n}$) during the first year (i.e., t = 0) following a volcanic eruption (mg/m^3).

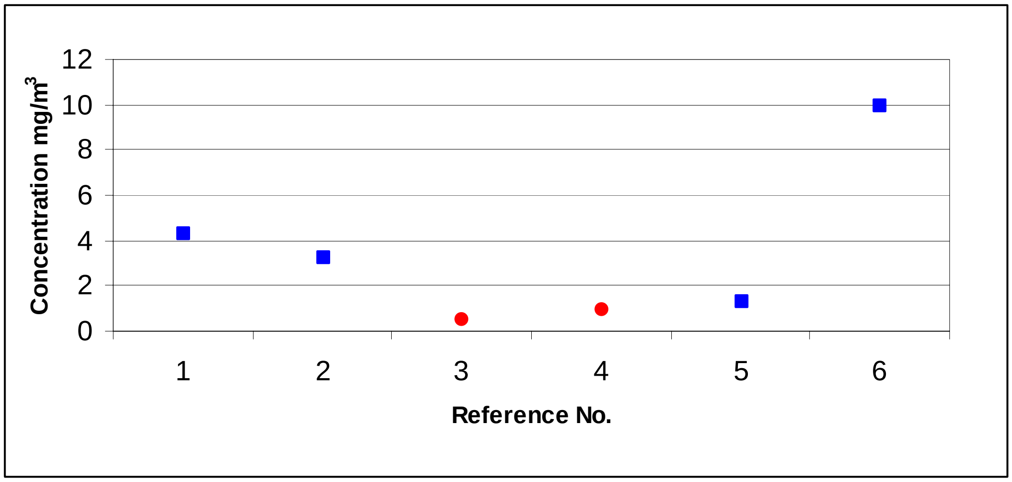
$f(t)$ = Mass loading time function, which describes the rate of change in mass loading after a volcanic eruption.

S_n is used in the calculation of the BDCF component $BDCF_{inh,p,i}$ and $S_{v,n}$ is used in the calculation of the BSCF component $BDCF_{inh,v,i}$. The distributions of elevated mass loading concentrations, $S_{v,n}$ are developed in the remainder of this section. Because $S_{v,n}$ is combined with S_n to calculate the total mass loading in receptor environments following a volcanic eruption, $S_{v,n}$ represents only the additional concentrations of resuspended ash/dust in excess of nominal conditions during the first year following an eruption at Yucca Mountain. Because mass loading for crops is not treated as a function of time, that parameter distribution is representative of the entire concentration of resuspended particles following a volcanic eruption. The mass loading time function is developed in Section 6.3.

6.2.1 Active Outdoor Environment

A review of applicable literature (see Section 4.1.1) was conducted to identify the magnitude of change in mass loading following the deposition of ash the first year following a volcanic eruption. Studies were considered applicable if personal exposure to TSP or PM_{10} were measured during dust-disturbing activities, or ambient TSP concentrations were measured during dust-disturbing activities, in areas having a relatively recent tephra deposit (i.e., less than about 5 years old). Summary values for each study reviewed are presented in Table 6-5.

Table 6-5. Particulate Concentrations–Postvolcanic Active Outdoor Environment

	Reference	Concentration, mg/m^3		Comments
		$\bar{x}$	Range	
1	Buist et al. 1986 (DIRS 144632), Table 2	4.34	1.48-9.01	TSP, dusty occupations, weeks following Mount St. Helens
2	Merchant et al. 1982 (DIRS 160102), Table 6	3.28	0.13-8.31	TSP, loggers, weeks following Mount St. Helens
3	Searl et al. 2002 (DIRS 160104), Table 11	0.5	0.2-10	PM_{10}, during eruptive phase of Soufriere Hills
4	Baxter et al. 1999 (DIRS 150713), Figure 3	1	0.3-2.5	PM_{10}, during eruptive phase of Soufriere Hills
5	Buist et al. 1983 (DIRS 159738), p. 717	1.35	1.24-1.46	TSP, children at summer camp, includes all daytime activities. Average of 2 sessions.
6	Hill and Connor 2000 (DIRS 160103), p. 71	10	1 and 10	TSP while driving (10 mg/m^3) and walking (1 mg/m^3), 4 years after Cerro Negro (note that data are not published)
 Squares = TSP, circles = PM_{10}				

$\bar{x}$ = mean or other value representative of the central tendency (see text); PM_{10} = particles with an aerodynamic diameter ≤10 μm; TSP= total suspended particles

6.2.1.1 Literature Review

Buist et al. (1986 [DIRS 144632], Table 2) report personal exposure to TSP for numerous occupations during the weeks following the eruption of Mount St. Helens. The methods used for that study are described in Hewett (1980 [DIRS 168490]). Many of the people monitored were involved in cleanup and removal of ash. Average concentrations were 2.65 mg/m^3 (range = 0.64–6.46) for hand-shoveling and sweeping, 5.50 mg/m^3 (range = 0.60–23.1) for sweeper-truck and broom-truck drivers, 5.96 mg/m^3 (range = 0.01–31.9) for grader operators, 1.48 mg/m^3 (0.23–6.14) for water-truck drivers, 9.01 mg/m^3 (range = 0.73–25.5) for rubbish workers, 1.42 mg/m^3 (range = 0.79–3.20) for agricultural workers, and 0.57 mg/m^3 (range = 0.04–4.17) for law enforcement personnel. The average of all occupational averages except law enforcement (excluded because law enforcement personnel may not have been conducting activities that resuspend ash) is 4.34 mg/m^3.

Merchant et al. (1982 [DIRS 160102], Table 6) compared personal exposure to TSP between loggers working in an area in Washington covered by ash from Mount St. Helens and loggers working in Oregon where there was no ash. See Sanderson (1982 [DIRS 168492]) for a description of the methods and location of the study sites. Average TSP concentrations (and geometric SD) for Washington were 5.97 mg/m^3 (2.95) for cutters, 8.31 mg/m^3 (5.50) for choker setters, 0.49 for one truck driver, 0.13 mg/m^3 (3.84) for yarder and loader operators, and 1.52 mg/m^3 (5.24) for landing men. The average of these five occupations was 3.28 mg/m^3. Average concentrations for cutters in Washington were about twice those of cutters in Oregon (average = 2.81 mg/m^3, SD = 1.46), but concentrations for yarder and loader operators (average = 0.17 mg/m^3, SD = 1.04) were similar.

Searl et al. (2002 [DIRS 160104]) measured ambient concentrations and personal exposure to PM_4 and PM_{10} on the island of Montserrat in the British West Indies during 1996–2000. The Soufriere Hills volcano erupted periodically during much of this study, and was most active during 1996 through mid-1998. Measurements were taken throughout the island, including on the southern portion, where the tephra deposit was from about 5 cm to more than 30 cm thick (these areas were evacuated during 1996–1997 in part because of concerns about high concentrations of airborne particles), and to the north, where the ash was less than 1 cm to about 5 cm thick. Average personal exposure to PM_4 during 1997 was 0.825 mg/m^3 (range = 0.817–0.833) for gardeners, more than 20 mg/m^3 (range = 0.077 to 71) for road workers, and 0.442 mg/m^3 for a housekeeper (Searl et al. 2002 [DIRS 160104], Table 7). Concentrations of PM_{10} associated with mowing grass and sweeping inside were of the order of 10 to 20 mg/m^3. During 2000, personal exposure by those groups was considerably lower: 0.134 mg/m^3 (range = 0.007 to 0.444) for gardeners and 0.050 mg/m^3 (range = 0.012 to 0.105) for housekeepers (Searl et al. 2002 [DIRS 160104], Table 8). Personal exposure to PM_{10} by children at school during 2000 was estimated to be 0.144 mg/m^3 while playing outdoors, 0.098 to 0.155 mg/m^3 while indoors, and 0.272 mg/m^3 while sweeping (Searl et al. 2002 [DIRS 160104], Table 9). To model population exposure, the authors estimated average personal exposure to PM_{10} during various activities and for four levels of ash (Searl et al. 2002 [DIRS 160104], Table 11). The low ash and raised ash concentrations appear to be most appropriate for this analysis, because alert and very high levels occurred during less than five percent of days on the northern and middle (i.e., Salem) portions of the island (Searl et al. 2002 [DIRS 160104],

Table 6). The very high and alert concentrations appear to correspond to days when the Soufriere Hills volcano was erupting and the wind was blowing ash toward a community. Estimated concentrations of PM_{10} during dusty work were 0.2 to 0.5 mg/m^3 for low and raised ash conditions, and 5 to 10 mg/m^3 for very high and alert concentrations. Estimated concentrations for outdoor play were 0.1 to 0.5 mg/m^3 for low and raised ash conditions, and 5 to 10 mg/m^3 for very high and alert conditions. Estimates for "active outside" were 0.05 to 0.2 mg/m^3 and 1 to 3 mg/m^3 for low to raised and very high to alert levels, respectively. A summary value of 0.5 mg/m^3, based on the estimate for dusty work during raised ash conditions, and a range of 0.2 to 10 mg/m^3 (also based on dusty work) is presented in Table 6-5 for this study. Assuming a $TSP:PM_{10}$ ratio of about 10:1 (e.g., Nieuwenhuijsen et al. 1998 [DIRS 150855], Table 2), an approximate TSP concentration for dusty work during this study is about 5 mg/m^3.

Baxter et al. (1999 [DIRS 150713], Figure 3) reported concentrations of PM_{10} at two outdoor settings during an eruptive phase of the Soufriere Hills volcano. Peak concentrations during human activity were about 0.5–1.5 mg/m^3 outside at a primary school and 0.3 to 2.5 at a resort. A summary value of 1 mg/m^3 is presented in Table 6-5; this value is the approximate midpoint between low and high peak concentrations.

Buist et al. (1983 [DIRS 159738]) measured personal exposure to TSP during the summer of 1980 among children ages 8 to 13 at a summer camp where about 1.2 cm of ash had fallen after the June 12 eruption of Mount St. Helens. The methods used for that study are described in Hewett (1980 [DIRS 168491]). Daytime personal exposure averaged 1.24 mg/m^3 and 1.46 mg/m^3 during two sessions (Buist et al. 1983 [DIRS 159738], p. 717). No information was presented on the percentage of time the children were active; therefore, these values may underestimate exposure in the active outdoor environment.

The following information, which is not listed as an input in Section 4.1.1 (because it has not yet been published in a peer-reviewed journal), is included here to corroborate results of the other studies. Concentrations of TSP were measured in 1999 above the tephra deposit from the 1995 eruption of the basaltic volcano Cerro Negro in Nicaragua. Concentrations during light activity such as walking were on the order of 1 mg/m^3, and concentrations while driving over the tephra deposits in an open truck were on the order of 10 mg/m^3 (Hill and Connor 2000 [DIRS 160103], p. 71).

6.2.1.2 Parameter Distribution

The types of activities monitored during the studies reviewed in this section include activities known to or expected to occur in the Yucca Mountain region, including removal of ash by hand and with machinery, agricultural work, gardening, and outdoor play. The measurements of personal exposure during those activities on tephra deposits (Table 6-5) are similar to measurements taken under nominal conditions in areas without tephra (Table 6-1), except that most maximum post-volcanic measurements are lower than those from nominal conditions. For example, TSP concentrations for agricultural workers after the eruption of Mount St. Helens (average = 1.42 mg/m^3, Buist et al. 1986 [DIRS 144632], Table 2) generally were lower than those reported by Nieuwenhuijsen et al. (1998 [DIRS 150855], Table 2), although the distribution of all activities reported by Buist et al. is not substantially different from that of

Nieuwenhuijsen et al. In the only study where a comparison was made of personal exposure in areas with and without ash, average respirable and total dust concentrations were about twice as high or less for various groups of loggers in areas with and without ash (Merchant et al. 1982 [DIRS 160102], Table 6). Measurements of mass loading over disturbed tephra deposits may be similar to those over other soil because most soils contain a reservoir of particles that are readily suspended when disturbed. Because measurements for nominal and post-volcanic conditions are very similar, and because there is a high probability that the initial tephra deposit south of Yucca Mountain will be very shallow (BSC 2004 [DIRS 170026], Table 6-4; CRWMS M&O 2000 [DIRS 153246], Section 3.10.5.1), a lower bound of a distribution of mass loading in the post-volcanic, active outdoor environment of 1 mg/m^3 is selected, the same as that for nominal conditions.

The maximum post-volcanic concentrations in Table 6-5 probably are lower than those reported for nominal conditions (Table 6-1) because few measurements have been taken on tephra deposits for the types of activities expected to occur in the Yucca Mountain region that would create very large concentrations of mass loading, such as farming (although see Buist et al. 1986 [DIRS 144632], Table 2). In addition, no studies were conducted in areas as arid as the current conditions at Yucca Mountain. The climate in the region where some measurements were taken following the eruption of Mount St. Helens is predicted to be consistent with that likely to occur at Yucca Mountain over much of the next 10,000 years. The other measurements were taken in more mesic areas where fine particles may be more rapidly removed from the ground surface by precipitation. However, because most studies reviewed were conducted shortly after eruptions occurred, there likely was insufficient time for resuspendable particles to be eroded from the tephra deposit. Also, none of the values presented above except those of Hill and Connor (2000 [DIRS 160103]) are from basaltic tephra deposits like those predicted to occur at Yucca Mountain (see Section 6.3.3 for a discussion of this uncertainty). Therefore, there is some uncertainty about the consistency of the study conditions to the conditions in the Yucca Mountain region. To account for that uncertainty, a mode of 7.5 mg/m^3 and maximum upper bound of 15 mg/m^3 are selected, 50 percent greater than that selected for nominal conditions.

For use in equation 6.2-3, mass loading distributions for the first year following a volcanic eruption, $S_{v,n}$ must be presented as the expected average annual increase in concentrations of resuspended particles that is greater than nominal concentrations. Thus, the recommended distribution of mass loading for S_v in the active outdoor environment is triangular, with a mode of 2.5, minimum of zero (i.e., equal to the minimum mass loading predicted for nominal conditions), and maximum of 5 mg/m^3. Because some relevant conditions under which the analogue measurements were taken are consistent with the conditions in the Yucca Mountain region, and because the range of the distribution was selected to bound uncertainty in other relevant conditions that may have differed, this distribution of mass loading is consistent with the applicable current and predicted future conditions in the Yucca Mountain region. This consistency supports a conclusion that the FEPs associated with this parameter (Table 1-1) are also consistent with the present knowledge of the conditions in the region surrounding the Yucca Mountain site, as required by 10 CFR 63.305(a) [DIRS 156605].

6.2.2 Inactive Outdoor Environment

Measurements of TSP before and after the eruption of Mount St. Helens were analyzed to evaluate changes in the inactive outdoor environment before and after a volcanic eruption. A literature review also was conducted to confirm the results of data analysis.

6.2.2.1 Data Analysis

A dataset containing 24-hour concentrations of TSP measured in the state of Washington during 1979 through 1992 was obtained from the EPA Office of Air Quality and Standards (DTN: MO0008SPATSP00.013 [DIRS 151750]). The dataset was sorted by date and concentration, and values for May 18 to July 31, 1980, (the 10-week period during which the four largest eruptions occurred) (Sarna-Wojcicki et al. 1982 [DIRS 160227], Figure 350) were examined to identify monitoring sites where large increases in TSP were measured following the eruption of Mount St. Helens. Thirteen sites in six cities were identified that had at least one 24-hour concentration greater than 0.4 mg/m^3. A value of 0.4 mg/m^3 was chosen as representative of a large increase because it is substantially higher than most other concentrations in this dataset. The thickness of the tephra deposit at these cities ranged from about 0.5 mm to about 10 mm (Sarna-Wojcicki et al. 1982 [DIRS 160227], Figures 336, 344, 345, and 346). Clarkston had about 0.5 mm deposited on May 18, and Richland had 0.5–1 mm deposited on that date. Longview had 1–2 mm deposited on May 25 and less than 1 mm on June 12. Vancouver had more than 1 mm deposited on May 25 and 4–5 mm deposited on June 12. Spokane had 2.5–5 mm deposited on May 18, and Yakima had 5-10 mm on that date (Sarna-Wojcicki et al. 1982 [DIRS 160227], Figures 336, 344, and 345).

For this analysis, one site was selected from each city. For all cities except Vancouver, data from the monitoring site with the highest reading during May 18 to July 31, 1980, were selected. Data from the Vancouver site with the second highest reading were selected, because data from May 28 through September 5, 1980, were missing for the site with the highest concentration. The only monitoring station in Clarkston was established in September 1979. Measurements from the six sites are listed in Appendix D.

Average concentrations for the six sites were calculated for the 12-month periods March 1979–February 1980, June 1980–May 1981, and June 1981–May 1982 (Table 6-6). The first period ends before initial volcanic activity in March 1980, and the second period starts about 2 weeks after the major eruption on May 18. These three periods represent average annual TSP concentrations the year before and the two years following the major eruption.

Changes in concentrations the year following the eruption appear to have been influenced by ash thickness (Table 6-6). Average annual concentrations and SDs at the two sites with less than 1 mm of ash (Clarkston and Richland) were lower or only slightly higher than concentrations the year before the eruption. Concentrations at the other four sites were about 40 to 90 percent higher, and variation was about two to three times higher the year following the eruption. Average concentrations and SDs the second year after the eruption were very similar to those before the eruption at all sites (Table 6-6).

Table 6-6. Average Concentrations of TSP (mg/m^3) at Six Sites in Washington Before (Mar 79-Feb 80), One Year After (Jun 80–May 81), and Two Years After (Jun 81-May 82) the May 1980 Eruption of Mount St. Helens

Site (EPA site #) and Ash Depth[a,b]					
Dates	$\bar{x}$	**SD**	**Minimum**	**Maximum**	**n**
Clarkston (53-003-0003) 0.5 mm ash					
Mar 79 – Feb 80	0.091	0.044	0.023	0.221	49
Jun 80 - May 81	0.107	0.058	0.048	0.388	76
Jun 81 - May 82	0.084	0.029	0.051	0.168	54
Richland (53-005-1001) 0.5–1.0 mm ash					
Mar 79 - Feb 80	0.069	0.057	0.005	0.333	60
Jun 80 - May 81	0.063	0.040	0.009	0.181	60
Jun 81 - May 82	0.050	0.028	0.011	0.111	59
Longview (53-015-0008) 1–3 mm ash					
Mar 79 - Feb 80	0.054	0.041	0.008	0.222	57
Jun 80 - May 81	0.097	0.141	0.021	0.986	56
Jun 81 - May 82	0.054	0.030	0.018	0.161	56
Spokane (53-063-0016) 2.5–5 mm ash					
Mar 79 - Feb 80	0.165	0.093	0.028	0.375	57
Jun 80 - May 81	0.226	0.155	0.024	0.743	59
Jun 81 - May 82	0.168	0.131	0.029	0.846	55
Vancouver (53-011-0006) 4–5 mm ash					
Mar 79 - Feb 80	0.050	0.030	0.005	0.158	61
Jun 80 - May 81	0.076	0.075	0.014	0.474	61
Jun 81 - May 82	0.055	0.029	0.014	0.124	61
Yakima (53-077-1006) 5–10 mm ash					
Mar 79 - Feb 80	0.060	0.041	0.011	0.259	59
Jun 80 - May 81	0.116	0.089	0.014	0.426	60
Jun 81 - May 82	0.061	0.046	0.012	0.339	61

Source: DTN: MO0008SPATSP00.013 (DIRS 151750).

[a] See Appendix D for the daily concentrations upon which these values were based.

[b] Initial ash depth, from Sarna-Wojcicki et al. (1982 [DIRS 160227], Figures 336, 344, 345, and 346).

$\bar{x}$ = average, SD = standard deviation, n = Number of 24-hour measurements.

Based on this analysis, it was concluded that, in areas having less than 1 to 10 mm of ash from the eruption of Mount St. Helens, average concentrations of TSP were no more than two times higher the year following the eruption, but returned to pre-eruption levels the following year.

6.2.2.2 Literature Review

Information about concentrations of resuspended particles during and after eruptions of two additional volcanoes was reviewed to evaluate whether the analysis of data collected following the eruption of Mount St. Helens produced reasonable conclusions.

Gordian et al. (1996 [DIRS 160111]) examined the association between PM_{10} levels and daily outpatient visits in Anchorage, Alaska, after about 3 mm of ash were deposited from the August 1992 eruption of Mount Spurr (McGimsey et al. 2001 [DIRS 160386], p. 4). During the 3 months before the eruption, PM_{10} concentrations in Anchorage ranged from about 0.010 to 0.080 mg/m^3 (Gordian et al. 1996 [DIRS 160111], Figure 1). The peak 1-hour concentration during the eruption was 3 mg/m^3 and the 24-hour average concentration the day after the eruption was 0.565 mg/m^3 (Gordian et al. 1996 [DIRS 160111], p. 290). Concentrations returned to pre-eruption levels after about 3 months, although there were occasional peaks of 0.1–0.2 mg/m^3 for about 9 months. By May 1993, PM_{10} concentrations had returned to pre-eruption levels. Gordian et al. (1996 [DIRS 160111], p. 293) concluded that PM_{10} concentrations in Anchorage were influenced by the volcano August 18 through December 31, 1992. Average PM_{10} concentrations during that period were about 0.70 mg/m^3, less than twice the average concentration of 0.40 mg/m^3 during periods not influenced by the eruption (May 1, 1992, through August 17, 1992, and January 1, 1993, through March 1, 1994).

Yano et al. (1990 [DIRS 160112]) compared TSP concentrations in the city of Kanoya, Japan, with those of Tahiro. Kanoya is 25 km from Mount Sakurajima and in the region that experiences the highest exposure to ash from that volcano, which "erupts hundreds of times each year" (Yano et al. 1990 [DIRS 160112], p. 368). Tashiro is 50 km from the volcano and outside of the affected area, and is similar to Kanoya in size and industrial development. Monthly average TSP concentrations (calculated as the sum of suspended particulate matter and respirable particulates in Table 1 of Yano et al. (1990 [DIRS 160112]) during summer 1995 were about twice as high in Kayona (0.030 mg/m^3) than in Tashiro (0.013 mg/m^3). Winter concentrations were about three times greater in Kayona (0.596 mg/m^3) compared to Tashiro (0.196 mg/m^3).

6.2.2.3 Parameter Distribution

Average ambient outdoor concentrations of TSP no more than doubled the year following the 1980 eruption of Mount St. Helens, and returned to pre-eruption levels the second year. This information is consistent with most climatic conditions and the thickness of the tephra deposit predicted for the area south of Yucca Mountain. Four of the six cities included in this analysis are in eastern Washington and have a climate consistent with that predicted for Yucca Mountain for much of the next 10,000 years (BSC 2004 [DIRS 170002], p. Section 6.6.2) (Clarkston [average annual precipitation = 16.5 in., average annual snowfall = 15.1 in.], Richland [precipitation = 7.0 in., snowfall = 10.2 in.], Spokane [precipitation = 16.2 in., snowfall = 42.14 in.], and Yakima [precipitation = 8.25 in., snowfall = 23.4 in.], NCDC 1998 [DIRS 125325]). Therefore, the influence of precipitation and vegetation on consolidation and removal of ash at those sites following Mount St. Helens likely would be similar to that after an eruption at Yucca Mountain. Also, ash thickness at the four sites examined (1 mm to 10 mm) was as high or higher than about 95 percent of predicted ash depths 20 km south of Yucca Mountain under normal, variable wind conditions (CRWMS M&O 2000 [DIRS 153246], Section 3.10.5.1). Information from two other volcanoes confirms that the average annual ambient concentrations of TSP are about twice as high the year following an eruption compared to pre-eruption levels or to similar areas without ash. Therefore, a triangular distribution with a mode of 0.120 mg/m^3 and a lower bound of 0.050 mg/m^3 are selected for the post-volcanic, inactive outdoor environment, twice that selected for nominal conditions.

None of the data analyzed or studies reviewed above were from areas that had tephra deposits as thick as the maximum predicted for 18 km downwind of Yucca Mountain (BSC 2004 [DIRS 170026], Table 6-4). Because the thickness of the initial tephra blanket may influence mass loading the year following deposition, there is some uncertainty about the upper end of the distribution for the inactive outdoor environment. Also, none of the measurements were taken in areas as arid as the current conditions at Yucca Mountain. The increase in precipitation and vegetative cover in eastern Washington may have resulted in lower mass loading in those regions soon after the eruption. In addition, there is uncertainty about the influence of redistribution of ash from aeolian and fluvial processes on mass loading. For example, if heavy rains occur soon after an eruption, additional ash particles may be carried through Fortymile Wash into the region south of Yucca Mountain, causing a temporary increase in mass loading within and near that wash (see Section 6.3 for additional information). To account for this uncertainty, a maximum value of 0.300 mg/m^3 is selected, three times the maximum selected for nominal conditions. A higher value is not selected, because a tephra deposit of more than 1 cm (the maximum thickness for which analogue data is available) would be an uncommon event south of Yucca Mountain in the area to be considered as the location of the receptor (CRWMS M&O 2000 [DIRS 153246], Section 3.10.5.1; BSC 2004 [DIRS 170026], Table 6-4) and because the influence of fluvial transport of ash on mass loading likely will be temporary and restricted to the vicinity of Fortymile Wash.

The distribution to be used in the biosphere model, which represents the increase in mass loading in the inactive outdoor environment the first year following a volcanic eruption at Yucca Mountain, is triangular with a mode of 0.060, minimum of 0.025, and maximum of 0.200 mg/m^3. Because some relevant conditions under which the analogue measurements were taken are consistent with the conditions in the Yucca Mountain region, and because the range of the distribution was selected to bound uncertainty in other relevant conditions that may have differed, this distribution of mass loading is consistent with the applicable current and predicted future conditions in the Yucca Mountain region. This consistency supports a conclusion that the FEPs associated with this parameter (Table 1-1) are also consistent with the present knowledge of the conditions in the region surrounding the Yucca Mountain site, as required by 10 CFR 63.305(a) [DIRS 156605].

6.2.3 Active Indoor Environment

Applicable literature (see Section 4.1.1) was reviewed to evaluate mass loading concentrations indoors following volcanic eruptions. Because few such measurements have been taken, an assumption (Section 5.2) was developed and is used with the results of the literature review to develop a distribution for the active indoor environment.

6.2.3.1 Literature Review

Buist et al. (1986 [DIRS 144632], Table 2) reported concentrations of TSP measured indoors in the weeks following the eruption of Mount St. Helens by the National Institute of Occupational Safety and Health. Average TSP concentrations were 0.09 mg/m^3 in homes (range = 0.03 to 0.20), 0.30 mg/m^3 in schools (range = 0.20 to 0.50), and 0.30 mg/m^3 in commercial establishments (range = 0.1 to 0.44). Buist et al. (1986 [DIRS 144632], p. 41) concluded that

"Generally, there were very low levels of airborne respirable dust in homes and other buildings and, for the most part, it is likely that the general population received a very low exposure."

Searl et al. (2002 [DIRS 160104]) measured PM_4 and PM_{10} concentrations during 1996–2000 in areas where ash was being or had been deposited by the Soufriere Hills volcano. Personal exposure concentrations of PM_4 were 0.050 mg/m^3 for housekeepers (range = 0.012 to 0.105), 0.105 mg/m^3 for shopworkers (range = 0.083 to 0.126), 0.012 mg/m^3 for one housewife, and 0.039 mg/m^3 for one office worker (Searl et al. 2002 [DIRS 160104], Table 8). To model population exposure, the authors estimated average personal exposure to PM_{10} during various activities and for four levels of ash concentrations (Searl et al. 2002 [DIRS 160104], Table 11). The low ash and raised ash concentrations are the most consistent with the predicted conditions in the Yucca Mountain region because alert and very high concentrations occurred during less than five percent of days on the portions of the island where ash thickness was less than 5 cm (Searl et al. 2002 [DIRS 160104], Table 6). The very high and alert concentrations appear to correspond to days when the Soufriere Hills volcano was erupting and the winds were blowing ash toward a community. Estimated concentrations of PM_{10} while active indoors were 0.05 to 0.15 mg/m^3 for low and raised ash concentrations, and 0.5 to 2.0 mg/m^3 for very high and alert concentrations. If the ratio of TSP to PM_{10} in this environment is approximately 2.5:1 (see Section 6.1.3), then corresponding TSP ratios for the low and raised ash conditions would be 0.125 and 0.375 mg/m^3.

6.2.3.2 Parameter Development

Because an insufficient number of measurements of mass loading in the active indoor environment following a volcanic eruption have been reported, an assumption was developed (Section 5.2) that predicts that changes in the active indoor environment will be proportional to changes predicted for the inactive outdoor environment. The distribution selected for the active indoor environment under nominal conditions is triangular with a mode of 0.100 mg/m^3 and a range of 0.060 to 0.175 mg/m^3. Based on measurements of TSP the year following the eruption of Mount St. Helens, and a review of literature from Mount St. Helens, Mount Spurr, and Montserrat, it was predicted that outdoor mass loading would double the first year after an eruption at Yucca Mountain (Section 6.2.2). Thus, the predicted distribution of TSP for the active indoor environment the first year following a volcanic eruption at Yucca Mountain is triangular with a mode of 0.200 mg/m^3 and a range of 0.120 to 0.350 mg/m^3.

For the inactive outdoor environment, the maximum value in the distribution was three times higher than that predicted for nominal conditions. The maximum for the active indoor environment was doubled for the following reasons. As explained in Section 5.2, the rate at which indoor concentrations are assumed to increase relative to outdoor concentrations is about twice that measured in most studies, and was selected to account for uncertainty in the relationship between indoor and outdoor concentrations during very dusty conditions. Increasing that ratio further is unreasonable because such an increase would be greater than any applicable measured value. Also, it is unlikely that people would allow their homes to be extremely dusty for a long period following an eruption. In contrast to outdoor dust concentrations, which cannot be controlled easily, indoor concentrations can be decreased easily by dusting, vacuuming, changing air filters, and keeping windows and doors shut.

Predicted and measured concentrations of TSP indoors during and immediately following the eruptions of Mount St. Helens and Soufriere Hills ranged from about 0.09 mg/m^3 to 0.375 mg/m^3, respectively. These values are similar to the minimum and maximum values of the predicted range for the indoor active environment, and this range and the assumption upon which it was based therefore appear to be reasonable.

The distribution to be used in the biosphere model, which represents the increase in mass loading in the active indoor environment the first year following a volcanic eruption at Yucca Mountain, is triangular with a mode of 0.100, minimum of 0.060, and maximum of 0.175 mg/m^3. Because the range of the distribution, and the assumption upon which it was based, was selected to bound uncertainty in relevant conditions in the Yucca Mountain region, this distribution of mass loading is consistent with the applicable current and predicted future conditions in the Yucca Mountain region. This consistency supports a conclusion that the FEPs associated with this parameter (Table 1-1) are also consistent with the present knowledge of the conditions in the region surrounding the Yucca Mountain site, as required by 10 CFR 63.305(a) [DIRS 156605].

6.2.4 Asleep Indoor Environment

Applicable literature (see Section 4.1.1) was reviewed to evaluate mass loading concentrations in the asleep indoor environment following volcanic eruptions. Because few such measurements have been taken, an assumption (Section 5.2) was developed and is used with the results of the literature review to develop a distribution for this environment.

