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Title:

AMBIENT AIRBORNE BERYLLIUM MEASUREMENTS AT LOS ALAMOS NATIONAL LABORATORY

(1989—2001)

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AT
LOS ALAMOS NATIONAL LABORATORY
(1989—2001)

EXECUTIVE SUMMARY

The purpose of this document is to compile all of the data from Los Alamos National Laboratory (LANL) ambient airborne beryllium (Be) measurements for 1989—2001, evaluate the data, and draw conclusions from the data regarding any detectable LANL contributions to the natural Be background.

Beryllium (Be) has been used in processes at LANL for many years. The primary facilities where Be has been used are TA-3-39 (shop 4), TA-3-102 (shop 13), TA-35-213, TA-3-141, and TA-55-4. Their emissions were and are so low that they normally are not measurable at the stacks. Dynamic testing at the LANL firing sites, primarily TA-15, produces some airborne Be. If any LANL Be is measurable in ambient air, it would most likely come from these tests, since they generally are conducted in open air without any ventilation controls.

AIRNET is the name of the LANL ambient environmental radiological air-monitoring network. This extensive environmental air-sampling network consists of approximately 50 air samplers distributed among several areas: on LANL property, around the perimeter of LANL, in nearby populated areas, and in regional areas some distance from LANL.

In 1989 LANL began doing measurements for stable airborne Be using AIRNET. Analyses were done on quarterly composites of filters from selected biweekly AIRNET ambient-air samples. Except for the years 1996-97, Be measurements have been made each year from 1989 through 2001 as part of the AIRNET program and are expected to continue indefinitely.

Beryllium occurs naturally in the soil and in the air all over the world. Based on soil measurements and total suspended particle measurements, the expected soil-based Be concentration in AIRNET samples is expected typically to be in the general range of about 0.005-0.1 ng/m^3. This estimate agrees very well with the actual measurements.

The *maximum* quarterly Be concentration measured during 1989-93 was 0.1 ng/m^3 observed at the Pojoaque station in 1993. The overall average value for the entire 5-year period was about 0.02 ng/m^3. None of these measurements exceeded the New Mexico standard of 10 ng/m^3 that was in effect then. In fact, the highest reading was only 1% of that standard.

The highest 1998-2001 Regional station average was 0.068 ng/m^3at Jemez Pueblo. The overall Regional Group average was 0.030 ng/m^3. The highest 1998-2001 Perimeter station average was 0.103 ng/m^3at the Landfill. The overall Perimeter Group average was 0.024 ng/m^3. Note that the average airborne Be for Perimeter stations is *lower* than the average for the Regional stations immediately above. Thus, it appears that the, apparently natural, airborne Be concentrations at populated locations well removed from LANL are actually *higher* than the airborne Be concentrations in populated areas closer to LANL. The 1998-

2001 Firing-Site station average was 0.007 ng/m^3. This data set is remarkably consistent and has a significantly *lower* Group average Be concentration than either the Regional or the Perimeter Group averages.

During the fourth quarter of 1999, TA-54 AIRNET station 27 had the highest single Be concentration measured anywhere at LANL (0.693 ng/m^3). Since Be is not handled at TA-54, the high values measured there are attributed to very high airborne dust from construction and traffic activities that occurred there during this period. However, even that concentration did not exceed the EPA-NESHAP standard of 10 ng/m^3 (that, although numerically identical to the NM standard, had replaced the NM standard). In fact, that *highest* quarterly measurement was just 7% of the standard.

Several factors affect airborne soil and, thus, the soil-borne Be. These factors include soil availability and texture, wind, precipitation, traffic, excavation activities, ground cover or the lack of it, and, probably several other factors. If most or all of the airborne Be is soil based, then its airborne concentrations should vary with seasons and location. The peak concentrations in northern New Mexico appear normally to occur during the first or second calendar quarters. The lowest concentrations tend to occur in the third and fourth quarters. This seasonal cycling is typically seen at all sample sites, some more strongly than others. Airborne Be concentrations also exhibit spatial variations. That is, some locations will have higher or lower airborne Be concentrations than other locations, independent of the season. Spatial variations are more a function of airborne dust than actual variations in the concentration of Be in the soil. That is, the more airborne dust, the higher the airborne Be concentration.

Because uranium-234 (U-234) and cerium (Ce) both occur naturally in soil, it would be reasonable to expect, assuming the Be is soil based, that U-234 and Ce would both increase in general proportion with Be as it increased in air samples. Of course, there could be some confounding of the U-234 proportion if a significant LANL contribution is included in the U-234 soil inventory. However, the few Laboratory locations (firing sites) known to have detectable enriched or depleted uranium in air do not significantly affect the results seen in such Be/U-234 comparisons. Cerium is not used at LANL; therefore it should only occur naturally in the measurements. The 1998-2001 data show a linear relationship between U-234 and Be and between Ce and Be concentrations in air, implying the Be is natural.

Based on the data and discussions presented in this paper, it does not appear that any LANL contributions to airborne Be are distinguishable from the natural levels normally found in airborne measurements. In all cases, no sample result exceeded the 10 ng/m3 standards. The single highest quarterly Be measurement (taken at TA-54) was just 7% of that standard. Except for a few special cases, virtually all Be measurements were less than 1% of the standard. Thus, it may be concluded that, whether natural or LANL contributed, the airborne Be measured by this program does not present any significant health hazard to anyone.

AMBIENT AIRBORNE BERYLLIUM MEASUREMENTS AT LOS ALAMOS NATIONAL LABORATORY (1989—2001)

1.0 PURPOSE

The purpose of this document is to compile all of the data from Los Alamos National Laboratory (LANL) ambient airborne beryllium (Be) measurements for 1989—2001, evaluate the data, and draw conclusions from the data regarding any detectable LANL contributions to the natural Be background. As part of that purpose, this document will give background information on Be use at LANL, the sampling and analytical methods used to make the measurements, and the natural occurrence of Be in the environment. Additionally, this document will present and discuss the Be measurements data set, compare it to other applicable environmental parameters, analyze temporal and spatial variations, and determine if the measurements have detected any LANL Be emissions.

Besides the information presented here, the reader may want to refer to the annual LANL Environmental Surveillance Reports (ESR) for additional information on this subject. For example, the ESRs provide detailed descriptions of the AIRNET sites and provide a map of their locations.

2.0 BACKGROUND

This BACKGROUND section provides background information on the

- use of Be at LANL,
- operation of the AIRNET ambient environmental air monitoring network,
- measurement of Be using AIRNET, and
- occurrence of Be in the environment.

