MOL.19960329.0171

WBS 1.2.8.4.2
QA: NA

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

METEOROLOGICAL MONITORING PROGRAM

PARTICULATE MATTER AMBIENT AIR QUALITY MONITORING REPORT

JANUARY 1992 THROUGH DECEMBER 1995

(SCPB: N/A)

February 29, 1996

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Under Contract Number
DE-AC01-91RW00134

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES (continued)

1.0 EXECUTIVE SUMMARY

Environmental field studies in the Yucca Mountain site characterization activities have included monitoring ambient levels of particulate matter since April 1989. The monitoring and reporting work was performed by the Environmental Field Programs Division (EFPD). The parameters monitored, methods used in the monitoring, and the sampling schedule followed U.S. Environmental Protection Agency (EPA) regulations and monitoring guidance. The inhalable particulate matter (PM_{10}) results have been reported to the State of Nevada since July 1991 to comply with State of Nevada air quality permit requirements. Two previous project reports presented the results obtained through 1991 (EFPD, 1992a and 1992b). This report covers the results obtained during the four years from 1992 through 1995.

Results of the particulate matter monitoring program continue to be well below applicable ambient air quality standards. The maximum PM_{10} result from the four year period was 67 micrograms per standard cubic meter ($\mu g/m^3$); this result is less than one-half of the applicable 24-hour National (and Nevada) Ambient Air Quality Standard. The annual PM_{10} averages for the period were approximately one-fourth of the applicable annual standard. There was very little change in the average or maximum observed PM_{10} concentrations throughout the period 1992 through 1995, which also compare reasonably well with results from 1989 to 1991.

2.0 BACKGROUND AND METHODS

The Scientific Investigation Implementation Package for Air Quality Monitoring (EFPD, 1995a) contains a description of the regulatory rationale and technical aspects of the monitoring program. Total Suspended Particulate Matter (TSP) and Inhalable Particulate Matter (PM_{10}) monitoring began in 1989 at two sites. The monitoring was intended to determine background airborne particulate matter levels prior to the onset of major site disturbance activities associated with the site characterization program. Two more sites, with PM_{10} samplers, were added late in 1992 along the southern and western borders of the Nevada Test Site, where typical wind patterns could carry airborne particulate matter associated with site characterization activities beyond the Nevada Test Site.

2.1 Regulatory Rationale

The level for the National and Nevada Primary and Secondary Ambient Air Quality Standards for particulate matter is 150 $\mu g/m^3$ for a 24-hour average concentration (40 CFR 50a). This standard is attained when the expected number of days (40 CFR 50b) is less than or equal to one. The standards include a maximum annual arithmetic average of 50 $\mu g/m^3$.

The State of Nevada air quality permit covering surface disturbance site characterization activities includes the requirement to report results of the PM_{10} monitoring, with corresponding meteorological data. The permit conditions include that the monitoring and reporting be accomplished following the permit "Attachment A" guidance (Nevada, 1994). The PM_{10} results have been reported to the State of Nevada for each calendar quarter period since July 1991 to comply with the permit requirements.

The National Ambient Air Quality Standards (NAAQS) for particulate matter (40 CFR 50a) were expressed as TSP until 1987, when the standard was changed to PM_{10}. The State of Nevada changed its standards to follow the federal changes in 1991 (Nevada, 1995). TSP samplers measure airborne particulate matter up to approximately 50 micrometers aerodynamic diameter. Inhalable particulate matter includes particles with an aerodynamic diameter less than 10 micrometers (PM_{10}). Both TSP and PM_{10} are measured partly because of the transition of the Nevada ambient air quality standards from TSP to PM_{10} in 1991, and partly to provide a more complete particulate matter characterization for environmental study purposes.

There are additional applications of the particulate matter monitoring results beyond the air quality permit requirements. For example, the monitoring results and the composition of the material captured on the filters may be useful in aeolian dust studies.

2.2 Network Description

Particulate matter monitoring has included both total suspended particulate matter (TSP) and the inhalable fraction of particulate matter (PM_{10}) at Sites 1 and 5 since the program began in April 1989. PM_{10} monitoring began at Sites 6 and 9 late in 1992. The four site locations are shown in Figure 2-1, and are described in Table 2-1. The rationale for choosing these locations follows.

- Site 1 (NTS-60) is near the Exploratory Studies Facility in Midway Valley. The results from before and after the beginning of the major site disturbance activities provides a measure of air quality impacts of these activities. The collocated pairs of TSP and PM_{10} samplers are both at Site 1.

- Site 5 (Fortymile Wash) is along Fortymile Wash, about half-way between the major surface disturbance area in Midway Valley near Site 1 and the nearest populated area, Amargosa Valley.

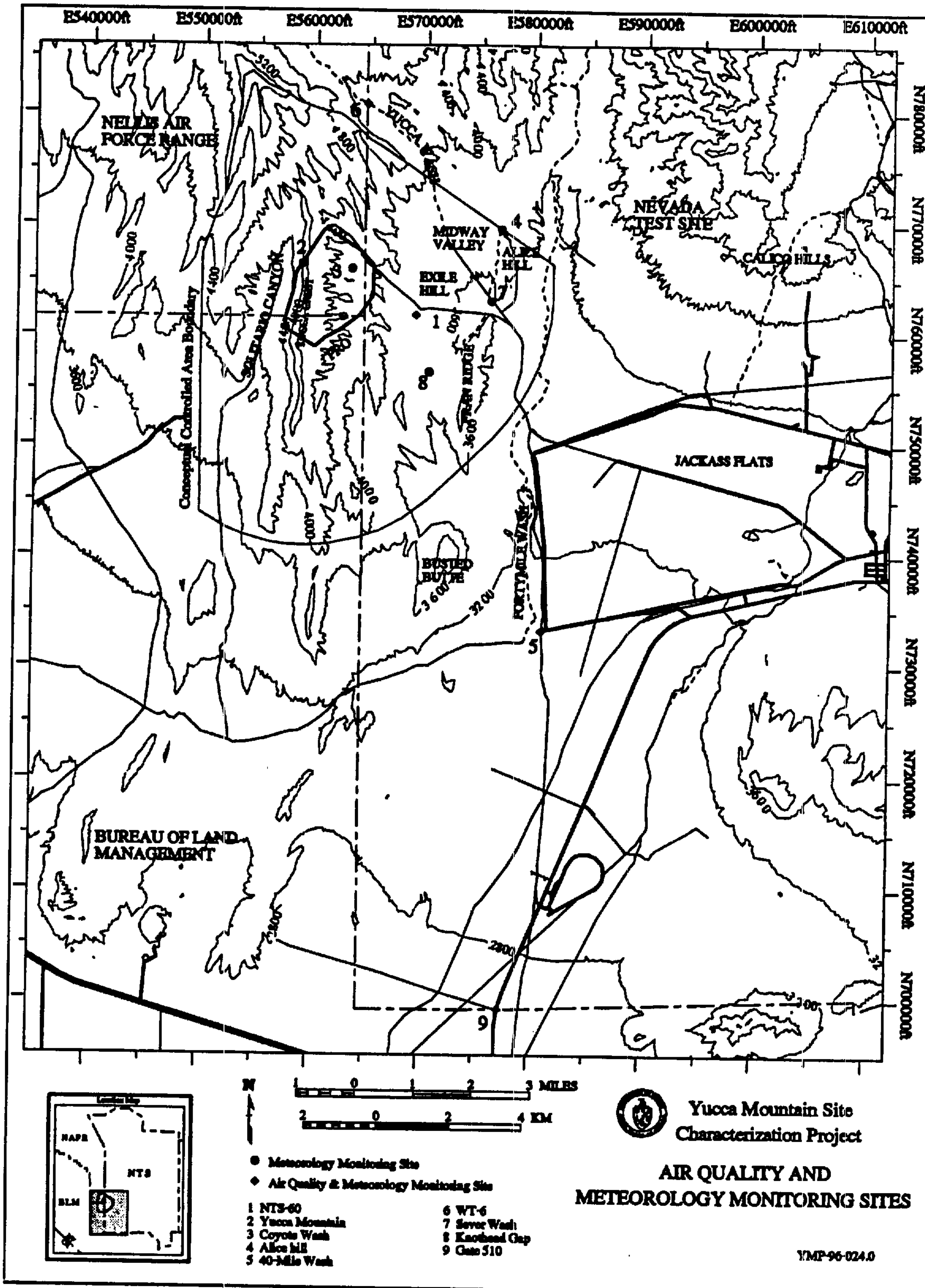

Figure 2-1. Site Locations

- Site 6 (WT-6) is a remote location on the border between the Nevada Test Site and Nellis Air Force Base Gunnery Range in Yucca Wash. This location is on a possible pathway of particulate matter through Midway Valley towards the community of Beatty, Nevada.

- Site 9 (Gate 510) is along the southern border of the Nevada Test Site near the community of Amargosa Valley. Results from this site are the most significant indicator of actual "ambient" PM_{10} concentrations; that is, inhalable particulate matter levels at locations where the general public has unrestricted access.

Table 2-1. Coordinates of the Particulate Monitoring Sites.