6.2.4.1 Literature Review

Buist et al. (1983 [DIRS 159738]) measured personal TSP exposure concentrations of children ages 8 to 13 that were attending a summer camp in Oregon shortly after 1.2 cm of ash had fallen from the eruption of Mount St. Helens. The methods used for that study are fully described in Hewett (1980 [DIRS 168491]). Nighttime TSP concentrations were at or below the 0.01-mg/m^3 limit of detection of sampling equipment (Buist et al. 1983 [DIRS 159738, p. 717).

Searl et al. (2002 [DIRS 160104]) measured PM_4 and PM_{10} concentrations during 1996–2000 in areas where ash was being or had been deposited by the Soufriere Hills volcano. To model population exposure, the authors estimated average personal exposure to PM_{10} during various activities and for four levels of ash concentrations (Searl et al. 2002 [DIRS 160104], Table 11). The low ash and raised ash concentrations are the most consistent with the predicted conditions in the Yucca Mountain region because alert and very high concentrations occurred during less than five percent of days on the portions of the island where ash thickness was less than 5 cm (Searl et al. 2002 [DIRS 160104], Table 6). The very high and alert concentrations appear to correspond to days when the Soufriere Hills volcano was erupting and the winds were blowing ash toward a community. Estimated concentrations of PM_{10} while inactive were 0.03 to 0.1 mg/m^3 for low and raised ash conditions, and 0.3 to 1.0 mg/m^3 for very high and alert concentrations. If the ratio of TSP to PM_{10} in this environment were 1.6:1 (from Thatcher and Layton 1995 [DIRS 159600], Figure 3 [see Section 6.1.4]), then corresponding TSP ratios for the low and raised ash conditions would be about 0.048 and 0.160 mg/m^3.

6.2.4.2 Parameter Development

Because an insufficient number of measurements of mass loading in the active indoor environment following a volcanic eruption have been reported, an assumption was developed (Section 5.2) that predicts that changes in mass loading indoors following a volcanic eruption will be proportional to changes predicted for the inactive outdoor environment. The distribution selected for the asleep indoor environment under nominal conditions is triangular with a mode of 0.030 mg/m^3 and a range of 0.010 to 0.050 mg/m^3. Based on measurements of TSP the year following the eruption of Mount St. Helens, and a review of literature from Mount St. Helens, Mount Spurr, and Montserrat, it was predicted that outdoor mass loading in the Yucca Mountain region would double the first year after an eruption at Yucca Mountain (Section 6.2.2). Thus, the predicted distribution of TSP for the asleep indoor environment the first year following a volcanic eruption at Yucca Mountain is triangular, with a mode of 0.060 mg/m^3 and a range of 0.020 to 0.100 mg/m$^{3.}$

For the inactive outdoor environment, the maximum value in the distribution was three times higher than that predicted for nominal conditions. The maximum for the asleep indoor environment was doubled for the following reasons. As explained in Section 5.2, the rate at which indoor concentrations increase relative to outdoor concentrations is about twice that measured in most studies, and was selected to account for uncertainty in the relationship between indoor and outdoor concentrations during very dusty conditions. Increasing that ratio further is unreasonable because such an increase would be greater than any applicable measured value. Also, it is unlikely that people would allow their homes to be three times as dusty for a long period following an eruption. In contrast to outdoor dust concentrations, which cannot be controlled easily, indoor concentrations can be decreased easily by dusting, vacuuming, changing air filters, and keeping windows and doors shut.

Predicted and measured concentrations of TSP indoors during and immediately following the eruptions of Mount St. Helens and Soufriere Hills ranged from less than 0.010 mg/m^3 to about 0.160 mg/m^3. The high value is the predicted value of Searl et al. (2002 [DIRS 160104]) for raised ash conditions while inactive, and is higher than the predicted maximum for the asleep indoor environment. The value from Searl et al. is based on sleeping and sedentary activities while awake, such as watching television (Searl et al. 2002 [DIRS 160104], Table 10) and is 20 times higher than the maximum values measured by Buist et al. (1983 [DIRS 159738]). Because it includes concentrations while people are awake, it likely is an overestimate of concentrations while asleep. Thus, the predicted range for the asleep indoor environment, and the assumption upon which it was based, appear to be reasonable.

The distribution to be used in the biosphere model, which represents the increase in mass loading in the asleep indoor environment the first year following a volcanic eruption at Yucca Mountain, is triangular with a mode of 0.030, minimum of 0.010, and maximum of 0.050 mg/m^3. Because the range of the distribution, and the assumption upon which it was based, was selected to bound uncertainty in relevant conditions in the Yucca Mountain region, this distribution of mass loading is consistent with the applicable current and predicted future conditions in the Yucca Mountain region. This consistency supports a conclusion that the FEPs associated with this parameter (Table 1-1) are also consistent with the present knowledge of the conditions in the region surrounding the Yucca Mountain site, as required by 10 CFR 63.305(a) [DIRS 156605].

6.2.5 Mass Loading–Crops

No measurements have been taken of mass loading near crops, so it is assumed that the distribution of mass loading in fields where crops are growing is similar to or higher than that in the inactive outdoor environment, with a minimum value equal to the minimum value of the inactive outdoor environment, and a modal and maximum value twice that of the inactive outdoor environment. See Section 5.1 for justification of this assumption. As described in the introduction to Section 6.2, mass loading for crops is not treated as a function of time in the biosphere model. Therefore, this distribution of mass loading must be representative of the total concentration of resuspended particles following a volcanic eruption (versus the increase the first year following an eruption, as is done for mass loading distributions for human environments).

The distribution of mass loading in the inactive outdoor environment the first year following a volcanic eruption is predicted to have a mode of 0.120 mg/m^3, and a range of 0.050 to 0.300 mg/m^3. Based on the above assumption, the distribution of mass loading for crops is predicted to have a mode of 0.240 mg/m^3, and a range of 0.050 to 0.600 mg/m^3.

6.3 MASS LOADING–TIME FUNCTION

The mass loading time function is used within the volcanic-eruption analysis of the TSPA model to calculate the change in dose through time resulting from a decrease in mass loading following a volcanic eruption, as shown in Equation 6.2-3.

Ash from a volcanic eruption initially would be more readily suspendable than the soil upon which it was deposited, and mass loading therefore would be higher than it was prior to the eruption (i.e., under nominal conditions defined in Section 6.1). Through time the tephra deposit would erode; become mixed into the soil; buried; removed from homes, yards, and other living areas; or otherwise become stabilized. That erosion, removal, and stabilization would result in a decrease in mass loading, with concentrations eventually returning to nominal conditions. Because of this change in mass loading through time, dose resulting from a volcanic eruption must be calculated in the TSPA model as a function of time.

If mass loading decreases exponentially through time, the mass loading time function in Equation 6.2-3 is expressed as:

$$S_{v,n}\, f(t) = S_{v,n} e^{-\lambda t} \qquad \text{(Eq. 6.3-1)}$$

where:

λ = Mass loading decrease constant (1/years).

t = Time (years); $0 \leq t \leq 1$ is the first year after a volcanic eruption.

The other variables in this equation are defined for Equation 6.2-3.

An exponential decrease in mass loading following a volcanic eruption is selected for Equation 6.3-1 based on commonly used equations for predicting the change in concentrations of resuspended particles and radionuclides through time. Dahneke (1975 [DIRS 151756], p. 194) developed a generalized exponential equation for particle resuspension of $N_t = N_0e^{-\lambda t}$, where N_t = concentration at time t, N_0 = initial concentration, λ = resuspension factor or decrease constant (i.e., an estimate of how quickly the decay occurs), and t = time. Similar exponential decay equations have been used to calculate resuspension in dose assessment models (Till and Meyer 1983 [DIRS 101895], p. 5-32 through 5-33; IAEA 1982 [DIRS 103768], p. 20; IAEA 1992 [DIRS 103772], Figure 1 on p. 13; Napier et al. 1988 [DIRS 100953], p. 4.64).

Inverse or inverse power functions have also been used to predict concentrations of resuspended radionuclides (IAEA 1992 [DIRS 103772], Figure 1 on p. 13; Garger et al., 1997 [DIRS 124902], p. 1651). Garger et al. (1997 [DIRS 124902], Figure 3 on p. 1654) evaluated how eight equations (six exponential, one inverse power, and one combination) predicted temporal changes in radionuclide concentrations following the accident at the Chernobyl nuclear power plant. Equations with an inverse power function generally predicted concentrations more accurately than the exponential equations in that mesic environment (Garger et al. 1997 [DIRS 124902], p. 1655) because the exponential equations overestimated concentrations (i.e., did not calculate a rapid enough decay). However, an inverse decay function is less conservative than an exponential function because it predicts a more rapid decrease in concentrations.

The mass loading decrease constant controls the rate at which the mass loading concentration would decrease over time. Figure 6-1 is a plot of the decrease in mass loading per year for seven values of λ.

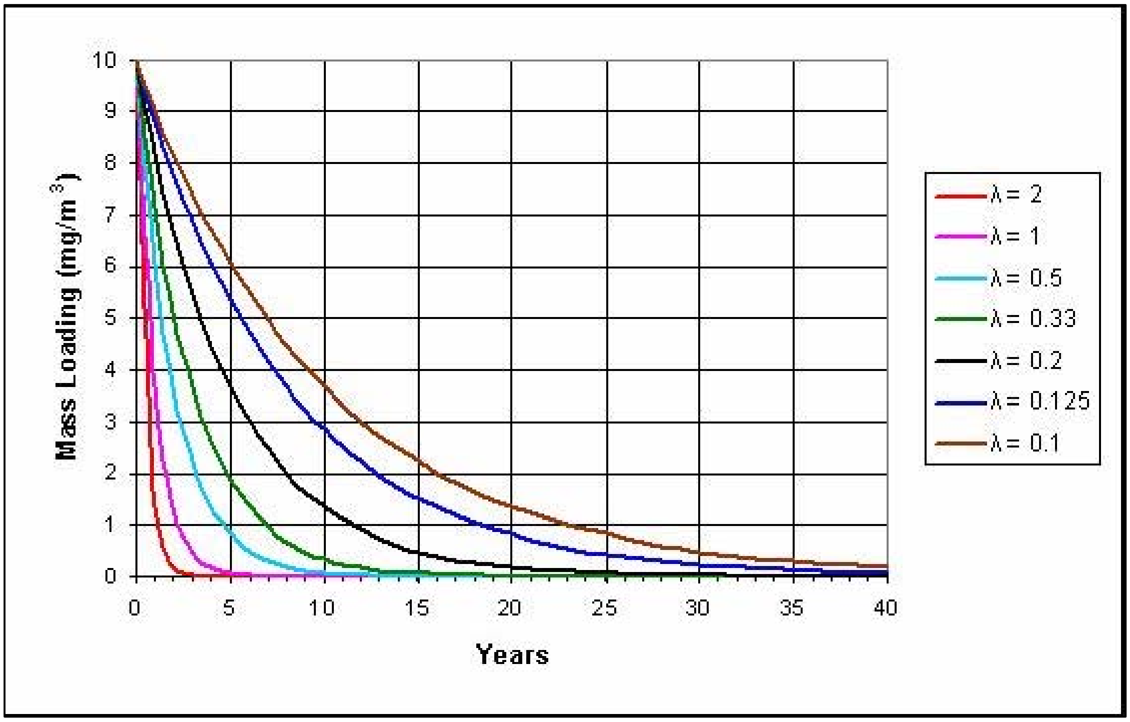


Figure 6-1. Examples of the Rate of Change of Mass Loading from a Hypothetical Initial Concentration of 10 mg/m^3 for Seven Values of the Mass Loading Decrease Constant (λ)

The average annual concentration for a period of years *TI* ($S_{\bar{X},TI}$), and an initial concentration $S_{v,n}$ can be calculated using the following equation, which was developed by integrating Equation 6.3-1 between the times of zero and the time interval *TI* and dividing this by the time interval, as shown in Equation 6.3-2. This equation is used only within this analysis to compare average concentrations among selected decrease constants; it is not used in the biosphere model report.

$$S_{\bar{x},TI} = \frac{\int dS_n}{\int dt} = \frac{S_{v,n}}{t} \times \frac{1}{\lambda} \times \left(1 - e^{-\lambda t}\right) \qquad \text{(Eq. 6.3-2)}$$

Concentrations of TSP measured before and after eruptions of Mount St. Helens were analyzed to predict the mass loading decrease constant for a volcanic eruption at Yucca Mountain. Literature from that and other volcanoes were reviewed to corroborate the rate at which mass loading returns to pre-eruptive conditions.

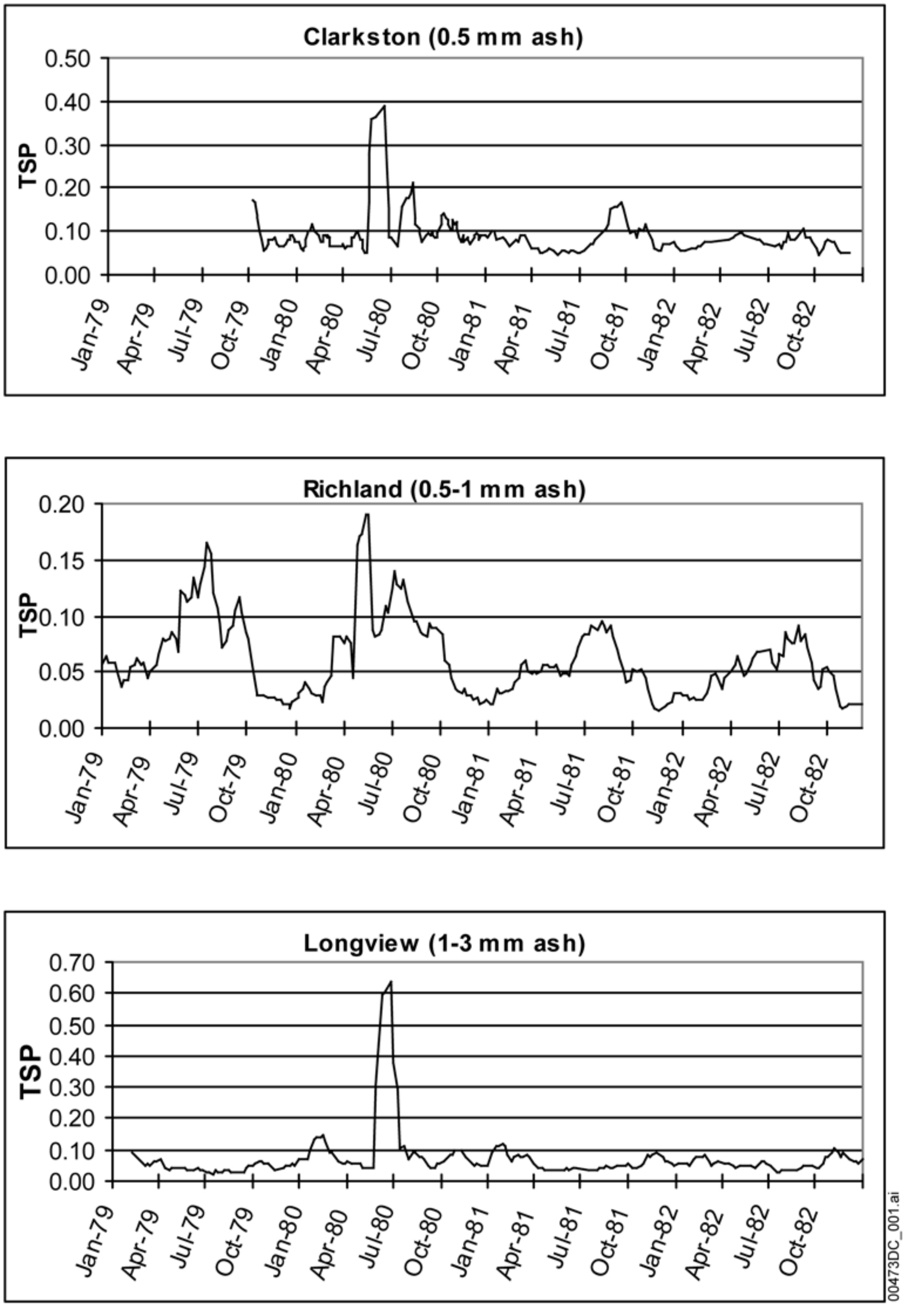
6.3.1 Data Analysis

Mount St. Helens TSP Data–TSP measurements for 1979–1982 from six sites in Washington that had about 0.5 to 10 mm of ash were plotted to evaluate the rate at which ash stabilized after the eruption of Mount St. Helens. The dataset (DTN MO0008SPATSP00.013 [DIRS 151750]) and methods used to select the six sites are described in Section 6.2.2.1.

TSP concentrations at the sites are plotted in Figure 6-2. This figure displays five-measurement running averages, which were calculated to smooth changes over short periods. These averages were calculated as the average of the concentration for a date and the four previous measurements (Appendix D). Concentrations returned to pre-eruption levels at Clarkston, Richland, Longview, and Vancouver within about three months, and within about six to eight months at Spokane and Yakima. Average annual concentrations two years after the eruption were equal to pre-eruption concentrations at all sites (Table 6-6). The corresponding λ for this rate of decrease is at least 2.0 year^{-1}or greater (Figure 6-1).

6.3.2 Literature Review

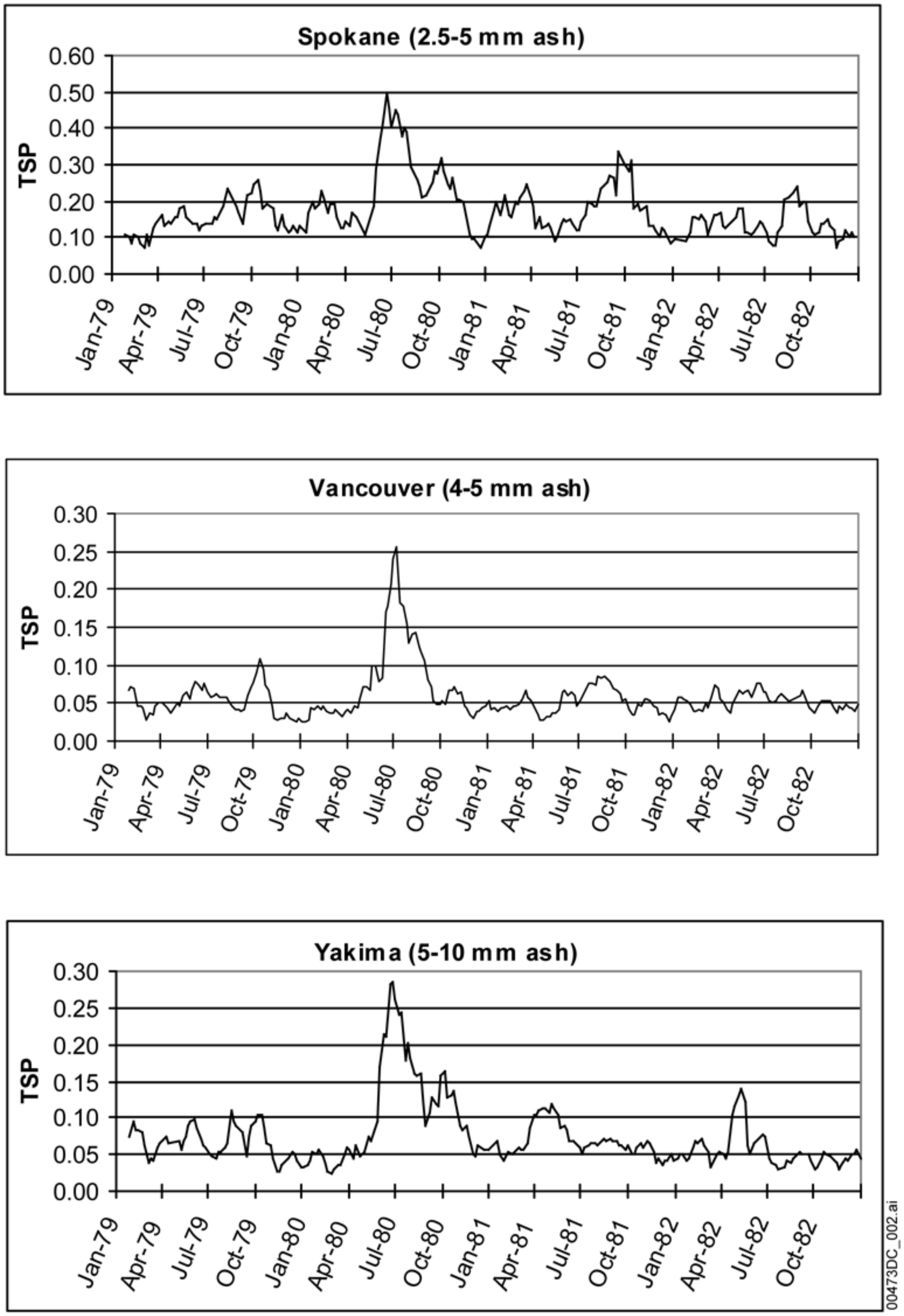
Buist et al. (1986 [DIRS 160308], p. 70) report changes in personal-exposure concentrations of respirable dust for loggers working in areas having substantial deposits of ash from Mount St. Helens. Sanderson (1982 [DIRS 168492]) gives a complete description of the methods and location of the study sites. Dust concentrations for cutting crews were 0.900 mg/m^3 in June 1980 (one month or less after the major eruption of Mount St. Helens) and 0.270 mg/m^3 in September 1980. This is a 70 percent decrease in mass loading over four months (maximum of 122 days), or 0.57 percent per day (0.7/122 days x 100), which is approximately equal to a λ of 2.1 year^{-1} (0.57 percent per day x 365 days).



DTN: MO0008SPATSP00.013 (DIRS 151750).

NOTE: TSP is presented as the running average of 5 consecutive measurements (Appendix D).

Figure 6-2. TSP Concentrations (mg/m^3) at Six Sites in Washington Before and After the Eruption of Mount St. Helens in May–June 1980



NOTE: TSP is presented as the running average of 5 consecutive measurements (Appendix D).

Figure 6-2. TSP Concentrations (mg/m^3) at Six Sites in Washington Before and After the Eruption of Mount St. Helens in May-June 1980 (Continued)

Buist et al. (1986 [DIRS 144632], p. 41) summarize results of monitoring of personal exposure to dust and ash for many other occupations and settings following the eruption of Mount St. Helens. Although they do not present data on how concentrations changed through time, they state that high occupational exposures were "largely restricted to the summer months" (i.e., 3–4 months following the eruption), and that "environmental exposures were also modest except in the path of the plume for the few days immediately following the May 18, 1980 eruption." They also state that "In exposed areas, rain and weathering have tended to create a crust that has helped to reduce the aerosolization of the ash, and on farmed land, the ash has gradually become worked into the topsoil."

Gordian et al. (1996 [DIRS 160111]) presents a plot of PM_{10} concentrations in Anchorage, Alaska, before and after about 3 mm of ash were deposited from the August 1992 eruption of Mount Spurr (McGimsey et al. 2001 [DIRS 160386], p. 4). During the three months prior to the eruption, PM_{10} concentrations in Anchorage ranged from about 0.010 to 0.080 mg/m^3 (Gordian et al. 1996 [DIRS 160111], Figure 1). The peak one-hour concentration during the eruption was 3 mg/m^3 and the 24-hour average concentration the day after the eruption was 0.565 mg/m^3 (Gordian et al. 1996 [DIRS 160111], p. 290). Concentrations returned to pre-eruption levels after about three months, although there were occasional peaks of 0.1–0.2 mg/m^3 for about nine months. By May 1993, PM_{10} concentrations had returned to pre-eruption levels. The corresponding λ for this rate of decrease is at least 2.0 $year^{-1}$ (Figure 6-1).

Yano et al. (1990 [DIRS 160112], p. 373) stated although concentrations as high as 2 mg/m^3 have been measured in high-exposure areas after the eruption of Mount Sakurijima (Japan), "these high levels of suspended particulate matter seldom last long, and they usually decrease rapidly to approximately 0.1 mg/m^3."

In summary, the mass loading decrease constant for six sites in Washington following the eruption of Mount St. Helens, and in Anchorage following the eruption of Mount Spurr, was about 2.0 $year^{-1}$ (see Figure 6-1). The average concentration for a decrease constant of 2 $year^{-1}$and a hypothetical S_v of 10 mg/m^3 is 0.5 mg/m^3 over 10 years and 0.25 mg/m^3 over 20 years (using Equation 6.3-2). This rate of decrease in mass loading following eruptions is corroborated by other reports of conditions following Mount St. Helens and from monitoring following the eruptions of Mount Spurr and Mount Sakurijima.

6.3.3 Parameter Development

The conditions under which the data from Mount St. Helens were collected are consistent with the average thickness of the tephra deposit and the coolest, wettest climatic conditions predicted for the area south of Yucca Mountain. The climate at the four cities in eastern Washington examined (Clarkston [average annual precipitation = 16.5 in., average annual snowfall = 15.1 in.], Richland [precipitation = 7.0 in., snowfall = 10.2 in.], Spokane [precipitation = 16.2 in., snowfall = 42.1 in.] and Yakima [precipitation = 8.3 in., snowfall = 23.4 in.], NCDC 1998 [DIRS 125325]) is predicted to be consistent with that at Yucca Mountain for much of the next 10,000 years (BSC 2004 [DIRS 170002], Section 6.6.2). Therefore, the influence of precipitation and vegetation on consolidation and removal of ash at those sites following Mount St. Helens likely will be consistent with that after an eruption at Yucca Mountain.

There are, however, other differences between the conditions under which data from Mount St. Helens were measured and those expected at Yucca Mountain. These differences may be important sources of uncertainty in the use of information from Mount St. Helens and other volcanoes to develop a distribution of the mass load decay constant. First, the size, resuspendability, or other characteristics of ash from non-basaltic volcanoes such as Mount St. Helens and other volcanoes may differ from that of the type of basaltic volcano predicted for Yucca Mountain. Second, climatic conditions at Mount St. Helens are wetter and cooler than current conditions at Yucca Mountain. Third, no data are available on the rate of change in mass loading following an initial deposit of more than 1 cm. Also, all locations where changes in mass loading through time were measured after volcanic eruptions were outside of the volcanoes' watersheds; therefore, the only important source of ash was the initial, airborne deposit. Amargosa Valley is within the watershed of Yucca Mountain and ash initially deposited upstream of Amargosa Valley may be washed and blown into and through that valley.

If ash particles from non-basaltic volcanoes used as analogues in this analyses (Mount St. Helens, and to a lesser extent Soufriere Hills, Mount Spurr, and Mount Sakurijima) are larger than those from a basaltic volcano of the type predicted at Yucca Mountain, then predicted concentrations of resuspended ash developed from those analogues may underestimate mass loading following an eruption at Yucca Mountain and overestimate the rate at which concentrations decrease through time. All of the following measurements of particle size distributions are presented as percent mass. Hill and Connor (2000 [DIRS 160103], p. 71) report that ash 21 km from the vent of the basaltic Cerro Negro volcano had about two percent of particles by weight less than 10 μm, 10 percent less than 60 μm, and 50 percent less than 200 μm. They report that other fall deposits from larger basaltic cinder cone eruptions (Paricutin, Tolbachik, Sunset Crater) may contain two to five percent weight of particles less than 10 μm at 20 km. Hill and Connor (2000 [DIRS 160103], p. 71) also state that basaltic volcanoes may produce unusually fine-grained deposits (greater than 40 percent of particle weight less than 60 μm) late in an eruption during subsurface brecciation events. About 10 percent or less of the ash from Mount St. Helens was less than 10 μm (Craighead et al. 1983 [DIRS 160338], p. 6; Buist et al. 1986 [DIRS 144632], p. 40). Ash at two sites 30 to 35 km east of Anchorage from the August 1992 eruption of Mount Spurr had about 30 to 35 percent of particles equal to or less than 63 μm, 8 to 15 percent less than 15 μm, and 5 to 10 percent equal to or less than 7.5 μm (McGimsey et al. 2001 [DIRS 160386], Figure 12 [particle sizes are midpoints of values from bar charts]). However, ash collected at a site about 25 km west of Anchorage (closer to Mount Spurr) had few or no particles equal to or less than 63 μm. Ash from Soufriere Hills had 13 to 20 percent weight of particles equal to or less than 10 μm and 60 to 70 percent weight of particles 10 to 125 μm (Baxter et al. 1999 [DIRS 150713], p. 1142). Thus, ash from the volcanoes used as analogues in this analysis appears to have had higher concentrations of fine particles than that from basaltic volcanoes. In addition, Baxter (in McKague 1998 [DIRS 151841], Enclosure 3 – Item 17) stated "For exposure estimates, the [PM_{10}] results obtained from Mount St. Helens and Monsterrat will almost certainly need to be reduced by a factor to allow for the coarser material emitted at Cerro Negro." Thus, ash particles from the analogue volcanoes used in this analysis generally were similar in size or smaller than those from basaltic volcanoes. However, the amount of fine ash deposited at a site can be quite variable, depending on wind direction and speed, distance from the volcano, and possibly other factors (Sarna-Wojcicki et al. 1982 [DIRS 160227], pp. 585-588, McGimsey et al. 2001

[DIRS 160386], Figure 12). In addition, other characteristics of the ash and environment, such as grain adhesion and the presence of an indurated surface layer, may affect the concentrations of resuspended ash particles. The presence of the characteristics at the analogue sites considered in this analysis, and their effects on measurements of resuspended particles considered here, are unknown. For example, measurements of mass loading taken over the tephra deposit from the eruption of basaltic Cerro Negro (Hill and Conner 2000 [DIRS 160103], p. 71) are higher than analogous measurements taken following the eruption of the silicic Mount St. Helens (Buist et al. 1986 [DIRS 144632], Table 2; Merchant et al. 1982 [DIRS 160102], Table 6) (see Section 6.2.1). To account for uncertainty about the influence of differences in the characteristics of ash from analogue measurements considered here and the potential conditions in the reference biosphere following an eruption, the modal and lower bounds of the distribution of the decay constant described below are smaller (i.e., have a slower decay rate) than the value of about 2 measured after eruptions of Mount St. Helens and Mount Spurr.

The present-day, arid climate at Yucca Mountain is predicted to continue for less than 1,000 years (BSC 2004 [DIRS 170002], Table 6-1). The rate of change in mass loading measured in eastern Washington under wetter and cooler conditions may not apply to current conditions. However, concentrations of airborne particulates currently do not differ much among arid, rural sites with less than 20 in. of precipitation and less than about 45 in. of snowfall (Appendix C); therefore, changes in mass loading through time likely would not differ greatly between present-day and future climates predicted for Yucca Mountain. To ensure that uncertainty in the effects of current, arid conditions are not underestimated, the lower bound of the distribution of the decay constant below is smaller than the value measured at analogue sites.