2.1 Be Use at LANL

Beryllium (Be) has been used in processes at LANL for many years. The primary facilities where Be has been used are TA-3-39 (shop 4), TA-3-102 (shop 13), TA-35-213, TA-3-141, and TA-55-4. These Be stacks are all filtered. They have been monitored and determined to be well within the emissions standard of 10 ng/m^3. In fact, their emissions were and are so low that they normally are not measurable at the stacks. Consequently, they should have negligible impact on air quality. Dynamic testing at the LANL firing sites, primarily TA-15, produces some airborne Be. If any LANL Be is measurable in ambient air, it would most likely come from these tests, since they generally are conducted in open air without any ventilation controls.

2.2 AIRNET Monitoring Network

Ambient environmental air sampling for radionuclides has been done at LANL, essentially since the Laboratory began. AIRNET is the name of the LANL ambient environmental radiological air-monitoring network. This extensive environmental air-sampling network consists of approximately 50 air samplers with more occasionally added for special needs. The samplers are distributed among several areas: on LANL property, around the perimeter of LANL, in nearby populated areas, and in regional areas some distance from LANL. Biweekly total-suspended-particle (TSP) samples of about 2000 cubic meters are continuously collected on air filters. (Water vapor samples are also collected but are not related to this study.) Some of these AIRNET samples are analyzed for Be as described below. Please see the ESRs for additional information about AIRNET.

2.3 Be measurements using AIRNET

In 1989 LANL began doing measurements for stable (nonradioactive) airborne Be using AIRNET. Analyses were done on quarterly composites of filters from selected AIRNET ambient-air samples. These Be measurements continued through 1995. Apparently, because the results for those seven years did not appear to indicate any significant Be above natural levels and certainly not above the New Mexico 30-day standard of 10 ng/m^3, the analyses were discontinued for 1996-97. However, with renewed public interest in Be, measurements for airborne Be were re-instituted in 1998, have continued through mid-2002, and are expected to continue indefinitely. Thus, except for the years 1996-97, Be measurements have been made each year from 1989 through 2001 as part of the AIRNET program.

From 1989 to 1994, beryllium analyses of AIRNET filters were done using graphite furnace atomic absorption. Typical detection limits were about 100 ng/sample or roughly 0.05 ng/m^3 for a 2000-m^3 sample. From 1994 to date, all measurements have been made using inductively coupled plasma optical emission spectrometry (ICPOES). The typical detection limit for ICPOES is about 5 ng/sample or about 0.0025 ng/m^3 for a 2000-m3 sample. These detection limits do not mean that measurements below these values are not detectable, only that their analytical uncertainty is greater than a predetermined value.

2.4 Occurrence of Be in the Environment

Beryllium occurs naturally in the soil and in the air all over the world. Appendix A describes soil measurements of Be taken in Los Alamos and gives estimates by others of worldwide concentrations of Be in soil. Based on that discussion, and LANL total-suspended-particle measurements, also discussed in Appendix A, it is possible to estimate the expected soil-based Be concentration in AIRNET samples. Appendix A shows that the airborne Be concentration in the Los Alamos and northern New Mexico region is expected typically to be in the general range of about 0.005-0.1 ng/m^3. As will be seen in the next section of this paper, this estimate agrees very well with the actual measurements.

3.0 BE MEASUREMENTS DATA SET

The data set addressed in this paper covers all of the AIRNET Be analyses done at LANL during 1989 through 2001. The full data set is reproduced in two parts in Appendices B and C. Appendix B gives the results for 1989-1993. Appendix C gives the results for 1994-2001. As previously stated, no measurements were done during 1996-97.

3.1 1989-1993 Measurements

The data set for 1989-1993 is provided in Appendix B. These data *by quarter* do not appear to be easily retrievable from old records. However, their quarterly maximums, minimums, and means are readily available in the ESRs for each of those years. Maps and site descriptions are also available in the ESRs. Because quarterly data are *not* readily available for 1989-93, this data is not used in any of the evaluations in subsequent sections of this paper.

The table below identifies (with an "x") the AIRNET stations that were included in the Be program each year during 1989-93. The reader should be aware that AIRNET station numbers (#) and names changed frequently during this period, but master IDs (MI#) are unique.

AIRNET Stations Included in Be Analyses, 1989-93

#	MI#	Station	1989	1990	1991	1992	1993
2	147	Pojoaque	x	x	x	x	x
4	112	Barranca School, Los Alamos	x	x	x	x	x
6,7	149	48th Street, Los Alamos	x	x	x	x	x
7,10,	150	Exxon/Shell Station, Los Alamos	x	x	x	x	
10	157	East Gate, Los Alamos				x	
12	151	Royal Crest, Los Alamos				x	
13	119	Pinon School, White Rock				x	
13,14	121	Pajarito Acres, White Rock	x	x	x	x	x
17	133	Bandelier			x	x	x
31	171	TA-3			x	x	x
19,23	148	TA-5/52, Beta Site	x	x	x	x	x
20,24	145	TA-16, S Site	x	x	x	x	x
25,26	158	TA-16-450	x	x	x	x	
19	135	TA-21 DP Site				x	
20	169	TA-21 Area B				x	
26	124	TA-49				x	
22	136	TA-53, LAMPF (LANSCE)				x	
22	152	TA-54	x	x			
27	170	TA-54 Area G by QA			x		

The *maximum* quarterly Be concentration measured during 1989-93 was 0.1 ng/m^3 observed at the Pojoaque station in 1993. (An apparent data error in the 1989 ESR lists Pajarito Acres at 0.2 ng/m^3.) The *minimum* quarterly Be concentration reported during 1989-93 was 0.01

ng/m^3 and occurred at a large number of stations. However, there were a number of results that were below the detection limit and it is not clear how those values were used in the results. The overall average value for the entire 5-year period was about 0.02 ng/m^3. These results agree very well with the concentration range estimated in the previous section. None of these measurements exceeded the New Mexico standard of 10 ng/m^3 that was in effect then. In fact, the highest reading was only 1% of that standard.

3.2 1994-2001 Measurements

The data set for 1994-2001 is provided in Appendix C. The individual quarterly data are readily available and are presented as such. As previously stated, no Be measurements were made during 1996-97. Maps and site descriptions are available in the ESRs. Because quarterly data **are** readily available for 1994-2001, some of this data set, particularly for 1998-2001, **is** used in the evaluations in subsequent sections of this paper. The 1998-2001 period was chosen for further evaluation because it includes more sites, is more complete, and has had more detailed quality verification than earlier data.

The table below identifies (with an "x") the AIRNET stations that were included in the Be program each year during 1994-97. (No Be analyses were taken 1996-97.)