Site	UTM Coordinates Zone 11 (meters)	Nevada System (feet)	Latitude-Longitude (deg° min' sec")	Elevation (msl)
Site 1 (NTS-60)	550,784E 4,077,374N	569,126E 761,795N	116°25'50"W 36°50'34"N	3750 ft 1143 m
Site 5 (40-Mile Wash)	554,385E 4,068,727N	580,843E 733,378N	116°23'26"W 36°45'52"N	3125 ft 953 m
Site 6 (WT-6)	549,388E 4,083,097N	564,612E 780,592N	116°26'45"W 36°53'40"N	4315 ft 1315 m
Site 9 (G-510)	553,418E 4,058,398N	577,554E 699,491N	116°24'08"W 36°40'17"N	2750 ft 838 m

2.3 Particulate Matter Sampling Methods

The TSP and PM_{10} monitoring was performed using high-volume air samplers following the sampling techniques given in approved work instruction procedures (EFPD, 1992c, 1994a, 1994b, 1995b, 1995c, and 1995d). The procedures were based in part on 40 CFR 50, Appendix J, and EPA monitoring guidance in the EPA Quality Assurance Handbook for Ambient Air Quality Monitoring, Volume II, sections 2.11 (PM_{10}) and 2.2 (TSP) (EPA, 1990). The procedures followed project conventional quality assurance requirements. The routine monitoring, maintenance, and quality control procedures were designed so the sampling program should meet at least an 80 percent data recovery rate, to comply with the State of Nevada permit Attachment A.

Airflow through the high-volume air samplers is controlled by a fixed critical orifice, which minimizes airflow control problems. The sampler airflow is checked at least once each calendar quarter by EFPD technical staff, and again each quarter during an independent performance audit. All flow checks were performed using orifice calibrators certified traceable to National Institute of Standards and Technology flow testing devices. The collocated pairs of PM_{10} (MS1 and MS2) and TSP (MS5 and MS6) samplers are both at Site 1. Data from these samplers provide for an assessment of the precision of the monitoring data following U.S. EPA quality assurance requirements (40 CFR 58) and the Nevada monitoring guidance (Nevada, 1994).

The samplers were operated for 24-hours every sixth day on the EPA and State of Nevada schedule. The samplers at Sites 1, 5, and 9 were powered by standard electrical power, and were operated from midnight-to-midnight on the scheduled sampling dates by a timer. The sampler at Site 6 was powered by a propane-fueled electric generator; this sampler was manually started, and stopped automatically at the end of a 24-hour period.

Gravimetric analyses of the filters include equilibrating the filters to laboratory conditions for the pre-sampling and post-sampling filter weighing. The filter net weight gain is the particulate matter sampled. This weight, when combined with sampler airflow data and seasonal average site conditions, produce average concentrations of particulate matter. The results are reported in micrograms per standard cubic meter ($\mu g/m^3$), referenced to the standard temperature and pressure (25 Celsius and 760 millimeters of mercury, per 40 CFR 50, §50.3) (40 CFR 50d).

3.0 RESULTS

The primary assessment of air quality monitoring for regulatory compliance purposes was to compare monitoring program results to applicable standards. The results of data evaluation were well below applicable ambient air quality standards (see section 2.1), indicating that inhalable particulate matter concentrations do not jeopardize health and welfare of the general public. The strict interpretation of the ambient air quality standards does allow PM_{10} concentration levels to exceed the 24-hour level once per year; hence, the second-highest value becomes the critical indicator of compliance with the standard. Some additional statistical interpretations of the results are presented to facilitate understanding. The particulate matter sampling results are included in the data appendix within this report. Assessments of data quality based on U.S. EPA quality assurance requirements are included.

3.1 Data Recovery

Regulatory monitoring stipulations (air quality permit Attachment A) include a data recovery criterion that at least 80 percent of the required samples are expected to be reported. This criterion only applies to the PM_{10} data, though it was used as the goal for TSP as well. The annual PM_{10} and TSP data recovery rates for the four sites are presented in Table 3-1. The table shows that the criterion was met for all primary samplers. Nearly all the data recovery rates exceeded 90 percent, and the average data recovery rates for the primary samplers in this reporting period exceeded 95 percent.

Table 3-1. Data Recovery Rates.

	PM_{10}					TSP		
Year	MS1	MS2	FM3	G510	WT6	MS5	MS6	FM4
1992	98.4%	96.7%	96.7%	(Note[1])	(Note[1])	93.4%	77.0%	96.7%
1993	91.8%	93.4%	96.7%	93.4%	85.0%	91.8%	96.7%	96.7%
1994	100.0%	98.4%	100.0%	100.0%	100.0%	100.0%	98.4%	100.0%
1995	100.0%	100.0%	96.7%	100.0%	100.0%	100.0%	95.1%	98.4%
Avg.	97.5%	97.1%	97.5%	97.8%	95.0%	96.3%	91.8%	97.9%
Min.	91.8%	93.4%	96.7%	93.4%	85.0%	91.8%	77.0%	95.0%

Note[1]: Sampling started too late in the year to calculate data recovery.

Table entries are the annual data recovery rates for each sampler expressed as the number of valid samples taken compared to the scheduled number of samples in percent. The averages (Avg) and minimums (Min) of the annual values by sampler are shown in the bottom two rows.

The one exception to the otherwise excellent data recovery rate was the 77 percent rate for the MS6 collocated TSP sampler during 1992. This occurred during a period when an unusually high number of motor failures were occurring due to manufacturer changes in the electric motor brushes.

3.2 Regulatory compliance

Results of the PM_{10} sampling indicate that the monitoring area easily attained the particulate matter ambient air quality standards. The highest 24-hour sampling result in all four years was 67 $\mu g/m^3$, which was less than half of the regulatory standard of 150 $\mu g/m^3$. This result came from Site 5 (Fortymile Wash) on April 9, 1995. The next highest result was 49 $\mu g/m^3$, also from Site 5, on April 30, 1992. The annual highest, second-highest, and annual average results for the primary PM_{10} samplers are shown in Tables 3-2 through 3-4.

Table 3-2. PM_{10} (μg/m³) Highest 24-Hour Average.

Year	MS1	FM3	G510	WT6
1992	30	49	31	(Note[1])
1993	30	21	21	22
1994	39	42	39	25
1995	21	67	15	14

Note[1]: Sampling started too late in the year to calculate statistic

Table 3-3. PM_{10} (μg/m³) Second-Highest 24-Hour Average.

Year	MS1	FM3	G510	WT6
1992	24	27	31	(Note[1])
1993	22	20	21	21
1994	26	23	19	20
1995	20	21	14	13

Note[1]: Sampling started too late in the year to calculate statistic

Table 3-4. PM_{10} (μg/m³) Annual Average.

Year	MS1	FM3	G510	WT6
1992	12	12	(Note[1])	(Note[1])
1993	10	9	9	10
1994	10	9	8	7
1995	10	10	7	7

Note[1]: Sampling started too late in the year to calculate statistic

The highest result from Site 1 (NTS-60, in Midway Valley) was 39 μg/m³. This result occurred on July 19, 1994 and coincided with the 1994 annual maxima at all sampling. The maximum PM_{10} values reported at Site 6 (WT-6 in upper Yucca Wash) and Site 9 (Gate 510, near Amargosa Valley), which were 25 μg/m³ and 39 μg/m³, respectively.

The second-highest result is often the best measure of regulatory compliance, since the standard allows for one value each year that exceeds the standard level. The maximum second-highest value from all four sites during the period was 31 μg/m³, which was sampled at Site 9 (Gate 510). This value is approximately one-fifth the standard level, further indicating the very low particulate matter levels in the area.

The highest arithmetic mean value from the four primary PM_{10} samplers during the four-year reporting period was 12 μg/m³. This value is approximately one-fourth of the ambient air quality standard (50 μg/m³).

3.3 TSP Results

Results of the TSP sampling also show generally low levels of particulate matter in the area. The highest TSP result was an anomalous 310 μg/m³. This result came from Site 5 (Fortymile Wash) on April 9, 1995 and is discussed below. The next highest TSP result was 130 μg/m³, which was sampled at Site 5 on April 30, 1992. The maximum second-highest result was only 74 μg/m³. The annual highest and second-highest results for the primary TSP samplers are shown in Tables 3-5 through 3-7.

Table 3-5. TSP (μg/m³) Highest 24-Hour Average.

Year	MS5	FM4
1992	73	130
1993	86	56
1994	99	98
1995	56	310

Table 3-6. TSP (μg/m³) Second-Highest 24-Hour Average.

Year	MS5	FM4
1992	67	73
1993	62	54
1994	74	41
1995	53	69

Table 3-7. TSP (μg/m³) Annual Average.

Year	MS5	FM4
1992	27	30
1993	25	20
1994	22	19
1995	23	27

The ratio of PM_{10} to TSP was calculated as an indicator of the fraction of inhalable portion of particulate matter to total suspended particulate matter. The calculations were using PM_{10} and TSP levels for the primary (MS1 and MS5) sampler pair at Site 1 and for the samplers at Site 5 (FM3 and FM4). The ratio was calculated for three groupings of PM_{10} levels to investigate the effect of the typically very low particulate matter concentrations on the ratio. The groupings were for the whole 1992 through 1995 period and included: all values and those with both concentration values greater than 4 and greater than 9 $\mu g/m^3$. The means of the ratios are shown in Table 3-8. The results were approximately one-half at both sites. This is approximately the same level observed in other rural environments.

Table 3-8. Ratio of PM_{10} to TSP Results.