The analogue data from Mount St. Helens used in this analysis is from ash deposits of 10 mm or less. Although an ash deposit greater than 10 mm is unlikely in the area south of Yucca Mountain at the receptor location (CRWMS M&O 2000 [DIRS 153246], Section 3.10.5.1; BSC 2004 [170026], Table 6-4), the influence of such a deposit on the mass loading time function must be included. Because there is much more uncertainty in the decay constant for ash deposits equal to or more than 10 mm, separate distributions of this parameter are developed below for deposits less than 10 and equal to or greater than 10 mm deep.

There is also uncertainty associated with the effects of aeolian and fluvial redistribution of ash into northern Amargosa Valley. Large quantities of ash from an eruption at Yucca Mountain may be deposited in the Fortymile Wash watershed. During and after very heavy precipitation events, some of the ash in that watershed would be washed downstream and deposited in Amargosa Valley. During that fluvial transport, some of the fuel and ash may be broken down into smaller particles. If the quantity of resuspendable fuel and ash at or near the location of the receptor is greater than the quantity of resuspendable soil now washed through that area, dust concentrations would increase temporarily after deposition.

The Fortymile Wash watershed starts approximately 25 miles north of Yucca Mountain, and continues southward along the eastern edge of Yucca Mountain before entering Amargosa Valley. The wash terminates at the Amargosa River in western Amargosa Valley. It drains the southern part of Pahute Mesa, western Jackass Flats, and the eastern slopes of Fortymile Wash. Just south of the southern boundary of the Nevada Test Site (i.e., about 20 km south of Yucca Mountain), the Fortymile Wash channel changes from a moderately confined channel to several distributary channels that are poorly defined (Tanko and Glancy 2001 [DIRS 159895], Figure 1). Fortymile Wash flows into Amargosa Valley infrequently and flows into the Amargosa River have been documented only three times since 1969. During the two floods (1995 and 1998) that have been well studied, unusually severe or long-lasting rains combined with melting of the snowpack in the northern part of the watershed resulted in flows throughout all or most of the major tributaries of Fortymile Wash and the Amargosa River (Beck and Glancy 1995 [DIRS 160389]; Tanko and Glancy 2001 [DIRS 159895]). Thus, any sediment from one portion of the watershed was mixed with and buried within sediment from throughout the watershed.

There is little evidence of flooding over the bank in the washes in Amargosa Valley (BSC 2004 [DIRS 169980], Section 6.3.4.2.5); therefore, most sediment transported into Amargosa Valley would be restricted primarily to the bottoms and sides of the channels of Fortymile Wash. Although Fortymile Wash consists of a series of diffuse channels in Amargosa Valley, the surface area of the channels is small relative to the entire valley. Tephra blankets deposited throughout entire regions following other volcanic eruptions resulted in increases in resuspended particles for only months (e.g., Figure 6-1). Therefore, it is reasonable to expect that ash redistributed during flooding restricted to the channels of Fortymile Wash and well-mixed with other sediment would affect mass loading for a much shorter period of time, likely days to at most weeks. In addition, any increase in mass loading would be small relative to the change predicted for the first year following an eruption, which were caused by widespread, undiluted tephra deposits. To account for uncertainty in how long mass loading would remain high after such flooding, how much higher than background levels it would be, changes in particle size distributions over time, and how frequently Fortymile Wash would flood in the future, the selected modal and minimum values of the mass loading decrease constant are much lower than those measured following other volcanic eruptions.

For an initial ash thickness of less than 10 mm, a triangular distribution of the mass load decrease constant with a mode of 0.33 year^{-1}, maximum of 2.0 year^{-1}, and minimum of 0.2 year^{-1} is selected.

- The maximum value of 2.0 year^{-1} is approximately equal to the rate measured at community monitoring sites following the eruption of Mount St. Helens (Figure 6-2). It is also similar to the change in personal exposure to resuspended particles during logging after Mount St. Helens erupted (Buist et al 1986 [DIRS 160308]), and to the decrease in mass loading following the eruptions of Mount Spurr and Mount Sakurijima (Gordian et al 1996 [DIRS 160111]; Yano et al. 1990 [DIRS 160112]). A rate of 2.0 year^{-1} would result in a decrease in mass loading to 5 percent of the maximum concentrations in about 2 years and an average annual concentration over 10 years of about 0.5 mg/m^3 for a hypothetical S_v of 10 mg/m^3 (from Equation 6.3-2).

- The modal rate of 0.33 year^{-1} would result in a decrease of about 96 percent over 10 years (Figure 6-1) and an average annual concentration over 10 years of 2.9 mg/m^3 for a hypothetical S_v of 10 mg/m^3 (from Equation 6.3-2). This corresponds to a rate that takes at least 10 times longer to approach pre-eruption levels, and an average annual concentration over 10 years about 6 times greater than for a λ of 2 year^{-1} (0.5 mg/m^3), the approximate decrease constant following the eruptions at Mount St. Helens and other volcanoes for which data is available. This modal rate was selected to account for uncertainty in the effects of differences such as precipitation, vegetation, ash characteristics, and ash redistribution, between those sites and the reference biosphere.

- The minimum rate of 0.2 year^{-1} would result in a decrease of about 86 percent in 10 years and an average annual concentration over 10 years of 4.3 mg/m^3 for a hypothetical S_v of 10 mg/m^3, more than eight times greater than that for a λ of 2 year^{-1}. For this rate it would take about 15 to 16 years for mass loading to decrease to 5 percent of initial concentrations. Because this rate is much slower than those measured over tephra deposits of similar depth to those expected at the reference biosphere, it reasonably bounds uncertainty in the effects of differences in conditions between analogue sites and the reference biosphere.

For an initial ash thickness of 10 mm or greater, a triangular distribution of the mass load decrease constant with a mode of 0.2 year^{-1}, maximum of 1.0 year^{-1}, and minimum of 0.125 year^{-1} is selected. These lower (i.e., slower) rates were selected to account for the additional uncertainty in the effects of an initial tephra deposit greater than those measured at analogue sites.

- The maximum value of this distribution is slightly larger than the decay constant of about 2.0 year^{-1} measured after other eruptions, and was selected because some predicted ash depths covered by this distribution are only slightly greater than the 10 mm maximum ash thickness for analogue data from Mount St. Helens. This rate would result in a decrease in mass loading to 5 percent of the maximum concentrations in 5 to 6 years and an average annual concentration over 10 years of about 1.0 mg/m^3 for a hypothetical S_v of 10 mg/m^3 (from Equation 6.3-2).

- The modal rate of 0.2 year^{-1} would result in a decrease of about 86 percent in 10 years and 98 percent in 20 years (Figure 6-1). The average annual concentration over 10 years for a λ of 0.2 year^{-1} and a hypothetical S_v of 10 mg/m^3 would be 4.3 mg/m^3 (from Equation 6.3-2), more than eight times greater than for a λ of 2.0 year^{-1}.

- The minimum decay constant of 0.125 year^{-1} would result in a decrease of 71 percent over 10 years, 92 percent decrease over 20 years, and 98 percent decrease over 30 years. It would take about 24 years for mass loading to decrease to 5 percent of the initial concentration. The average annual concentrations for a λ of 0.125 year^{-1} and a hypothetical S_v of 10 mg/m^3 would be 5.7 and 3.7 mg/m^3 over 10 and 20 years, respectively. This is more than an order of magnitude higher than for a λ of 2.0 year^{-1}; therefore, this rate reasonably bounds uncertainty in the effects of differences in conditions between analogue sites and the reference biosphere, including the effects of an initial tephra deposit deeper than 1 cm.

7. CONCLUSIONS

7.1 PARAMETER DISTRIBUTIONS

This analysis report documents the selection of distributions for mass loading and the mass loading decrease function for use in the biosphere model. This information is summarized in Table 7-1 and contained in the product output DTN MO0407SPAINEXI.002. The only limitation on the use of these distributions and the function is that they are intended for the present-day and predicted future climatic conditions for the Yucca Mountain reference biosphere during the next 10,000 years. They must be used with caution for other, more mesic and colder conditions. Uncertainties in the inputs and assumption related to use of analogue data, climate change, thickness of the initial tephra deposit, and redistribution of tephra by aeolian and fluvial transport are described in Section 6.

Table 7-1. Inhalation Exposure Input Parameters for the Biosphere Model

Parameter Environment or Condition	Type of Distribution	Mode	Minimum	Maximum
Mass Loading – Nominal Conditions				
Active Outdoors (mg/m^3)	Triangular	5.000	1.000	10.000
Inactive Outdoors (mg/m^3)	Triangular	0.060	0.025	0.100
Active Indoors (mg/m^3)	Triangular	0.100	0.060	0.175
Asleep Indoors (mg/m^3)	Triangular	0.030	0.010	0.050
Crops (mg/m^3)	Triangular	0.120	0.025	0.200
Mass Loading – Post-Volcanic Conditions[a]				
Active Outdoors (mg/m^3)	Triangular	2.500	0.000	5.000
Inactive Outdoors (mg/m^3)	Triangular	0.060	0.025	0.200
Active Indoors (mg/m^3)	Triangular	0.100	0.060	0.175
Asleep Indoors (mg/m^3)	Triangular	0.030	0.010	0.050
Crops (mg/m^3)[b]	Triangular	0.240	0.050	0.600
Mass Loading Decrease Constant (λ) to be used in equation $S_0e^{-\lambda t}$				
For initial ash depth <10 mm (1/year)	Triangular	0.33	0.2	2.0
For initial ash depths ≥10 mm (1/year)	Triangular	0.20	0.125	1.0

Output DTN: MO0407SPAINEXI.002.

[a] Distributions for post-volcanic conditions for human environments represent the predicted change in mass loading the first year following a volcanic eruption. These values must be added to predicted values for nominal conditions to determine the total predicted mass load for post-volcanic conditions.

[b] The distribution for crops for post-volcanic conditions represents the total mass loading the first year following an eruption and should not be added to predicted values for nominal conditions.

7.2 HOW THE APPLICABLE ACCEPTANCE CRITERIA ARE ADDRESSED

The following information describes how this analysis report addresses the acceptance criteria in the *Yucca Mountain Review Plan, Final Report* (NRC 2003 [DIRS 163274], Section 2.2.1.3.14). Only those acceptance criteria that are applicable to this report (see Section 4.2) are discussed.

This analysis report is one of 10 reports (Figure 1-1) that support biosphere modeling and describe how the acceptance criteria have been addressed by the biosphere model. A consideration of all 10 reports is required to understand how all applicable acceptance criteria are satisfied by the biosphere model.

Acceptance Criterion 1 *System Description and Model Integration are Adequate.*

- Subcriterion (3): This analysis considers information and assumptions about climate change, ash depth, and ash redistribution that are developed or also considered in other TSPA modeling abstractions. The analysis of the effects of climate change on mass loading is described in Appendix C and is based on the three climate states modeled in other TSPA abstractions (present-day, monsoon, and glacial transition) (BSC 2003 [DIRS 166296], p. 79). The analogue weather stations representative of the future climatic conditions considered in Section 4.1.5, Appendix C, and elsewhere in this report are identified in the *Future Climate Analysis* (BSC 2004 [DIRS 170002], Table 6-1). The distribution of ash depth considered in Sections 6.2 and 6.3 was developed in the TSPA model abstraction that describes atmospheric dispersal of ash (BSC 2004 [DIRS 170026], Section 6.5). Information and assumptions about the redistribution of ash that were considered in the evaluation of uncertainty in the mass loading decrease constant (Section 6.3.3) are consistent with those considered in the development of the ash redistribution conceptual model (BSC 2004 [DIRS 169980], Section 6.3.4; BSC 2004 [DIRS 170026], Section 6.6).

Acceptance Criterion 2 *Data are Sufficient for Model Justification.*

- Subcriterion (1): The justification for the parameter distributions developed in this report, and the consistency of those distributions with the conditions in the Yucca Mountain region, are described in Section 6, with additional justification for assumptions in Section 5. The data identified in Sections 4.1 were used, interpreted, and appropriately synthesized into the parameter distributions as described in Section 6.

- Subcriterion (2): The sufficiency of data used to develop parameter distributions is described in Sections 4.1 and 6. Demonstration that the parameter distributions are consistent with present knowledge of the conditions in the Yucca Mountain region is in Section 6. The relationship between the parameters developed in this report and the FEPs included in biosphere characteristics modeling is shown in Table 1-1. Because the FEPs are comprised of several parameters, the determination that the parameters discussed in this report are consistent with present knowledge of conditions in the region surrounding Yucca Mountain supports a determination that the corresponding FEPs also are consistent with present knowledge of conditions in that region. However, a final determination of whether a FEP is consistent with present knowledge of conditions in the region surrounding Yucca Mountain can be made only after all of the parameters which contribute to that FEP have been evaluated for consistency with present knowledge of conditions in the region surrounding Yucca Mountain. Sensitivity and uncertainty analyses are addressed in other biosphere modeling reports listed in Figure 1-1.

Acceptance Criterion 3 *Data Uncertainty is Characterized and Propagated Through the Model Abstraction*

- Subcriterion (1): The technical defensibility of assumptions used in this analysis is included in Section 5. The technical defensibility of the probability distribution developed for each parameter is described in Section 6. The identification of uncertainties and variabilities, and how those uncertainties and variabilities were accounted for in the development of parameter bounds that do not under-represent risk, is also described in Section 6.

- Subcriterion (2): The technical defensibility of the technical bases for the parameter distributions is described in Section 6. The consistency of the data and mass loading parameter distributions with site characterization data and the climate and level of disturbance expected to be found at the location of the RMEI during the compliance time period is described in Sections 4.1 and 6.

- Subcriterion (3): No process-level models were used to determine parameter values in this analysis. The consistency of the parameter distributions with site characterization data, laboratory experiments, field measurements, and natural analogue research is described in Section 6.

- Subcriterion (4): The bounding values of the parameter distributions developed in this analysis were selected to adequately represent uncertainty and are supported by data, as described in Sections 5 and 6. No correlations among biosphere model input parameters are identified in this analysis.

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APPENDIX A

MASS LOAD SENSITIVITY ANALYSIS

APPENDIX A

MASS LOAD SENSITIVITY ANALYSIS

The analysis described in this appendix was conducted to evaluate the sensitivity of calculations of mass of inhaled particles to changes in the input parameter values.

The mass of inhaled particles was calculated in this analysis using the following equation.

$$Inhalation = \sum_{n} t_n BR_n S_n \qquad \text{(Eq. A-1)}$$

where:

$Inhalation$ = total mass of inhaled particles (mg).

n = environment.

t_n = time spend in environment $_n$ (hours).

BR_n = breathing rate in environment n (m^3/hour).

S_n = Mass loading concentration in environment n (mg/m^3).

This analysis was conducted by holding all parameters at an expected value except one parameter being examined (Table A-1). The ranges of parameter values used in this analysis were selected only to evaluate sensitivity and are intended to be reasonable estimates of the range of average annual values for the Amargosa Valley population and of average annual conditions in Amargosa Valley. They are not intended to represent the recommended values for calculating BDCFs. Nor is it necessary that the values used in this analysis match those used to calculate BDCFs, because the goal here is only to understand the relative importance of each parameter to the calculation of mass of inhaled particles.

Results–The mass of inhaled particles is most sensitive to changes in mass load in the active outdoor environment, primarily because mass loading concentrations are one to two orders of magnitude higher during dust-generating activities outdoors than in other environments (Table A-1). Changes in mass loading in the active indoor environment have the third largest effect, primarily because of the large amount of time spent in that environment. Changes in mass loading in the inactive outdoor and asleep indoor environments have little effect on inhalation of particulates.

Changes in time spent in the outdoor active environment have the second largest effect on the mass of particulates inhaled. This is due primarily to the large concentrations of particulates in that environment, but also to uncertainty in estimates of time spent outdoors. Changes in time spent in other environments have little influence on inhalation, in part because of the narrow range of values. Ranges of time spent in each environment are narrow because they represent variation and uncertainty around the average of the living style of the population in the town of Amargosa Valley, as required by 10 CFR 63.312(b) [DIRS 156605].

Breathing rates have little influence on the rate of inhalation of particulates, primarily because variation in those rates is low.

Table A-1. Mass Loading Sensitivity Analysis

Environment Parameter	**Expected Value**	**Minimum Values**			**Maximum Values**		
		Min	**Inhalation (mg)[b]**	**% Change[c]**	**Max**	**Inhalation (mg)[b]**	**% Change[c]**
Active Outdoors							
Time (hours)	0.5	0.3	3.831	-29.2%	0.8	7.776	43.8%
Breathing Rate (m^3/hr)	1.6	1.4	4.909	-9.2%	1.8	5.909	9.2%
Mass Load (mg/m^3)	5.0	1.0	2.209	-59.2%	10.0	9.409	74.0%
Inactive Outdoors							
Time	1.5	1	5.431	0.4%	2.0	5.387	-0.4%
Breathing Rate (m^3/hr)	1.1	0.95	5.395	-0.2%	1.25	5.422	0.2%
Mass Load (mg/m^3)	0.06	0.025	5.351	-1.1%	0.100	5.475	1.2%
Active Indoors							
Time	11.0	10	5.365	-0.8%	12	5.453	0.8%
Breathing Rate (m^3/hr)	1.1	0.95	5.244	-3.1%	1.25	5.574	3.1%
Mass Load (mg/m^3)	0.1	0.060	4.925	-8.9%	0.175	6.316	16.8%
Asleep Indoors							
Time	8.3	8.1	5.428	0.4%	8.5	5.389	-0.4%
Breathing Rate (m^3/hr)	0.4	0.35	5.396	-0.2%	0.45	5.421	0.2%
Mass Load (mg/m^3)	0.03	0.010	5.342	-1.2%	0.050	5.475	1.2%
Total Dust Inhaled (mg)	5.409[a]						

[a] Calculated as the sum over four environments of the expected values of (time x breathing rate x mass load).

[b] Total dust inhaled with all values held at the expected value except one, calculated using the equation in footnote a.

[c] Percent change in total dust inhaled from the expected value (5.409 mg). Time added or subtracted from the active and inactive outdoor environments was accounted for in the active indoor environment. Time added or subtracted from the active indoor environment was accounted for in the inactive outdoor environment. The total time does not add to 24 hours because an average of 2.7 hours per day spent away from contaminated areas is not shown.

APPENDIX B

TSP CONCENTRATION–ACTIVE OUTDOOR ENVIRONMENT

APPENDIX B

TSP CONCENTRATION–ACTIVE OUTDOOR ENVIRONMENT

This appendix summarizes information on TSP concentrations from rural, agricultural sites obtained from the EPA (DTN MO0210SPATSP01.023 [DIRS 160426]) and used in this analysis. Table B-1 is a list of average annual TSP concentrations for all rural agricultural sites in Arizona, California, Idaho, Nevada, New Mexico, Oregon (excluding those sites west of the Cascade Mountains), Utah, and Washington. Note that TSP concentrations are in units of micrograms per cubic meter (μg/m^3), the unit of measure reported by the EPA. Particulate concentrations in the remainder of this analysis are in units of milligrams per cubic meter (mg/m^3).

Table B-2 lists descriptive information about each rural, agricultural TSP monitoring site, including average annual precipitation and snowfall from the U.S. National Climatic Data Center (NCDC 1998 [DIRS 135900; DIRS 125325]).

Table B-1. Average Annual Concentrations of TSP (μg/m^3) from Rural, Agricultural Monitoring Sites in the Western United States

Monitoring Site					μg/m^3	
Site ID	**State**	**City**	**County**	**Year**	**Annual Average**	**Overall Average**
04-007-0003	Arizona	Miami	Gila	1974	62.3	49.8
				1975	37.2	
04-007-1902	Arizona	Miami	Gila	1975	24.5	29.6
				1976	36.6	
				1977	45.8	
				1978	20	
				1979	29.5	
				1980	16.5	
				1981	49.2	
				1982	15	
04-013-0008	Arizona	Guadalupe	Maricopa	1973	25.9	130.9
				1974	153.1	
				1975	172.7	
				1976	172	
04-019-0006	Arizona	Tucson	Pima	1971	132.5	132.5
04-019-0009	Arizona	Tucson	Pima	1973	118	81.3
				1974	74.7	
				1975	63.8	
				1976	68.5	
04-019-0010	Arizona	Tucson	Pima	1974	92.4	88.7
				1975	84.9	

Table B-1. Average Annual Concentrations of TSP (μg/m^3) from Rural, Agricultural Monitoring Sites in the Western United States (Continued)

Monitoring Site					μg/m^3	
Site ID	**State**	**City**	**County**	**Year**	**Annual Average**	**Overall Average**
06-013-1002	California	Bethel Island	Contra Costa	1986	40.8	41.1
				1988	48.4	
				1989	41.5	
				1990	39.7	
				1991	42.5	
				1994	33.8	
06-019-1002	California	Five Points	Fresno	1972	62.9	77.7
				1973	67.9	
				1974	88.4	
				1975	75.7	
				1976	90.1	
				1977	93.1	
				1978	87.8	
				1979	89.5	
				1980	83.8	
				1981	80	
				1982	62.6	
				1983	59.9	
				1984	68.4	
06-019-3001	California	Parlier	Fresno	1972	82.7	94.3
				1973	66	
				1974	104.8	
				1975	94.2	
				1976	132.6	
				1977	121.7	
				1978	57.8	
06-027-0002	California	Bishop	Inyo	1980	32.3	25.4
				1981	29.9	
				1982	17.4	
				1983	16	
				1984	31.8	
				1985	26.1	
				1986	24.9	
				1987	24.5	
06-027-0011	California	Olancha	Inyo	1986	15.8	22.6
				1987	25.8	
				1988	26.3	
06-031-0002	California	Corcoran	Kings	1980	131.2	120.2
				1981	153.9	
				1982	101.2	
				1983	94.6	

Table B-1. Average Annual Concentrations of TSP (μg/m^3) from Rural, Agricultural Monitoring Sites in the Western United States (Continued)

Monitoring Site					**μg/m^3**	
Site ID	**State**	**City**	**County**	**Year**	**Annual Average**	**Overall Average**
06-031-1002	California	Kettleman City	Kings	1980	107.3	86.4
				1981	99.7	
				1982	65	
				1983	68.6	
				1984	90.6	
				1985	91.4	
				1986	95.4	
				1987	84.1	
				1988	75.2	
06-033-0002	California	Kelseyville	Lake	1980	39.3	33.8
				1981	36	
				1982	45	
				1983	28.7	
				1984	28.6	
				1985	32.1	
				1986	27.2	
				1987	33.3	
06-033-0003	California	Upper Lake	Lake	1980	18	19.0
				1981	20.4	
				1982	18	
				1983	19.6	
06-049-1001	California	Cedarville	Modoc	1980	22.1	16.9
				1981	24.6	
				1982	15.1	
				1983	15.3	
				1984	11.8	
				1985	12.3	
06-061-0001	California	Auburn	Placer	1980	41.5	39.8
				1981	46.6	
				1982	33.6	
				1983	34.3	
				1984	43.1	
06-071-1101	California	Twentynine Palms	San Bernardino	1979	51.1	48.7
				1980	50.1	
				1981	53	
				1982	40.7	
				1983	45.1	
				1984	56.4	
				1985	49.9	
				1986	49.2	
				1987	47.7	

Table B-1. Average Annual Concentrations of TSP ($\mu g/m^3$) from Rural, Agricultural Monitoring Sites in the Western United States (Continued)

Monitoring Site					$\mu g/m^3$	
Site ID	State	City	County	Year	Annual Average	Overall Average
				1988	55.1	
				1989	37	
06-083-1011	California	Jalama	Santa Barbara	1987	44.4	45.2
				1988	47.1	
				1989	41.1	
				1990	46	
				1991	46	
				1992	44.9	
				1993	46.9	
06-083-1012	California	Concepcion	Santa Barbara	1987	42.5	43.1
				1988	43	
				1989	47.6	
				1990	38	
				1991	59.5	
				1992	36.7	
				1993	34.1	
06-083-1015	California	Gaviota	Santa Barbara	1988	28.5	24.1
				1989	24.3	
				1990	23.6	
				1991	25.1	
				1992	25.9	
				1993	17.4	
06-083-1016	California	Gaviota	Santa Barbara	1988	28	25.3
				1989	26.2	
				1990	24.7	
				1991	28.2	
				1992	27.9	
				1993	16.7	
06-083-1017	California	Gaviota	Santa Barbara	1987	36.2	38.5
				1988	35.7	
				1989	39.6	
				1990	38.6	
				1991	38	
				1992	39.6	
				1993	42	

Table B-1. Average Annual Concentrations of TSP ($\mu g/m^3$) from Rural, Agricultural Monitoring Sites in the Western United States (Continued)

Monitoring Site					$\mu g/m^3$	
Site ID	State	City	County	Year	Annual Average	Overall Average
06-083-1019	California	Gaviota	Santa Barbara	1987	23.5	29.9
				1988	27.1	
				1989	33.7	
				1990	32.1	
				1991	29.2	
				1992	34.6	
				1993	29.1	
06-083-1020	California	Isla Vista	Santa Barbara	1988	43.9	42.7
				1989	46.3	
				1990	47.1	
				1991	40.8	
				1992	42.2	
				1993	36	
06-083-1030	California	Concepcion	Santa Barbara	1987	42.7	38.0
				1988	38.5	
				1989	36.3	
				1990	37.3	
				1991	37.5	
				1992	35.9	
06-083-4003	California	Vandenburg AFB	Santa Barbara	1987	34	31.2
				1988	35.1	
				1989	33	
				1990	31.3	
				1991	27.5	
				1992	25.7	
				1993	31.5	
06-083-5001	California	Vandenburg AFB	Santa Barbara	1986	29.9	36.9
				1987	36.5	
				1988	44.2	
06-089-1002	California	Burney	Shasta	1985	40.7	33.5
				1986	26.3	
06-103-1001	California	Los Molinos	Tehama	1980	57.9	46.8
				1981	48.2	
				1982	44.6	
				1983	42.8	
				1984	45.9	
				1985	49.3	
				1986	43.3	

Table B-1. Average Annual Concentrations of TSP (μg/m^3) from Rural, Agricultural Monitoring Sites in the Western United States (Continued)

Monitoring Site					μg/m^3	
Site ID	State	City	County	Year	Annual Average	Overall Average
				1987	42.7	
				1983	43.9	
06-111-0004	California	Piru	Ventura	1982	50.4	46.8
				1984	53.6	
				1985	51	
				1986	45.3	
				1987	45.1	
				1988	38.5	
06-111-0005	California	Oak View	Ventura	1983	33.1	37.6
				1984	45.1	
				1985	41.8	
				1986	32.5	
				1987	35.6	
06-111-1101	California	Piru	Ventura	1979	65.3	64.3
				1980	63.3	
06-111-3001	California	El Rio	Ventura	1979	79.3	63.5
				1980	63	
				1981	70.2	
				1982	47.2	
				1983	45.7	
				1984	65.6	
				1985	68.8	
				1986	64	
				1987	60	
				1988	61.5	
				1989	67.5	
				1990	68.6	
				1991	64.4	
06-113-4001	California	Dunnigan	Yolo	1979	48.2	44.2
				1980	55.9	
				1981	48.8	
				1982	44.5	
				1983	33.2	
				1984	43	
				1985	42.8	
				1986	39	
				1987	43.7	
				1988	49.8	
				1989	46.1	
				1990	44.9	
				1991	35.2	

Table B-1. Average Annual Concentrations of TSP (μg/m^3) from Rural, Agricultural Monitoring Sites in the Western United States (Continued)

Monitoring Site					μg/m^3	
Site ID	**State**	**City**	**County**	**Year**	**Annual Average**	**Overall Average**
06-115-0002	California	Smartsville	Yuba	1980	38.3	26.6
				1983	14.8	
16-001-0001	Idaho	Boise	Ada	1972	39.3	44.0
				1973	52.3	
				1974	61.3	
				1975	41.2	
				1976	45.3	
				1977	58.9	
				1978	50.4	
				1979	49.4	
				1980	38.3	
				1981	42.4	
				1982	37.2	
				1983	32.4	
				1984	38.7	
				1985	49.4	
				1986	45.2	
				1987	46.2	
				1988	39.2	
				1989	44.4	
				1990	38.1	
				1991	29.9	
16-005-1003	Idaho	Pocatello	Bannock	1970	87.8	67.5
				1971	55.9	
				1972	58.9	
16-011-0001	Idaho	Grandview	Bingham	1971	49.3	49.3
16-029-0001	Idaho	Soda Springs	Caribou	1971	69.5	69.5
16-029-0002	Idaho	Conda	Caribou	1971	33.6	38.1
				1972	36.3	
				1973	43.1	
				1976	61.7	
				1977	57.7	
				1978	38.1	
				1979	26.7	
				1980	37.6	
				1981	45.8	
				1982	34.8	
				1983	27.9	
				1984	29	

Table B-1. Average Annual Concentrations of TSP ($\mu g/m^3$) from Rural, Agricultural Monitoring Sites in the Western United States (Continued)

Monitoring Site					$\mu g/m^3$	
Site ID	**State**	**City**	**County**	**Year**	**Annual Average**	**Overall Average**
				1985	36.3	
				1986	25.3	
				1987	30	
				1988	45.3	
16-053-0001	Idaho	Jerome	Jerome	1975	57.9	47.0
				1976	41.9	
				1977	65.8	
				1978	29.6	
				1979	35.3	
				1980	48.9	
				1981	49.4	
16-055-1002	Idaho	Coeur D'Alene	Kootenai	1970	49.1	51.5
				1971	43.3	
				1972	45.9	
				1973	69	
				1977	51.8	
				1978	44.3	
				1979	45.2	
				1980	63.6	
16-077-0005	Idaho	Pocatello	Power	1970	164.9	118.0
				1971	71.1	
16-083-0003	Idaho	Twin Falls	Twin Falls	1986	49.7	47.3
				1987	48.3	
				1988	44	
16-083-0004	Idaho	Hansen	Twin Falls	1989	32	38.2
				1990	39.2	
				1991	41.2	
				1992	40.2	
16-083-1001	Idaho	Twin Falls	Twin Falls	1971	49.5	44.7
				1972	45.6	
				1973	38.9	
32-003-1003	Nevada	Moapa	Clark	1972	61.2	61.2
32-031-1004	Nevada	Sparks	Washoe	1974	65.8	54.2
				1975	48.1	
				1976	43.1	
				1977	45	
				1978	46.3	
				1979	82.9	
				1980	70.7	
				1981	53.7	
				1982	43.1	
				1983	41.9	

Table B-1. Average Annual Concentrations of TSP (μg/m^3) from Rural, Agricultural Monitoring Sites in the Western United States (Continued)

Monitoring Site					μg/m^3	
Site ID	State	City	County	Year	Annual Average	Overall Average
				1984	53.3	
				1985	56.5	
32-031-2003	Nevada	Wadsworth	Washoe	1973	39	41.4
				1974	39.2	
				1975	45.9	
35-006-0007	New Mexico	Bluewater	Cibola	1981	91.3	75.2
				1982	59	
35-013-0004	New Mexico	Sunland Park	Dona Ana	1973	57.4	80.4
				1974	65.5	
				1975	63.1	
				1976	80.7	
				1977	76.3	
				1978	91.1	
				1979	81.5	
				1980	82.7	
				1981	97.5	
				1982	84.1	
				1983	77.6	
				1984	77.9	
				1985	71.5	
				1986	74.5	
				1987	92.9	
				1988	103.3	
				1989	90	
35-013-0006	New Mexico	Afton	Dona Ana	1973	75.1	44.9
				1974	28.6	
				1975	30.9	
35-013-0016	New Mexico	Anthony	Dona Ana	1988	132.3	137.5
				1989	142.6	
35-017-0002	New Mexico	Hurley	Grant	1973	115.9	84.8
				1974	49.8	
				1975	88.7	
35-045-0013	New Mexico	La Plata	San Juan	1973	33.9	33.5
				1974	34.2	
				1975	32.4	
35-045-0014	New Mexico	Kirtland	San Juan	1974	39	43.9
				1975	26.3	
				1976	72	
				1977	47.2	
				1978	47.1	
				1979	60.8	

Table B-1. Average Annual Concentrations of TSP (μg/m^3) from Rural, Agricultural Monitoring Sites in the Western United States (Continued)

Monitoring Site					μg/m^3	
Site ID	**State**	**City**	**County**	**Year**	**Annual Average**	**Overall Average**
				1980	57.8	
				1981	46.1	
				1982	40.1	
				1983	29.9	
				1984	40.9	
				1985	39	
				1987	31.6	
				1988	36.1	
35-045-0015	New Mexico		San Juan	1974	35.6	28.9
				1975	22.1	
35-045-0021	New Mexico	None	San Juan	1977	36.3	36.3
35-061-0007	New Mexico	Bluewater	Valencia	1977	64.5	70.9
				1978	64.5	
				1979	73.4	
				1980	72.5	
				1981	79.5	
41-059-1001	Oregon	Pendleton	Umatilla	1972	35.5	40.4
				1973	39.4	
				1974	65.6	
				1975	30.3	
				1976	31.4	
49-015-0002	Utah	Huntington	Emery	1975	23.6	29.6
				1976	27.8	
				1977	34.3	
				1978	32.8	
49-027-0002	Utah	Delta	Millard	1979	41	41.0
53-039-0002	Washington	Bingen	Klickitat	1975	50.3	56.2
				1976	59.8	
				1977	58	
				1978	56.8	
53-071-1001	Washington	Wallula Junction	Walla Walla	1983	48.7	65.6
				1984	59.7	
				1985	56.1	
				1986	51.2	
				1987	71	
				1988	84.8	
				1989	70.7	
				1990	80.5	
				1991	67.8	

Table B-1. Average Annual Concentrations of TSP (μg/m^3) from Rural, Agricultural Monitoring Sites in the Western United States (Continued)

Monitoring Site					μg/m^3	
Site ID	**State**	**City**	**County**	**Year**	**Annual Average**	**Overall Average**
53-075-0002	Washington	Pullman	Whitman	1975	22.6	37.6
				1976	41.8	
				1977	48.3	
53-077-0003	Washington	Sunnyside	Yakima	1982	61.9	61.7
				1983	56.5	
				1984	53.3	
				1985	56.2	
				1986	54.2	
				1987	69.5	
				1988	60.2	
				1989	61.1	
				1990	70.6	
				1991	73.6	

Source: DTN: MO0210SPATSP01.023 (DIRS 160426) (note that site ID numbers are not presented with leading zeros or dashes in the database).