AIRNET Stations Included in Be Analyses, 1994-1997

#	MI#	Station	1994	1995	1996	1997
2	147	Pojoaque	x	x		
4	112	Barranca School, Los Alamos	x	x		
6,7	149	48th Street, Los Alamos	x	x		
7,10,	150	Exxon/Shell Station, Los Alamos	x	x		
12	151	Royal Crest, Los Alamos	x	x		
17	133	Bandelier	x	x		
31	171	TA-3	x	x		
19,23	148	TA-5/52, Beta Site	x	x		
25	158	TA-16-450	x	x		
71	176	TA-21.01		x		
72	177	TA-21.02		x		
73	178	TA-21.03		x		
74	179	TA-21.04		x		
75	180	TA-21.05		x		
76	193	TA-15-41	x	x		
77	194	TA-36 IJ	x	x		
78	195	TA-15 N	x	x		

The *maximum* quarterly Be concentration measured during 1994-95 was 0.082 ng/m^3 observed at the TA-3 station in 1995. This value is slightly lower than the maximum observed during 1989-93. The *minimum* quarterly Be concentration reported during 1994-95 was about 0.001 ng/m^3 and occurred at a large number of stations. The overall average value for the 2-year period was about 0.01 ng/m^3. These results agree well with the concentration

range estimated in the previous section. None of these measurements exceeded the New Mexico standard of 10 ng/m^3 that was in effect then. In fact, the highest reading was less than 1% of that standard.

The table below identifies (with an "x") the AIRNET stations that were included in the Be program each year during 1998-2001.

AIRNET Stations Included in Be Analyses, 1998-2001

#	MI#	Station	1998	1999	2000	2001
1	116	Espanola	x	x	x	x
3	120	Santa Fe	x	x	x	x
41	185	San Ildefonso Pueblo	x	x	x	x
55	226	Santa Fe West		x	x	x
56	234	El Rancho	x	x	x	x
59	248	Jemez Pueblo		x	x	x
4	112	Barranca School, Los Alamos	x	x	x	x
7	150	Exxon/Shell Station, Los Alamos	x	x	x	
9	114	Los Alamos Airport	x	x	x	x
10	157	East Gate, Los Alamos		x	x	x
12	151	Royal Crest, Los Alamos	x	x	x	x
16	168	Nazarene Church, White Rock	x	x	x	x
26	124	TA-49		x	x	x
32	172	Landfill, Los Alamos	x	x	x	x
39	173	TA-49-QA (next to 26)		x	x	x
61	211	Hospital, Los Alamos	x	x	x	x
66	257	Los Alamos Inn South			x	
67	262	TA-3 Research Park			x	
68	290	Airport Road				x
80	107	Western Arizona Street				x
90	206	East Gate Backup				x
20	169	TA-21 Area B				x
23	148	TA-5/52e	x	x	x	x
31	171	TA-3	x	x	x	x
33	164	TA-49 Area AB	x			
57	246	TA-49 Area AB 2A North	x			
58	247	TA-49 Area AB Test Well 5A	x			
71	176	TA-21.01				x
76	193	TA-15-41 (formerly 15-61)	x	x	x	x
77	194	TA-36 IJ Site (formerly TA-15)	x	x	x	x
78	195	TA-15-N	x	x	x	x
27	170	TA-54 Area G by QA	x	x	x	x
35	160	TA-54 Area G-2 (back fence)	x	x	x	x
36	161	TA-54 Area G-3 (by office)	x	x	x	x
38	163	TA-54 Area G-QA (next to 27)	x	x	x	x

Because this 1998-2001 data set includes more sites, is more complete, and has had more detailed quality verification than earlier data, we will spend more time evaluating it.

The following table provides Be summary data on Regional AIRNET stations, those stations located some distance from LANL.

1998-2001 Regional AIRNET Station Be Results, ng/m^3

#	MI#	Station	Maximum	Minimum	Average
1	116	Espanola	0.043	0.013	0.025
3	120	Santa Fe	0.077	0.012	0.032
41	185	San Ildefonso Pueblo	0.047	0.015	0.026
55	226	Santa Fe West	0.017	0.003	0.011
56	234	El Rancho	0.031	0.006	0.016
59	248	Jemez Pueblo	0.105	0.038	0.068
NA	NA	Regional Group	0.105	0.003	0.030

The highest 1998-2001 Regional station average was 0.068 ng/m^{3}at Jemez Pueblo. If Jemez Pueblo is treated as an outlier, the overall Regional Group average reduces from 0.030 to 0.022 ng/m^3.

The following table provides Be summary data on Perimeter AIRNET stations, those stations located off LANL property but near the Laboratory boundary or in nearby communities.

1998-2001 Perimeter AIRNET Station Be Results, ng/m^3

#	MI#	Station	Maximum	Minimum	Average
4	112	Barranca School, Los Alamos	0.030	0.007	0.018
7	150	Exxon/Shell Station, Los Alamos	0.183	0.010	0.055
9	114	Los Alamos Airport	0.018	0.004	0.009
10	157	East Gate, Los Alamos	0.040	0.005	0.016
12	151	Royal Crest, Los Alamos	0.031	0.004	0.012
16	168	Nazarene Church, White Rock	0.023	0.003	0.009
26	124	TA-49	0.026	0.001	0.009
32	172	Landfill, Los Alamos	0.164	0.063	0.103
39	173	TA-49-QA (next to 26)	0.022	0.003	0.009
61	211	Hospital, Los Alamos	0.034	0.012	0.021
NA	NA	Perimeter Group	0.183	0.001	0.024

The highest 1998-2001 Perimeter station average was 0.103 ng/m^{3}at the Landfill. If the Landfill is treated as an outlier, the overall Perimeter Group average reduces from 0.024 to 0.015 ng/m^3. Note that the average airborne Be for Perimeter stations is *lower* than the average for the Regional stations immediately above. Only if the Jemez Regional outlier is **removed** and the Landfill Perimeter outlier is **retained** does the Perimeter group average slightly exceed the Regional group average. Thus, it appears that the, apparently natural, airborne Be concentrations at populated locations well removed from LANL are actually

higher than the airborne Be concentrations in populated areas closer to LANL. The abnormal-appearing Landfill and other results will be further discussed in a later section.

The following table provides Be summary data on Firing-Site AIRNET stations, those stations located on LANL property near to and downwind of dynamic testing areas where Be is periodically involved in open-air explosives testing.

1998-2001 Firing-Site AIRNET Station Be Results, ng/m^3

#	MI#	Station	Maximum	Minimum	Average
76	193	TA-15-41 (formerly 15-61)	0.020	0.002	0.007
77	194	TA-36 IJ Site (formerly TA-15)	0.016	0.002	0.008
78	195	TA-15-N	0.014	0.001	0.005
NA	NA	Firing-Site Group	0.02	0.001	0.007

The Firing-Site data set is remarkably consistent and has a significantly *lower* Group average Be concentration than either the Regional or the Perimeter Group averages, even after removing the high Regional and Perimeter outliers. This seeming contradiction (very low Be concentrations downwind of a firing site) will be discussed in a later section.