Samplers	all pairs	>4 $\mu g/m^3$	>9 $\mu g/m^3$
MS1/MS5 (Site 1)	0.454	0.468	0.477
FM3/FM4 (Site 5)	0.449	0.472	0.485

3.4 Summary and Particulate Matter Trends

Analyses of the particulate matter data lead to two primary conclusions about observed concentration levels and chronological trends. These two main points follow, with discussion text following to support the primary conclusions.

- Particulate matter levels in the primary site characterization area were quite low most of the time, well below the applicable standards. Results from the summertime months tend to be slightly higher than those during the remainder of the year. The highest levels observed at all sites were values well above the remainder of the data, indicating the presence of unusual circumstances causing those results. Approximately one-half of the total suspended particulate matter (TSP) is in the inhalable (PM_{10}) size range.

- The years 1992 through 1995 show similar particulate matter concentration levels, with generally slight differences in the highest levels observed from year to year. There were only slight differences between the annual groupings of results, with no significant chronological trend seen. Thus, there does not seem to be any detectable increase in particulate matter levels with the onset of increased site disturbance activities.

From a regulatory perspective, the highest and second-highest 24-hour PM_{10} concentrations and the annual average PM_{10} values represent the best measure of particulate matter levels. The results presented in section 3.2 show that the maximum indicators are well below the applicable ambient air quality standards. Figures 3-1 through 3-8 show chronological plots of the PM_{10} and TSP values for each of the four years.