TSP=total suspended particles

Table B-2. Average Concentration of TSP (mg/m^3) at Rural, Agricultural Monitoring Sites in the Western United States

Monitoring Site				Inches					
EPA Site ID	**State**	**City**	**County**	$\bar{x}$ **Snowfall**	$\bar{x}$ **Precipitation**	**Weather Station**	$\bar{x}$ **TSP (mg/m^3)**	**N Years**	**Comments**
04-007-0003	Arizona	Miami	Gila	2.9	19.3	25512	0.050	2	Duplicate with 04-007-1902
04-007-1902	Arizona	Miami	Gila	2.9	19.3	25512	0.030	8	Selected
04-013-0008	Arizona	Guadalupe	Maricopa	0.0	8.9	28499	0.131	4	Has atypical values due to updraft
04-019-0006	Arizona	Tucson	Pima	0.0	13.9	28795	0.133	1	Duplicate with 04-019-0010
04-019-0009	Arizona	Tucson	Pima	0.0	13.9	28795	0.081	4	Near power plant substation
04-019-0010	Arizona	Tucson	Pima	0.0	13.9	28795	0.089	2	Selected
06-013-1002	California	Bethel Island	Contra Costa	0.0	12.7	45232	0.041	6	Selected
06-019-1002	California	Five Points	Fresno	0.2	6.6	43083	0.078	13	Selected
06-019-3001	California	Parlier	Fresno	0.1	10.9	43257	0.094	7	Duplicate with 06-031-1002
06-027-0002	California	Bishop	Inyo	8.0	5.3	40822	0.025	8	Selected
06-027-0011	California	Olancha	Inyo	4.2	6.7	43710	0.023	3	Duplicate with 06-027-0002
06-031-0002	California	Corcoran	Kings	0.1	7.2	42012	0.120	4	Duplicate with 06-031-1002
06-031-1002	California	Kettleman City	Kings	0.1	7.2	42012	0.086	9	Selected
06-033-0002	California	Kelseyville	Lake	0.5	29.1	44701	0.034	8	Precipitation >20 in.
06-033-0003	California	Upper Lake	Lake	0.5	29.1	44701	0.019	4	Precipitation >20 in.
06-049-1001	California	Cedarville	Modoc	32.6	13.1	41614	0.017	6	Snowfall > 20 in.
06-061-0001	California	Auburn	Placer	1.2	35.3	40383	0.040	5	Precipitation >20 in.
06-071-1101	California	Twentynine Palms	San Bernardino	1.0	4.1	49099	0.049	11	Selected
06-083-1011	California	Jalama	Santa Barbara	0.0	14.6	45064	0.045	7	Selected
06-083-1012	California	Concepcion	Santa Barbara	0.0	14.6	45064	0.043	7	Duplicate with 06-083-1011
06-083-1015	California	Gaviota	Santa Barbara	0.0	14.6	45064	0.024	6	Duplicate with 06-083-1011
06-083-1016	California	Gaviota	Santa Barbara	0.0	14.6	45064	0.025	6	Duplicate with 06-083-1011
06-083-1017	California	Gaviota	Santa Barbara	0.0	14.6	45064	0.039	7	Duplicate with 06-083-1011
06-083-1019	California	Gaviota	Santa Barbara	0.0	14.6	45064	0.030	7	Duplicate with 06-083-1011
06-083-1020	California	Isla Vista	Santa Barbara	0.0	17.8	47902	0.043	6	Duplicate with 06-083-1011
06-083-1030	California	Concepcion	Santa Barbara	0.0	14.6	45064	0.038	6	Duplicate with 06-083-1011

Table B-2. Average Concentration of TSP (mg/m^3) at Rural, Agricultural Monitoring Sites in the Western United States (Continued)

Monitoring Site				Inches					
EPA Site ID	**State**	**City**	**County**	$\bar{x}$ **Snowfall**	$\bar{x}$ **Precipitation**	**Weather Station**	$\bar{x}$ **TSP (mg/m^3)**	**N Years**	**Comments**
06-083-4003	California	Vandenburg AFB	Santa Barbara	0.0	14.6	45064	0.031	7	Duplicate with 06-083-1011
06-083-5001	California	Vandenburg AFB	Santa Barbara	0.0	12.6	47946	0.037	3	Duplicate with 06-083-1011
06-089-1002	California	Burney	Shasta	50.6	27.5	41214	0.034	2	Precipitation >20 in.
06-103-1001	California	Los Molinos	Tehama	2.3	22.8	47292	0.047	8	Precipitation >20 in.
06-111-0004	California	Piru	Ventura	0.0	17.0	46940	0.047	7	Duplicate with 06-111-3001
06-111-0005	California	Oak View	Ventura	0.1	21.2	46399	0.038	5	Precipitation >20 in.
06-111-1101	California	Piru	Ventura	0.0	17.0	46940	0.064	2	Duplicate with 06-111-3001
06-111-3001	California	El Rio	Ventura	0.1	14.4	46569	0.064	13	Selected
06-113-4001	California	Dunnigan	Yolo	0.1	18.6	49781	0.044	13	Selected
06-115-0002	California	Smartsville	Yuba	10.2	53.2	43573	0.027	2	Precipitation >20 in.
16-001-0001	Idaho	Boise	Ada	20.9	11.9	101022	0.044	20	Snowfall > 20 in.
16-005-1003	Idaho	Pocatello	Bannock	41.8	11.8	107211	0.068	3	Snowfall > 20 in.
16-011-0001	Idaho	Grandview	Bingham	22.4	11.4	103297	0.049	1	Snowfall > 20 in.
16-029-0001	Idaho	Soda Springs	Caribou	43.8	16.1	108535	0.070	1	Snowfall > 20 in.
16-029-0002	Idaho	Conda	Caribou	95.0	22.1	104230	0.038	16	Precipitation >20 in.
16-053-0001	Idaho	Jerome	Jerome	23.2	10.3	104670	0.047	7	Snowfall > 20 in.
16-055-1002	Idaho	Coeur D'Alene	Kootenai	51.3	25.4	101956	0.052	8	Precipitation >20 in.
16-077-0005	Idaho	Pocatello	Power	41.8	11.8	107211	0.118	2	Snowfall > 20 in.
16-083-0003	Idaho	Twin Falls	Twin Falls	28.2	10.8	109303	0.047	3	Snowfall > 20 in.
16-083-0004	Idaho	Hansen	Twin Falls	28.2	10.8	109303	0.038	4	Snowfall > 20 in.
16-083-1001	Idaho	Twin Falls	Twin Falls	28.2	10.8	109303	0.045	3	Snowfall > 20 in.
32-003-1003	Nevada	Moapa	Clark	0.4	4.1	265846	0.061	1	Selected
32-031-1004	Nevada	Sparks	Washoe	6.9	8.1	267697	0.054	12	Selected
32-031-2003	Nevada	Wadsworth	Washoe	0.3	5.7	268838	0.041	3	Duplicate with 32-031-1004
35-013-0004	New Mexico	Sunland Park	Dona Ana	4.5	9.4	298535	0.080	17	Selected
35-013-0006	New Mexico	Afton	Dona Ana	4.5	9.4	298535	0.045	3	Duplicate with 35-013-0004
35-013-0016	New Mexico	Anthony	Dona Ana	4.5	9.4	298535	0.137	2	Duplicate with 35-013-0004
35-017-0002	New Mexico	Hurley	Grant	10.0	15.8	293265	0.085	3	Selected

Table B-2. Average Concentration of TSP (mg/m^3) at Rural, Agricultural Monitoring Sites in the Western United States (Continued)

Monitoring Site				**Inches**					
EPA Site ID	**State**	**City**	**County**	$\bar{x}$ **Snowfall**	$\bar{x}$ **Precipitation**	**Weather Station**	$\bar{x}$ **TSP (mg/m^3)**	**N Years**	**Comments**
35-045-0013	New Mexico	La Plata	San Juan	7.8	8.8	293134	0.034	3	Duplicate with 35-045-0014
35-045-0014	New Mexico	Kirtland	San Juan	11.5	8.1	293340	0.044	14	Selected
35-045-0015	New Mexico		San Juan	16.4	10.1	290692	0.029	3	Duplicate with 35-045-0014
35-045-0021	New Mexico		San Juan	7.8	8.8	293134	0.036	1	Duplicate with 35-045-0014
35-061-0007 35-006-0007	New Mexico	Bluewater	Valencia/Cibola	14.8	10.8	293682	0.071	6	Selected. Data from 2 sites at same location were combined.
41-059-1001	Oregon	Pendleton	Umatilla	17.1	12.2	356546	0.040	5	Selected
49-015-0002	Utah	Huntington	Emery	17.8	7.7	421214	0.030	4	Selected
49-015-0003	Utah		Emery	17.8	7.7	421214	0.017	4	Duplicate with 49-015-0002
49-027-0002	Utah	Delta	Millard	25.2	7.8	422090	0.041	1	Snowfall > 20 in.
53-039-0002	Washington	Bingen	Klickitat	19.8	13.7	451968	0.056	4	Selected
53-071-1001	Washington	Wallula Junction	Walla Walla	7.7	10.1	453883	0.066	9	Selected
53-075-0002	Washington	Pullman	Whitman	28.3	21.5	456789	0.038	3	Precipitation >20 in.
53-077-0003	Washington	Sunnyside	Yakima	11.5	7.0	458207	0.062	10	Selected

Source: DTN: MO0210SPATSP01.023 (DIRS 160426); NCDC 1998 (DIRS 135900; DIRS 125325).

EPA=U.S. Environmental Protection Agency; ID=identification; N= Number of years; $\bar{x}$ TSP= average of annual average total suspended particle concentrations

APPENDIX C

INFLUENCE OF CLIMATE CHANGE

APPENDIX C

INFLUENCE OF CLIMATE CHANGE

This appendix documents a comparison of TSP concentrations in areas with lower and higher amounts of precipitation and snowfall to determine whether separate distributions of mass loading should be used for the present-day and future climatic conditions predicted to occur in the Yucca Mountain region over the next 10,000 years.

Average annual precipitation at Yucca Mountain currently is approximately 4–6 in. (CRWMS M&O 1999 [DIRS 102877], Appendix A) and snowfall is rare. It is predicted that the coolest, wettest conditions during the next 10,000 years will be consistent with that currently found in parts of eastern Washington. Analogue weather stations for the coolest, wettest conditions are Spokane (average annual precipitation = 16.2 in., average annual snowfall = 42.1 in.), Rosalia (precipitation = 18.1 in., snowfall = 24.3 in.), and St. Johns (precipitation = 17.1 in., snowfall =25.8 in.) (BSC 2004 [DIRS 170002], Table 6-1). Climate data are from National Climatic Data Center reports (NCDC 1998 [DIRS 135900; DIRS 125325]).

To determine whether mass loading may differ due to a change in climate, average annual concentrations of TSP measured at rural, agricultural sites in the western United States were compared among sites with different amounts of precipitation and snowfall. The data used in this comparison were obtained from the EPA AirData database (DTN MO0210SPATSP01.023 [DIRS 160426]) and the National Climatic Data Center (NCDC 1988 [DIRS 135900; DIRS 125325]) and are listed in Tables B-1 and B-2. See Section 6.1.2 for a description of how the data were obtained and processed. See Table B-2 for a description of each site. Because the sites have comparable land uses and settings, sources of resuspended particulate matter should be similar among sites.

To evaluate the influence of precipitation on concentrations of resuspended particles, the average TSP for sites with less than 10, 10 to 20, and more than 20 in. of precipitation per year was calculated (Table C-1). For this comparison, 25 duplicate sites within a county and 2 sites with conditions that may not be typical for rural agricultural settings were deleted from consideration (see Section 6.1.2). To evaluate the influence of snowfall, the average TSP for sites with less than 10, 10–20, and more than 20 in. of snowfall per year was calculated (Table C-2). To eliminate the influence of high precipitation, the 10 sites listed in Table C-1 that have more than 20 in. of precipitation were not included in this analysis.

Average TSP concentrations differed little between 11 sites with less than 10 in. of precipitation (average = 0.055, SD = 0.020) and 21 sites with 10 to 20 in. (average = 0.056, SD = 0.023). Ten sites with more than 20 in. of precipitation per year had much lower concentrations (average =0.037, SD = 0.009). There was little difference in TSP concentrations among 14 sites with less than 10 in. of snowfall (average = 0.058, SD = 0.020), 7 sites with 10 to 20 in. of snowfall (average = 0.055, SD = 0.019), and 11 sites with more than 20 in. of snowfall (average = 0.053, SD = 0.026).

The conclusion of this analysis is that rural agricultural sites with less than 20 in. of precipitation and less than approximately 45 in. of snowfall have similar concentrations of resuspended particles. Therefore, separate distributions of mass loading are not required for present-day and future climatic states predicted to occur in the Yucca Mountain region during the next 10,000 years.

Table C-1. Average Annual Snowfall (in.), Precipitation (in.), and TSP (mg/m^3) at Rural, Agricultural Sites in the Western United States with Less Than 10, 10–20, and More Than 20 in. of Precipitation

<10 in. Precipitation				**10–20 in. Precipitation**				**>20 in. Precipitation**			
EPA Site ID	**Snow**	**Precip**	**TSP**	**EPA Site ID**	**Snow**	**Precip**	**TSP**	**EPA Site ID**	**Snow**	**Precip**	**TSP**
06-071-1101	1.0	4.1	0.049	53-071-1001	7.7	10.1	0.066	06-111-0005	0.1	21.2	0.038
32-003-1003	0.4	4.1	0.061	16-053-0001	23.2	10.3	0.047	53-075-0002	28.3	21.5	0.038
06-027-0002	8.0	5.3	0.025	35-061-0007	14.8	10.8	0.071	16-029-0002	95.0	22.1	0.038
06-019-1002	0.2	6.6	0.078	16-083-0003	28.2	10.8	0.047	06-103-1001	2.3	22.8	0.047
53-077-0003	11.5	7.0	0.062	16-083-0004	28.2	10.8	0.038	16-055-1002	51.3	25.4	0.052
06-031-1002	0.1	7.2	0.086	16-083-1001	28.2	10.8	0.045	06-089-1002	50.6	27.5	0.034
49-015-0002	17.8	7.7	0.030	16-011-0001	22.4	11.4	0.049	06-033-0002	0.5	29.1	0.034
49-027-0002	25.2	7.8	0.041	16-005-1003	41.8	11.8	0.068	06-033-0003	0.5	29.1	0.019
32-031-1004	6.9	8.1	0.054	16-077-0005	41.8	11.8	0.118	06-061-0001	1.2	35.3	0.040
35-045-0014	11.5	8.1	0.044	16-001-0001	20.9	11.9	0.044	06-115-0002	10.2	53.2	0.027
35-013-0004	4.5	9.4	0.080	41-059-1001	17.1	12.2	0.040			N =	10
		N =	11	06-013-1002	0.0	12.7	0.041			$\bar{x}$ =	0.037
		$\bar{x}$ =	0.055	06-049-1001	32.6	13.1	0.017			SD =	0.009
		SD =	0.020	53-039-0002	19.8	13.7	0.056				
				04-019-0010	0.0	13.9	0.089				
				06-111-3001	0.1	14.4	0.064				
				06-083-1012	0.0	14.6	0.043				
				35-017-0002	10.0	15.8	0.085				
				16-029-0001	43.8	16.1	0.070				
				06-113-4001	0.1	18.6	0.044				
				04-007-1902	2.9	19.3	0.030				
						N =	21				
						$\bar{x}$ =	0.056				
						SD =	0.023				

Source: DTN: MO0210SPATSP01.023 (DIRS 160426); NCDC 1998 (DIRS 135900; DIRS 125325). See Table B-2 for list of data.

EPA=U.S. Environmental Protection Agency; ID=identification; N=number of sites; SD=standard deviation; TSP=average total suspended particle concentration

Table C-2. Average Annual Snowfall (in.), Precipitation (in.), and TSP (mg/m^3) at Rural, Agricultural Sites in the Western United States with Less Than 10, 10–20, and More Than 20 in. of Snowfall

<10 in. Snowfall				**10–20 in. Snowfall**				**>20 in. Snowfall**			
EPA Site ID	**Snow**	**Precip**	**TSP**	**EPA Site ID**	**Snow**	**Precip**	**TSP**	**EPA Site ID**	**Snow**	**Precip**	**TSP**
06-013-1002	0.0	12.7	0.041	35-017-0002	10.0	15.8	0.085	16-001-0001	20.9	11.9	0.044
04-019-0010	0.0	13.9	0.089	35-045-0014	11.5	8.1	0.044	16-011-0001	22.4	11.4	0.049
06-083-1012	0.0	14.6	0.043	53-077-0003	11.5	7.0	0.062	16-053-0001	23.2	10.3	0.047
06-031-1002	0.1	7.2	0.086	35-061-0007	14.8	10.8	0.071	49-027-0002	25.2	7.8	0.041
06-111-3001	0.1	14.4	0.064	41-059-1001	17.1	12.2	0.040	16-083-0003	28.2	10.8	0.047
06-113-4001	0.1	18.6	0.044	49-015-0002	17.8	7.7	0.030	16-083-0004	28.2	10.8	0.038
06-019-1002	0.2	6.6	0.078	53-039-0002	19.8	13.7	0.056	16-083-1001	28.2	10.8	0.045
32-003-1003	0.4	4.1	0.061			N =	7	06-049-1001	32.6	13.1	0.017
06-071-1101	1.0	4.1	0.049			$\bar{x}$ =	0.055	16-005-1003	41.8	11.8	0.068
04-007-1902	2.9	19.3	0.030			SD =	0.019	16-077-0005	41.8	11.8	0.118
35-013-0004	4.5	9.4	0.080					16-029-0001	43.8	16.1	0.070
32-031-1004	6.9	8.1	0.054							N =	11
53-071-1001	7.7	10.1	0.066							$\bar{x}$ =	0.053
06-027-0002	8.0	5.3	0.025							SD =	0.026
		N =	14								
		$\bar{x}$ =	0.058								
		SD =	0.020								

Source: DTN: MO0210SPATSP01.023 (DIRS 160426);]NCDC 1998 (DIRS 135900; DIRS 125325). See Table B-2 for list of data.

EPA=U.S. Environmental Protection Agency; ID=identification; N= number of sites; SD=standard deviation; TSP= average total suspended particle concentration

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APPENDIX D

TSP CONCENTRATIONS–MOUNT ST. HELENS, 1979-1982

APPENDIX D

TSP CONCENTRATIONS–MOUNT ST. HELENS, 1979-1982

Table D-1 contains measurements of 24-hour concentrations of TSP taken at Clarkston, Richland, and Longview, Washington, during 1979 through 1982. Table D-2 contain TSP measurements for the same period from Spokane, Vancouver, and Yakima, Washington. The data were obtained from the EPA AirData database (DTN: MO0008SPATSP00.013 [DIRS 151750]). The running average is the average of the measurements for a day and the four previous measurements.

Table D-1. Twenty-Four-Hour and Running Average Concentrations (mg/m^3) of TSP at Clarkston, Richland, and Longview, Washington, 1979–1982

Clarkston (53-003-0003)			Richland (53-005-1001)			Longview (53-015-0008)		
Date	TSP	$\bar{x}$[a]	Date	TSP	$\bar{x}$[a]	Date	TSP	$\bar{x}$[a]
9/25/79	0.221		1/3/79	0.072		1/15/79	0.116	
9/27/79	0.212		1/9/79	0.059		1/21/79	0.074	
9/30/79	0.096		1/15/79	0.043		1/27/79	0.074	
10/6/79	0.172		1/21/79	0.046		2/2/79	0.128	
10/9/79	0.155	0.1712	1/27/79	0.066	0.0572	2/8/79	0.054	0.089
10/12/79	0.203	0.1676	2/2/79	0.102	0.0632	2/14/79	0.089	0.084
10/16/79	0.066	0.1384	2/8/79	0.037	0.0588	2/22/79	0.020	0.073
10/18/79	0.063	0.1318	2/14/79	0.043	0.0588	2/26/79	0.040	0.066
10/21/79	0.023	0.102	2/20/79	0.042	0.058	3/4/79	0.032	0.047
10/24/79	0.047	0.0804	2/26/79	0.031	0.051	3/10/79	0.100	0.056
10/27/79	0.076	0.055	3/4/79	0.03	0.0366	3/16/79	0.062	0.051
10/30/79	0.078	0.0574	3/10/79	0.067	0.0426	3/22/79	0.092	0.065
11/1/79	0.079	0.0606	3/16/79	0.043	0.0426	3/28/79	0.037	0.065
11/6/79	0.069	0.0698	3/22/79	0.1	0.0542	4/3/79	0.050	0.068
11/8/79	0.107	0.0818	3/28/79	0.038	0.0556	4/9/79	0.023	0.053
11/11/79	0.083	0.0832	4/3/79	0.066	0.0628	4/15/79	0.025	0.045
11/14/79	0.074	0.0824	4/9/79	0.036	0.0566	4/21/79	0.041	0.035
11/17/79	0.074	0.0814	4/15/79	0.053	0.0586	4/27/79	0.057	0.039
11/20/79	0.087	0.085	4/25/79	0.03	0.0446	5/3/79	0.055	0.040
11/23/79	0.044	0.0724	4/27/79	0.069	0.0508	5/9/79	0.029	0.041
11/28/79	0.058	0.0674	5/3/79	0.072	0.052	5/15/79	0.021	0.041
12/2/79	0.069	0.0664	5/9/79	0.059	0.0566	5/21/79	0.051	0.043
12/8/79	0.078	0.0672	5/15/79	0.101	0.0662	5/27/79	0.029	0.037
12/11/79	0.108	0.0714	5/21/79	0.097	0.0796	6/2/79	0.044	0.035
12/13/79	0.101	0.0828	5/27/79	0.061	0.078	6/8/79	0.038	0.037
12/17/79	0.047	0.0806	6/2/79	0.079	0.0794	6/14/79	0.039	0.040
12/20/79	0.121	0.091	6/8/79	0.093	0.0862	6/20/79	0.008	0.032
12/23/79	0.079	0.0912	6/14/79	0.065	0.079	6/26/79	0.037	0.033
12/27/79	0.064	0.0824	6/20/79	0.043	0.0682	7/2/79	0.027	0.030
12/29/79	0.059	0.074	6/26/79	0.333	0.1226	7/8/79	0.025	0.027
1/4/80	0.065	0.0776	7/2/79	0.063	0.1194	7/14/79	0.025	0.024
1/8/80	0.033	0.06	7/8/79	0.055	0.1118	7/20/79	0.047	0.032

Table D-1. Twenty-Four-Hour and Running Average Concentrations (mg/m^3) of TSP at Clarkston, Richland, and Longview, Washington, 1979–1982 (Continued)

Clarkston (53-003-0003)			Richland (53-005-1001)			Longview (53-015-0008)		
Date	**TSP**	$\bar{x}$[a]	**Date**	**TSP**	$\bar{x}$[a]	**Date**	**TSP**	$\bar{x}$[a]
1/13/80	0.062	0.0566	7/14/79	0.089	0.1166	7/26/79	0.031	0.031
1/15/80	0.095	0.0628	7/20/79	0.126	0.1332	8/1/79	0.024	0.030
1/17/80	0.068	0.0646	7/26/79	0.25	0.1166	8/7/79	0.034	0.032
1/19/80	0.157	0.083	8/1/79	0.116	0.1272	8/13/79	0.033	0.034
1/22/80	0.097	0.0958	8/7/79	0.141	0.1444	8/19/79	0.013	0.027
1/24/80	0.093	0.102	8/13/79	0.191	0.1648	8/25/79	0.023	0.025
1/28/80	0.082	0.0994	8/19/79	0.082	0.156	8/31/79	0.026	0.026
1/30/80	0.145	0.1148	8/25/79	0.072	0.1204	9/6/79	0.040	0.027
2/3/80	0.086	0.1006	8/31/79	0.051	0.1074	9/12/79	0.049	0.030
2/6/80	0.073	0.0958	9/6/79	0.068	0.0928	9/18/79	0.059	0.039
2/9/80	0.083	0.0938	9/12/79	0.09	0.0726	9/24/79	0.072	0.049
2/12/80	0.068	0.091	9/18/79	0.112	0.0786	9/30/79	0.038	0.052
2/15/80	0.077	0.0774	9/24/79	0.116	0.0874	10/6/79	0.064	0.056
2/20/80	0.08	0.0762	9/30/79	0.066	0.0904	10/12/79	0.098	0.066
2/22/80	0.154	0.0924	10/6/79	0.143	0.1054	10/18/79	0.034	0.061
2/26/80	0.071	0.09	10/12/79	0.146	0.1166	10/24/79	0.037	0.054
2/28/80	0.058	0.088	10/18/79	0.041	0.1024	10/30/79	0.036	0.054
3/1/80	0.093	0.0912	10/24/79	0.027	0.0846	11/5/79	0.027	0.046
3/4/80	0.041	0.0834	10/30/79	0.037	0.0788	11/11/79	0.046	0.036
3/6/80	0.059	0.0644	11/5/79	0.02	0.0542	11/29/79	0.069	0.043
3/28/80	0.082	0.0666	11/14/79	0.031	0.0312	12/5/79	0.062	0.048
4/1/80	0.073	0.0696	11/17/79	0.031	0.0292	12/11/79	0.034	0.048
4/3/80	0.056	0.0622	11/23/79	0.024	0.0286	12/17/79	0.052	0.053
4/6/80	0.047	0.0634	11/29/79	0.038	0.0288	12/23/79	0.026	0.049
4/8/80	0.068	0.0652	12/5/79	0.009	0.0266	12/29/79	0.160	0.067
4/12/80	0.094	0.0676	12/19/79	0.037	0.0278	1/16/80	0.066	0.068
4/15/80	0.071	0.0672	12/23/79	0.02	0.0256	1/22/80	0.187	0.098
4/17/80	0.144	0.0848	12/29/79	0.018	0.0244	1/28/80	0.222	0.132
4/21/80	0.054	0.0862	1/4/80	0.023	0.0214	2/3/80	0.080	0.143
4/24/80	0.129	0.0984	1/16/80	0.005	0.0206	2/9/80	0.157	0.142
4/27/80	0.113	0.1022	1/18/80	0.022	0.0176	2/15/80	0.085	0.146
4/30/80	0.037	0.0954	1/22/80	0.049	0.0234	2/21/80	0.075	0.124
5/3/80	0.081	0.0828	1/31/80	0.038	0.0274	2/27/80	0.052	0.090
5/6/80	0.043	0.0806	2/3/80	0.039	0.0306	3/4/80	0.072	0.088
5/9/80	0.029	0.0606	2/9/80	0.024	0.0344	3/16/80	0.036	0.064
5/13/80	0.061	0.0502	2/15/80	0.051	0.0402	3/22/80	0.048	0.057
5/15/80	0.032	0.0492	2/21/80	0.025	0.0354	3/28/80	0.061	0.054
5/18/80	0.678	0.1686	2/27/80	0.017	0.0312	4/3/80	0.107	0.065
5/21/80	0.601	0.2802	3/4/80	0.024	0.0282	4/9/80	0.026	0.056
5/24/80	0.423	0.359	3/13/80	0.028	0.029	4/15/80	0.035	0.055
6/2/80	0.089	0.3646	3/16/80	0.022	0.0232	4/21/80	0.037	0.053
6/20/80	0.149	0.388	3/22/80	0.095	0.0372	4/27/80	0.066	0.054
6/24/80	0.062	0.2648	3/28/80	0.033	0.0404	5/3/80	0.050	0.043
6/26/80	0.044	0.1534	4/3/80	0.057	0.047	5/9/80	0.026	0.043

Table D-1. Twenty-Four-Hour and Running Average Concentrations (mg/m^3) of TSP at Clarkston, Richland, and Longview, Washington, 1979–1982 (Continued)