The following table provides Be summary data on AIRNET stations located in the LANL TA-54 radioactive-waste disposal area.

1998-2001 TA-54 AIRNET Station Be Results, ng/m^3

#	MI#	Station	Maximum	Minimum	Average
27	170	TA-54 Area G by QA	0.693	0.018	0.135
35	160	TA-54 Area G-2 (back fence)	0.052	0.013	0.032
36	161	TA-54 Area G-3 (by office)	0.098	0.009	0.032
38	163	TA-54 Area G-QA (next to 27)	0.312	0.026	0.101
NA	NA	TA-54 Group	0.693	0.009	0.055

During the fourth quarter of 1999, TA-54 AIRNET station 27 had the highest single Be concentration measured anywhere at LANL (0.693 ng/m^3). Since Be is not handled at TA-54, the high values measured there are attributed to very high airborne dust from construction and traffic activities that occurred there during this period. However, even that concentration did not exceed the EPA-NESHAP standard of 10 ng/m^3 (that, although numerically identical to the NM standard, had replaced the NM standard). In fact, that *highest* quarterly measurement was just 7% of the standard.

4.0 TEMPORAL AND SPATIAL VARIATIONS

It makes sense to ask if airborne Be varies significantly with the seasons (temporally) and with physical location (spatially). Several factors affect airborne soil and, thus, the soil-borne Be. These factors include soil availability and texture, wind, precipitation, traffic, excavation activities, ground cover or the lack of it, and, probably several other factors. If most or all of the airborne Be is soil based, then its airborne concentrations should vary with seasons and location.

4.1 Temporal Variations

Airborne Be concentrations typically exhibit temporal (seasonal) variations. The peak concentrations in northern New Mexico appear normally to occur during the spring (first) or summer (second) quarters. The lowest concentrations tend to occur toward the fall and winter (third or fourth) quarters. This seasonal cycling is typically seen at all sample sites, some more strongly than others. The graph on the next page provides a good example of this phenomenon. At times, the Santa Fe station peak appears to lead by one quarter ahead of Espanola and San Ildefonso. However, they generally appear to reach their minimums about the same time. Seasonal winds and other weather parameters that affect airborne dust would cause these temporal variations. More frequent sample analyses, such as monthly instead of quarterly, would, likely, provide a clearer picture of these natural seasonal variations.

4.2 Spatial Variations

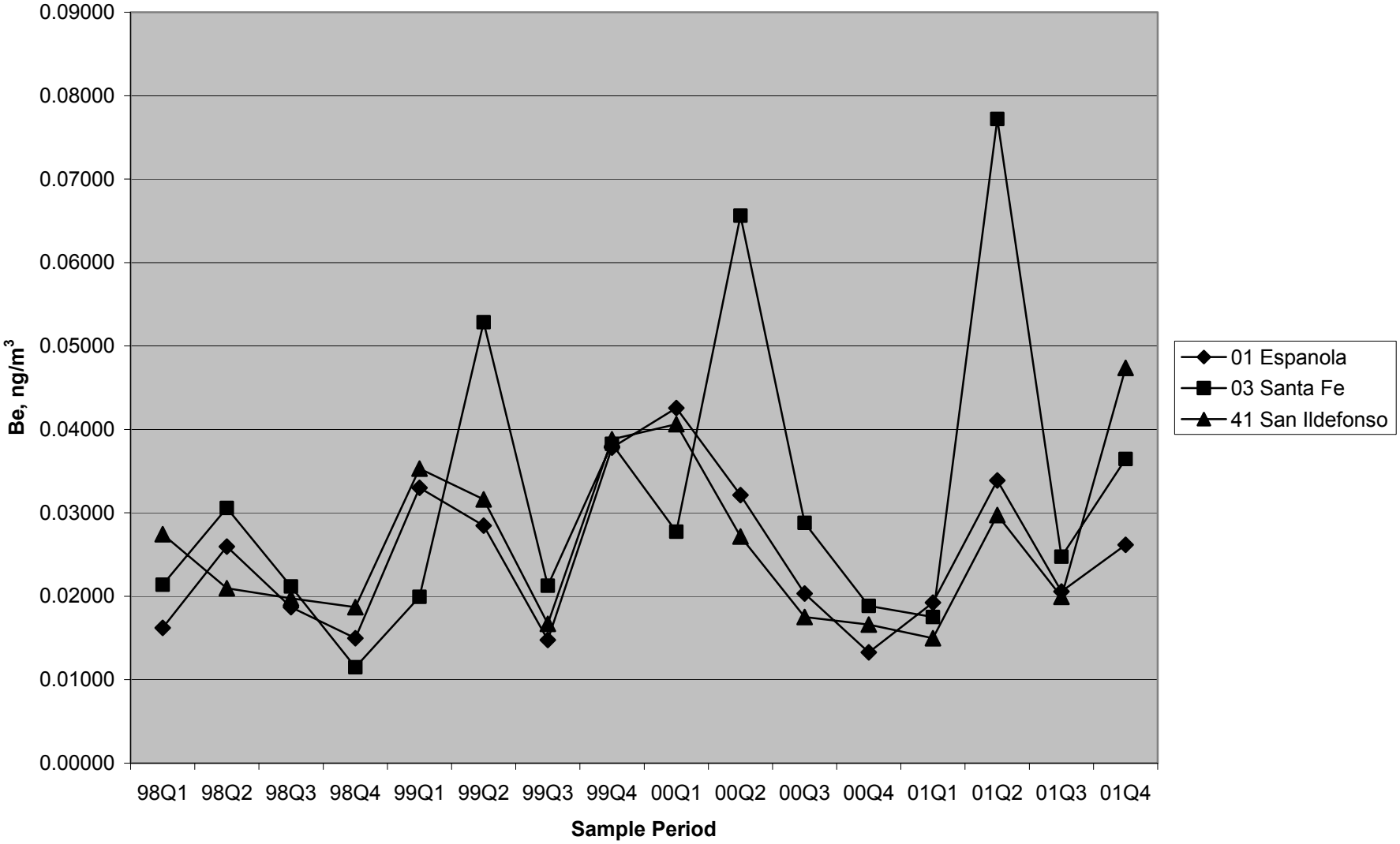
Airborne Be concentrations also exhibit spatial (location) variations. That is, some locations will have higher or lower airborne Be concentrations than other locations, independent of the season. Local weather differences (such as rainfall amounts), geographical differences (such as ground cover or its lack), and human activities (such as traffic) can contribute to these spatial differences. The second graph, two pages after this page, provides a visual example of significant spatial (as well as the previously mentioned seasonal) variations in airborne Be concentrations.