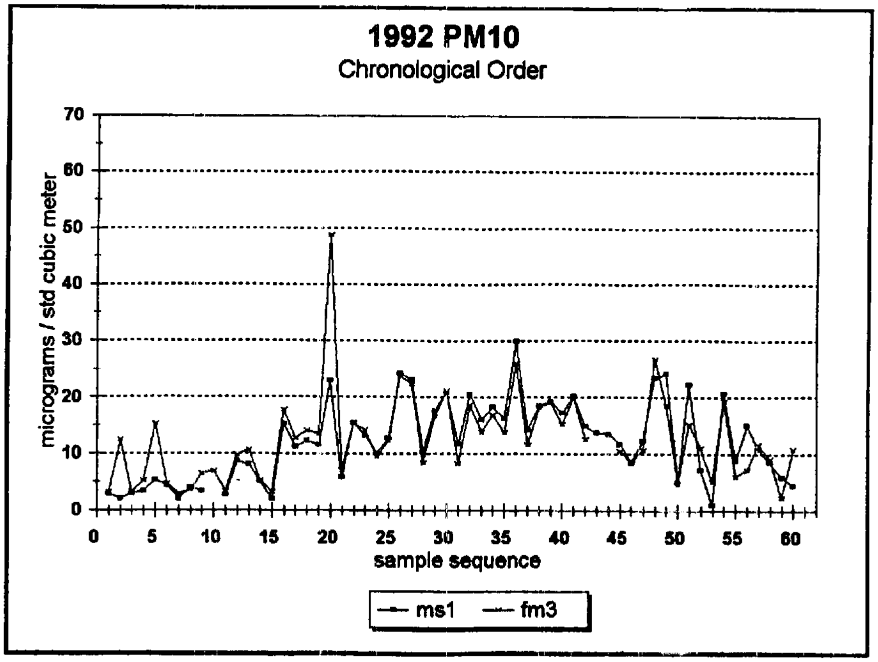

Figure 3-1. Chronological Plot of the PM_{10} Values for 1992

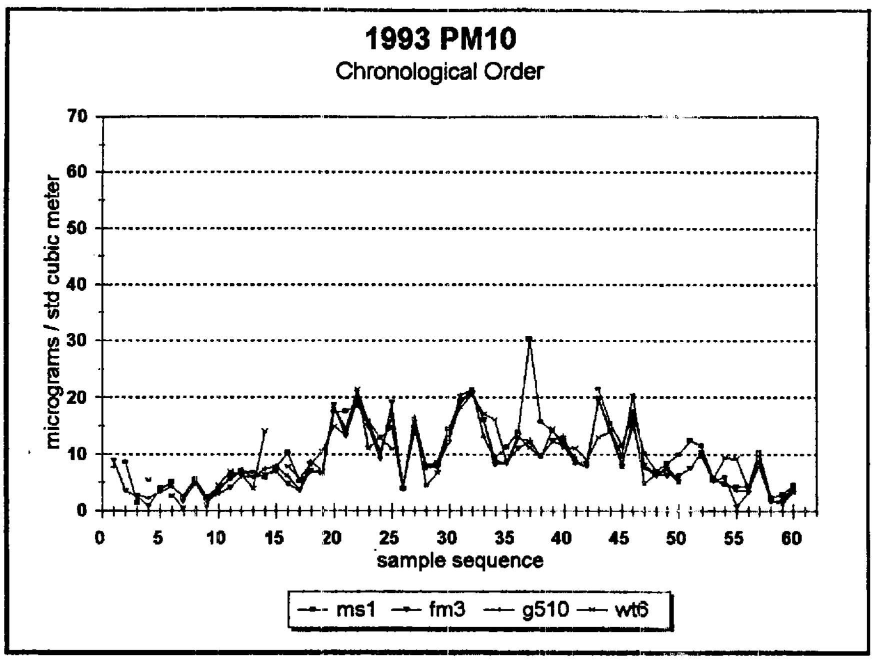

Figure 3-2. Chronological Plot of the PM_{10} Values for 1993

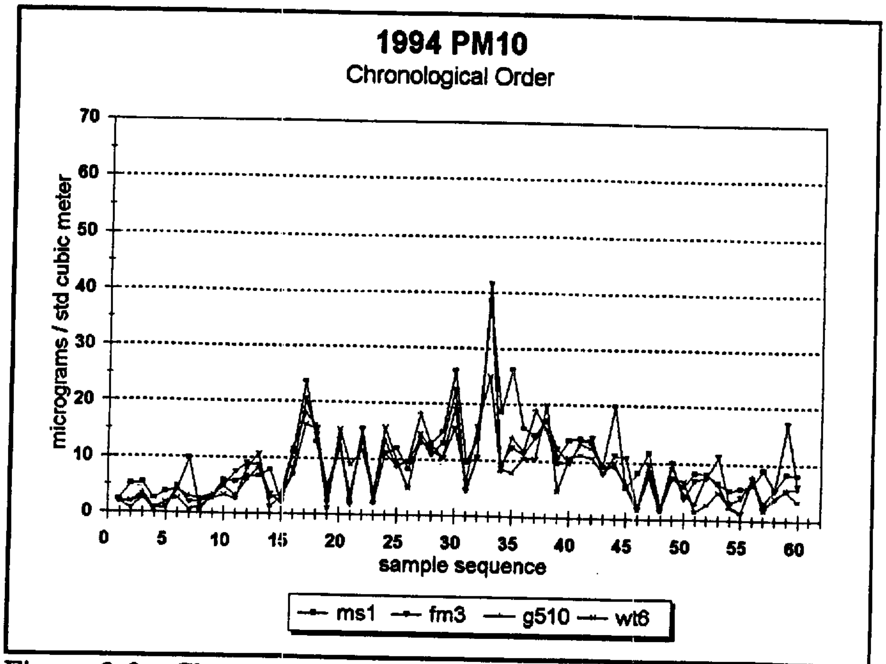

Figure 3-3. Chronological Plot of the PM_{10} Values for 1994

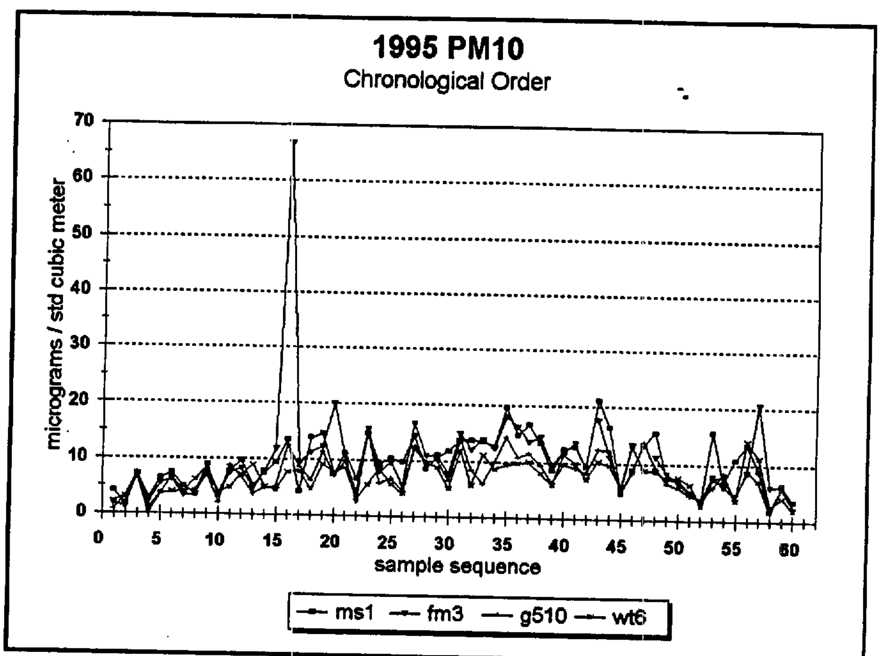

Figure 3-4. Chronological Plot of the PM_{10} Values for 1995

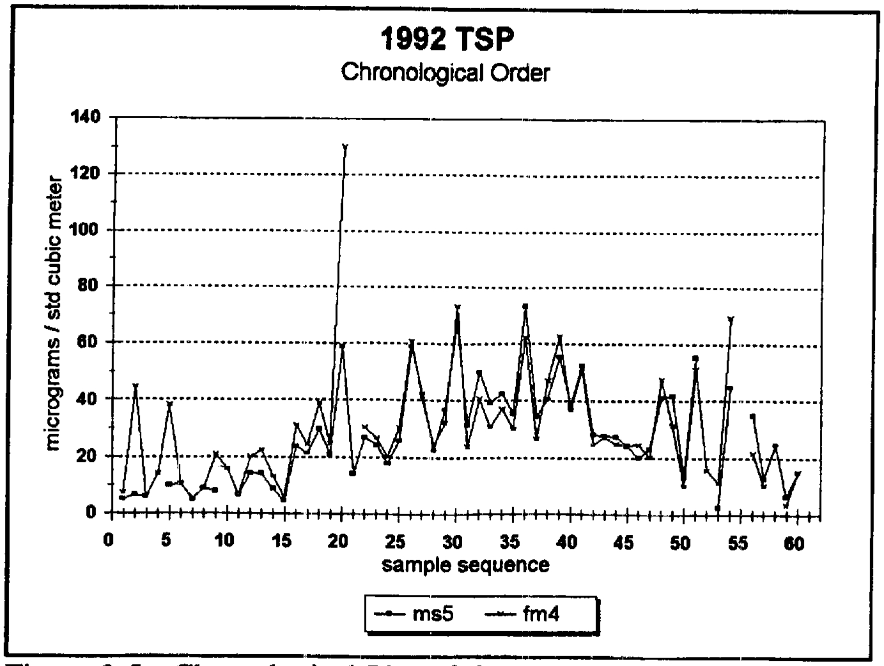

Figure 3-5. Chronological Plot of the $_{TSP}$ Values for 1992

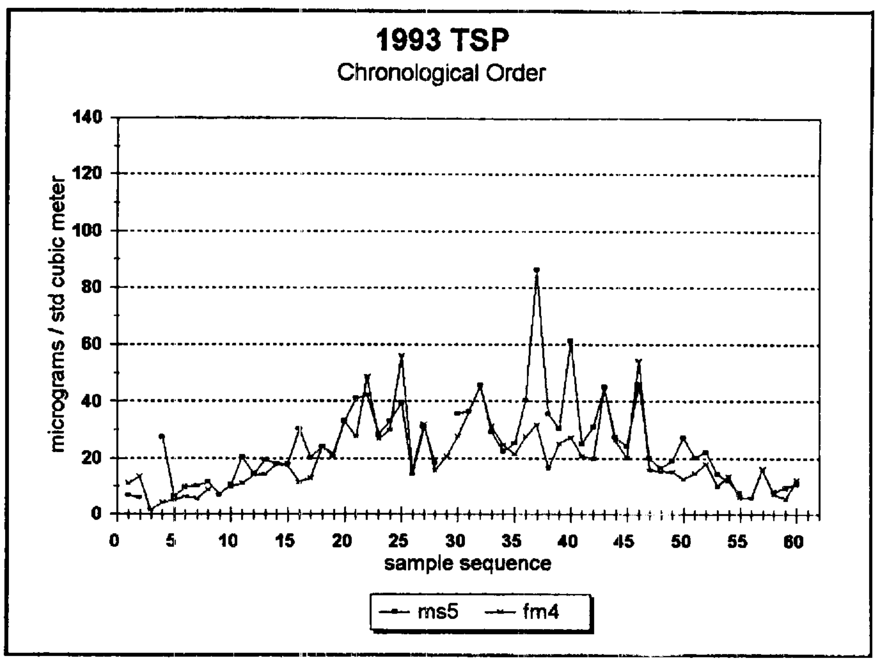

Figure 3-6. Chronological Plot of the TSP Values for 1993

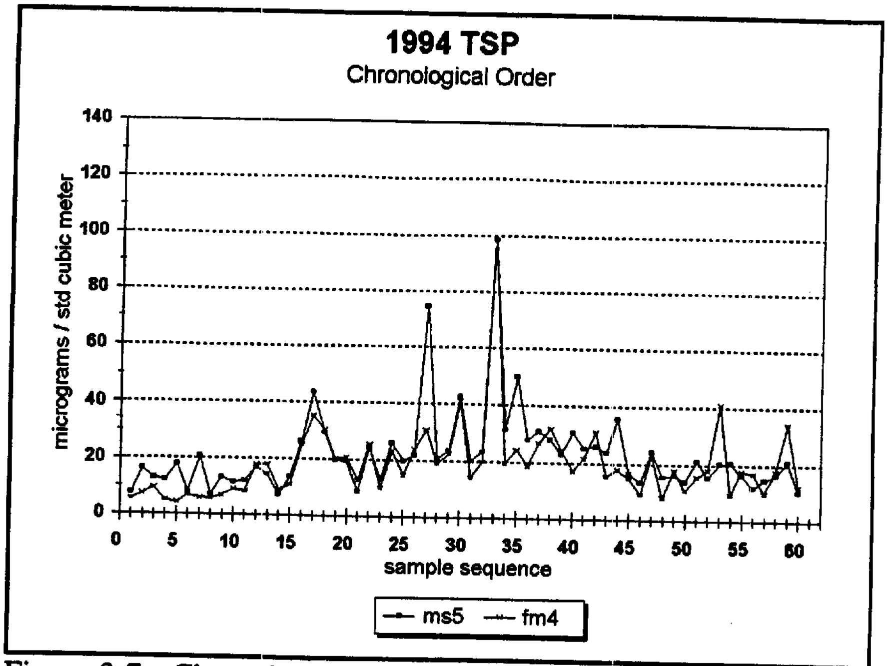

Figure 3-7. Chronological Plot of the TSP Values for 1994

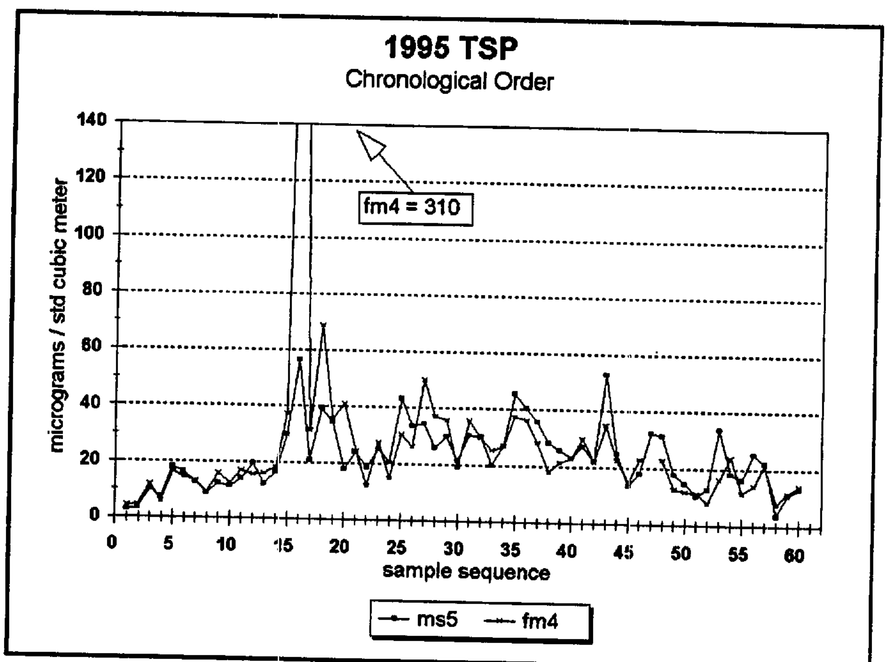

Figure 3-8. Chronological Plot of the TSP Values for 1995

The particulate matter values typically were higher during the summer than winter. Plots of all operating sampler data show the similarity in the annual trends. The plots also show that the annual maximum values are typically well above the remainder of the results.

In addition to the highest and second-highest values comparisons were made of the annual 95th-percentile, median, and mean statistics. The mean value is significant because the annual standards are based on the arithmetic mean value. The median indicates the mid-range point in a ranked set, which minimizes the numerical impact of a few extremely high values. The 95th-percentile value is presented as a further indicator of a higher ranked occurrence, with less emphasis on the very few extremely high values relative to the remainder of the data. The 95th-percentile statistic has been promoted as a possible replacement for the standard determination, since it typically is a more robust measure of the particulate matter levels than the highest one or two extreme values. These annual results are shown in Tables 3-9 through 3-11. The results show only slight differences between the PM_{10} results from the four sites. The results also show there were small differences from year to year. The results from the two TSP sites show similar relationships between sites and years.

Further comparisons between the four monitoring sites based on frequency distributions of particulate matter are presented in Table 3-12. The data from 1993 through 1995 were used in this comparison because very few samples were taken at Sites 6 and 9 during 1992. These results from the four sites are very similar, though Site 6 (WT-6 in upper Yucca Wash) and Site 9 (Gate 510) have slightly more frequent occurrences of PM_{10} levels less than 10 $\mu g/m^3$ than Sites 1 (NTS-60) and 5 (Fortymile Wash). Plots of the ranked occurrences are shown in the distribution presented in Figures 3-9 through 3-12. These plots show the similarities between different years for given sites and the similarities between the results from various samplers. These plots also show the extent to which the maximum values are well above the remainder of the results.

Table 3-9. 95th-Percentile Values ($\mu g/m^3$) for PM_{10} and TSP.