Clarkston (53-003-0003)			**Richland (53-005-1001)**			**Longview (53-015-0008)**		
Date	**TSP**	$\bar{x}$[a]	**Date**	**TSP**	$\bar{x}$[a]	**Date**	**TSP**	$\bar{x}$[a]
6/29/80	0.094	0.0876	4/9/80	0.202	0.0818	5/15/80	0.036	0.043
7/2/80	0.076	0.085	4/21/80	0.017	0.0808	5/21/80	0.017	0.039
7/14/80	0.05	0.0652	4/27/80	0.065	0.0748	5/27/80	1.420	0.310
7/23/80	0.526	0.158	5/3/80	0.067	0.0816	6/2/80	0.526	0.405
8/1/80	0.147	0.1786	5/9/80	0.023	0.0748	6/8/80	0.986	0.597
8/4/80	0.089	0.1776	5/15/80	0.05	0.0444	6/14/80	0.071	0.604
8/7/80	0.128	0.188	5/23/80	0.611	0.1632	6/26/80	0.168	0.634
8/13/80	0.167	0.2114	5/29/80	0.099	0.17	7/2/80	0.143	0.379
8/16/80	0.133	0.1328	6/2/80	0.083	0.1732	7/8/80	0.097	0.293
8/19/80	0.054	0.1142	6/10/80	0.109	0.1904	7/14/80	0.053	0.106
8/21/80	0.085	0.1134	6/14/80	0.049	0.1902	7/20/80	0.106	0.113
8/25/80	0.102	0.1082	6/20/80	0.093	0.0866	7/26/80	0.067	0.093
8/27/80	0.104	0.0956	6/26/80	0.074	0.0816	8/1/80	0.044	0.073
8/31/80	0.039	0.0768	7/2/80	0.091	0.0832	8/7/80	0.181	0.090
9/6/80	0.119	0.0898	7/8/80	0.133	0.088	8/13/80	0.046	0.089
9/10/80	0.109	0.0946	7/14/80	0.15	0.1082	8/19/80	0.054	0.078
9/12/80	0.106	0.0954	7/20/80	0.065	0.1026	8/25/80	0.048	0.075
9/16/80	0.077	0.09	7/26/80	0.181	0.124	8/31/80	0.025	0.071
9/18/80	0.087	0.0996	8/1/80	0.171	0.14	9/6/80	0.056	0.046
9/22/80	0.076	0.091	8/7/80	0.077	0.1288	9/12/80	0.036	0.044
9/24/80	0.091	0.0874	8/13/80	0.128	0.1244	9/18/80	0.055	0.044
9/28/80	0.094	0.085	8/19/80	0.103	0.132	9/24/80	0.093	0.053
9/30/80	0.144	0.0984	8/25/80	0.081	0.112	9/30/80	0.053	0.059
10/7/80	0.18	0.117	9/6/80	0.091	0.096	10/6/80	0.062	0.060
10/9/80	0.182	0.1382	9/12/80	0.071	0.0948	10/12/80	0.077	0.068
10/12/80	0.105	0.141	9/18/80	0.085	0.0862	10/18/80	0.119	0.081
10/15/80	0.055	0.1332	9/24/80	0.086	0.0828	10/24/80	0.118	0.086
10/18/80	0.114	0.1272	9/30/80	0.076	0.0818	10/30/80	0.103	0.096
10/21/80	0.114	0.114	10/7/80	0.146	0.0928	11/5/80	0.059	0.095
10/24/80	0.13	0.1036	10/12/80	0.049	0.0884	11/11/80	0.078	0.095
10/28/80	0.123	0.1072	10/18/80	0.094	0.0902	11/17/80	0.037	0.079
10/30/80	0.148	0.1258	10/24/80	0.075	0.088	11/23/80	0.078	0.071
11/2/80	0.063	0.1156	10/30/80	0.052	0.0832	11/29/80	0.026	0.056
11/5/80	0.139	0.1206	11/5/80	0.033	0.0606	12/5/80	0.040	0.052
11/7/80	0.049	0.1044	11/11/80	0.025	0.0558	12/11/80	0.088	0.054
11/11/80	0.04	0.0878	11/17/80	0.037	0.0444	12/17/80	0.028	0.052
11/13/80	0.082	0.0746	11/23/80	0.023	0.034	12/23/80	0.046	0.046
11/17/80	0.143	0.0906	11/29/80	0.048	0.0332	12/29/80	0.055	0.051
11/20/80	0.075	0.0778	12/5/80	0.019	0.0304	1/4/81	0.145	0.072
11/23/80	0.052	0.0784	12/11/80	0.046	0.0346	1/10/81	0.182	0.091
11/25/80	0.086	0.0876	12/17/80	0.013	0.0298	1/16/81	0.133	0.112
11/29/80	0.048	0.0808	12/23/80	0.022	0.0296	1/22/81	0.053	0.114
12/3/80	0.105	0.0732	12/29/80	0.028	0.0256	1/28/81	0.065	0.116
12/9/80	0.133	0.0848	1/4/81	0.028	0.0274	2/3/81	0.110	0.109

Table D-1. Twenty-Four-Hour and Running Average Concentrations (mg/m^3) of TSP at Clarkston, Richland, and Longview, Washington, 1979–1982 (Continued)

Clarkston (53-003-0003)			Richland (53-005-1001)			Longview (53-015-0008)		
Date	TSP	$\bar{x}$[a]	Date	TSP	$\bar{x}$[a]	Date	TSP	$\bar{x}$[a]
12/11/80	0.08	0.0904	1/10/81	0.015	0.0212	2/9/81	0.066	0.085
12/14/80	0.102	0.0936	1/16/81	0.027	0.024	2/15/81	0.027	0.064
12/18/80	0.036	0.0912	1/22/81	0.031	0.0258	2/21/81	0.106	0.075
12/20/80	0.065	0.0832	1/28/81	0.009	0.022	2/27/81	0.103	0.082
12/23/80	0.175	0.0916	2/3/81	0.024	0.0212	3/5/81	0.095	0.079
12/29/80	0.081	0.0918	2/9/81	0.08	0.0342	3/11/81	0.066	0.079
1/4/81	0.073	0.086	2/15/81	0.014	0.0316	3/17/81	0.065	0.087
1/11/81	0.109	0.1006	2/21/81	0.024	0.0302	3/23/81	0.040	0.074
1/16/81	0.072	0.102	2/27/81	0.024	0.0332	3/29/81	0.028	0.059
1/22/81	0.08	0.083	3/5/81	0.023	0.033	4/4/81	0.052	0.050
2/3/81	0.085	0.0838	3/11/81	0.086	0.0342	4/10/81	0.036	0.044
2/9/81	0.047	0.0786	3/17/81	0.043	0.04	4/16/81	0.041	0.039
2/15/81	0.055	0.0678	3/23/81	0.052	0.0456	4/22/81	0.021	0.036
2/21/81	0.097	0.0728	3/29/81	0.073	0.0554	5/22/81	0.038	0.038
2/27/81	0.118	0.0804	4/4/81	0.046	0.06	5/28/81	0.053	0.038
3/5/81	0.059	0.0752	4/10/81	0.036	0.05	6/3/81	0.046	0.040
3/11/81	0.123	0.0904	4/16/81	0.038	0.049	6/9/81	0.026	0.037
3/17/81	0.046	0.0886	4/22/81	0.057	0.05	6/15/81	0.048	0.042
3/23/81	0.053	0.0798	4/28/81	0.066	0.0486	6/21/81	0.021	0.039
3/29/81	0.025	0.0612	5/4/81	0.052	0.0498	7/15/81	0.050	0.038
4/10/81	0.053	0.06	5/10/81	0.072	0.057	7/21/81	0.018	0.033
4/16/81	0.074	0.0502	5/16/81	0.037	0.0568	7/27/81	0.052	0.038
4/22/81	0.055	0.052	5/22/81	0.046	0.0546	8/2/81	0.028	0.034
4/28/81	0.066	0.0546	5/28/81	0.064	0.0542	8/8/81	0.071	0.044
5/5/81	0.046	0.0588	6/3/81	0.065	0.0568	8/14/81	0.044	0.043
5/10/81	0.033	0.0548	6/9/81	0.024	0.0472	8/20/81	0.034	0.046
5/22/81	0.039	0.0478	6/15/81	0.046	0.049	8/26/81	0.048	0.045
5/28/81	0.097	0.0562	6/21/81	0.041	0.048	9/1/81	0.019	0.043
6/3/81	0.063	0.0556	6/27/81	0.061	0.0474	9/7/81	0.098	0.049
6/9/81	0.028	0.052	7/3/81	0.111	0.0566	9/13/81	0.054	0.051
6/15/81	0.053	0.056	7/9/81	0.064	0.0646	9/19/81	0.036	0.051
6/21/81	0.032	0.0546	7/15/81	0.083	0.072	9/25/81	0.037	0.049
6/27/81	0.078	0.0508	7/21/81	0.084	0.0806	10/1/81	0.053	0.056
7/3/81	0.065	0.0512	7/27/81	0.08	0.0844	10/7/81	0.025	0.041
7/9/81	0.058	0.0572	8/2/81	0.102	0.0826	10/13/81	0.062	0.043
7/15/81	0.066	0.0598	8/8/81	0.107	0.0912	10/19/81	0.025	0.040
7/21/81	0.092	0.0718	8/20/81	0.068	0.0882	10/25/81	0.076	0.048
7/27/81	0.081	0.0724	8/23/81	0.098	0.091	10/31/81	0.083	0.054
8/2/81	0.097	0.0788	8/26/81	0.099	0.0948	11/6/81	0.161	0.081
8/8/81	0.111	0.0894	9/1/81	0.085	0.0914	11/12/81	0.038	0.077
8/15/81	0.108	0.0978	9/7/81	0.077	0.0854	11/18/81	0.059	0.083
8/20/81	0.123	0.104	9/13/81	0.094	0.0906	11/24/81	0.103	0.089
8/26/81	0.139	0.1156	9/19/81	0.057	0.0824	12/6/81	0.041	0.080
9/1/81	0.278	0.1518	9/25/81	0.04	0.0706	12/12/81	0.064	0.061

Table D-1. Twenty-Four-Hour and Running Average Concentrations (mg/m^3) of TSP at Clarkston, Richland, and Longview, Washington, 1979–1982 (Continued)

Clarkston (53-003-0003)			Richland (53-005-1001)			Longview (53-015-0008)		
Date	**TSP**	$\bar{x}$[a]	**Date**	**TSP**	$\bar{x}$[a]	**Date**	**TSP**	$\bar{x}$[a]
9/7/81	0.126	0.1548	10/1/81	0.041	0.0618	12/18/81	0.048	0.063
9/13/81	0.108	0.1548	10/7/81	0.02	0.0504	12/24/81	0.033	0.058
9/19/81	0.191	0.1684	10/13/81	0.05	0.0416	12/30/81	0.059	0.049
9/26/81	0.048	0.1502	10/19/81	0.066	0.0434	1/5/82	0.069	0.055
10/1/81	0.083	0.1112	10/25/81	0.083	0.052	1/11/82	0.088	0.059
10/8/81	0.056	0.0972	10/31/81	0.036	0.051	1/17/82	0.028	0.055
10/14/81	0.121	0.0998	11/12/81	0.023	0.0516	1/23/82	0.024	0.054
10/21/81	0.118	0.0852	11/18/81	0.011	0.0438	1/29/82	0.053	0.052
10/25/81	0.159	0.1074	11/24/81	0.024	0.0354	2/4/82	0.156	0.070
10/31/81	0.041	0.099	11/30/81	0.017	0.0222	2/10/82	0.122	0.077
11/6/81	0.134	0.1146	12/6/81	0.012	0.0174	2/16/82	0.030	0.077
11/12/81	0.044	0.0992	12/12/81	0.016	0.016	2/22/82	0.035	0.079
11/18/81	0.032	0.082	12/24/81	0.032	0.0202	2/28/82	0.063	0.081
11/24/81	0.047	0.0596	12/30/81	0.025	0.0204	3/6/82	0.058	0.062
11/30/81	0.032	0.0578	1/5/82	0.033	0.0236	3/12/82	0.049	0.047
12/6/81	0.127	0.0564	1/11/82	0.052	0.0316	3/18/82	0.086	0.058
12/12/81	0.104	0.0684	1/17/82	0.012	0.0308	3/24/82	0.075	0.066
12/19/81	0.048	0.0716	1/23/82	0.029	0.0302	4/5/82	0.026	0.059
12/24/81	0.036	0.0694	1/29/82	0.019	0.029	4/11/82	0.031	0.053
12/30/81	0.061	0.0752	2/4/82	0.032	0.0288	4/17/82	0.049	0.053
1/5/82	0.069	0.0636	2/10/82	0.038	0.026	4/23/82	0.051	0.046
1/11/82	0.067	0.0562	2/16/82	0.021	0.0278	4/29/82	0.056	0.043
1/17/82	0.057	0.058	2/22/82	0.015	0.025	5/5/82	0.071	0.052
1/23/82	0.031	0.057	2/28/82	0.02	0.0252	5/11/82	0.029	0.051
2/4/82	0.07	0.0588	3/6/82	0.035	0.0258	5/17/82	0.029	0.047
2/10/82	0.084	0.0618	3/12/82	0.067	0.0316	5/23/82	0.045	0.046
2/17/82	0.081	0.0646	3/18/82	0.044	0.0362	5/29/82	0.064	0.048
2/22/82	0.071	0.0674	3/24/82	0.066	0.0464	6/4/82	0.047	0.043
2/28/82	0.065	0.0742	3/30/82	0.027	0.0478	6/10/82	0.064	0.050
3/6/82	0.073	0.0748	4/5/82	0.023	0.0454	6/16/82	0.096	0.063
3/12/82	0.095	0.077	4/11/82	0.016	0.0352	6/22/82	0.041	0.062
4/18/82	0.09	0.0788	4/17/82	0.091	0.0446	6/28/82	0.025	0.055
4/24/82	0.101	0.0848	4/23/82	0.083	0.048	7/4/82	0.031	0.051
4/30/82	0.099	0.0916	4/29/82	0.04	0.0506	7/10/82	0.028	0.044
5/6/82	0.104	0.0978	5/5/82	0.053	0.0566	7/16/82	0.029	0.031
5/12/82	0.095	0.0978	5/11/82	0.057	0.0648	7/22/82	0.044	0.031
5/17/82	0.064	0.0926	5/17/82	0.029	0.0524	7/28/82	0.044	0.035
5/29/82	0.062	0.0848	5/23/82	0.053	0.0464	8/3/82	0.031	0.035
6/10/82	0.072	0.0794	5/29/82	0.046	0.0476	8/9/82	0.023	0.034
6/16/82	0.104	0.0794	6/4/82	0.096	0.0562	8/15/82	0.039	0.036
6/22/82	0.059	0.0722	6/10/82	0.084	0.0616	8/21/82	0.049	0.037
6/28/82	0.045	0.0684	6/16/82	0.062	0.0682	8/27/82	0.041	0.037
7/16/82	0.036	0.0632	6/22/82	0.056	0.0688	9/2/82	0.068	0.044
7/22/82	0.098	0.0684	7/10/82	0.054	0.0704	9/8/82	0.045	0.048

Table D-1. Twenty-Four-Hour and Running Average Concentrations (mg/m^3) of TSP at Clarkston, Richland, and Longview, Washington, 1979–1982 (Continued)

Clarkston (53-003-0003)			**Richland (53-005-1001)**			**Longview (53-015-0008)**		
Date	**TSP**	$\bar{x}$[a]	**Date**	**TSP**	$\bar{x}$[a]	**Date**	**TSP**	$\bar{x}$[a]
7/28/82	0.075	0.0626	7/16/82	0.031	0.0574	9/14/82	0.051	0.051
7/30/82	0.129	0.0766	7/22/82	0.063	0.0532	9/20/82	0.031	0.047
8/3/82	0.04	0.0756	7/26/82	0.094	0.0596	9/26/82	0.038	0.047
8/9/82	0.129	0.0942	7/28/82	0.087	0.0658	10/2/82	0.041	0.041
8/15/82	0.034	0.0814	8/3/82	0.041	0.0632	10/8/82	0.048	0.042
8/21/82	0.072	0.0808	8/9/82	0.146	0.0862	10/14/82	0.130	0.058
8/27/82	0.16	0.087	8/15/82	0.031	0.0798	10/20/82	0.135	0.078
9/8/82	0.135	0.106	8/21/82	0.077	0.0764	10/26/82	0.040	0.079
9/14/82	0.036	0.0874	8/27/82	0.085	0.076	11/1/82	0.107	0.092
9/20/82	0.036	0.0878	9/2/82	0.121	0.092	11/7/82	0.115	0.105
9/26/82	0.018	0.077	9/8/82	0.073	0.0774	11/13/82	0.072	0.094
10/2/82	0.076	0.0602	9/14/82	0.065	0.0842	11/19/82	0.054	0.078
10/8/82	0.051	0.0434	9/20/82	0.014	0.0716	11/25/82	0.097	0.089
10/14/82	0.122	0.0606	9/26/82	0.017	0.058	12/1/82	0.046	0.077
10/20/82	0.108	0.075	10/2/82	0.041	0.042	12/7/82	0.065	0.067
10/26/82	0.039	0.0792	10/8/82	0.034	0.0342	12/13/82	0.060	0.064
11/1/82	0.053	0.0746	10/14/82	0.081	0.0374	12/19/82	0.046	0.063
11/7/82	0.046	0.0736	10/20/82	0.087	0.052	12/25/82	0.050	0.053
11/13/82	0.042	0.0576	10/26/82	0.032	0.055	12/31/82	0.139	0.072
11/19/82	0.065	0.049	11/1/82	0.018	0.0504			
11/25/82	0.051	0.0514	11/7/82	0.011	0.0458			
12/1/82	0.057	0.0522	11/13/82	0.027	0.035			
12/7/82	0.034	0.0498	11/19/82	0.01	0.0196			
			11/25/82	0.026	0.0184			
			12/1/82	0.023	0.0194			
			12/7/82	0.019	0.021			
			12/13/82	0.024	0.0204			
			12/19/82	0.011	0.0206			
			12/25/82	0.033	0.022			
			12/31/82	0.018	0.021			

Source: DTN: MO008SPATSP00.013 (DIRS 151750).

[a] Running average of the measurement for a day and the four previous measurements

TSP=total suspended particles

Table D-2. Twenty-Four-Hour and Running Average Concentrations (mg/m^3) of TSP at Spokane, Vancouver, and Yakima, Washington, 1979–1982

Spokane (53-063-0016)			**Vancouver (53-011-0006)**			**Yakima (53-077-1006)**		
Date	**TSP**	$\bar{x}$[a]	**Date**	**TSP**	$\bar{x}$[a]	**Date**	**TSP**	$\bar{x}$[a]
1/3/79	0.146		1/3/79	0.072		1/3/79	0.083	
1/9/79	0.122		1/9/79	0.025		1/9/79	0.103	
1/15/79	0.106		1/15/79	0.159		1/15/79	0.048	
1/21/79	0.055		1/21/79	0.041		1/21/79	0.026	
1/27/79	0.121	0.110	1/27/79	0.034	0.0662	1/27/79	0.117	0.075
2/2/79	0.100	0.101	2/2/79	0.096	0.071	2/2/79	0.183	0.095
2/8/79	0.044	0.085	2/8/79	0.016	0.0692	2/8/79	0.038	0.082
2/14/79	0.210	0.106	2/14/79	0.048	0.047	2/14/79	0.048	0.082
2/21/79	0.045	0.104	2/20/79	0.039	0.0466	2/21/79	0.022	0.082
2/27/79	0.026	0.085	2/26/79	0.016	0.043	2/26/79	0.026	0.063
3/4/79	0.028	0.071	3/4/79	0.019	0.0276	3/4/79	0.059	0.039
3/10/79	0.233	0.108	3/10/79	0.067	0.0378	3/10/79	0.067	0.044
3/16/79	0.060	0.078	3/16/79	0.031	0.0344	3/16/79	0.036	0.042
3/23/79	0.285	0.126	3/22/79	0.094	0.0454	3/22/79	0.115	0.061
3/28/79	0.093	0.140	3/28/79	0.039	0.05	3/28/79	0.057	0.067
4/9/79	0.133	0.161	4/3/79	0.019	0.05	4/9/79	0.094	0.074
4/15/79	0.082	0.131	4/9/79	0.047	0.046	4/15/79	0.027	0.066
4/21/79	0.141	0.147	4/15/79	0.018	0.0434	5/5/79	0.045	0.068
4/27/79	0.230	0.136	4/21/79	0.057	0.036	5/9/79	0.063	0.057
5/3/79	0.188	0.155	4/27/79	0.075	0.0432	5/15/79	0.119	0.070
5/9/79	0.140	0.156	5/3/79	0.055	0.0504	5/17/79	0.119	0.075
5/15/79	0.210	0.182	5/9/79	0.025	0.046	5/21/79	0.098	0.089
5/21/79	0.173	0.188	5/15/79	0.083	0.059	5/27/79	0.073	0.094
5/27/79	0.054	0.153	5/21/79	0.089	0.0654	6/2/79	0.084	0.099
6/8/79	0.126	0.141	5/27/79	0.03	0.0564	6/8/79	0.059	0.087
6/14/79	0.126	0.138	6/2/79	0.108	0.067	6/14/79	0.048	0.072
6/20/79	0.116	0.119	6/8/79	0.083	0.0786	6/20/79	0.043	0.061
6/26/79	0.234	0.131	6/14/79	0.055	0.073	6/26/79	0.067	0.060
7/2/79	0.089	0.138	6/20/79	0.053	0.0658	7/2/79	0.037	0.051
7/8/79	0.129	0.139	6/26/79	0.083	0.0764	7/8/79	0.040	0.047
7/14/79	0.125	0.139	7/2/79	0.046	0.064	7/14/79	0.039	0.045
7/20/79	0.195	0.154	7/8/79	0.051	0.0576	7/20/79	0.083	0.053
7/26/79	0.209	0.149	7/14/79	0.072	0.061	7/26/79	0.075	0.055
8/7/79	0.262	0.184	7/20/79	0.057	0.0618	8/1/79	0.059	0.059
8/13/79	0.366	0.231	7/26/79	0.067	0.0586	8/7/79	0.068	0.065
8/19/79	0.091	0.225	8/1/79	0.043	0.058	8/13/79	0.259	0.109
8/25/79	0.123	0.210	8/7/79	0.054	0.0586	8/19/79	0.020	0.096
8/31/79	0.082	0.185	8/13/79	0.049	0.054	8/25/79	0.042	0.090
9/6/79	0.165	0.165	8/19/79	0.015	0.0456	8/31/79	0.027	0.083
9/12/79	0.235	0.139	8/25/79	0.045	0.0412	9/6/79	0.055	0.081
9/18/79	0.281	0.177	8/31/79	0.041	0.0408	9/12/79	0.094	0.048
9/24/79	0.307	0.214	9/6/79	0.044	0.0388	9/18/79	0.151	0.074
9/30/79	0.122	0.222	9/12/79	0.064	0.0418	9/24/79	0.115	0.088

Table D-2. Twenty-Four-Hour and Running Average Concentrations (mg/m^3) of TSP at Spokane, Vancouver, and Yakima, Washington, 1979–1982 (Continued)

Spokane (53-063-0016)			**Vancouver (53-011-0006)**			**Yakima (53-077-1006)**		
Date	**TSP**	$\bar{x}$ [a]	**Date**	**TSP**	$\bar{x}$ [a]	**Date**	**TSP**	$\bar{x}$ [a]
10/6/79	0.277	0.244	9/18/79	0.104	0.0596	9/30/79	0.062	0.095
10/12/79	0.315	0.260	9/24/79	0.11	0.0726	10/6/79	0.099	0.104
10/18/79	0.105	0.225	9/30/79	0.061	0.0766	10/12/79	0.100	0.105
10/24/79	0.081	0.180	10/6/79	0.112	0.0902	10/18/79	0.050	0.085
10/30/79	0.193	0.194	10/12/79	0.158	0.109	10/24/79	0.023	0.067
11/11/79	0.214	0.182	10/18/79	0.028	0.0938	10/30/79	0.041	0.063
11/17/79	0.055	0.130	10/24/79	0.015	0.0748	11/5/79	0.011	0.045
11/23/79	0.046	0.118	10/30/79	0.021	0.0668	11/11/79	0.015	0.028
11/29/79	0.315	0.165	11/5/79	0.012	0.0468	11/17/79	0.046	0.027
12/5/79	0.036	0.133	11/11/79	0.069	0.029	11/23/79	0.062	0.035
12/11/79	0.123	0.115	11/17/79	0.027	0.0288	11/29/79	0.080	0.043
12/17/79	0.092	0.122	11/23/79	0.019	0.0296	12/5/79	0.027	0.046
12/23/79	0.090	0.131	11/29/79	0.018	0.029	12/11/79	0.053	0.054
12/29/79	0.221	0.112	12/5/79	0.053	0.0372	12/17/79	0.032	0.051
1/4/80	0.132	0.132	12/11/79	0.038	0.031	12/23/79	0.013	0.041
1/10/80	0.074	0.122	12/17/79	0.016	0.0288	12/29/79	0.035	0.032
1/16/80	0.048	0.113	12/23/79	0.005	0.026	1/4/80	0.036	0.034
1/22/80	0.375	0.170	12/29/79	0.04	0.0304	1/10/80	0.062	0.036
1/28/80	0.357	0.197	1/4/80	0.03	0.0258	1/16/80	0.057	0.041
2/3/80	0.047	0.180	1/10/80	0.038	0.0258	1/22/80	0.074	0.053
2/9/80	0.120	0.189	1/16/80	0.026	0.0278	1/28/80	0.029	0.052
2/15/80	0.229	0.226	1/22/80	0.082	0.0432	2/3/80	0.055	0.055
2/21/80	0.297	0.210	1/28/80	0.03	0.0412	2/9/80	0.020	0.047
2/27/80	0.142	0.167	2/3/80	0.054	0.046	2/15/80	0.020	0.040
3/4/80	0.178	0.193	2/9/80	0.021	0.0426	2/21/80	0.016	0.028
3/10/80	0.113	0.192	2/15/80	0.04	0.0454	2/27/80	0.011	0.024
3/16/80	0.041	0.154	2/21/80	0.053	0.0396	3/4/80	0.076	0.029
3/22/80	0.163	0.127	2/27/80	0.022	0.038	3/10/80	0.055	0.036
3/28/80	0.145	0.128	3/4/80	0.047	0.0366	3/16/80	0.013	0.034
4/3/80	0.261	0.145	3/10/80	0.042	0.0408	3/22/80	0.101	0.051
4/9/80	0.063	0.135	3/16/80	0.018	0.0364	3/28/80	0.051	0.059
4/15/80	0.197	0.166	3/22/80	0.037	0.0332	4/3/80	0.055	0.055
4/21/80	0.118	0.157	3/28/80	0.054	0.0396	4/9/80	0.010	0.046
4/27/80	0.093	0.146	4/3/80	0.058	0.0418	4/15/80	0.092	0.062
5/10/80	0.072	0.109	4/9/80	0.014	0.0362	4/21/80	0.033	0.048
5/27/80	0.461	0.188	4/15/80	0.063	0.0452	4/27/80	0.057	0.049
6/2/80	0.699	0.289	4/21/80	0.036	0.045	5/3/80	0.075	0.053
6/8/80	0.521	0.369	4/27/80	0.102	0.0546	5/9/80	0.114	0.074
6/14/80	0.299	0.410	5/3/80	0.137	0.0704	5/15/80	0.062	0.068
6/20/80	0.520	0.500	5/9/80	0.024	0.0724	5/28/80	0.172	0.096
6/26/80	0.228	0.453	5/15/80	0.041	0.068	6/2/80	0.426	0.170
7/2/80	0.449	0.403	5/21/80	0.196	0.1	6/8/80	0.289	0.213
7/8/80	0.743	0.448	5/27/80	0.093	0.0982	6/14/80	0.105	0.211
7/14/80	0.253	0.439	6/3/80	0.044	0.0796	6/20/80	0.422	0.283

Table D-2. Twenty-Four-Hour and Running Average Concentrations (mg/m^3) of TSP at Spokane, Vancouver, and Yakima, Washington, 1979–1982 (Continued)

Spokane (53-063-0016)			Vancouver (53-011-0006)			Yakima (53-077-1006)		
Date	**TSP**	$\bar{x}$[a]	**Date**	**TSP**	$\bar{x}$[a]	**Date**	**TSP**	$\bar{x}$[a]
7/20/80	0.220	0.379	6/8/80	0.046	0.084	6/26/80	0.180	0.284
7/27/80	0.335	0.400	6/15/80	0.474	0.1706	7/2/80	0.315	0.262
8/1/80	0.402	0.391	6/21/80	0.233	0.178	7/8/80	0.176	0.240
8/7/80	0.266	0.295	6/26/80	0.239	0.2072	7/14/80	0.130	0.245
8/13/80	0.185	0.282	7/1/80	0.206	0.2396	7/20/80	0.093	0.179
8/19/80	0.114	0.260	7/8/80	0.134	0.2572	7/26/80	0.295	0.202
8/25/80	0.247	0.243	7/15/80	0.095	0.1814	8/1/80	0.205	0.180
8/31/80	0.232	0.209	7/20/80	0.216	0.178	8/7/80	0.075	0.160
9/6/80	0.299	0.215	7/29/80	0.118	0.1538	8/13/80	0.119	0.157
9/18/80	0.354	0.249	8/1/80	0.087	0.13	8/19/80	0.107	0.160
9/24/80	0.285	0.283	8/7/80	0.193	0.1418	8/25/80	0.104	0.122
9/30/80	0.224	0.279	8/13/80	0.105	0.1438	8/31/80	0.036	0.088
10/6/80	0.431	0.319	8/19/80	0.117	0.124	9/6/80	0.171	0.107
10/12/80	0.111	0.281	8/25/80	0.088	0.118	9/12/80	0.227	0.129
10/18/80	0.192	0.249	8/31/80	0.026	0.1058	9/18/80	0.058	0.119
10/24/80	0.213	0.234	9/6/80	0.069	0.081	9/24/80	0.091	0.117
10/30/80	0.371	0.264	9/12/80	0.053	0.0706	9/30/80	0.245	0.158
11/5/80	0.139	0.205	9/18/80	0.031	0.0534	10/6/80	0.196	0.163
11/11/80	0.098	0.203	9/24/80	0.06	0.0478	10/12/80	0.055	0.129
11/17/80	0.159	0.196	9/30/80	0.033	0.0492	10/18/80	0.066	0.131
11/23/80	0.087	0.171	10/6/80	0.084	0.0522	10/24/80	0.120	0.136
11/29/80	0.069	0.110	10/12/80	0.039	0.0494	10/30/80	0.160	0.119
12/5/80	0.057	0.094	10/18/80	0.123	0.0678	11/5/80	0.041	0.088
12/11/80	0.095	0.093	10/24/80	0.053	0.0664	11/11/80	0.035	0.084
12/23/80	0.050	0.072	10/30/80	0.058	0.0714	11/17/80	0.085	0.088
12/29/80	0.249	0.104	11/5/80	0.035	0.0616	11/23/80	0.052	0.075
1/4/81	0.079	0.106	11/11/80	0.057	0.0652	11/29/80	0.037	0.050
1/10/81	0.191	0.133	11/17/80	0.03	0.0466	12/5/80	0.029	0.048
1/16/81	0.296	0.173	11/23/80	0.034	0.0428	12/11/80	0.105	0.062
1/22/81	0.160	0.195	11/29/80	0.014	0.034	12/23/80	0.056	0.056
1/28/81	0.072	0.160	12/5/80	0.017	0.0304	12/30/80	0.056	0.057
2/3/81	0.205	0.185	12/11/80	0.096	0.0382	1/4/81	0.045	0.058
2/9/81	0.357	0.218	12/17/80	0.032	0.0386	1/16/81	0.076	0.068
2/15/81	0.024	0.164	12/23/80	0.065	0.0448	1/20/81	0.040	0.055
2/21/81	0.113	0.154	12/29/80	0.02	0.046	1/22/81	0.030	0.049
2/27/81	0.289	0.198	1/4/81	0.058	0.0542	1/28/81	0.014	0.041
3/5/81	0.184	0.193	1/10/81	0.036	0.0422	2/3/81	0.082	0.048
3/11/81	0.450	0.212	1/16/81	0.038	0.0434	2/9/81	0.094	0.052
3/17/81	0.112	0.230	1/22/81	0.044	0.0392	2/15/81	0.036	0.051
3/23/81	0.198	0.247	1/28/81	0.04	0.0432	2/21/81	0.043	0.054
3/29/81	0.098	0.208	2/3/81	0.062	0.044	2/27/81	0.037	0.058
4/4/81	0.080	0.188	2/9/81	0.043	0.0454	3/5/81	0.076	0.057
4/10/81	0.147	0.127	2/15/81	0.015	0.0408	3/11/81	0.091	0.057
4/16/81	0.252	0.155	2/21/81	0.065	0.045	3/17/81	0.084	0.066