Note that the Be concentration at the Landfill (32) is always higher than the Regional station at Espanola. Further, note that the Firing-Site station at TA-15N is always lower than either the Landfill or Espanola stations. In fact, all of the firing sites consistently have some of the *lowest* airborne Be concentrations of all the Be measurements. These spatial variations are more a function of airborne dust than actual variations in the concentration of Be in the soil. That is, the more airborne dust, the higher the airborne Be concentration.

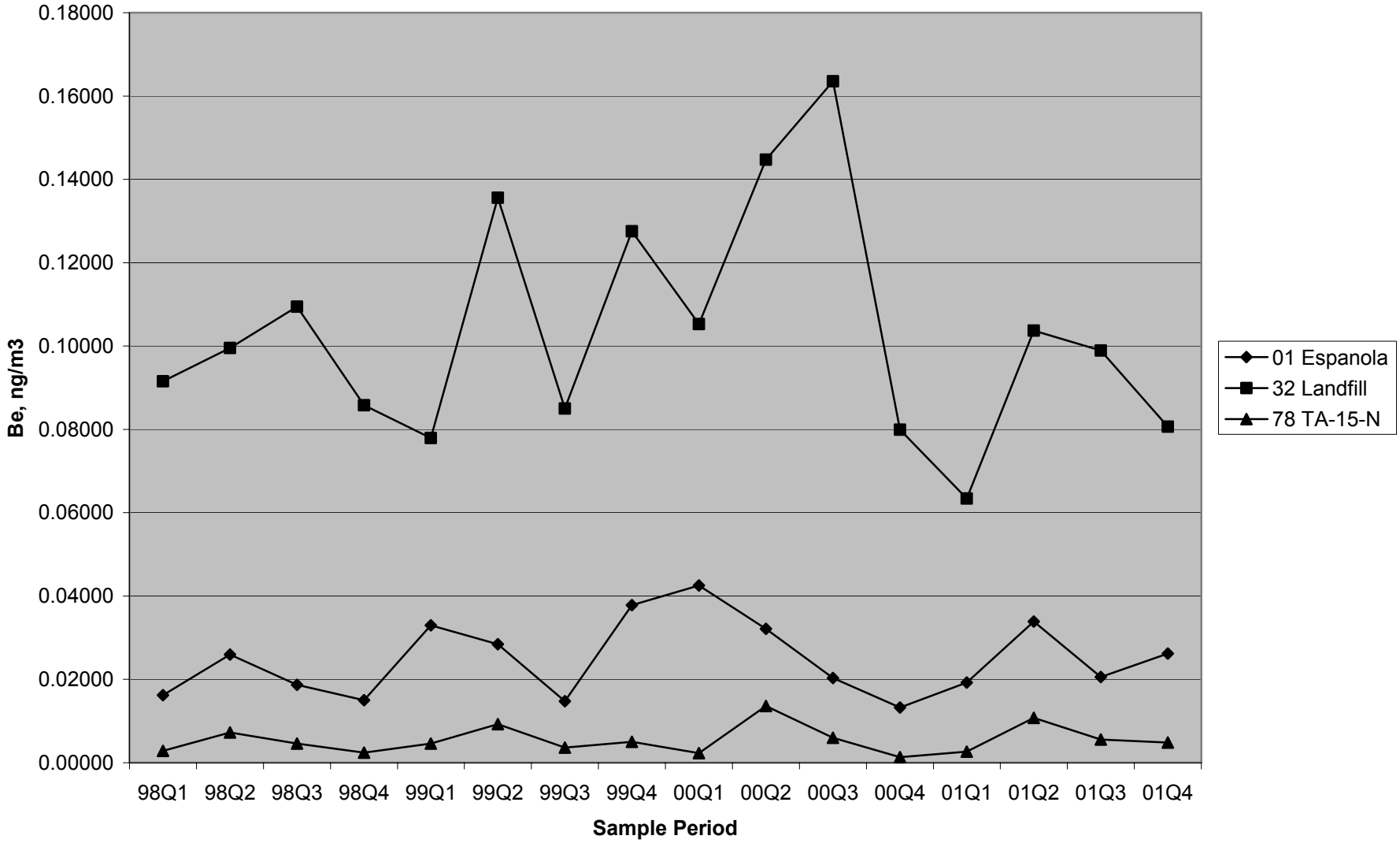
The Landfill is a very dusty area with large amounts of truck and heavy equipment traffic moving over unpaved ground. Furthermore, a large amount of dirt is routinely being disturbed at the Landfill. Thus, it is not surprising that the Landfill consistently has the highest **off-site** average airborne Be concentration of any AIRNET station location. Similarly, heavy equipment traffic and earth-moving operations occurred at TA-54 (near stations 24 and 27) during the 1998-2001 period. Thus, their high Be values are not particularly surprising, even though no LANL Be handling operations occur there. Although not presented in the graph under discussion, station 7 at the service station in Los Alamos clearly showed the effects of a nearby construction project during the fourth quarter of 1999 and the first two quarters of 2000. The firing sites are believed to have low airborne Be concentrations because of ground cover and low traffic in the area that minimize airborne dust.

The next section will further explore the premise that the airborne Be detected in AIRNET samples is soil based.

Example of Seasonal Variations in Be Concentrations



Example of Spatial (Location) Variations in Airborne Be



5.0 COMPARISON WITH OTHER APPLICABLE MEASURMENTS

This section compares airborne Be with both uranium-234 (U-234) and cerium (Ce) airborne concentrations. Because U-234 and Ce both occur naturally in soil, it would be reasonable to expect, assuming the Be is soil based, that U-234 and Ce would both increase in general proportion with Be as it increased in air samples. Of course, there could be some confounding of the U-234 proportion if a significant LANL contribution is included in the U-234 soil inventory. However, the few Laboratory locations (firing sites) known to have detectable enriched or depleted uranium in air do not significantly affect the results seen in the Be/U-234 comparison graphs on the following pages. Cerium is not used at LANL; therefore it should only occur naturally in the measurements.