	PM_{10}				**TSP**	
Year	**MS1**	**FM3**	**G510**	**WT6**	**MS5**	**FM4**
1992	24	24	(Note[1])	(Note[1])	59	63
1993	20	20	20	17	46	46
1994	24	17	18	16	44	35
1995	16	18	14	12	43	41

Note[1]: Sampling started too late in the year to calculate statistics

Table 3-10. Median Values (μg/m³) for PM_{10} and TSP.

	PM_{10}				TSP	
Year	MS1	FM3	G510	WT6	MS5	FM4
1992	12	11	(Note[1])	(Note[1])	24	25
1993	9	8	8	8	21	16
1994	8	8	6	6	20	18
1995	9	8	7	7	21	19

Note[1]: Sampling started too late in the year to calculate statistic

Table 3-11. Mean Values (μg/m³) for PM_{10} and TSP.

	PM_{10}				TSP	
Year	MS1	FM3	G510	WT6	MS5	FM4
1992	12	12	(Note[1])	(Note[1])	27	30
1993	10	9	9	10	25	20
1994	10	9	8	7	22	19
1995	10	10	7	7	23	27

Note[1]: Sampling started too late in the year to calculate statistic

Table 3-12. Distribution of 24-Hour Particulate Matter Values for 1993-1995.

	PM_{10}				TSP	
PM Level (μg/m³)	MS1	FM3	G510	WT6	MS5	FM4
1 to <5	35	48	55	52	3	5
5 to <10	66	60	72	69	17	29
10 to <15	48	44	33	32	33	35
15 to <20	20	15	12	12	28	35
20 to <30	6	6	3	4	54	41
30 to <50	2	1	1	0	36	29
50 to <70	0	1	0	0	4	4
70 to <100	0	0	0	0	3	1
100 to <300	0	0	0	0	0	0
300 and above	0	0	0	0	0	1

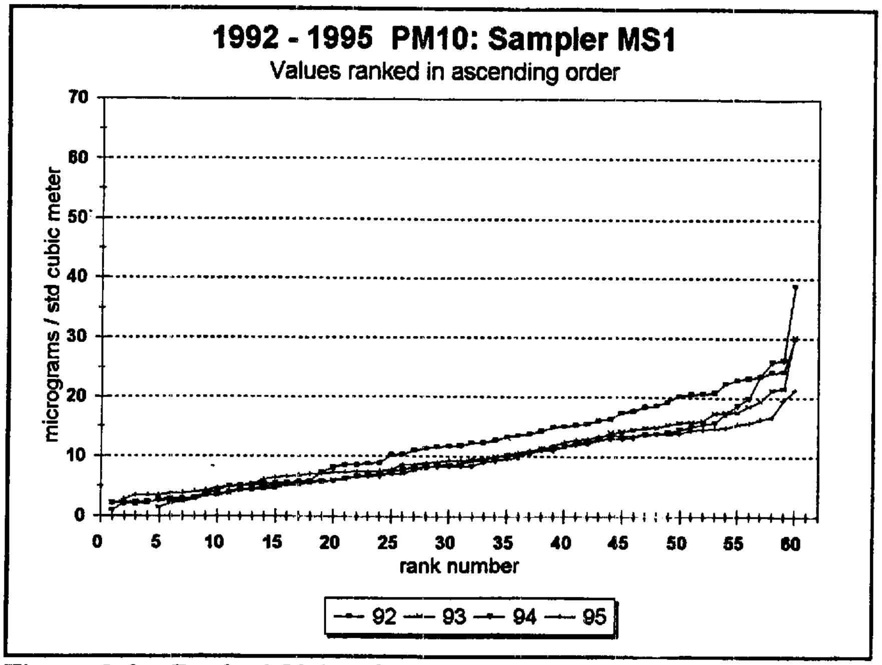

Figure 3-9. Ranked Value Occurrences for MS1

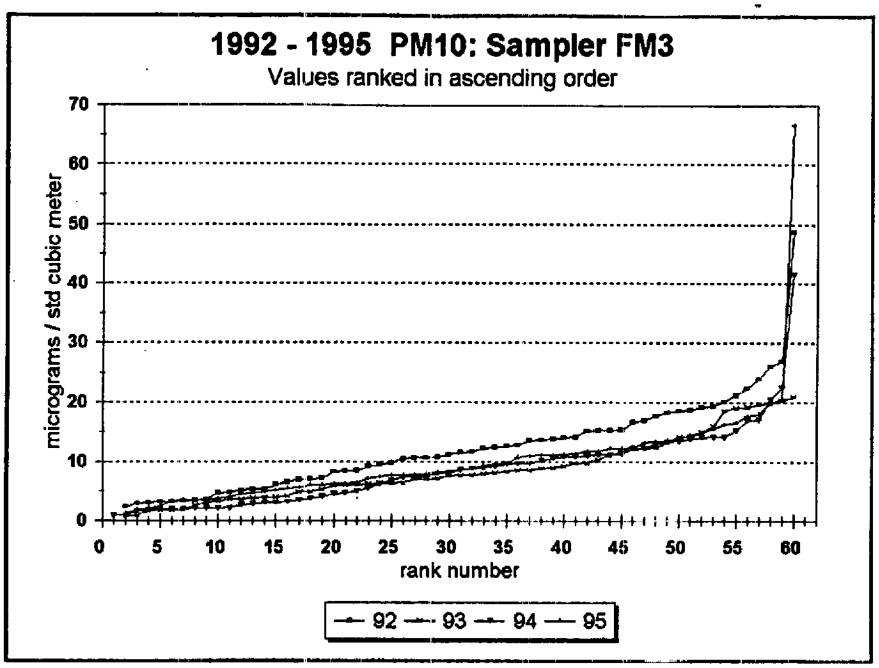

Figure 3-10. Ranked Value Occurrences for FM3

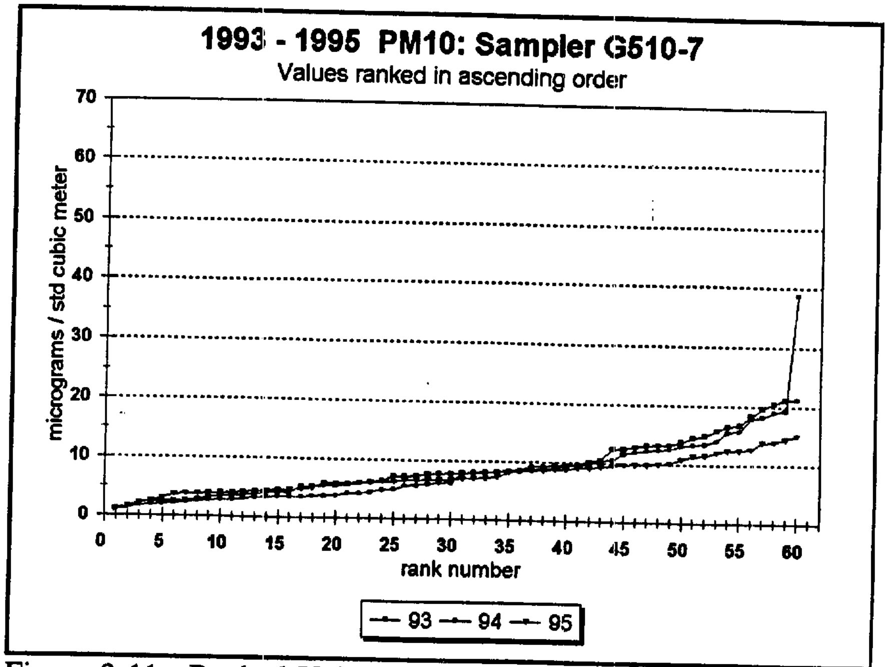

Figure 3-11. Ranked Value Occurrences for G510-7

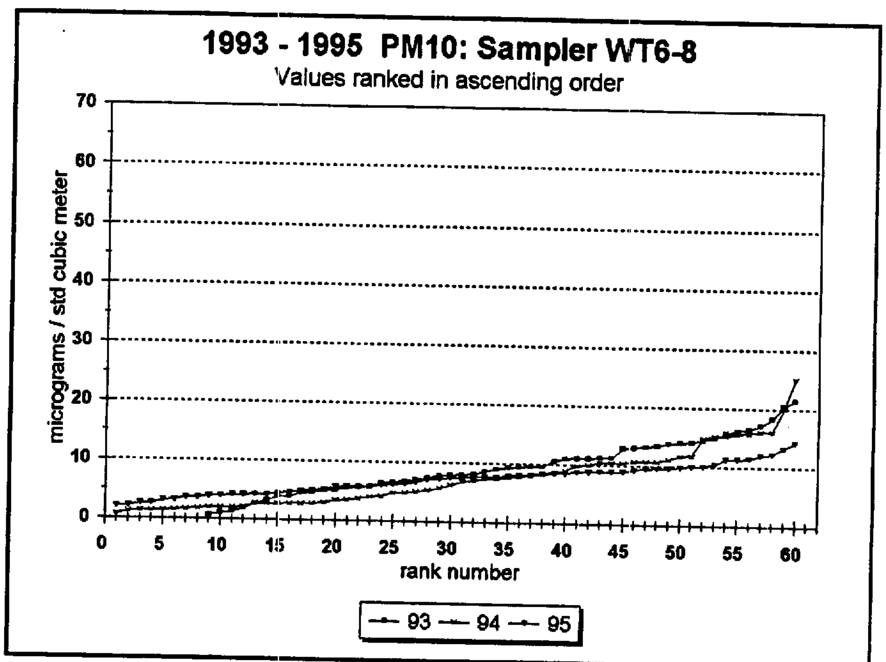

Figure 3-12. Ranked Value Occurrences for WT6-8

Further investigation of the maximum values observed shows that some of the higher particulate matter concentrations were representative of the overall area, rather than being due to localized conditions. The dates that the highest and second-highest results occurred are shown in Table 3-13. For example, note that the highest PM_{10} and TSP values in 1994 for all samplers occurred on July 19, indicating an area-wide occurrence of high level suspended particulate matter concentrations.