Table D-2. Twenty-Four-Hour and Running Average Concentrations (mg/m^3) of TSP at Spokane, Vancouver, and Yakima, Washington, 1979–1982 (Continued)

Spokane (53-063-0016)			**Vancouver (53-011-0006)**			**Yakima (53-077-1006)**		
Date	**TSP**	$\bar{x}$[a]	**Date**	**TSP**	$\bar{x}$[a]	**Date**	**TSP**	$\bar{x}$[a]
4/22/81	0.053	0.126	2/27/81	0.046	0.0462	3/23/81	0.148	0.087
4/28/81	0.122	0.131	3/5/81	0.075	0.0488	3/29/81	0.116	0.103
5/4/81	0.122	0.139	3/11/81	0.077	0.0556	4/4/81	0.086	0.105
5/10/81	0.088	0.127	3/17/81	0.066	0.0658	4/10/81	0.115	0.110
5/16/81	0.069	0.091	3/23/81	0.028	0.0584	4/16/81	0.097	0.112
5/22/81	0.107	0.102	3/29/81	0.018	0.0528	4/22/81	0.146	0.112
5/28/81	0.298	0.137	4/4/81	0.035	0.0448	4/28/81	0.093	0.107
6/3/81	0.176	0.148	4/10/81	0.021	0.0336	5/4/81	0.138	0.118
6/9/81	0.072	0.144	4/16/81	0.038	0.028	5/10/81	0.092	0.113
6/15/81	0.105	0.152	4/22/81	0.031	0.0286	5/16/81	0.054	0.105
6/21/81	0.050	0.140	4/28/81	0.037	0.0324	5/22/81	0.050	0.085
6/27/81	0.194	0.119	5/4/81	0.031	0.0316	5/28/81	0.111	0.089
7/3/81	0.192	0.123	5/10/81	0.05	0.0374	6/3/81	0.112	0.084
7/9/81	0.167	0.142	5/16/81	0.035	0.0368	6/9/81	0.018	0.069
7/15/81	0.217	0.164	5/22/81	0.05	0.0406	6/15/81	0.053	0.069
7/21/81	0.216	0.197	5/28/81	0.159	0.065	6/21/81	0.030	0.065
7/27/81	0.169	0.192	6/3/81	0.039	0.0666	6/27/81	0.083	0.059
8/2/81	0.173	0.188	6/9/81	0.019	0.0604	7/3/81	0.074	0.052
8/8/81	0.163	0.188	6/15/81	0.056	0.0646	7/9/81	0.059	0.060
8/14/81	0.456	0.235	6/21/81	0.025	0.0596	7/15/81	0.060	0.061
8/20/81	0.245	0.241	6/27/81	0.096	0.047	7/21/81	0.055	0.066
8/26/81	0.213	0.250	7/3/81	0.071	0.0534	7/27/81	0.084	0.066
9/1/81	0.276	0.271	7/9/81	0.068	0.0632	8/2/81	0.054	0.062
9/7/81	0.131	0.264	7/15/81	0.095	0.071	8/8/81	0.075	0.066
9/13/81	0.226	0.218	7/21/81	0.054	0.0768	8/14/81	0.085	0.071
9/19/81	0.846	0.338	7/27/81	0.096	0.0768	8/20/81	0.041	0.068
9/25/81	0.090	0.314	8/2/81	0.054	0.0734	8/26/81	0.099	0.071
10/1/81	0.204	0.299	8/8/81	0.124	0.0846	9/2/81	0.044	0.069
10/7/81	0.039	0.281	8/14/81	0.085	0.0826	9/7/81	0.077	0.069
10/13/81	0.367	0.309	8/20/81	0.07	0.0858	9/13/81	0.048	0.062
10/19/81	0.202	0.180	8/26/81	0.073	0.0812	9/19/81	0.045	0.063
10/25/81	0.156	0.194	9/1/81	0.036	0.0776	9/25/81	0.062	0.055
10/31/81	0.111	0.175	9/7/81	0.085	0.0698	10/1/81	0.076	0.062
11/12/81	0.083	0.184	9/13/81	0.072	0.0672	10/7/81	0.021	0.050
11/18/81	0.097	0.130	9/19/81	0.042	0.0616	10/13/81	0.050	0.051
11/24/81	0.199	0.129	9/25/81	0.035	0.054	10/19/81	0.084	0.059
11/30/81	0.102	0.118	10/1/81	0.044	0.0556	10/25/81	0.102	0.067
12/6/81	0.041	0.104	10/7/81	0.019	0.0424	10/31/81	0.033	0.058
12/12/81	0.188	0.125	10/13/81	0.028	0.0336	11/6/81	0.079	0.070
12/18/81	0.057	0.117	10/19/81	0.042	0.0336	11/13/81	0.031	0.066
12/30/81	0.041	0.086	10/25/81	0.109	0.0484	11/19/81	0.027	0.054
1/5/82	0.147	0.095	10/31/81	0.036	0.0468	11/24/81	0.016	0.037
1/29/82	0.029	0.092	11/6/81	0.064	0.0558	11/30/81	0.071	0.045
2/4/82	0.291	0.113	11/12/81	0.023	0.0548	12/6/81	0.027	0.034

Table D-2. Twenty-Four-Hour and Running Average Concentrations (mg/m^3) of TSP at Spokane, Vancouver, and Yakima, Washington, 1979–1982 (Continued)

Spokane (53-063-0016)			**Vancouver (53-011-0006)**			**Yakima (53-077-1006)**		
Date	**TSP**	$\bar{x}$ [a]	**Date**	**TSP**	$\bar{x}$ [a]	**Date**	**TSP**	$\bar{x}$ [a]
2/10/82	0.278	0.157	11/18/81	0.034	0.0532	12/12/81	0.062	0.041
2/16/82	0.047	0.158	11/24/81	0.075	0.0464	12/18/81	0.026	0.040
2/22/82	0.101	0.149	11/30/81	0.024	0.044	12/24/81	0.065	0.050
2/28/82	0.081	0.160	12/6/81	0.018	0.0348	12/30/81	0.028	0.042
3/6/82	0.205	0.142	12/12/81	0.028	0.0358	1/5/82	0.045	0.045
3/12/82	0.115	0.110	12/18/81	0.023	0.0336	1/11/82	0.082	0.049
3/24/82	0.312	0.163	12/24/81	0.03	0.0246	1/17/82	0.027	0.049
3/30/82	0.084	0.159	12/30/81	0.066	0.033	1/23/82	0.021	0.041
4/5/82	0.121	0.167	1/5/82	0.064	0.0422	1/29/82	0.052	0.045
4/11/82	0.040	0.134	1/11/82	0.109	0.0584	2/4/82	0.108	0.058
4/17/82	0.083	0.128	1/17/82	0.025	0.0588	2/10/82	0.134	0.068
4/23/82	0.370	0.140	1/23/82	0.014	0.0556	2/16/82	0.019	0.067
4/29/82	0.116	0.146	1/29/82	0.051	0.0526	2/22/82	0.038	0.070
5/5/82	0.175	0.157	2/4/82	0.039	0.0476	2/28/82	0.019	0.064
5/11/82	0.161	0.181	2/10/82	0.071	0.04	3/6/82	0.050	0.052
5/17/82	0.066	0.178	2/16/82	0.019	0.0388	3/12/82	0.030	0.031
5/23/82	0.057	0.115	2/22/82	0.024	0.0408	3/18/82	0.060	0.039
5/29/82	0.097	0.111	2/28/82	0.044	0.0394	3/24/82	0.091	0.050
6/4/82	0.167	0.110	3/6/82	0.099	0.0514	3/30/82	0.034	0.053
6/10/82	0.182	0.114	3/12/82	0.036	0.0444	4/5/82	0.031	0.049
6/16/82	0.148	0.130	3/18/82	0.089	0.0584	4/11/82	0.012	0.046
6/22/82	0.119	0.143	3/24/82	0.104	0.0744	4/17/82	0.105	0.055
6/28/82	0.081	0.139	3/30/82	0.018	0.0692	4/23/82	0.339	0.104
7/4/82	0.032	0.112	4/5/82	0.025	0.0544	4/29/82	0.099	0.117
7/10/82	0.081	0.092	4/11/82	0.023	0.0518	5/5/82	0.096	0.130
7/16/82	0.067	0.076	4/17/82	0.038	0.0416	5/11/82	0.054	0.139
7/22/82	0.121	0.076	4/23/82	0.083	0.0374	5/17/82	0.027	0.123
7/28/82	0.260	0.112	4/29/82	0.072	0.0482	5/23/82	0.036	0.062
8/3/82	0.133	0.132	5/5/82	0.075	0.0582	5/29/82	0.040	0.051
8/9/82	0.453	0.207	5/11/82	0.061	0.0658	6/4/82	0.169	0.065
8/15/82	0.091	0.212	5/17/82	0.026	0.0634	6/10/82	0.068	0.068
8/21/82	0.152	0.218	5/23/82	0.089	0.0646	6/16/82	0.052	0.073
8/27/82	0.286	0.223	5/29/82	0.084	0.067	6/22/82	0.062	0.078
9/2/82	0.213	0.239	6/4/82	0.034	0.0588	6/28/82	0.024	0.075
9/8/82	0.183	0.185	6/10/82	0.108	0.0682	7/4/82	0.016	0.044
9/14/82	0.166	0.200	6/16/82	0.068	0.0766	7/10/82	0.038	0.038
9/20/82	0.132	0.196	6/22/82	0.081	0.075	7/16/82	0.032	0.034
9/26/82	0.035	0.146	6/28/82	0.036	0.0654	7/22/82	0.039	0.030
10/2/82	0.048	0.113	7/4/82	0.032	0.065	8/3/82	0.038	0.033
10/8/82	0.149	0.106	7/10/82	0.05	0.0534	8/9/82	0.060	0.041
10/14/82	0.205	0.114	7/16/82	0.053	0.0504	8/15/82	0.029	0.040
10/20/82	0.267	0.141	7/22/82	0.089	0.052	8/21/82	0.059	0.045
10/26/82	0.030	0.140	7/28/82	0.063	0.0574	8/27/82	0.059	0.049
11/1/82	0.104	0.151	8/3/82	0.051	0.0612	9/2/82	0.066	0.055

Table D-2. Twenty-Four-Hour and Running Average Concentrations (mg/m^3) of TSP at Spokane, Vancouver, and Yakima, Washington, 1979–1982 (Continued)

Spokane (53-063-0016)			**Vancouver (53-011-0006)**			**Yakima (53-077-1006)**		
Date	**TSP**	$\bar{x}$ [a]	**Date**	**TSP**	$\bar{x}$ [a]	**Date**	**TSP**	$\bar{x}$ [a]
11/7/82	0.067	0.135	8/9/82	0.037	0.0586	9/8/82	0.044	0.051
11/13/82	0.120	0.118	8/15/82	0.031	0.0542	9/20/82	0.021	0.050
11/19/82	0.029	0.070	8/21/82	0.08	0.0524	9/26/82	0.024	0.043
11/25/82	0.137	0.091	8/27/82	0.076	0.055	9/30/82	0.030	0.037
12/1/82	0.123	0.095	9/2/82	0.068	0.0584	10/2/82	0.036	0.031
12/7/82	0.178	0.117	9/8/82	0.05	0.061	10/8/82	0.045	0.031
12/13/82	0.039	0.101	9/14/82	0.061	0.067	10/14/82	0.083	0.044
12/19/82	0.082	0.112	9/20/82	0.023	0.0556	10/20/82	0.072	0.053
12/25/82	0.073	0.099	9/26/82	0.022	0.0448	10/26/82	0.011	0.049
12/31/82	0.110	0.096	10/2/82	0.044	0.04	11/1/82	0.028	0.048
			10/8/82	0.032	0.0364	11/7/82	0.030	0.045
			10/14/82	0.107	0.0456	11/13/82	0.052	0.039
			10/20/82	0.056	0.0522	11/19/82	0.031	0.030
			10/26/82	0.022	0.0522	11/25/82	0.043	0.037
			11/1/82	0.053	0.054	12/2/82	0.066	0.044
			11/7/82	0.024	0.0524	12/7/82	0.022	0.043
			11/13/82	0.063	0.0436	12/13/82	0.093	0.051
			11/19/82	0.025	0.0374	12/19/82	0.028	0.050
			11/25/82	0.064	0.0458	12/25/82	0.067	0.055
			12/1/82	0.029	0.041	12/31/82	0.014	0.045
			12/7/82	0.056	0.0474			
			12/13/82	0.046	0.044			
			12/19/82	0.03	0.045			
			12/25/82	0.036	0.0394			
			12/31/82	0.075	0.0486			

Source: DTN: MO008SPATSP00.013 (DIRS 151750).

[a] Running average of the measurement for a day and the four previous measurements.

TSP=total suspended particles

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APPENDIX E

TSP:PM_{10} RATIOS–YUCCA MOUNTAIN

APPENDIX E

TSP:PM_{10} RATIOS–YUCCA MOUNTAIN

Table E-1 presents 1,276 measurements of PM_{10} and TSP concentrations (μg/m^3) taken simultaneously at three sites at Yucca Mountain from 1989 through 1997 (no measurements were take from October through December 1991), and the TSP:PM_{10} ratio of those measurements. Measurements resulting in 24 ratios of less than or equal to 1.0 are not shown (see Section 6.1.3.1 for justification).

Table E-1. TSP:PM_{10} Ratios–Yucca Mountain, 1989–1997

Site	Date	PM_{10}	TSP[a]	Ratio[b]	DTN
1	4/22/89	17	37	2.2	TM000000000001.082
1C	4/22/89	18	35	1.9	TM000000000001.082
1C	4/28/89	6	12	2.0	TM000000000001.082
1	5/4/89	8	12	1.5	TM000000000001.082
1C	5/4/89	10	11	1.1	TM000000000001.082
1	5/10/89	12	24	2.0	TM000000000001.082
5	5/10/89	15	34	2.3	TM000000000001.082
1C	5/10/89	12	23	1.9	TM000000000001.082
1	5/16/89	9	12	1.3	TM000000000001.082
5	5/16/89	10	18	1.8	TM000000000001.082
1C	5/16/89	7	11	1.6	TM000000000001.082
1	5/22/89	15	27	1.8	TM000000000001.082
5	5/22/89	16	32	2.0	TM000000000001.082
1	6/3/89	11	17	1.5	TM000000000001.082
5	6/3/89	11	23	2.1	TM000000000001.082
1C	6/3/89	13	16	1.2	TM000000000001.082
1	6/9/89	13	26	2.0	TM000000000001.082
5	6/9/89	18	62	3.4	TM000000000001.082
1C	6/9/89	12	23	1.9	TM000000000001.082
1	6/15/89	16	24	1.5	TM000000000001.082
5	6/15/89	17	30	1.8	TM000000000001.082
1C	6/15/89	15	24	1.6	TM000000000001.082
5	6/21/89	8	21	2.6	TM000000000001.082
1	6/27/89	13	25	1.9	TM000000000001.082
5	6/27/89	15	39	2.6	TM000000000001.082
1C	6/27/89	12	26	2.2	TM000000000001.082
1	7/3/89	10	15	1.5	TM000000000001.082
1	7/9/89	41	88	2.1	TM000000000001.082
5	7/9/89	38	90	2.4	TM000000000001.082
1C	7/9/89	38	86	2.3	TM000000000001.082
5	7/15/89	18	34	1.9	TM000000000001.082
1	7/21/89	26	52	2.0	TM000000000001.082
5	7/21/89	26	50	1.9	TM000000000001.082
1	7/27/89	27	50	1.9	TM000000000001.082
1C	7/27/89	27	48	1.8	TM000000000001.082
1	8/8/89	23	42	1.8	TM000000000001.082
5	8/8/89	22	58	2.6	TM000000000001.082
1	8/20/89	16	34	2.1	TM000000000001.082
5	8/20/89	13	27	2.1	TM000000000001.082
1	8/26/89	14	30	2.1	TM000000000001.082
5	8/26/89	14	23	1.6	TM000000000001.082
1C	8/26/89	19	34	1.8	TM000000000001.082
1	9/1/89	10	24	2.4	TM000000000001.082
1	9/7/89	17	41	2.4	TM000000000001.082
5	9/7/89	16	40	2.5	TM000000000001.082
1	9/13/89	9	17	1.9	TM000000000001.082
5	9/13/89	10	21	2.1	TM000000000001.082
1C	9/13/89	9	13	1.4	TM000000000001.082
1C	9/19/89	8	13	1.6	TM000000000001.082
1	9/25/89	9	20	2.2	TM000000000001.082
1C	9/25/89	9	15	1.7	TM000000000001.082
1	10/7/89	7	11	1.6	TM000000000001.082
1C	10/7/89	6	9	1.5	TM000000000001.082
5	10/13/89	11	22	2.0	TM000000000001.082
1	10/19/89	7	88	12.6	TM000000000001.082
1	10/25/89	4	19	4.8	TM000000000001.082
5	10/25/89	5	16	3.2	TM000000000001.082
5	10/31/89	5	11	2.2	TM000000000001.082
1	11/6/89	8	23	2.9	TM000000000001.082
5	11/6/89	9	17	1.9	TM000000000001.082
1	11/12/89	7	15	2.1	TM000000000001.082
5	11/12/89	8	14	1.8	TM000000000001.082
1	11/18/89	3	10	3.3	TM000000000001.082
5	11/18/89	5	9	1.8	TM000000000001.082
1	11/24/89	16	29	1.8	TM000000000001.082
1	11/30/89	2	8	4.0	TM000000000001.082

Table E-1. TSP:PM_{10} Ratios – Yucca Mountain, 1989–1997 (Continued)

Site	Date	PM_{10}	TSP[a]	Ratio[b]	DTN
1	12/6/89	3	9	3.0	TM000000000001.082
5	12/6/89	4	14	3.5	TM000000000001.082
1	12/12/89	5	9	1.8	TM000000000001.082
5	12/12/89	3	5	1.7	TM000000000001.082
1	12/18/89	4	12	3.0	TM000000000001.082
5	12/18/89	5	11	2.2	TM000000000001.082
1	12/24/89	2	4	2.0	TM000000000001.082
5	12/24/89	2	3	1.5	TM000000000001.082
5	12/30/89	2	10	5.0	TM000000000001.082
1	1/5/90	2	4	2.0	TM000000000001.082
5	1/5/90	2	4	2.0	TM000000000001.082
1	1/11/90	4	7	1.8	TM000000000001.082
5	1/11/90	4	6	1.5	TM000000000001.082
1C	1/11/90	4	7	1.8	TM000000000001.082
1	1/17/90	3	4	1.3	TM000000000001.082
1C	1/17/90	2	3	1.5	TM000000000001.082
1	1/23/90	3	6	2.0	TM000000000001.082
1C	1/23/90	3	5	1.7	TM000000000001.082
1	1/29/90	4	9	2.3	TM000000000001.082
1C	1/29/90	3	9	3.0	TM000000000001.082
1	2/4/90	5	10	2.0	TM000000000001.082
1C	2/4/90	5	10	2.0	TM000000000001.082
1	2/10/90	2	4	2.0	TM000000000001.082
1C	2/28/90	7	12	1.7	TM000000000001.082
1	3/6/90	2	5	2.5	TM000000000001.082
1C	3/6/90	2	4	2.0	TM000000000001.082
1	3/12/90	1	9	9.0	TM000000000001.082
1C	3/12/90	1	9	9.0	TM000000000001.082
1	3/18/90	4	6	1.5	TM000000000001.082
1C	3/18/90	4	5	1.3	TM000000000001.082
1	3/24/90	6	9	1.5	TM000000000001.082
1C	3/24/90	6	8	1.3	TM000000000001.082
1	3/30/90	6	11	1.8	TM000000000001.082
1C	3/30/90	6	11	1.8	TM000000000001.082
1	4/5/90	7	12	1.7	TM000000000001.082
1C	4/5/90	8	14	1.8	TM000000000001.082
1	4/11/90	7	8	1.1	TM000000000001.082
1C	4/11/90	7	8	1.1	TM000000000001.082
1	4/17/90	5	8	1.6	TM000000000001.082
1C	4/17/90	5	10	2.0	TM000000000001.082
1	4/23/90	25	56	2.2	TM000000000001.082
1	4/29/90	8	17	2.1	TM000000000001.082
1	5/11/90	24	40	1.7	TM000000000001.082
1	5/23/90	31	64	2.1	TM000000000001.082
1	5/29/90	5	7	1.4	TM000000000001.082
1	6/4/90	12	19	1.6	TM000000000001.082
1	6/10/90	7	21	3.0	TM000000000001.082
1	6/16/90	8	30	3.8	TM000000000001.082
1	6/22/90	13	48	3.7	TM000000000001.082
1	6/28/90	10	38	3.8	TM000000000001.082
1	7/4/90	15	24	1.6	TM000000000001.082
1	7/10/90	12	21	1.8	TM000000000001.082
1	7/16/90	9	19	2.1	TM000000000001.082
1	7/28/90	14	29	2.1	TM000000000001.082
1	8/3/90	41	80	2.0	TM000000000001.082
1	8/21/90	15	26	1.7	TM000000000001.082
1	9/8/90	14	23	1.6	TM000000000001.082
1	9/14/90	11	21	1.9	TM000000000001.082
1	9/20/90	9	18	2.0	TM000000000001.082
1	9/26/90	12	20	1.7	TM000000000001.082
1	10/8/90	9	14	1.6	TM000000000001.082
5	10/8/90	7	18	2.6	TM000000000001.082
1C	10/8/90	8	13	1.6	TM000000000001.082
1	10/14/90	9	13	1.4	TM000000000001.082
5	10/14/90	8	12	1.5	TM000000000001.082
1C	10/14/90	8	11	1.4	TM000000000001.082
1	10/20/90	4	8	2.0	TM000000000001.082
5	10/20/90	5	9	1.8	TM000000000001.082
1C	10/20/90	4	6	1.5	TM000000000001.082
5	10/26/90	8	11	1.4	TM000000000001.082
1C	10/26/90	6	11	1.8	TM000000000001.082
1	11/1/90	6	18	3.0	TM000000000001.082
1	11/7/90	2	9	4.5	TM000000000001.082
5	11/7/90	6	13	2.2	TM000000000001.082
1C	11/7/90	3	8	2.7	TM000000000001.082
1	11/13/90	8	9	1.1	TM000000000001.082
5	11/13/90	5	8	1.6	TM000000000001.082
1C	11/13/90	6	8	1.3	TM000000000001.082
1	11/19/90	11	19	1.7	TM000000000001.082
5	11/19/90	12	18	1.5	TM000000000001.082
1C	11/19/90	11	17	1.5	TM000000000001.082
1	11/25/90	62	152	2.5	TM000000000001.082
1	12/1/90	4	11	2.8	TM000000000001.082
1C	12/1/90	3	13	4.3	TM000000000001.082
1	12/7/90	4	13	3.3	TM000000000001.082
5	12/7/90	4	7	1.8	TM000000000001.082

Table E-1. TSP:PM$_{10}$ Ratios – Yucca Mountain, 1989–1997 (Continued)

Site	Date	PM$_{10}$	TSP[a]	Ratio[b]	DTN
5	12/13/90	9	16	1.8	TM000000000001.082
1C	12/13/90	10	15	1.5	TM000000000001.082
1	12/19/90	49	145	3.0	TM000000000001.082
5	12/25/90	1	6	6.0	TM000000000001.082
1	12/31/90	1	7	7.0	TM000000000001.082
5	12/31/90	2	10	5.0	TM000000000001.082
1	1/6/91	1	4	4.0	TM000000000001.041
1	1/12/91	1	6	6.0	TM000000000001.041
5	1/12/91	4	11	2.8	TM000000000001.041
1	1/30/91	6	27	4.5	TM000000000001.041
5	1/30/91	3	24	8.0	TM000000000001.041
1C	1/30/91	6	27	4.5	TM000000000001.041
1	2/5/91	5	14	2.8	TM000000000001.041
5	2/11/91	6	11	1.8	TM000000000001.041
1	2/17/91	4	10	2.5	TM000000000001.041
5	2/17/91	5	14	2.8	TM000000000001.041
1C	2/17/91	4	9	2.3	TM000000000001.041
1	2/23/91	7	13	1.9	TM000000000001.041
1C	2/23/91	7	10	1.4	TM000000000001.041
1	3/1/91	1	4	4.0	TM000000000001.041
5	3/1/91	2	4	2.0	TM000000000001.041
1C	3/1/91	1	4	4.0	TM000000000001.041
1	3/7/91	2	4	2.0	TM000000000001.041
5	3/7/91	3	5	1.7	TM000000000001.041
1C	3/7/91	2	4	2.0	TM000000000001.041
1	3/13/91	6	14	2.3	TM000000000001.041
5	3/13/91	5	14	2.8	TM000000000001.041
1C	3/13/91	6	13	2.2	TM000000000001.041
1	3/19/91	4	14	3.5	TM000000000001.041
5	3/19/91	5	16	3.2	TM000000000001.041
1C	3/19/91	5	14	2.8	TM000000000001.041
1	3/25/91	9	21	2.3	TM000000000001.041
5	3/25/91	10	23	2.3	TM000000000001.041
1C	3/25/91	9	20	2.2	TM000000000001.041
1	3/31/91	7	13	1.9	TM000000000001.041
1C	3/31/91	7	12	1.7	TM000000000001.041
5	4/6/91	16	41	2.6	TM000000000001.041
1C	4/6/91	22	49	2.2	TM000000000001.041
1	4/12/91	6	12	2.0	TM000000000001.041
5	4/12/91	4	13	3.3	TM000000000001.041
1C	4/12/91	5	18	3.6	TM000000000001.041
1	4/18/91	6	10	1.7	TM000000000001.041
1	4/24/91	18	33	1.8	TM000000000001.041
5	4/24/91	20	33	1.7	TM000000000001.041
1C	4/24/91	19	33	1.7	TM000000000001.041
1	4/30/91	10	20	2.0	TM000000000001.041
5	4/30/91	10	19	1.9	TM000000000001.041
1C	4/30/91	10	19	1.9	TM000000000001.041
1	5/6/91	9	18	2.0	TM000000000001.041
5	5/6/91	10	14	1.4	TM000000000001.041
1C	5/6/91	9	16	1.8	TM000000000001.041
5	5/12/91	11	20	1.8	TM000000000001.041
1C	5/12/91	10	21	2.1	TM000000000001.041
1	5/18/91	8	21	2.6	TM000000000001.041
1C	5/18/91	9	21	2.3	TM000000000001.041
1	5/24/91	11	18	1.6	TM000000000001.041
5	5/24/91	11	17	1.5	TM000000000001.041
1C	5/24/91	11	18	1.6	TM000000000001.041
1	5/30/91	22	63	2.9	TM000000000001.041
5	5/30/91	33	103	3.1	TM000000000001.041
1	6/5/91	20	37	1.9	TM000000000001.041
5	6/5/91	22	41	1.9	TM000000000001.041
1C	6/5/91	17	37	2.2	TM000000000001.041
1	6/11/91	21	40	1.9	TM000000000001.041
1C	6/11/91	21	41	2.0	TM000000000001.041
1	6/17/91	12	28	2.3	TM000000000001.041
1	6/23/91	15	27	1.8	TM000000000001.041
1C	6/23/91	15	24	1.6	TM000000000001.041
5	6/29/91	11	26	2.4	TM000000000001.041
1	7/5/91	25	62	2.5	TM000000000001.042
5	7/5/91	26	54	2.1	TM000000000001.042
1C	7/5/91	27	59	2.2	TM000000000001.042
5	7/11/91	12	24	2.0	TM000000000001.042
1C	7/11/91	13	19	1.5	TM000000000001.042
1	7/17/91	10	15	1.5	TM000000000001.042
5	7/17/91	9	18	2.0	TM000000000001.042
1	7/23/91	9	17	1.9	TM000000000001.042
5	7/23/91	9	16	1.8	TM000000000001.042
1C	7/23/91	9	18	2.0	TM000000000001.042
1	7/29/91	14	35	2.5	TM000000000001.042
5	7/29/91	15	38	2.5	TM000000000001.042
1C	7/29/91	14	38	2.7	TM000000000001.042
1	8/4/91	10	20	2.0	TM000000000001.042
5	8/4/91	31	53	1.7	TM000000000001.042
1	8/10/91	33	61	1.8	TM000000000001.042
5	8/10/91	45	87	1.9	TM000000000001.042

Table E-1. TSP:PM$_{10}$ Ratios – Yucca Mountain, 1989–1997 (Continued)