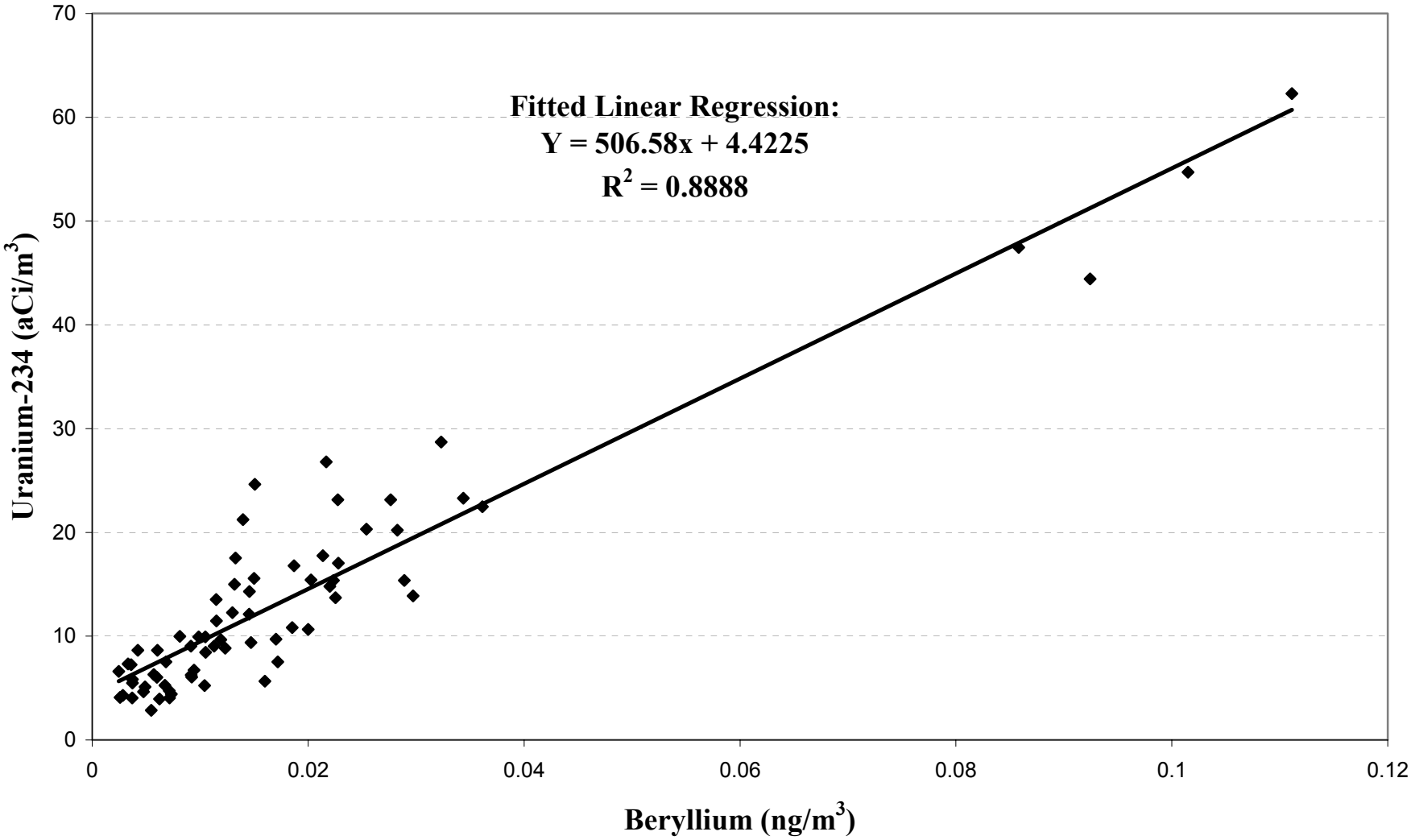
The first four graphs following this page show the linear relationship between U-234 and Be concentrations in air for 1998-2001. The second three graphs show the linear relationship between Ce and Be concentrations in air for 1999-2001. Large divergences **below** the regression lines would imply either non-natural Be or non-natural depleted uranium was present. Large divergences **above** the regression line would imply non-natural enriched uranium or non-natural Ce. There do not appear to be any large divergences **below** the regression lines. Thus, the measured Be appears to be natural in all cases. There are a few large divergences **above** the line in the year 2000-01 graphs for U-234. These imply enriched uranium contamination or above average natural uranium deposits, which are known to occur in some areas around LANL.

6.0 CONCLUSION

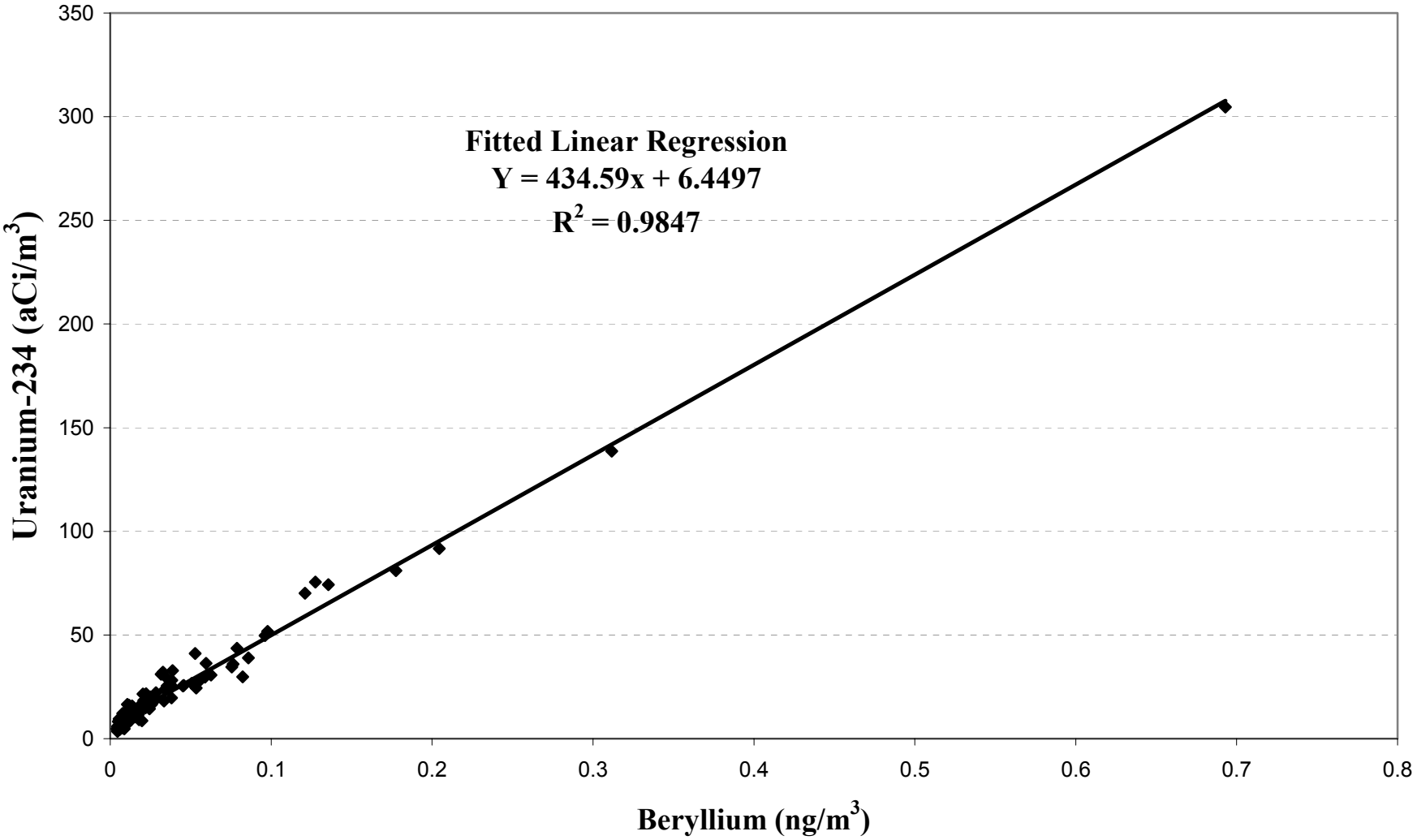
Based on the data presented in this paper and the forgoing discussions, it does not appear that any LANL contributions to airborne Be are distinguishable from the natural levels normally found in airborne measurements. In fact the places where any LANL-contributed airborne Be would be expected to be detected (firing sites and around those areas) have some of the lowest measured Be while the regional measurements taken many miles from LANL often generally show higher Be levels than most areas nearer LANL.