Table 3-13. Dates (Month/Day) of Highest Particulate Matter Occurrences.

	PM_{10}		TSP		PM_{10}	TSP	PM_{10}	
Year	**MS1**	**MS2**	**MS5**	**MS6**	**FM3**	**FM4**	**G510**	**WT6**
1992	8/4	8/4	8/4	6/29	4/30	4/30	11/02	(Note[1])
1993	8/11	8/11	8/11	8/11	7/12	5/31	7/21	5/13
1994	7/19	7/19	7/19	7/19	7/19	7/19	7/19	7/19
1995	9/18	9/18	4/9	4/9	4/9	4/9	5/21	12/5

Note[1]: Sampling started too late in the year to report result.

The maximum PM_{10} value observed for the whole period appears to be a good example of local conditions affecting the results. The highest PM_{10} was 67 $\mu g/m^3$, which was sampled on April 9, 1995 at Site 5 (Fortymile Wash). The PM_{10} results from the remaining three sites were at typically low concentration levels. It is possible that a temporary increase in traffic on the dirt roads within a few hundred meters of the samplers at Site 5 created enough loose soil to contribute to the high concentrations. Meteorological conditions on that date appear to have played a significant role in these relatively high concentrations. Dry northwesterly winds averaged well over 10 meters per second (m/s) for the first half of the day on that date. Northwesterly winds could bring airborne suspended particulate matter from nearby dirt roads to the samplers at Site 5. Gusts at Site 5 exceeded 22 m/s (nearly 50 miles per hour) for five hours early in the morning.

The highest TSP value observed during the whole period, 310 $\mu g/m^3$, also occurred on April 9, 1995 at the Site 5. The influence of sustained high wind speeds from the direction of the dirt roads is the same for TSP as for PM_{10} described above. Coincidentally, the highest TSP results occurring in 1995 at Site 1 also occurred on April 9. Site 1 experienced similar strong northwesterly winds. The higher TSP concentration relative to the PM_{10} result on this day could reflect the transport of particles predominantly larger than the PM_{10} size range.

The highest 24-hour values and the annual averages for the primary samplers for the 1989 through 1991 reporting period are presented in Table 3-14. As with the 1992 through 1995 results, results from previous years indicate few occurrences of higher concentrations, with typically low values contributing to low mean values.

Table 3-14. Results from Previous Years.

		PM_{10}		TSP	
Year	Statistic	MS1	FM3	MS5	FM4
1989	Highest 24-Hour Average	42	40	90	94
	Annual Average	12	12	26	27
1990	Highest 24-Hour Average	62	48	150	106
	Annual Average	12	10	24	22
1991	Highest 24-Hour Average	33	46	62	103
	Annual Average	10	11	22	25

Table entries are the highest 24-hour and annual average particulate matter values.

4.0 QUALITY ASSURANCE ASSESSMENT

Three quantitative quality assurance assessments are reported in this section: precision, accuracy, and the sampling integrity. The assessments of precision and accuracy follow the U.S. EPA requirements applicable to Prevention of Significant Deterioration (PSD) programs, Title 40 CFR, Part 58, Appendix B. The results from slightly different assessment methods currently required by the State of Nevada for PM_{10} monitoring programs are also reported. The technique used to assess sample integrity is included in the U.S. EPA Quality Assurance Handbook (EPA, 1990). This assessment began in 1993. Data recovery is considered as an element of quality assurance. These results were presented in section 3.1.

4.1 Precision

The precision of the particulate matter monitoring program was assessed using the results of simultaneous measurements by the collocated samplers. Precision is a measure of the consistency in application of the sampler operations and laboratory analyses. The collocated samplers are located at Site 1 (NTS-60); the PM_{10} samplers are MS1 and MS2, and the TSP samplers are MS5 and MS6. The State of Nevada monitoring guidance (Nevada, 1994) requires the average of the difference in concentrations for values less than 80 $\mu g/m^3$. The U.S. EPA PSD technique (40 CFR 58) is based on the percent difference (%-diff) of the paired sample results (X and Y) from the two samplers compared to the average of the paired values.

$$\%\text{-diff} = 100\% \bullet (X - Y) / [(X + Y) / 2]$$

A separate calculation of the precision results was made for samples with concentrations at least 4 μg/m^3 to reduce the unrealistically high percent-difference values calculated from the difference of two very small numbers. The upper and lower 95-percent confidence intervals are calculated based on the mean (M) and the standard deviation (SD) of the percent differences using the following equation:

$$95\% \text{ interval} = M \pm [1.96 \bullet SD / (2)^{1/2}]$$

The annual precision results are shown in Tables 4-1 through 4-3. The differences based on the State of Nevada method ranged from -0.1 to -0.5 μg/m^3 for PM_{10}, and from -0.5 to +0.3 μg/m^3 for TSP. The highest upper and lowest lower 95% interval values were +31.8% and -36.5% for PM_{10}, and +28.7% and -32.0% for TSP. The modified calculation for the PM_{10} results (only using values at least 4 μg/m^3) eliminated approximately one-fourth of the differences. The modified 95% interval results are +15.9% and -20.7%. EPA does not have guidance on acceptable data precision. These results are seen as acceptable for the purposes of demonstrating regulatory compliance and general environmental characterization.

Table 4-1. Annual PM_{10} Precision Assessment Results (all concentrations).

Year	Concentration	Upper 95%	Lower 95%
1992	-0.5	28.6%	-32.0%
1993	-0.1	21.7%	-21.8%
1994	-0.2	31.8%	-36.5%
1995	-0.4	20.4%	-29.7%

Concentrations are differences between primary and collocated sampler results, in micrograms per standard cubic meter (μg/m^3).
Upper 95% and Lower 95% confidence interval limits shown based on percent differences.

Table 4-2. Annual PM_{10} Precision Assessment Results (concentrations greater than 4 μg/m^3).

Year	Concentration	Upper 95%	Lower 95%
1992	-0.7	9.2%	-18.1%
1993	-0.1	13.0%	-15.8%
1994	-0.1	15.9%	-20.2%
1995	-0.5	12.5%	-20.7%

Concentrations are differences between primary and collocated sampler results, in micrograms per standard cubic meter (μg/m^3).
Upper 95% and Lower 95% confidence interval limits shown based on percent differences.

Table 4-3. Annual TSP Precision Assessment Results (all concentrations).

Year	Concentration	Upper 95%	Lower 95%
1992	-0.5	28.6%	-32.0%
1993	-0.5	19.4%	-24.4%
1994	0.1	19.7%	-21.8%
1995	0.3	28.7%	-25.8%

Concentrations are differences between primary and collocated sampler results, in micrograms per standard cubic meter (μg/m^3).
Upper 95% and Lower 95% confidence interval limits shown based on percent differences.

4.2 Accuracy

The accuracy of the particulate matter monitoring program was assessed using the results from independent performance audit measures of sampler airflow rates. The auditor measured the typical operating airflow rate and used a calibrated orifice to determine the actual airflow rate at the indicated operating airflow. The recommended tolerance (EPA, 1990) for the differences between the flow rates indicated by the audit orifice calibrator and the operational sampler are +6%; exceeding this value indicates a need to recalibrate the sampler. Flow rates within +10% of the design flow rate (1.13 m^3/min) are considered acceptable (EPA, 1990). These audits were performed once during each calendar quarter.

The results of the audits of both the PM_{10} and TSP samples are shown in Table 4-4 and 4-5.

Table 4-4. Summary of Performance Audits of PM_{10} Samplers.

	Sampler & Orifice			Sampler & Design (1.13 m^3/min)		
Year	max	min	avg	max	min	avg
1992	7.6%	0.5%	3.6%	-2.0%	-8.8%	-4.4%
1993	5.6%	-6.0%	-0.2%	9.7%	-6.2%	1.1%
1994	2.7%	-4.1%	-1.0%	8.8%	-3.5%	1.6%
1995	1.9%	-4.2%	-0.7%	6.2%	-5.3%	-1.6%

Table 4-5 . Summary of Performance Audits of TSP Samplers.

	Sampler & Orifice			Sampler & Design (1.13 m^3/min)		
Year	max	min	avg	max	min	avg
1992	9.3%	3.4%	5.9%	11.4%	1.2%	5.8%
1993	1.8%	-2.5%	-0.1%	4.4%	-0.9%	2.1%
1994	4.4%	-0.9%	0.7%	5.3%	0.9%	3.4%
1995	3.5%	-4.1%	-0.7%	7.1%	-3.2%	1.3%

These results reasonably indicate that the samplers were operating within acceptable tolerances. Investigations were promptly initiated to explain results that exceed the limits given above. Corrective actions were taken when necessary.