Site	Date	PM$_{10}$	TSP[a]	Ratio[b]	DTN
1C	8/10/91	31	63	2.0	TM000000000001.042
5	8/16/91	15	24	1.6	TM000000000001.042
1C	8/16/91	15	26	1.7	TM000000000001.042
5	8/22/91	10	20	2.0	TM000000000001.042
1C	8/22/91	16	29	1.8	TM000000000001.042
1	8/28/91	11	28	2.5	TM000000000001.042
5	8/28/91	11	28	2.5	TM000000000001.042
1C	8/28/91	14	26	1.9	TM000000000001.042
1	9/3/91	17	45	2.6	TM000000000001.042
5	9/3/91	16	45	2.8	TM000000000001.042
1C	9/3/91	17	44	2.6	TM000000000001.042
1	9/9/91	14	33	2.4	TM000000000001.042
5	9/9/91	17	41	2.4	TM000000000001.042
1	9/15/91	6	15	2.5	TM000000000001.042
5	9/15/91	6	16	2.7	TM000000000001.042
1C	9/15/91	6	20	3.3	TM000000000001.042
1	9/21/91	18	35	1.9	TM000000000001.042
5	9/21/91	17	33	1.9	TM000000000001.042
1C	9/21/91	17	48	2.8	TM000000000001.042
1	9/27/91	12	22	1.8	TM000000000001.042
1C	9/27/91	9	28	3.1	TM000000000001.042
1	1/1/92	3	7	2.3	TM000000000001.039
5	1/1/92	3	5	1.7	TM000000000001.039
1C	1/1/92	3	7	2.3	TM000000000001.039
1	1/7/92	3	5	1.7	TM000000000001.039
5	1/7/92	3	7	2.3	TM000000000001.039
1C	1/7/92	2	6	3.0	TM000000000001.039
1	1/13/92	2	7	3.5	TM000000000001.039
1C	1/13/92	3	6	2.0	TM000000000001.039
1	1/19/92	3	6	2.0	TM000000000001.039
5	1/19/92	3	6	2.0	TM000000000001.039
1C	1/19/92	3	5	1.7	TM000000000001.039
5	1/25/92	5	14	2.8	TM000000000001.039
1C	1/25/92	4	8	2.0	TM000000000001.039
1	1/31/92	5	10	2.0	TM000000000001.039
5	1/31/92	15	38	2.5	TM000000000001.039
1C	1/31/92	6	10	1.7	TM000000000001.039
1	2/6/92	5	11	2.2	TM000000000001.039
5	2/6/92	5	10	2.0	TM000000000001.039
1C	2/6/92	5	10	2.0	TM000000000001.039
1	2/12/92	2	5	2.5	TM000000000001.039
5	2/12/92	3	5	1.7	TM000000000001.039
1C	2/12/92	2	5	2.5	TM000000000001.039
5	2/19/92	4	9	2.3	TM000000000001.039
1C	2/19/92	5	10	2.0	TM000000000001.039
1	2/24/92	3	8	2.7	TM000000000001.039
5	2/24/92	7	21	3.0	TM000000000001.039
1C	2/24/92	3	9	3.0	TM000000000001.039
5	3/1/92	7	16	2.3	TM000000000001.039
1	3/7/92	3	7	2.3	TM000000000001.039
5	3/7/92	3	6	2.0	TM000000000001.039
1C	3/7/92	2	7	3.5	TM000000000001.039
1	3/13/92	9	14	1.6	TM000000000001.039
5	3/13/92	10	20	2.0	TM000000000001.039
1C	3/13/92	8	15	1.9	TM000000000001.039
1	3/19/92	8	14	1.8	TM000000000001.039
5	3/19/92	11	22	2.0	TM000000000001.039
1C	3/19/92	8	15	1.9	TM000000000001.039
1	3/25/92	5	9	1.8	TM000000000001.039
5	3/25/92	5	13	2.6	TM000000000001.039
1C	3/25/92	5	8	1.6	TM000000000001.039
1	3/31/92	2	5	2.5	TM000000000001.039
5	3/31/92	3	6	2.0	TM000000000001.039
1C	3/31/92	3	6	2.0	TM000000000001.039
1	4/6/92	15	24	1.6	TM000000000001.039
5	4/6/92	18	31	1.7	TM000000000001.039
1C	4/6/92	15	25	1.7	TM000000000001.039
1	4/12/92	11	21	1.9	TM000000000001.039
5	4/12/92	13	24	1.8	TM000000000001.039
1C	4/12/92	11	23	2.1	TM000000000001.039
1	4/18/92	12	30	2.5	TM000000000001.039
5	4/18/92	14	39	2.8	TM000000000001.039
1C	4/18/92	12	30	2.5	TM000000000001.039
1	4/24/92	12	21	1.8	TM000000000001.039
5	4/24/92	14	25	1.8	TM000000000001.039
1C	4/24/92	12	22	1.8	TM000000000001.039
5	4/30/92	49	130	2.7	TM000000000001.039
1C	4/30/92	23	61	2.7	TM000000000001.039
1	5/6/92	6	14	2.3	TM000000000001.039
1C	5/6/92	6	15	2.5	TM000000000001.039
1	5/12/92	15	27	1.8	TM000000000001.039
5	5/12/92	15	31	2.1	TM000000000001.039
1C	5/12/92	15	28	1.9	TM000000000001.039
1	5/18/92	13	24	1.8	TM000000000001.039
5	5/18/92	14	27	1.9	TM000000000001.039
1C	5/18/92	12	25	2.1	TM000000000001.039

Table E-1. TSP:PM_{10} Ratios – Yucca Mountain, 1989–1997 (Continued)

Site	Date	PM_{10}	TSP[a]	Ratio[b]	DTN
1	5/24/92	10	18	1.8	TM000000000001.039
5	5/24/92	9	20	2.2	TM000000000001.039
1	5/30/92	13	26	2.0	TM000000000001.039
5	5/30/92	12	31	2.6	TM000000000001.039
1C	5/30/92	13	28	2.2	TM000000000001.039
1	6/5/92	24	59	2.5	TM000000000001.039
5	6/5/92	24	61	2.5	TM000000000001.039
1C	6/5/92	24	58	2.4	TM000000000001.039
1	6/11/92	23	42	1.8	TM000000000001.039
5	6/11/92	22	41	1.9	TM000000000001.039
1C	6/11/92	22	45	2.0	TM000000000001.039
1	6/17/92	10	23	2.3	TM000000000001.039
5	6/17/92	9	24	2.7	TM000000000001.039
1C	6/17/92	10	24	2.4	TM000000000001.039
1	6/23/92	18	37	2.1	TM000000000001.039
5	6/23/92	17	32	1.9	TM000000000001.039
1C	6/23/92	17	40	2.4	TM000000000001.039
1	6/29/92	21	67	3.2	TM000000000001.039
5	6/29/92	21	73	3.5	TM000000000001.039
1C	6/29/92	20	68	3.4	TM000000000001.039
1	7/5/92	12	32	2.7	TM000000000001.039
5	7/5/92	8	24	3.0	TM000000000001.039
1C	7/5/92	11	30	2.7	TM000000000001.039
1	7/11/92	21	50	2.4	TM000000000001.039
5	7/11/92	19	41	2.2	TM000000000001.039
1C	7/11/92	21	49	2.3	TM000000000001.039
1	7/17/92	16	39	2.4	TM000000000001.039
5	7/17/92	14	31	2.2	TM000000000001.039
1	7/23/92	18	43	2.4	TM000000000001.039
5	7/23/92	17	37	2.2	TM000000000001.039
1	7/29/92	16	36	2.3	TM000000000001.039
5	7/29/92	14	30	2.1	TM000000000001.039
1	8/4/92	30	73	2.4	TM000000000001.039
5	8/4/92	26	62	2.4	TM000000000001.039
1	8/10/92	14	35	2.5	TM000000000001.039
5	8/10/92	12	27	2.3	TM000000000001.039
1	8/16/92	19	41	2.2	TM000000000001.039
5	8/16/92	18	47	2.6	TM000000000001.039
5	8/22/92	19	63	3.3	TM000000000001.039
1C	8/22/92	18	54	3.0	TM000000000001.039
1	8/28/92	17	39	2.3	TM000000000001.039
5	8/28/92	15	37	2.5	TM000000000001.039
1	9/3/92	20	53	2.7	TM000000000001.039
5	9/3/92	20	52	2.6	TM000000000001.039
1	9/9/92	15	28	1.9	TM000000000001.039
5	9/9/92	13	25	1.9	TM000000000001.039
1	9/15/92	14	28	2.0	TM000000000001.039
1	9/21/92	14	28	2.0	TM000000000001.039
1	9/27/92	12	24	2.0	TM000000000001.039
5	9/27/92	11	24	2.2	TM000000000001.039
1	10/3/92	9	20	2.2	TM000000000001.079
5	10/3/92	8	25	3.1	TM000000000001.079
1C	10/3/92	7	22	3.1	TM000000000001.079
1	10/9/92	12	23	1.9	TM000000000001.079
5	10/9/92	11	20	1.8	TM000000000001.079
1C	10/9/92	12	24	2.0	TM000000000001.079
1	10/15/92	24	41	1.7	TM000000000001.079
5	10/15/92	27	48	1.8	TM000000000001.079
1C	10/15/92	24	42	1.8	TM000000000001.079
1	10/21/92	24	42	1.8	TM000000000001.079
5	10/21/92	19	31	1.6	TM000000000001.079
1C	10/21/92	23	43	1.9	TM000000000001.079
1	10/27/92	5	13	2.6	TM000000000001.079
5	10/27/92	5	10	2.0	TM000000000001.079
1C	10/27/92	5	13	2.6	TM000000000001.079
1	11/2/92	22	56	2.5	TM000000000001.079
5	11/2/92	15	51	3.4	TM000000000001.079
1C	11/2/92	16	54	3.4	TM000000000001.079
5	11/8/92	11	16	1.5	TM000000000001.079
1	11/14/92	1	3	3.0	TM000000000001.079
5	11/14/92	5	11	2.2	TM000000000001.079
1	11/20/92	21	45	2.1	TM000000000001.079
5	11/20/92	19	69	3.6	TM000000000001.079
1C	11/20/92	14	45	3.2	TM000000000001.079
1	12/2/92	15	35	2.3	TM000000000001.079
5	12/2/92	7	22	3.1	TM000000000001.079
1C	12/2/92	14	34	2.4	TM000000000001.079
1	12/8/92	11	13	1.2	TM000000000001.079
1C	12/8/92	9	12	1.3	TM000000000001.079
1	12/16/92	9	25	2.8	TM000000000001.079
1	12/26/92	4	15	3.8	TM000000000001.079
5	12/26/92	11	15	1.4	TM000000000001.079
1C	12/26/92	5	6	1.2	TM000000000001.079
5	1/7/93	9	11	1.2	TM000000000001.079
5	1/13/93	4	14	3.5	TM000000000001.079
1C	1/13/93	6	11	1.8	TM000000000001.079

Table E-1. TSP:PM_{10} Ratios – Yucca Mountain, 1989–1997 (Continued)

Site	Date	PM_{10}	TSP[a]	Ratio[b]	DTN
5	1/25/93	1	5	5.0	TM000000000001.079
1C	1/25/93	10	29	2.9	TM000000000001.079
1	1/31/93	4	6	1.5	TM000000000001.079
1C	1/31/93	3	5	1.7	TM000000000001.079
1	2/6/93	5	10	2.0	TM000000000001.079
1C	2/6/93	6	8	1.3	TM000000000001.079
5	2/12/93	2	6	3.0	TM000000000001.079
1	2/18/93	6	12	2.0	TM000000000001.079
5	2/18/93	5	10	2.0	TM000000000001.079
1C	2/18/93	5	11	2.2	TM000000000001.079
1	2/24/93	2	7	3.5	TM000000000001.079
5	2/24/93	2	9	4.5	TM000000000001.079
1C	2/24/93	2	11	5.5	TM000000000001.079
5	3/2/93	3	10	3.3	TM000000000001.079
1	3/3/93	3	11	3.7	TM000000000001.079
1C	3/3/93	4	10	2.5	TM000000000001.079
1	3/8/93	6	21	3.5	TM000000000001.079
5	3/8/93	4	11	2.8	TM000000000001.079
1C	3/8/93	7	19	2.7	TM000000000001.079
1	3/14/93	7	14	2.0	TM000000000001.079
5	3/14/93	6	14	2.3	TM000000000001.079
1C	3/14/93	6	13	2.2	TM000000000001.079
1	3/20/93	7	19	2.7	TM000000000001.079
5	3/20/93	6	14	2.3	TM000000000001.079
1C	3/20/93	7	17	2.4	TM000000000001.079
1	3/26/93	6	18	3.0	TM000000000001.079
5	3/26/93	6	53	8.8	TM000000000001.079
1C	3/26/93	7	15	2.1	TM000000000001.079
1	4/1/93	8	18	2.3	TM000000000001.079
5	4/1/93	7	17	2.4	TM000000000001.079
1C	4/1/93	7	19	2.7	TM000000000001.079
1	4/7/93	10	30	3.0	TM000000000001.079
5	4/7/93	5	12	2.4	TM000000000001.079
1C	4/7/93	11	30	2.7	TM000000000001.079
1	4/13/93	5	20	4.0	TM000000000001.079
5	4/13/93	4	13	3.3	TM000000000001.079
1C	4/13/93	5	19	3.8	TM000000000001.079
1	4/19/93	7	24	3.4	TM000000000001.079
5	4/19/93	7	24	3.4	TM000000000001.079
1C	4/19/93	8	24	3.0	TM000000000001.079
1	4/25/93	7	21	3.0	TM000000000001.079
5	4/25/93	7	22	3.1	TM000000000001.079
1C	4/25/93	7	18	2.6	TM000000000001.079
1	5/1/93	18	33	1.8	TM000000000001.079
5	5/1/93	19	33	1.7	TM000000000001.079
1C	5/1/93	18	34	1.9	TM000000000001.079
5	5/7/93	13	28	2.2	TM000000000001.079
1	5/13/93	19	42	2.2	TM000000000001.079
5	5/13/93	20	49	2.5	TM000000000001.079
1C	5/13/93	19	42	2.2	TM000000000001.079
1	5/19/93	16	28	1.8	TM000000000001.079
5	5/19/93	15	27	1.8	TM000000000001.079
1C	5/19/93	16	28	1.8	TM000000000001.079
1	5/25/93	13	33	2.5	TM000000000001.079
5	5/25/93	9	30	3.3	TM000000000001.079
1C	5/25/93	11	35	3.2	TM000000000001.079
1	5/31/93	15	39	2.6	TM000000000001.079
5	5/31/93	19	56	2.9	TM000000000001.079
1C	5/31/93	15	39	2.6	TM000000000001.079
1	6/6/93	4	14	3.5	TM000000000001.079
5	6/6/93	4	16	4.0	TM000000000001.079
1C	6/6/93	4	13	3.3	TM000000000001.079
1	6/12/93	15	31	2.1	TM000000000001.079
5	6/12/93	14	32	2.3	TM000000000001.079
1C	6/12/93	15	32	2.1	TM000000000001.079
1	6/18/93	8	18	2.3	TM000000000001.079
5	6/18/93	8	16	2.0	TM000000000001.079
5	6/24/93	8	21	2.6	TM000000000001.079
1C	6/24/93	9	27	3.0	TM000000000001.079
1	6/30/93	15	36	2.4	TM000000000001.079
5	6/30/93	12	28	2.3	TM000000000001.079
1C	6/30/93	14	35	2.5	TM000000000001.079
1	7/7/93	20	37	1.9	TM000000000001.079
5	7/7/93	19	36	1.9	TM000000000001.079
1C	7/7/93	20	38	1.9	TM000000000001.079
1	7/12/93	21	46	2.2	TM000000000001.079
5	7/12/93	21	46	2.2	TM000000000001.079
1C	7/12/93	21	44	2.1	TM000000000001.079
1	7/18/93	16	29	1.8	TM000000000001.079
5	7/18/93	16	31	1.9	TM000000000001.079
1C	7/18/93	13	30	2.3	TM000000000001.079
1	7/24/93	9	22	2.4	TM000000000001.079
5	7/24/93	8	25	3.1	TM000000000001.079
1C	7/24/93	9	22	2.4	TM000000000001.079
1	7/30/93	11	25	2.3	TM000000000001.079
5	7/30/93	9	21	2.3	TM000000000001.079

Table E-1. TSP:PM_{10} Ratios – Yucca Mountain, 1989–1997 (Continued)

Site	Date	PM_{10}	TSP[a]	Ratio[b]	DTN
1C	7/30/93	12	25	2.1	TM000000000001.079
1	8/5/93	14	40	2.9	TM000000000001.079
5	8/5/93	11	28	2.5	TM000000000001.079
1	8/11/93	30	86	2.9	TM000000000001.079
5	8/11/93	12	32	2.7	TM000000000001.079
1C	8/11/93	32	82	2.6	TM000000000001.079
1	8/17/93	16	36	2.3	TM000000000001.079
5	8/17/93	10	16	1.6	TM000000000001.079
1C	8/17/93	16	35	2.2	TM000000000001.079
5	8/23/93	12	25	2.1	TM000000000001.079
1C	8/23/93	14	29	2.1	TM000000000001.079
5	8/29/93	12	27	2.3	TM000000000001.079
1C	8/29/93	13	29	2.2	TM000000000001.079
1	9/4/93	9	25	2.8	TM000000000001.079
5	9/4/93	9	21	2.3	TM000000000001.079
1C	9/4/93	8	27	3.4	TM000000000001.079
5	9/10/93	8	20	2.5	TM000000000001.079
1C	9/10/93	11	28	2.5	TM000000000001.079
1	9/16/93	22	45	2.0	TM000000000001.079
5	9/16/93	20	45	2.3	TM000000000001.079
1C	9/16/93	20	46	2.3	TM000000000001.079
1	9/22/93	15	27	1.8	TM000000000001.079
5	9/22/93	14	26	1.9	TM000000000001.079
1C	9/22/93	15	27	1.8	TM000000000001.079
1	9/28/93	12	24	2.0	TM000000000001.079
5	9/28/93	10	20	2.0	TM000000000001.079
1C	9/28/93	11	24	2.2	TM000000000001.079
1	10/4/93	17	46	2.7	TM000000000001.079
5	10/4/93	20	54	2.7	TM000000000001.079
1C	10/4/93	18	43	2.4	TM000000000001.079
1	10/10/93	10	20	2.0	TM000000000001.079
5	10/10/93	8	16	2.0	TM000000000001.079
1C	10/10/93	9	19	2.1	TM000000000001.079
1	10/16/93	7	17	2.4	TM000000000001.079
5	10/16/93	6	15	2.5	TM000000000001.079
1C	10/16/93	6	17	2.8	TM000000000001.079
1	10/22/93	8	19	2.4	TM000000000001.079
5	10/22/93	6	15	2.5	TM000000000001.079
1C	10/22/93	8	19	2.4	TM000000000001.079
1	10/28/93	10	27	2.7	TM000000000001.079
5	10/28/93	6	13	2.2	TM000000000001.079
1C	10/28/93	10	28	2.8	TM000000000001.079
1	11/3/93	12	20	1.7	TM000000000001.079
5	11/3/93	8	15	1.9	TM000000000001.079
1C	11/3/93	13	19	1.5	TM000000000001.079
1C	11/9/93	12	22	1.8	TM000000000001.079
1	11/15/93	6	14	2.3	TM000000000001.079
5	11/15/93	5	10	2.0	TM000000000001.079
1C	11/15/93	6	14	2.3	TM000000000001.079
1	11/21/93	5	12	2.4	TM000000000001.079
5	11/21/93	6	14	2.3	TM000000000001.079
1	11/27/93	4	8	2.0	TM000000000001.079
5	11/27/93	1	6	6.0	TM000000000001.079
1C	11/27/93	4	7	1.8	TM000000000001.079
5	12/3/93	3	6	2.0	TM000000000001.079
1C	12/3/93	6	12	2.0	TM000000000001.079
5	12/9/93	9	16	1.8	TM000000000001.079
1C	12/9/93	10	19	1.9	TM000000000001.079
1	12/15/93	2	8	4.0	TM000000000001.079
5	12/15/93	2	7	3.5	TM000000000001.079
1C	12/15/93	2	7	3.5	TM000000000001.079
1	12/21/93	3	9	3.0	TM000000000001.079
5	12/21/93	2	6	3.0	TM000000000001.079
1C	12/21/93	3	6	2.0	TM000000000001.079
1	12/27/93	5	11	2.2	TM000000000001.079
1C	12/27/93	4	9	2.3	TM000000000001.079
1	1/2/94	3	9	3.0	TM000000000001.079
5	1/2/94	3	11	3.7	TM000000000001.079
1C	1/2/94	2	8	4.0	TM000000000001.079
1	1/8/94	2	8	4.0	TM000000000001.079
5	1/8/94	2	5	2.5	TM000000000001.079
1	1/14/94	5	16	3.2	TM000000000001.079
5	1/14/94	1	7	7.0	TM000000000001.079
1C	1/14/94	5	15	3.0	TM000000000001.079
1	1/20/94	5	13	2.6	TM000000000001.079
5	1/20/94	3	9	3.0	TM000000000001.079
1C	1/20/94	5	10	2.0	TM000000000001.079
1	1/26/94	3	12	4.0	TM000000000001.079
5	1/26/94	1	5	5.0	TM000000000001.079
1C	1/26/94	2	12	6.0	TM000000000001.079
1	2/1/94	4	18	4.5	TM000000000001.079
5	2/1/94	1	4	4.0	TM000000000001.079
1C	2/1/94	5	16	3.2	TM000000000001.079
1	2/7/94	4	8	2.0	TM000000000001.079
5	2/7/94	5	7	1.4	TM000000000001.079
1C	2/7/94	3	8	2.7	TM000000000001.079

Table E-1. TSP:PM_{10} Ratios – Yucca Mountain, 1989–1997 (Continued)

Site	Date	PM_{10}	TSP[a]	Ratio[b]	DTN
5	2/13/94	2	6	3.0	TM000000000001.079
1	2/15/94	10	21	2.1	TM000000000001.079
1C	2/15/94	10	21	2.1	TM000000000001.079
1	2/19/94	1	7	7.0	TM000000000001.079
1C	2/19/94	3	8	2.7	TM000000000001.079
1	2/25/94	3	13	4.3	TM000000000001.079
5	2/25/94	3	7	2.3	TM000000000001.079
1C	2/25/94	3	11	3.7	TM000000000001.079
1	3/3/94	6	11	1.8	TM000000000001.079
5	3/3/94	5	9	1.8	TM000000000001.079
1C	3/3/94	5	12	2.4	TM000000000001.079
1C	3/9/94	5	12	2.4	TM000000000001.079
1	3/15/94	7	17	2.4	TM000000000001.079
5	3/15/94	9	18	2.0	TM000000000001.079
1C	3/15/94	6	19	3.2	TM000000000001.079
1	3/21/94	7	14	2.0	TM000000000001.079
5	3/21/94	9	18	2.0	TM000000000001.079
1C	3/21/94	9	16	1.8	TM000000000001.079
1	4/2/94	2	14	7.0	TM000000000001.079
5	4/2/94	2	11	5.5	TM000000000001.079
1C	4/2/94	2	12	6.0	TM000000000001.079
1	4/8/94	11	26	2.4	TM000000000001.079
5	4/8/94	8	25	3.1	TM000000000001.079
1C	4/8/94	9	26	2.9	TM000000000001.079
1	4/14/94	24	44	1.8	TM000000000001.079
5	4/14/94	21	35	1.7	TM000000000001.079
1C	4/14/94	24	42	1.8	TM000000000001.079
1	4/20/94	13	30	2.3	TM000000000001.079
5	4/20/94	14	30	2.1	TM000000000001.079
1C	4/20/94	15	29	1.9	TM000000000001.079
1	4/26/94	5	20	4.0	TM000000000001.079
5	4/26/94	2	20	10.0	TM000000000001.079
1C	4/26/94	4	19	4.8	TM000000000001.079
1	5/2/94	12	19	1.6	TM000000000001.079
5	5/2/94	13	21	1.6	TM000000000001.079
1C	5/2/94	13	18	1.4	TM000000000001.079
1	5/8/94	3	9	3.0	TM000000000001.079
5	5/8/94	2	13	6.5	TM000000000001.079
1C	5/8/94	2	9	4.5	TM000000000001.079
1	5/14/94	16	25	1.6	TM000000000001.079
5	5/14/94	15	26	1.7	TM000000000001.079
1C	5/14/94	16	24	1.5	TM000000000001.079
1	5/20/94	2	13	6.5	TM000000000001.079
5	5/20/94	2	10	5.0	TM000000000001.079
1C	5/20/94	3	10	3.3	TM000000000001.079
1	5/26/94	11	26	2.4	TM000000000001.079
1	6/1/94	12	20	1.7	TM000000000001.079
1C	6/1/94	12	19	1.6	TM000000000001.079
1	6/7/94	8	22	2.8	TM000000000001.079
5	6/7/94	10	24	2.4	TM000000000001.079
1C	6/7/94	9	22	2.4	TM000000000001.079
5	6/13/94	14	31	2.2	TM000000000001.079
1C	6/13/94	13	29	2.2	TM000000000001.079
1	6/19/94	13	21	1.6	TM000000000001.079
5	6/19/94	11	19	1.7	TM000000000001.079
1C	6/19/94	12	21	1.8	TM000000000001.079
1	6/25/94	15	24	1.6	TM000000000001.079
5	6/25/94	13	22	1.7	TM000000000001.079
1C	6/25/94	14	22	1.6	TM000000000001.079
1	7/1/94	26	43	1.7	TM000000000001.079
5	7/1/94	23	41	1.8	TM000000000001.079
1C	7/1/94	26	43	1.7	TM000000000001.079
1	7/7/94	10	20	2.0	TM000000000001.079
5	7/7/94	5	14	2.8	TM000000000001.079
1	7/13/94	14	24	1.7	TM000000000001.079
5	7/13/94	11	20	1.8	TM000000000001.079
1C	7/13/94	12	23	1.9	TM000000000001.079
1	7/19/94	39	99	2.5	TM000000000001.079
5	7/19/94	42	98	2.3	TM000000000001.079
1C	7/19/94	40	102	2.6	TM000000000001.079
1	7/25/94	19	32	1.7	TM000000000001.079
5	7/25/94	9	20	2.2	TM000000000001.079
1C	7/25/94	19	38	2.0	TM000000000001.079
1	7/29/94	26	50	1.9	TM000000000001.079
1C	7/29/94	25	51	2.0	TM000000000001.079
5	7/31/94	12	24	2.0	TM000000000001.079
1	8/6/94	16	28	1.8	TM000000000001.079
5	8/6/94	11	19	1.7	TM000000000001.079
1C	8/6/94	16	28	1.8	TM000000000001.079
1	8/12/94	15	31	2.1	TM000000000001.079
5	8/12/94	14	27	1.9	TM000000000001.079
1C	8/12/94	15	31	2.1	TM000000000001.079
1	8/18/94	17	28	1.6	TM000000000001.079
5	8/18/94	17	32	1.9	TM000000000001.079
1C	8/18/94	16	29	1.8	TM000000000001.079
5	8/24/94	12	25	2.1	TM000000000001.079

Table E-1. TSP:PM$_{10}$ Ratios – Yucca Mountain, 1989–1997 (Continued)

Site	Date	PM$_{10}$	TSP[a]	Ratio[b]	DTN
1C	8/24/94	11	24	2.2	TM000000000001.079
1	8/30/94	14	31	2.2	TM000000000001.079
5	8/30/94	10	17	1.7	TM000000000001.079
1	9/5/94	14	25	1.8	TM000000000001.079
1C	9/5/94	14	27	1.9	TM000000000001.079
1	9/11/94	13	26	2.0	TM000000000001.079
5	9/11/94	14	31	2.2	TM000000000001.079
1C	9/11/94	14	27	1.9	TM000000000001.079
1C	9/17/94	11	25	2.3	TM000000000001.079
1	9/23/94	20	36	1.8	TM000000000001.079
5	9/23/94	11	18	1.6	TM000000000001.079
1C	9/23/94	20	37	1.9	TM000000000001.079
1	9/29/94	6	17	2.8	TM000000000001.079
1C	9/29/94	5	17	3.4	TM000000000001.079
1	10/5/94	8	13	1.6	TM000000000001.079
5	10/5/94	2	9	4.5	TM000000000001.079
1C	10/5/94	6	14	2.3	TM000000000001.079
1	10/11/94	12	24	2.0	TM000000000001.079
5	10/11/94	10	23	2.3	TM000000000001.079
1C	10/11/94	12	25	2.1	TM000000000001.079
1	10/17/94	2	15	7.5	TM000000000001.079
5	10/17/94	2	8	4.0	TM000000000001.079
1C	10/17/94	3	17	5.7	TM000000000001.079
1	10/23/94	7	16	2.3	TM000000000001.079
5	10/23/94	10	18	1.8	TM000000000001.079
1C	10/23/94	10	17	1.7	TM000000000001.079
5	10/29/94	4	11	2.8	TM000000000001.079
1C	10/29/94	6	13	2.2	TM000000000001.079
1	11/4/94	8	21	2.6	TM000000000001.079
5	11/4/94	7	16	2.3	TM000000000001.079
1	11/10/94	8	15	1.9	TM000000000001.079
5	11/10/94	7	18	2.6	TM000000000001.079
1C	11/10/94	3	16	5.3	TM000000000001.079
1	11/16/94	7	20	2.9	TM000000000001.079
5	11/16/94	11	41	3.7	TM000000000001.079
1C	11/16/94	6	20	3.3	TM000000000001.079
1	11/22/94	5	21	4.2	TM000000000001.079
5	11/22/94	3	9	3.0	TM000000000001.079
5	11/28/94	4	18	4.5	TM000000000001.079
1	11/29/94	6	16	2.7	TM000000000001.079
1C	11/29/94	6	20	3.3	TM000000000001.079
1	12/4/94	6	12	2.0	TM000000000001.079
5	12/4/94	7	17	2.4	TM000000000001.079
1C	12/4/94	7	14	2.0	TM000000000001.079
1	12/10/94	9	15	1.7	TM000000000001.079
5	12/10/94	3	10	3.3	TM000000000001.079
1C	12/10/94	6	18	3.0	TM000000000001.079
5	12/16/94	5	18	3.6	TM000000000001.079
1C	12/16/94	6	11	1.8	TM000000000001.079
1	12/22/94	8	21	2.6	TM000000000001.079
5	12/22/94	17	35	2.1	TM000000000001.079
1C	12/22/94	9	12	1.3	TM000000000001.079
1	12/28/94	8	10	1.3	TM000000000001.079
5	12/28/94	6	12	2.0	TM000000000001.079
1	1/3/95	4	8	2.0	TM000000000001.079
5	1/3/95	4	7	1.8	TM000000000001.079
1C	1/3/95	4	8	2.0	TM000000000001.079
5	1/9/95	2	4	2.0	TM000000000001.079
1	1/15/95	2	3	1.5	TM000000000001.079
5	1/15/95	1	4	4.0	TM000000000001.079
1C	1/15/95	1	5	5.0	TM000000000001.079
1	1/21/95	7	10	1.4	TM000000000001.079
5	1/21/95	7	12	1.7	TM000000000001.079
1C	1/21/95	7	12	1.7	TM000000000001.079
1	1/27/95	3	7	2.3	TM000000000001.079
5	1/27/95	2	6	3.0	TM000000000001.079
1C	1/27/95	2	4	2.0	TM000000000001.079
1	2/2/95	6	18	3.0	TM000000000001.079
5	2/2/95	5	16	3.2	TM000000000001.079
1C	2/2/95	7	21	3.0	TM000000000001.079
1	2/8/95	7	16	2.3	TM000000000001.079
5	2/8/95	6	15	2.5	TM000000000001.079
1C	2/8/95	6	14	2.3	TM000000000001.079
1	2/14/95	5	13	2.6	TM000000000001.079
1C	2/14/95	4	14	3.5	TM000000000001.079
1	2/20/95	3	9	3.0	TM000000000001.079
5	2/20/95	4	9	2.3	TM000000000001.079
1C	2/20/95	4	11	2.8	TM000000000001.079
1	2/26/95	7	12	1.7	TM000000000001.079
5	2/26/95	9	16	1.8	TM000000000001.079
1C	2/26/95	8	13	1.6	TM000000000001.079
1	3/4/95	4	11	2.8	TM000000000001.079
5	3/4/95	3	13	4.3	TM000000000001.079
1C	3/4/95	4	7	1.8	TM000000000001.079
1	3/10/95	8	14	1.8	TM000000000001.079
5	3/10/95	7	17	2.4	TM000000000001.079