In all cases, no sample result exceeded the 10 ng/m3 standards. The single highest quarterly Be measurement (which occurred in TA-54) was just 7% of that standard. Except for a few special cases, virtually all Be measurements were less than 1% of the standard. Thus, it may be concluded that, whether natural or LANL contributed, the airborne Be measured by this program does not present any significant health hazard to anyone.

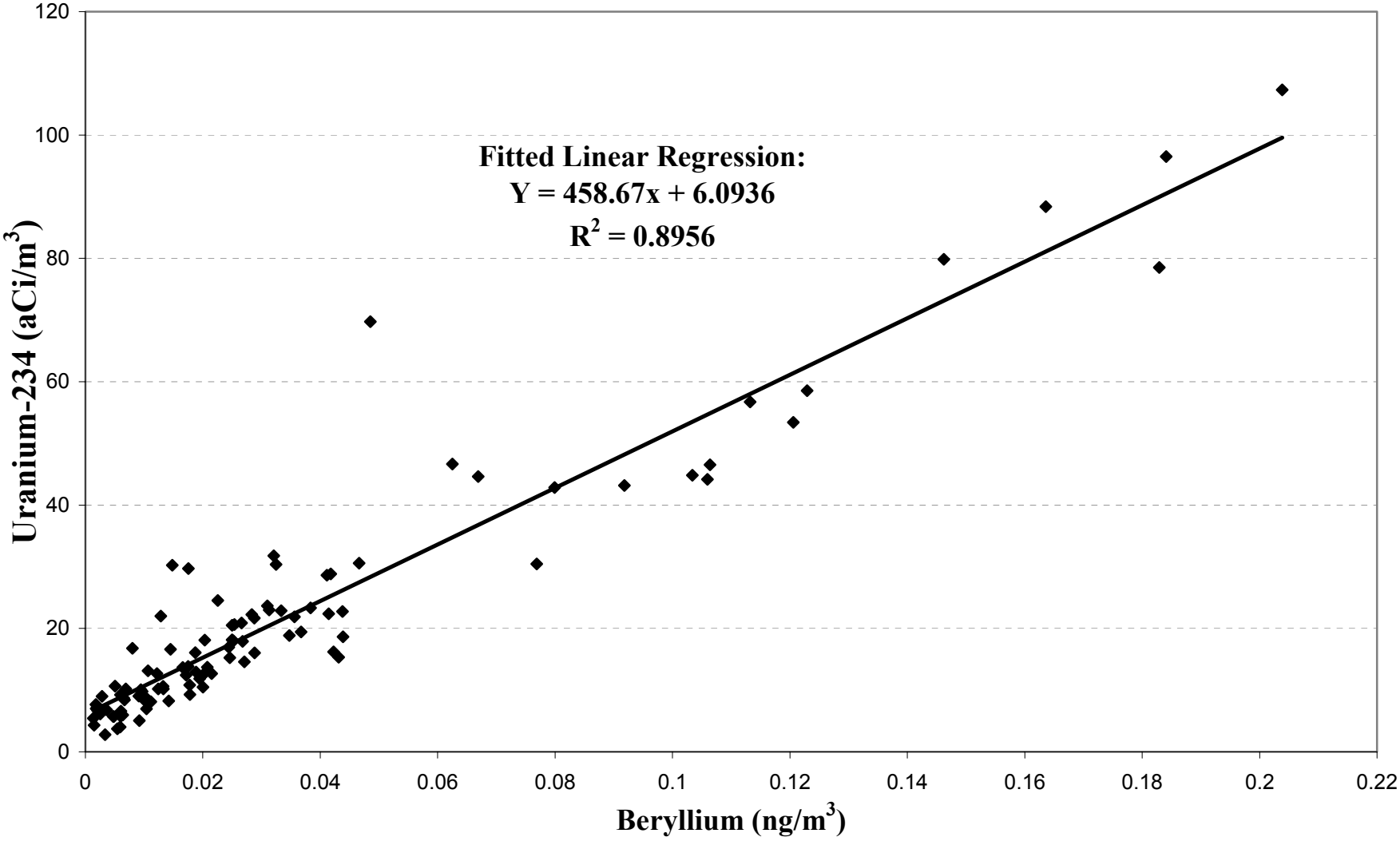
Quarterly Beryllium and Uranium-234 Concentrations for 1998