4.3 Sampling Integrity

The sampling integrity of the particulate matter monitoring program was assessed using the results of gravimetric analyses of blank filters. These filters were treated as samples except that they were removed from the sampler immediately after installation, without the sampler being run. Such samples are called "blanks" in some analytical operations. The blank filter samples have been created once each month beginning in 1993, using different samplers. The U.S. EPA guidance allows a +5 μg/m^3 equivalent concentration in this assessment.

The results of the annual summaries are shown in Table 4-6. The annual maxima and minima values range from -1.6 to +1.1 μg/m^3, except for 1995, which had a maximum value of +4.7 μg/m^3. The three annual average equivalent concentrations are -0.2, +0.1, and +0.5 μg/m^3.

Table 4-6. Sampling Integrity Results.

Year	Maximum	Minimum	Average	Count
1993	1.1	-1.6	-0.2	11
1994	1.1	-1.1	0.1	11
1995	4.7	-1.3	0.5	12

Table entries are annual maximum, minimum, and average values of the field blank sampling integrity assessment, with the "count" number of samples in each year.

These results further demonstrate the very good quality of field data.

5.0 REFERENCES

40 CFR 50a: Title 40, Code of Federal Regulations, Part 50 - National Primary and Secondary Ambient Air Quality Standards. Section 50.6: National Primary and Secondary Ambient Air Quality Standards for Particulate Matter.

40 CFR 50b: Title 40, Code of Federal Regulations, Part 50 - National Primary and Secondary Ambient Air Quality Standards. Appendix K: Interpretation of the National Ambient Air Quality Standards for Particulate Matter.

40 CFR 50c: Title 40, Code of Federal Regulations, Part 50 - National Primary and Secondary Ambient Air Quality Standards. Appendix J: Reference Method for the Determination of Particulate Matter as PM_{10} in the Atmosphere.

40 CFR 50d: Title 40, Code of Federal Regulations, Part 50 - National Primary and Secondary Ambient Air Quality Standards. Section 50.3: Reference Conditions.

40 CFR 58: Title 40, Code of Federal Regulations, Part 58 - Ambient Air Quality Surveillance. Appendix B: Quality Assurance Requirements for Prevention of Significant Deterioration (PSD) Air Monitoring.

EFPD, 1992a: Particulate Matter Ambient Air Quality Data Report for 1989 - 1990. March, 1992.

EFPD, 1992b: Particulate Matter Ambient Air Quality Data Report for 1991. October, 1992.

EFPD, 1992c: Technical and Management Support Services WI-AQ-002, Calibrations and Performance Audits of Particulate Matter Samplers.

EFPD, 1994a: Technical and Management Support Services WI-AQ-001, Routine Operations and Maintenance for Ambient Particulate Matter Samplers.

EFPD, 1994b: Technical and Management Support Services WI-AQ-016, Air Quality Monitoring: Gaseous and Particulate Data Processing Instructions.

EFPD, 1995a: Scientific Investigation Implementation Package for Air Quality Monitoring, Revision 1, August 1995, EFPD-91/002.

EFPD, 1995b: Nevada Work Instruction NWI-AQ-001, Routine Operations and Maintenance for Ambient Particulate Matter Sampling.

EFPD, 1995c: Nevada Work Instruction NWI-AQ-002, Calibrations and Performance Audits of Particulate Matter Samplers.

EFPD, 1995d: Nevada Work Instruction NWI-AQ-016, Air Quality Monitoring: Gaseous and Particulate Data Processing Instructions.

EPA, 1990: Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II: Ambient Air Specific Methods. Section 2.2: Reference Method for the Determination of Suspended Particulates in the Atmosphere (High-Volume Sampler Method). Section 2.11: Reference Method for the Determination of Particulate Matter as PM_{10} in the Atmosphere (High-Volume PM_{10} Sampler Method).

Nevada, 1994 ATTACHMENT A - Nevada Bureau of Air Quality, Ambient Air Quality Monitoring Guidelines

Nevada, 1995 Nevada Administrative Code Chapter 445B: Air Pollution. Section 445B.391: Standards of Quality for Ambient Air.

APPENDIX A

GLOSSARY OF ACRONYMS

CFR -- Code of Federal Regulations

EFPD -- Environmental Field Programs Division

EPA -- Environmental Protection Agency

$\mu g/m^3$ -- micrograms per cubic meter

NAAQS -- National Ambient Air Quality Standards

PM_{10} -- Inhalable Particulate Matter

PSD -- Prevention of Significant Deterioration

TSP -- Total Suspended Particulate Matter

APPENDIX B

PARTICULATE MATTER DATA APPENDIX

The following pages are listings of the individual 24-hour particulate matter sampling results for each scheduled sampling day. The concentrations are expressed in micrograms per standard cubic meter ($\mu g/m^3$). The data are presented with one page per reporting year, in columns by sampler. The samplers are:

MS1: Site 1 primary PM_{10} sampler

MS2: Site 1 collocated PM_{10} sampler
(for "precision" quality assurance assessment)

FM3: Site 5 PM_{10} sampler

G510-7: Site 9 PM_{10} sampler

WT6-8: Site 6 PM_{10} sampler

MS5: Site 1 primary TSP sampler

MS6: Site 1 collocated TSP sampler
(for "precision" quality assurance assessment)

FM4: Site 5 TSP sampler

Appendix B: Data Listing

	PM$_{10}$					TSP		
Dates	MS1	MS2	FM3	G510-7	WT6-8	MS5	MS6	FM4
01/01/92	3	3	3			7	7	5
01/07/92	3	2	3			5	6	7
01/13/92	2	3	12			7	6	45
01/19/92	3	3	3			6	5	6
01/25/92	3	4	5			0	8	14
01/31/92	5	6	15			10	10	38
02/06/92	5	5	5			11	10	10
02/12/92	2	2	3			5	5	5
02/18/92	4	5	4			9	10	9
02/24/92	3	3	7			8	9	21
03/01/92			7					16
03/07/92	3	2	3			7	7	6
03/13/92	9	8	10			14	15	20
03/19/92	8	8	11			14	15	22
03/25/92	5	5	5			9	8	13
03/31/92	2	3	3			5	6	6
04/06/92	15	15	18			24	25	31
04/12/92	11	11	13			21	23	24
04/18/92	12	12	14			30	30	39
04/24/92	12	12	14			21	22	25
04/30/92	23	23	49			59	61	130
05/06/92	6	6	7			14	15	
05/12/92	15	15	15			27	28	31
05/18/92	13	12	14			24	25	27
05/24/92	10	9	9			18	21	20
05/30/92	13	13	12			26	28	31
06/05/92	24	24	24			59	58	61

Appendix B: Data Listing

	PM_{10}					TSP		
Dates	MS1	MS2	FM3	G510-7	WT6-8	MS5	MS6	FM4
06/11/92	23	22	22			42	46	41
06/17/92	10	10	9			23	24	24
06/23/92	18	17	17			37	40	32
06/29/92	21	20	21			67	68	73
07/05/92	12	11	8			32	30	24
07/11/92	21	21	19			50	49	41
07/17/92	16	16	14			39		31
07/23/92	18	18	17			43		37
07/29/92	16	16	14			36		30
08/04/92	30	30	26			73		62
08/10/92	14	14	12			35		27
08/16/92	19	18	18			41		47
08/22/92	19	18	19			55	54	63
08/28/92	17	17	15			39		37
09/03/92	20	21	20			53	53	52
09/09/92	15	14	13			28		25
09/15/92	14	12				28		27
09/21/92	14	14				28		25
09/27/92	12	11	11			24		24
10/03/92	9	7	8	10	9	20	22	25
10/09/92	12	12	11	13	11	23	24	20
10/15/92	24	24	27	26		41	42	48
10/21/92	24	23	19	22	22	42	43	31
10/27/92	5	5	5	5	8	13	13	10
11/02/92	22	16	15	31		56	54	51
11/08/92	7	6	11	9				16
11/14/92	1	3	5	0		3	3	11

Appendix B: Data Listing

	PM$_{10}$					TSP		
Dates	MS1	MS2	FM3	G510-7	WT6-8	MS5	MS6	FM4
11/20/92	21	14	19	31		45	45	69
11/26/92	9	10	6	8				
12/02/92	15	14	7	14		35	34	22
12/08/92	11	9	12	9		13	12	10
12/16/92	9		9	1		25	19	0
12/20/92	6	3	2	3		6	7	3
12/26/92	4	5	11	9		15	6	15
01/01/93								
01/07/93			9	8		7	11	11
01/13/93	9	6	4			6	11	14
01/19/93	1	2	3	3			5	2
01/25/93		10	1	2	6	28	29	4
01/31/93	4	3	4	3		6	5	5
02/06/93	5	6		4	3	10	8	6
02/12/93		2	2	3	1	10		6
02/18/93	6	5	5	6		12	11	9
02/24/93	2	2	2	3	1	7	11	
03/02/93	3	4	3	4	5	11	10	10
03/08/93	6	7	4	6	7	21	19	11
03/14/93	7	6	6	7	6	14	13	14
03/20/93	7	7	6	6	4	19	17	14
03/26/93	6	7	6	7	14	18	15	18
04/01/93	8	7	7	8		18	19	17
04/07/93	10	11	5	6	8	30	30	12
04/13/93	5	5	4	4	6	20	19	13
04/19/93	7	8	7	9	8	24	24	24