Table E-1. TSP:PM$_{10}$ Ratios – Yucca Mountain, 1989–1997 (Continued)

Site	Date	PM$_{10}$	TSP[a]	Ratio[b]	DTN
1C	3/10/95	7	15	2.1	TM000000000001.079
1	3/16/95	10	19	1.9	TM000000000001.079
5	3/16/95	8	16	2.0	TM000000000001.079
1C	3/16/95	10	21	2.1	TM000000000001.079
5	3/22/95	5	16	3.2	TM000000000001.079
1C	3/22/95	5	13	2.6	TM000000000001.079
1	3/28/95	7	17	2.4	TM000000000001.079
5	3/28/95	8	18	2.3	TM000000000001.079
1C	3/28/95	7	18	2.6	TM000000000001.079
1	4/3/95	9	30	3.3	TM000000000001.079
5	4/3/95	12	37	3.1	TM000000000001.079
1C	4/3/95	10	30	3.0	TM000000000001.079
1	4/9/95	13	56	4.3	TM000000000001.079
5	4/9/95	67	310	4.6	TM000000000001.079
1C	4/9/95	9	51	5.7	TM000000000001.079
1	4/15/95	4	21	5.3	TM000000000001.079
5	4/15/95	9	32	3.6	TM000000000001.079
1C	4/15/95	9	20	2.2	TM000000000001.079
1	4/21/95	14	39	2.8	TM000000000001.079
5	4/21/95	11	69	6.3	TM000000000001.079
1C	4/21/95	10	25	2.5	TM000000000001.079
1	4/27/95	15	35	2.3	TM000000000001.079
5	4/27/95	12	36	3.0	TM000000000001.079
1C	4/27/95	12	37	3.1	TM000000000001.079
1	5/3/95	7	18	2.6	TM000000000001.079
5	5/3/95	20	41	2.1	TM000000000001.079
1C	5/3/95	8	18	2.3	TM000000000001.079
1	5/9/95	11	24	2.2	TM000000000001.079
5	5/9/95	11	24	2.2	TM000000000001.079
1C	5/9/95	12	25	2.1	TM000000000001.079
1	5/15/95	7	19	2.7	TM000000000001.079
5	5/15/95	3	12	4.0	TM000000000001.079
1C	5/15/95	3	18	6.0	TM000000000001.079
1	5/21/95	15	25	1.7	TM000000000001.079
5	5/21/95	16	28	1.8	TM000000000001.079
1C	5/21/95	15	27	1.8	TM000000000001.079
5	5/27/95	8	15	1.9	TM000000000001.079
1C	5/27/95	9	22	2.4	TM000000000001.079
1	6/2/95	10	43	4.3	TM000000000001.079
5	6/2/95	10	31	3.1	TM000000000001.079
1C	6/2/95	10	41	4.1	TM000000000001.079
1	6/8/95	10	34	3.4	TM000000000001.079
5	6/8/95	6	26	4.3	TM000000000001.079
1C	6/8/95	9	33	3.7	TM000000000001.079
1	6/14/95	14	35	2.5	TM000000000001.079
5	6/14/95	17	50	2.9	TM000000000001.079
1C	6/14/95	15	34	2.3	TM000000000001.079
5	6/20/95	11	37	3.4	TM000000000001.079
1C	6/20/95	9	26	2.9	TM000000000001.079
1	6/26/95	11	30	2.7	TM000000000001.079
5	6/26/95	11	36	3.3	TM000000000001.079
1C	6/26/95	11	31	2.8	TM000000000001.079
1	7/2/95	12	21	1.8	TM000000000001.079
5	7/2/95	8	19	2.4	TM000000000001.079
1	7/8/95	14	31	2.2	TM000000000001.079
5	7/8/95	15	36	2.4	TM000000000001.079
1C	7/8/95	14	33	2.4	TM000000000001.079
1	7/14/95	14	30	2.1	TM000000000001.079
5	7/14/95	12	30	2.5	TM000000000001.079
1C	7/14/95	13	43	3.3	TM000000000001.079
1	7/20/95	14	20	1.4	TM000000000001.079
5	7/20/95	14	25	1.8	TM000000000001.079
1C	7/20/95	9	26	2.9	TM000000000001.079
1	7/26/95	13	27	2.1	TM000000000001.079
5	7/26/95	12	27	2.3	TM000000000001.079
1C	7/26/95	12	34	2.8	TM000000000001.079
1	8/1/95	20	46	2.3	TM000000000001.079
5	8/1/95	18	38	2.1	TM000000000001.079
1C	8/1/95	19	45	2.4	TM000000000001.079
1	8/7/95	15	41	2.7	TM000000000001.079
5	8/7/95	16	36	2.3	TM000000000001.079
1C	8/7/95	15	43	2.9	TM000000000001.079
1	8/13/95	17	36	2.1	TM000000000001.079
5	8/13/95	14	28	2.0	TM000000000001.079
1C	8/13/95	16	36	2.3	TM000000000001.079
1	8/19/95	14	28	2.0	TM000000000001.079
5	8/19/95	14	18	1.3	TM000000000001.079
1	8/25/95	9	26	2.9	TM000000000001.079
5	8/25/95	10	21	2.1	TM000000000001.079
1C	8/25/95	9	19	2.1	TM000000000001.079
1	8/31/95	12	23	1.9	TM000000000001.079
5	8/31/95	12	23	1.9	TM000000000001.079
1C	8/31/95	13	26	2.0	TM000000000001.079
1	9/6/95	13	27	2.1	TM000000000001.079
1	9/12/95	9	22	2.4	TM000000000001.079
1C	9/12/95	10	26	2.6	TM000000000001.079

Table E-1. TSP:PM_{10} Ratios – Yucca Mountain, 1989–1997 (Continued)

Site	Date	PM_{10}	TSP[a]	Ratio[b]	DTN
1	9/18/95	21	53	2.5	TM000000000001.079
5	9/18/95	18	35	1.9	TM000000000001.079
1C	9/18/95	21	50	2.4	TM000000000001.079
1	9/24/95	16	25	1.6	TM000000000001.079
1C	9/24/95	12	24	2.0	TM000000000001.079
1	9/30/95	5	14	2.8	TM000000000001.079
5	9/30/95	5	15	3.0	TM000000000001.079
1C	9/30/95	5	14	2.8	TM000000000001.079
1	10/6/95	9	18	2.0	TM000000000001.079
5	10/6/95	13	23	1.8	TM000000000001.079
1C	10/6/95	9	20	2.2	TM000000000001.079
1	10/12/95	13	33	2.5	TM000000000001.079
1C	10/12/95	14	34	2.4	TM000000000001.079
1	10/18/95	16	31	1.9	TM000000000001.079
5	10/18/95	11	23	2.1	TM000000000001.079
1C	10/18/95	14	31	2.2	TM000000000001.079
1	10/24/95	7	18	2.6	TM000000000001.079
5	10/24/95	8	13	1.6	TM000000000001.079
1C	10/24/95	8	19	2.4	TM000000000001.079
1	10/30/95	7	15	2.1	TM000000000001.079
5	10/30/95	6	12	2.0	TM000000000001.079
1C	10/30/95	6	16	2.7	TM000000000001.079
1	11/5/95	5	10	2.0	TM000000000001.079
5	11/5/95	5	11	2.2	TM000000000001.079
1C	11/5/95	5	13	2.6	TM000000000001.079
1	11/11/95	3	13	4.3	TM000000000001.079
5	11/11/95	4	8	2.0	TM000000000001.079
1C	11/11/95	4	11	2.8	TM000000000001.079
1	11/17/95	16	34	2.1	TM000000000001.079
5	11/17/95	8	16	2.0	TM000000000001.079
1C	11/17/95	14	35	2.5	TM000000000001.079
1	11/23/95	7	18	2.6	TM000000000001.079
5	11/23/95	6	24	4.0	TM000000000001.079
1C	11/23/95	7	27	3.9	TM000000000001.079
5	11/29/95	5	12	2.4	TM000000000001.079
1	12/5/95	14	25	1.8	TM000000000001.079
5	12/5/95	9	14	1.6	TM000000000001.079
1C	12/5/95	13	26	2.0	TM000000000001.079
1	12/11/95	9	22	2.4	TM000000000001.079
1C	12/11/95	9	14	1.6	TM000000000001.079
1	12/17/95	2	4	2.0	TM000000000001.079
1C	12/17/95	1	4	4.0	TM000000000001.079
1	12/23/95	6	11	1.8	TM000000000001.079
5	12/23/95	6	12	2.0	TM000000000001.079
1C	12/23/95	6	10	1.7	TM000000000001.079
1	12/29/95	3	13	4.3	TM000000000001.079
1	1/4/96	4	9	2.3	TM000000000001.084
1C	1/4/96	5	10	2.0	TM000000000001.084
1	1/10/96	5	13	2.6	TM000000000001.084
5	1/10/96	4	9	2.3	TM000000000001.084
1C	1/10/96	5	13	2.6	TM000000000001.084
1	1/16/96	10	28	2.8	TM000000000001.084
5	1/16/96	7	25	3.6	TM000000000001.084
1C	1/16/96	10	28	2.8	TM000000000001.084
1	1/22/96	3	8	2.7	TM000000000001.084
5	1/22/96	2	5	2.5	TM000000000001.084
1C	1/22/96	2	8	4.0	TM000000000001.084
1	1/28/96	5	17	3.4	TM000000000001.084
5	1/28/96	5	16	3.2	TM000000000001.084
1C	1/28/96	5	17	3.4	TM000000000001.084
1	2/3/96	5	11	2.2	TM000000000001.084
5	2/3/96	4	8	2.0	TM000000000001.084
1C	2/3/96	5	11	2.2	TM000000000001.084
1	2/9/96	7	14	2.0	TM000000000001.084
5	2/9/96	7	13	1.9	TM000000000001.084
1C	2/9/96	7	14	2.0	TM000000000001.084
1	2/15/96	6	15	2.5	TM000000000001.084
5	2/15/96	8	17	2.1	TM000000000001.084
1C	2/15/96	7	14	2.0	TM000000000001.084
1	2/21/96	3	8	2.7	TM000000000001.084
1C	2/21/96	4	7	1.8	TM000000000001.084
1	2/27/96	3	8	2.7	TM000000000001.084
5	2/27/96	3	5	1.7	TM000000000001.084
1C	2/27/96	3	7	2.3	TM000000000001.084
1	3/4/96	8	28	3.5	TM000000000001.084
5	3/4/96	9	35	3.9	TM000000000001.084
1C	3/4/96	10	26	2.6	TM000000000001.084
1	3/10/96	5	12	2.4	TM000000000001.084
5	3/10/96	6	13	2.2	TM000000000001.084
1C	3/10/96	6	12	2.0	TM000000000001.084
1	3/16/96	6	12	2.0	TM000000000001.084
5	3/16/96	5	17	3.4	TM000000000001.084
1C	3/16/96	6	12	2.0	TM000000000001.084
1	3/22/96	22	51	2.3	TM000000000001.084
5	3/22/96	27	65	2.4	TM000000000001.084
1C	3/22/96	21	48	2.3	TM000000000001.084

Table E-1. TSP:PM_{10} Ratios – Yucca Mountain, 1989–1997 (Continued)

Site	Date	PM_{10}	TSP[a]	Ratio[b]	DTN
1	3/28/96	23	77	3.3	TM000000000001.084
5	3/28/96	35	126	3.6	TM000000000001.084
1C	3/28/96	22	72	3.3	TM000000000001.084
1	4/3/96	5	11	2.2	TM000000000001.096
1C	4/3/96	5	8	1.6	TM000000000001.096
1	4/9/96	9	21	2.3	TM000000000001.096
1C	4/9/96	10	21	2.1	TM000000000001.096
1	4/15/96	7	20	2.9	TM000000000001.096
5	4/15/96	7	34	4.9	TM000000000001.096
1C	4/15/96	8	18	2.3	TM000000000001.096
1	4/21/96	5	11	2.2	TM000000000001.096
5	4/21/96	5	16	3.2	TM000000000001.096
1C	4/21/96	5	10	2.0	TM000000000001.096
1	4/27/96	13	30	2.3	TM000000000001.096
5	4/27/96	15	38	2.5	TM000000000001.096
1C	4/27/96	14	27	1.9	TM000000000001.096
1	5/3/96	7	13	1.9	TM000000000001.096
5	5/3/96	8	26	3.3	TM000000000001.096
1C	5/3/96	7	12	1.7	TM000000000001.096
1	5/9/96	9	19	2.1	TM000000000001.096
5	5/9/96	10	23	2.3	TM000000000001.096
1C	5/9/96	10	19	1.9	TM000000000001.096
1	5/15/96	20	55	2.8	TM000000000001.096
1C	5/15/96	22	52	2.4	TM000000000001.096
1	5/21/96	15	25	1.7	TM000000000001.096
5	5/21/96	15	32	2.1	TM000000000001.096
1C	5/21/96	15	24	1.6	TM000000000001.096
1	5/27/96	12	25	2.1	TM000000000001.096
5	5/27/96	14	36	2.6	TM000000000001.096
1C	5/27/96	12	25	2.1	TM000000000001.096
1	6/2/96	11	17	1.5	TM000000000001.096
5	6/2/96	11	17	1.5	TM000000000001.096
1C	6/2/96	11	15	1.4	TM000000000001.096
1	6/8/96	18	27	1.5	TM000000000001.096
5	6/8/96	18	29	1.6	TM000000000001.096
1C	6/8/96	17	27	1.6	TM000000000001.096
1	6/14/96	17	28	1.6	TM000000000001.096
5	6/14/96	16	104	6.5	TM000000000001.096
1C	6/14/96	17	26	1.5	TM000000000001.096
1	6/20/96	19	34	1.8	TM000000000001.096
5	6/20/96	19	37	1.9	TM000000000001.096
1C	6/20/96	19	33	1.7	TM000000000001.096
1	6/26/96	7	15	2.1	TM000000000001.096
1C	6/26/96	7	15	2.1	TM000000000001.096
1	7/2/96	15	25	1.7	TM000000000001.097
5	7/2/96	15	23	1.5	TM000000000001.097
1C	7/2/96	17	24	1.4	TM000000000001.097
5	7/8/96	15	30	2.0	TM000000000001.097
1C	7/8/96	16	26	1.6	TM000000000001.097
1	7/14/96	10	23	2.3	TM000000000001.097
5	7/14/96	10	24	2.4	TM000000000001.097
1C	7/14/96	10	22	2.2	TM000000000001.097
1	7/20/96	10	21	2.1	TM000000000001.097
5	7/20/96	9	19	2.1	TM000000000001.097
1	7/26/96	60	147	2.5	TM000000000001.097
5	7/26/96	57	148	2.6	TM000000000001.097
1	8/1/96	11	21	1.9	TM000000000001.097
5	8/1/96	11	22	2.0	TM000000000001.097
1C	8/1/96	11	20	1.8	TM000000000001.097
5	8/7/96	13	24	1.8	TM000000000001.097
1C	8/7/96	14	25	1.8	TM000000000001.097
1	8/13/96	12	28	2.3	TM000000000001.097
5	8/13/96	13	26	2.0	TM000000000001.097
1C	8/13/96	12	27	2.3	TM000000000001.097
1	8/19/96	21	35	1.7	TM000000000001.097
5	8/19/96	21	34	1.6	TM000000000001.097
1C	8/19/96	22	34	1.5	TM000000000001.097
1	8/25/96	13	26	2.0	TM000000000001.097
5	8/25/96	13	29	2.2	TM000000000001.097
1C	8/25/96	14	26	1.9	TM000000000001.097
1	8/31/96	15	23	1.5	TM000000000001.097
1C	8/31/96	14	22	1.6	TM000000000001.097
1	9/6/96	10	20	2.0	TM000000000001.097
5	9/6/96	9	18	2.0	TM000000000001.097
1	9/12/96	9	24	2.7	TM000000000001.097
5	9/12/96	9	24	2.7	TM000000000001.097
1C	9/12/96	10	23	2.3	TM000000000001.097
1	9/18/96	6	18	3.0	TM000000000001.097
5	9/18/96	3	10	3.3	TM000000000001.097
1C	9/18/96	6	17	2.8	TM000000000001.097
1	9/24/96	9	17	1.9	TM000000000001.097
5	9/24/96	10	19	1.9	TM000000000001.097
1C	9/24/96	10	18	1.8	TM000000000001.097
1	9/30/96	10	20	2.0	TM000000000001.097
5	9/30/96	7	16	2.3	TM000000000001.097
1C	9/30/96	10	20	2.0	TM000000000001.097

Table E-1. TSP:PM$_{10}$ Ratios – Yucca Mountain, 1989–1997 (Continued)

Site	Date	PM$_{10}$	TSP^a	Ratio^b	DTN
5	10/6/96	8	14	1.8	TM000000000001.098
1C	10/6/96	7	14	2.0	TM000000000001.098
5	10/12/96	8	16	2.0	TM000000000001.098
1C	10/12/96	7	14	2.0	TM000000000001.098
1C	10/18/96	11	26	2.4	TM000000000001.098
1	10/24/96	9	27	3.0	TM000000000001.098
5	10/24/96	7	48	6.9	TM000000000001.098
1C	10/24/96	8	25	3.1	TM000000000001.098
1	10/30/96	5	13	2.6	TM000000000001.098
5	10/30/96	5	14	2.8	TM000000000001.098
1	11/5/96	8	13	1.6	TM000000000001.098
5	11/5/96	7	14	2.0	TM000000000001.098
1C	11/5/96	8	12	1.5	TM000000000001.098
1	11/11/96	3	10	3.3	TM000000000001.098
5	11/11/96	4	9	2.3	TM000000000001.098
1C	11/11/96	4	8	2.0	TM000000000001.098
5	11/17/96	7	21	3.0	TM000000000001.098
1C	11/17/96	8	21	2.6	TM000000000001.098
5	11/23/96	3	5	1.7	TM000000000001.098
1	11/26/96	6	20	3.3	TM000000000001.098
1C	11/26/96	6	20	3.3	TM000000000001.098
1	11/29/96	6	16	2.7	TM000000000001.098
5	11/29/96	4	13	3.3	TM000000000001.098
1C	11/29/96	6	16	2.7	TM000000000001.098
1	12/5/96	10	33	3.3	TM000000000001.098
5	12/5/96	6	22	3.7	TM000000000001.098
1C	12/5/96	10	31	3.1	TM000000000001.098
1	12/11/96	2	6	3.0	TM000000000001.098
5	12/11/96	2	8	4.0	TM000000000001.098
1C	12/11/96	2	4	2.0	TM000000000001.098
1	12/17/96	6	21	3.5	TM000000000001.098
5	12/17/96	2	7	3.5	TM000000000001.098
1C	12/17/96	5	17	3.4	TM000000000001.098
1	12/23/96	5	29	5.8	TM000000000001.098
5	12/23/96	4	25	6.3	TM000000000001.098
1C	12/23/96	5	27	5.4	TM000000000001.098
1	12/29/96	3	11	3.7	TM000000000001.098
5	12/29/96	3	8	2.7	TM000000000001.098
1C	12/29/96	3	7	2.3	TM000000000001.098
1	1/4/97	4	14	3.5	TM000000000001.099
5	1/4/97	2	7	3.5	TM000000000001.099
1C	1/4/97	4	14	3.5	TM000000000001.099
1	1/10/97	8	23	2.9	TM000000000001.099
5	1/10/97	5	15	3.0	TM000000000001.099
1C	1/10/97	8	22	2.8	TM000000000001.099
1	1/16/97	4	10	2.5	TM000000000001.099
1C	1/16/97	4	8	2.0	TM000000000001.099
1C	1/22/97	4	7	1.8	TM000000000001.099
5	1/25/97	4	11	2.8	TM000000000001.099
1	1/28/97	5	11	2.2	TM000000000001.099
5	1/28/97	6	17	2.8	TM000000000001.099
1C	1/28/97	5	11	2.2	TM000000000001.099
1	2/3/97	4	15	3.8	TM000000000001.099
5	2/3/97	2	11	5.5	TM000000000001.099
1C	2/3/97	4	14	3.5	TM000000000001.099
1	2/9/97	3	6	2.0	TM000000000001.099
5	2/9/97	3	9	3.0	TM000000000001.099
1C	2/9/97	3	5	1.7	TM000000000001.099
1	2/15/97	2	6	3.0	TM000000000001.099
5	2/15/97	4	11	2.8	TM000000000001.099
1C	2/15/97	2	6	3.0	TM000000000001.099
1	2/21/97	2	12	6.0	TM000000000001.099
5	2/21/97	2	10	5.0	TM000000000001.099
1C	2/21/97	2	11	5.5	TM000000000001.099
5	2/27/97	8	20	2.5	TM000000000001.099
1C	2/27/97	8	18	2.3	TM000000000001.099
1	3/5/97	4	9	2.3	TM000000000001.099
5	3/5/97	3	14	4.7	TM000000000001.099
1C	3/5/97	3	12	4.0	TM000000000001.099
1	3/11/97	10	22	2.2	TM000000000001.099
5	3/11/97	11	18	1.6	TM000000000001.099
1C	3/11/97	11	22	2.0	TM000000000001.099
1	3/17/97	10	18	1.8	TM000000000001.099
5	3/17/97	8	20	2.5	TM000000000001.099
1C	3/17/97	8	19	2.4	TM000000000001.099
1	3/23/97	11	24	2.2	TM000000000001.099
5	3/23/97	11	21	1.9	TM000000000001.099
1C	3/23/97	11	23	2.1	TM000000000001.099
1	3/29/97	6	14	2.3	TM000000000001.099
5	3/29/97	6	16	2.7	TM000000000001.099
1C	3/29/97	5	15	3.0	TM000000000001.099
1	4/4/97	9	22	2.4	TM000000000001.105
5	4/4/97	11	43	3.9	TM000000000001.105
1C	4/4/97	9	21	2.3	TM000000000001.105
1	4/10/97	6	16	2.7	TM000000000001.105
5	4/10/97	5	18	3.6	TM000000000001.105

Table E-1. TSP:PM_{10} Ratios – Yucca Mountain, 1989–1997 (Continued)

Site	Date	PM_{10}	TSP[a]	Ratio[b]	DTN
1C	4/10/97	7	16	2.3	TM000000000001.105
1	4/16/97	11	21	1.9	TM000000000001.105
5	4/16/97	11	23	2.1	TM000000000001.105
1C	4/16/97	12	22	1.8	TM000000000001.105
5	4/22/97	12	40	3.3	TM000000000001.105
1C	4/22/97	11	21	1.9	TM000000000001.105
1	4/28/97	14	30	2.1	TM000000000001.105
5	4/28/97	16	41	2.6	TM000000000001.105
1C	4/28/97	14	30	2.1	TM000000000001.105
1	5/4/97	9	17	1.9	TM000000000001.105
5	5/4/97	7	24	3.4	TM000000000001.105
1C	5/4/97	8	17	2.1	TM000000000001.105
1	5/10/97	12	33	2.8	TM000000000001.105
5	5/10/97	13	31	2.4	TM000000000001.105
1C	5/10/97	13	31	2.4	TM000000000001.105
1	5/16/97	14	31	2.2	TM000000000001.105
5	5/16/97	13	30	2.3	TM000000000001.105
1C	5/16/97	15	31	2.1	TM000000000001.105
1	5/22/97	17	34	2.0	TM000000000001.105
5	5/22/97	19	36	1.9	TM000000000001.105
1	5/28/97	12	28	2.3	TM000000000001.105
5	5/28/97	10	21	2.1	TM000000000001.105
1C	5/28/97	13	25	1.9	TM000000000001.105
1	6/3/97	19	36	1.9	TM000000000001.105
5	6/3/97	19	37	1.9	TM000000000001.105
1C	6/3/97	18	35	1.9	TM000000000001.105
1	6/9/97	16	33	2.1	TM000000000001.105
5	6/9/97	14	33	2.4	TM000000000001.105
1C	6/9/97	14	32	2.3	TM000000000001.105
1	6/15/97	4	12	3.0	TM000000000001.105
5	6/15/97	3	9	3.0	TM000000000001.105
1C	6/15/97	3	9	3.0	TM000000000001.105
1	6/21/97	18	35	1.9	TM000000000001.105
5	6/21/97	16	41	2.6	TM000000000001.105
1C	6/21/97	18	34	1.9	TM000000000001.105
1	6/27/97	19	38	2.0	TM000000000001.105
1C	6/27/97	20	37	1.9	TM000000000001.105
1	7/3/97	9	20	2.2	TM000000000001.108
5	7/3/97	8	19	2.4	TM000000000001.108
1C	7/3/97	7	19	2.7	TM000000000001.108
1	7/9/97	10	19	1.9	TM000000000001.108
5	7/9/97	9	18	2.0	TM000000000001.108
1C	7/9/97	10	17	1.7	TM000000000001.108
1	7/15/97	21	41	2.0	TM000000000001.108
5	7/15/97	13	21	1.6	TM000000000001.108
1C	7/15/97	21	36	1.7	TM000000000001.108
5	7/21/97	16	34	2.1	TM000000000001.108
1	7/27/97	10	23	2.3	TM000000000001.108
1C	7/27/97	11	22	2.0	TM000000000001.108
1	8/2/97	9	18	2.0	TM000000000001.108
5	8/2/97	8	15	1.9	TM000000000001.108
1C	8/2/97	10	16	1.6	TM000000000001.108
1	8/8/97	31	78	2.5	TM000000000001.108
5	8/8/97	26	57	2.2	TM000000000001.108
1C	8/8/97	34	76	2.2	TM000000000001.108
1	8/14/97	12	25	2.1	TM000000000001.108
5	8/14/97	12	21	1.8	TM000000000001.108
1C	8/14/97	12	23	1.9	TM000000000001.108
1	8/20/97	13	24	1.8	TM000000000001.108
5	8/20/97	10	17	1.7	TM000000000001.108
1	8/26/97	11	26	2.4	TM000000000001.108
5	8/26/97	9	16	1.8	TM000000000001.108
1C	8/26/97	13	26	2.0	TM000000000001.108
1	9/1/97	14	29	2.1	TM000000000001.108
5	9/1/97	14	28	2.0	TM000000000001.108
1C	9/1/97	14	28	2.0	TM000000000001.108
1	9/7/97	12	19	1.6	TM000000000001.108
5	9/7/97	12	18	1.5	TM000000000001.108
1C	9/7/97	12	19	1.6	TM000000000001.108
1	9/13/97	11	25	2.3	TM000000000001.108
5	9/13/97	10	23	2.3	TM000000000001.108
1C	9/13/97	10	24	2.4	TM000000000001.108
1	9/19/97	13	31	2.4	TM000000000001.108
5	9/19/97	13	29	2.2	TM000000000001.108
1C	9/19/97	14	30	2.1	TM000000000001.108
5	9/25/97	8	17	2.1	TM000000000001.108
1C	9/25/97	8	21	2.6	TM000000000001.108
1	10/1/97	8	19	2.4	MO98PSDALOG111.000
5	10/1/97	9	14	1.6	MO98PSDALOG111.000
1C	10/1/97	12	20	1.7	MO98PSDALOG111.000
1	10/7/97	21	50	2.4	MO98PSDALOG111.000
1C	10/7/97	21	50	2.4	MO98PSDALOG111.000
1	10/13/97	3	18	6.0	MO98PSDALOG111.000
1C	10/13/97	4	17	4.3	MO98PSDALOG111.000
1	10/19/97	10	22	2.2	MO98PSDALOG111.000
5	10/19/97	10	17	1.7	MO98PSDALOG111.000

Table E-1. TSP:PM_{10} Ratios – Yucca Mountain, 1989–1997 (Continued)

Site	Date	PM_{10}	TSP[a]	Ratio[b]	DTN
1C	10/19/97	11	21	1.9	MO98PSDALOG111.000
1	10/25/97	3	11	3.7	MO98PSDALOG111.000
5	10/25/97	3	9	3.0	MO98PSDALOG111.000
1C	10/25/97	4	10	2.5	MO98PSDALOG111.000
1	10/31/97	6	15	2.5	MO98PSDALOG111.000
5	10/31/97	4	9	2.3	MO98PSDALOG111.000
1C	10/31/97	5	13	2.6	MO98PSDALOG111.000
1	11/6/97	11	31	2.8	MO98PSDALOG111.000
5	11/6/97	5	11	2.2	MO98PSDALOG111.000
1C	11/6/97	12	30	2.5	MO98PSDALOG111.000
1	11/12/97	5	12	2.4	MO98PSDALOG111.000
5	11/12/97	5	8	1.6	MO98PSDALOG111.000
1C	11/12/97	5	12	2.4	MO98PSDALOG111.000
1	11/18/97	5	12	2.4	MO98PSDALOG111.000
1C	11/18/97	4	9	2.3	MO98PSDALOG111.000
1	11/24/97	10	29	2.9	MO98PSDALOG111.000
5	11/24/97	5	9	1.8	MO98PSDALOG111.000
1C	11/24/97	10	28	2.8	MO98PSDALOG111.000
1	11/30/97	3	7	2.3	MO98PSDALOG111.000
5	11/30/97	3	7	2.3	MO98PSDALOG111.000
1C	11/30/97	3	7	2.3	MO98PSDALOG111.000
1	12/6/97	2	6	3.0	MO98PSDALOG111.000
5	12/6/97	3	5	1.7	MO98PSDALOG111.000
1C	12/6/97	2	6	3.0	MO98PSDALOG111.000
1	12/12/97	1	5	5.0	MO98PSDALOG111.000
5	12/12/97	1	5	5.0	MO98PSDALOG111.000
1C	12/12/97	1	5	5.0	MO98PSDALOG111.000
1	12/18/97	4	12	3.0	MO98PSDALOG111.000
5	12/18/97	3	10	3.3	MO98PSDALOG111.000
1C	12/18/97	4	13	3.3	MO98PSDALOG111.000
1	12/24/97	2	6	3.0	MO98PSDALOG111.000
5	12/24/97	1	7	7.0	MO98PSDALOG111.000
1C	12/24/97	1	5	5.0	MO98PSDALOG111.000
1	12/30/97	4	10	2.5	MO98PSDALOG111.000
5	12/30/97	8	17	2.1	MO98PSDALOG111.000
1C	12/30/97	4	10	2.5	MO98PSDALOG111.000

[a] $\mu g/m^3$
[b] TSP ÷ PM_{10}

DTN=data tracking number, PM_{10} =particles with an aerodynamic diameter ≤ 10 μm, TSP=total suspended particles

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