Appendix B: Data Listing

	PM_{10}					TSP		
Dates	MS1	MS2	FM3	G510-7	WT6-8	MS5	MS6	FM4
04/25/93	7	7	7	7	11	21	18	22
05/01/93	18	18	19	18	15	33	34	33
05/07/93	18	18	13	15	13	41	39	28
05/13/93	19	19	20	21	22	42	42	49
05/19/93	16	16	15	16	11	28	28	27
05/25/93	13	11	9	11	13	33	35	30
05/31/93	15	15	19	17	11	39	39	56
06/06/93	4	4	4	4		14	13	16
06/12/93	15	15	14	17	16	31	32	32
06/18/93	8		8	8	4	18	17	16
06/24/93	9	9	8	8	7		27	21
06/30/93	15	14	12	13	14	36	35	28
07/06/93	20	20	19	20	18	37	38	36
07/12/93	21	21	21	21	21	46	44	46
07/18/93	16	13	16	13	17	29	30	31
07/24/93	9	9	8	9	16	22	22	25
07/30/93	11	12	9	8	9	25	25	21
08/05/93	14	14	11	13	13	41	39	28
08/11/93	30	32	12	13	11	86	82	32
08/17/93	16	16	10	9	10	36	35	16
08/23/93	14	14	12	12	14	30	29	25
08/29/93	12	13	12	13	11	62	29	27
09/04/93	9	8	9	8	11	25	27	21
09/10/93		11	8	9	9	31	28	20
09/16/93	22	20	20	20	13	45	46	45
09/22/93	15	15	14	14	14	27	27	26
09/28/93	12	11	10	8	8	24	24	20

Appendix B: Data Listing

	PM$_{10}$					TSP		
Dates	MS1	MS2	FM3	G510-7	WT6-8	MS5	MS6	FM4
10/16/93	7	6	6	6	7	17	17	15
10/22/93	8	8	6	8	7	19	19	15
10/28/93	10	10	6	5	5	27	28	13
11/03/93	12	13	8			20	19	15
11/09/93	12	12	10	10	10	22	22	18
11/15/93	6	6	5	5	6	14	14	10
11/21/93	5		6	5	9	12	13	14
11/27/93	4	4	1	4	9	8	7	6
12/03/93	4	6	3	3	4		12	6
12/09/93	10	10	9	10	8		19	16
12/15/93	2	2	2	0	2	8	7	7
12/21/93	3	3	2	2	1	9	6	6
12/27/93	5	4	4	4	3	11	9	12
01/02/94	3	2	3	4	4	9	8	11
01/08/94	2	2	2	2	2	8		5
01/14/94	5	5	1	2	2	16	15	7
01/20/94	5	5	3	3	3	13	10	9
01/26/94	3	2	1	1	1	12	12	5
02/01/94	4	5	1	1	2	18	16	4
02/07/94	4	3	5	4	3	8	8	7
02/13/94	10	10	2	3	1	21	21	6
02/19/94	1	3	2	3	1	7	8	6
02/25/94	3	3	3	3	3	13	11	7
03/03/94	6	5	5	5	3	11	12	9
03/09/94	6	5	7	3	3	12	12	8
03/15/94	7	6	9	6	8	17	19	18
03/21/94	7	9	9	8	11	14	16	18

Appendix B: Data Listing

	PM_{10}					TSP		
Dates	MS1	MS2	FM3	G510-7	WT6-8	MS5	MS6	FM4
03/27/94	8	8	4	3	1	7	7	9
04/02/94	2	2	2	4	3	14	12	11
04/08/94	11	9	8	12	7	26	26	25
04/14/94	24	24	21	18	16	44	42	35
04/20/94	13	15	14	16	15	30	29	30
04/26/94	5	4	2	4	1	20	19	20
05/02/94	12	13	13	12	15	19	18	21
05/08/94	3	2	2	4	9	9	9	13
05/14/94	16	16	15	13	12	25	24	26
05/20/94	2	3	2	4	4	13	10	10
05/26/94	11	11	11	13	16	26	27	23
06/01/94	12	12	9	9	10	20	19	15
06/07/94	8	9	10	10	5	22	22	24
06/13/94	13	13	14	18	15	74	29	31
06/19/94	13	12	11	13	12	21	21	19
06/25/94	15	14	13	10	10	24	22	22
07/01/94	26	26	23	19	16	43	43	41
07/07/94	10	10	5	5	6	20	22	14
07/13/94	14	12	11	10	16	24	23	20
07/19/94	39	40	42	39	25	99	102	98
07/25/94	19	19	9	8	9	32	38	20
07/31/94	26	25	12	14	8	50	51	24
08/06/94	16	16	11	12	10	28	28	19
08/12/94	15	15	14	19	10	31	31	27
08/18/94	17	16	17	16	20	28	29	32
08/24/94	11	11	12	10	5	23	24	25
08/30/94	14	15	10	10	11	31	33	17
09/05/94	14	14	13	13	11	25	27	22

Appendix B: Data Listing

	PM10					TSP		
Dates	MS1	MS2	FM3	G510-7	WT6-8	MS5	MS6	FM4
09/23/94	20	20	11	9	10	36	37	18
09/29/94	6	5	11	6	6	17	17	15
10/05/94	8	6	2	2	2	13	14	9
10/11/94	12	12	10	8	8	24	25	23
10/17/94	2	3	2	2	2	15	17	8
10/23/94	7	10	10	9	7	16	17	18
10/29/94	6	6	4	4	7	14	13	11
11/04/94	8		7	3	2	21	26	16
11/10/94	8	3	7	8	3	15	16	18
11/16/94	7	6	11	6	5	20	20	41
11/22/94	5	5	3	2	3	21	22	9
11/28/94	6	6	4	1	1	16	20	18
12/04/94	6	7	7	8	7	12	14	17
12/10/94	9	6	3	3	2	15	18	10
12/16/94	6	6	5	4	4	16	11	18
12/22/94	8	9	17	6	5	21	12	35
12/28/94	8	7	6	6	3	10	6	12
01/03/95	4	4	4	4	4	8	8	7
01/09/95	4	4	2	1	2	3	4	4
01/15/95	2	1	1	3	3	3	5	4
01/21/95	7	7	7	7	7	10	12	12
01/27/95	3	2	2	1	0	7	4	6
02/02/95	6	7	5	4	4	18	21	16
02/08/95	7	6	6	7	4	16	14	15
02/14/95	5	4	3	4	4	13	14	13
02/20/95	3	4	4	4	6	9	11	9

Appendix B: Data Listing

	PM_{10}					TSP		
Dates	MS1	MS2	FM3	G510-7	WT6-8	MS5	MS6	FM4
03/10/95	8	7	7	9	5	14	15	17
03/16/95	10	10	8	7	7	19	21	16
03/22/95	5	5	5	4	9	12	13	16
03/28/95	7	7	8	5	5	17	18	18
04/03/95	9	10	12	5	4	30	30	37
04/09/95	13	9	67	12	8	56	51	310
04/15/95	4	9	9	9	8	21	20	32
04/21/95	14	10	11	6	5	39	25	69
04/27/95	15	12	12	11	9	35	37	36
05/03/95	7	8	20	7	8	18	18	41
05/09/95	11	12	11	10	9	24	25	24
05/15/95	7	3	3	4	3	19	18	12
05/21/95	15	15	16	15	6	25	27	28
05/27/95	9	9	8	6	9	21	22	15
06/02/95	10	10	10	7	6	43	41	31
06/08/95	10	9	6	5	4	34	33	26
06/14/95	14	15	17	13	12	35	34	50
06/20/95	9	9	11	10	10	26	26	37
06/26/95	11	11	11	10	9	30	31	36
07/02/95	12	12	8	7	5	21		19
07/08/95	14	14	15	14	12	31	33	36
07/14/95	14	13	12	9	6	30	43	30
07/20/95	14	9	14	6	11	20	26	25
07/26/95	13	12	12	10	9	27	34	27
08/01/95	20	19	18	14	9	46	45	38
08/07/95	15	15	16	11	10	41	43	36
08/13/95	17	16	14	12	10	36	36	28

Appendix B: Data Listing

	PM$_{10}$					TSP		
Dates	MS1	MS2	FM3	G510-7	WT6-8	MS5	MS6	FM4
08/19/95	14	12	14	10	8	28		18
08/25/95	9	9	10	6	6	26	19	21
08/31/95	12	13	12	10	11	23	26	23
09/06/95	13	13	14	9	10	27		30
09/12/95	9	10		8	7	22	26	22
09/18/95	21	21	18	12	10	53	50	35
09/24/95	16	12	11	12	10	25	24	23
09/30/95	5	5	5	5	6	14	14	15
10/06/95	9	9	13	8	13	18	20	23
10/12/95	13	14		14	9	33	34	
10/18/95	16	14	11	9	9	31	31	23
10/24/95	7	8	8	7	7	18	19	13
10/30/95	7	6	6	6	8	15	16	12
11/05/95	5	5	5	4	6	10	13	11
11/11/95	3	4	4	4	3	13	11	8
11/17/95	16	14	8	6	7	34	35	16
11/23/95	7	7	6	8	8	18	27	24
11/29/95	11	12	5	4	4	16	15	12
12/05/95	14	13	9	9	14	25	26	14
12/11/95	9	9	21	7	11	22	14	21
12/17/95	2	1	6	2	3	4	4	8
12/23/95	6	6	6	6	4	11	10	12
12/29/95	3	4	4	3	2	13	9	14