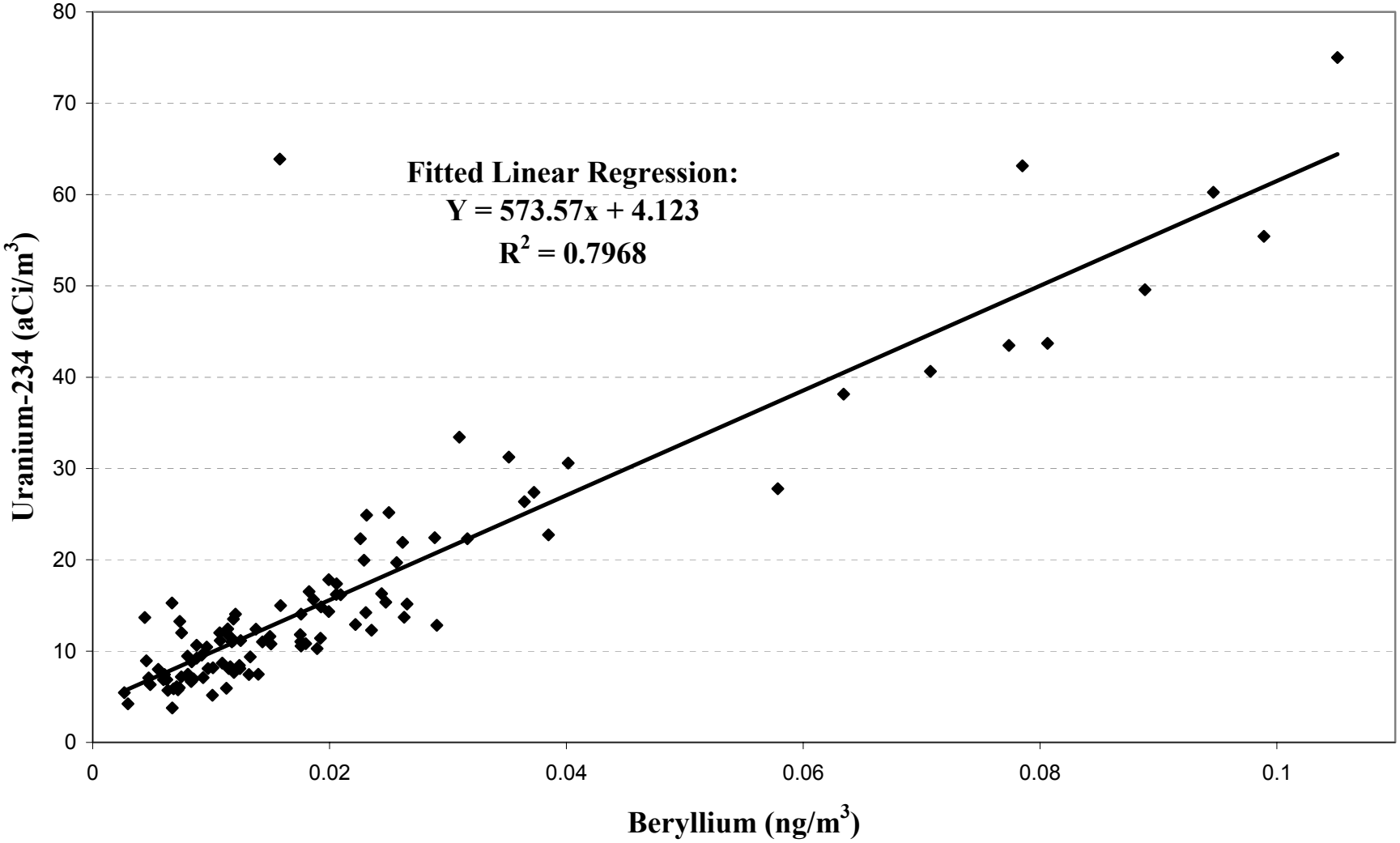
Quarterly Beryllium and Uranium-234 Concentrations for 1999



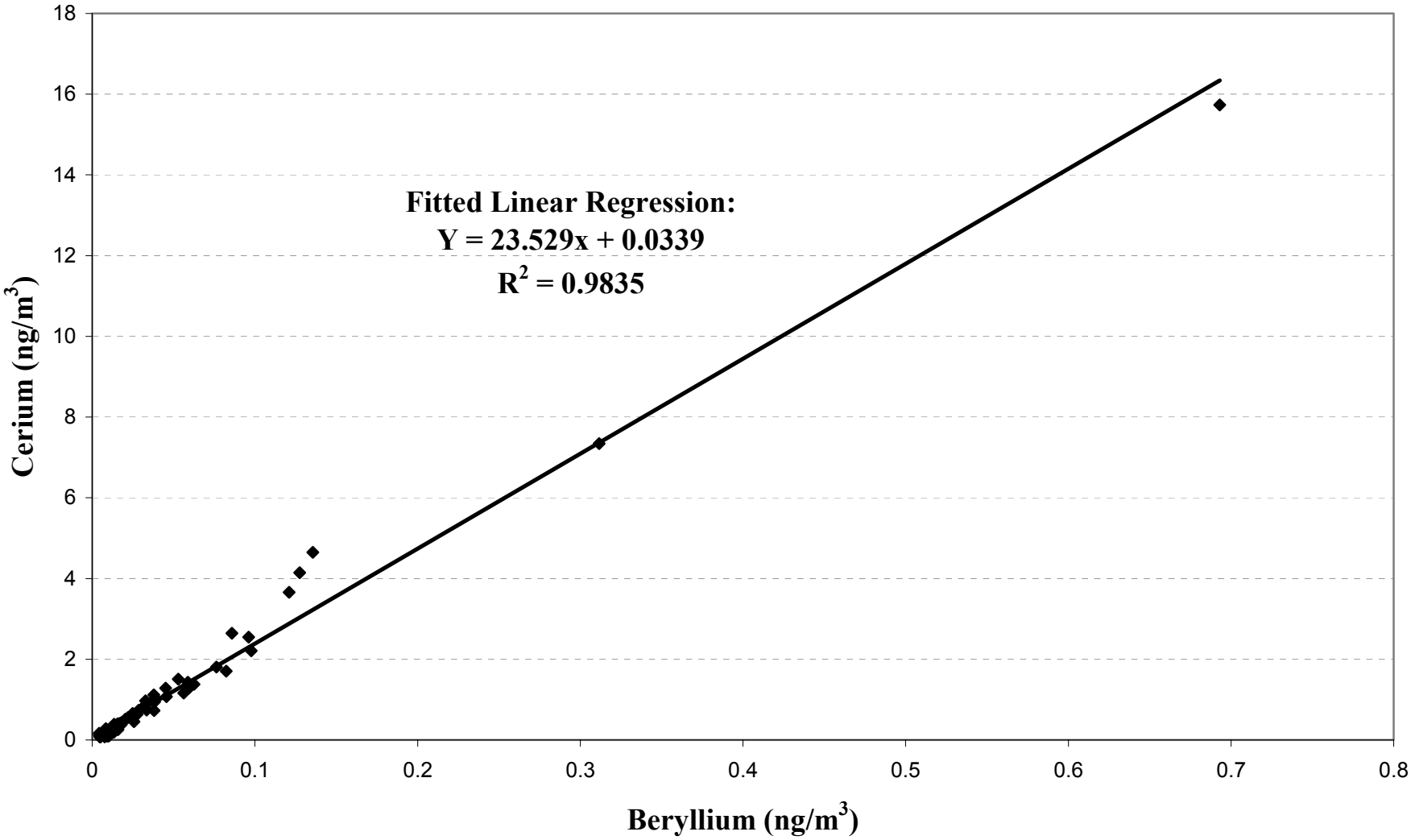
Quarterly Beryllium and Uranium-234 Concentrations for 2000



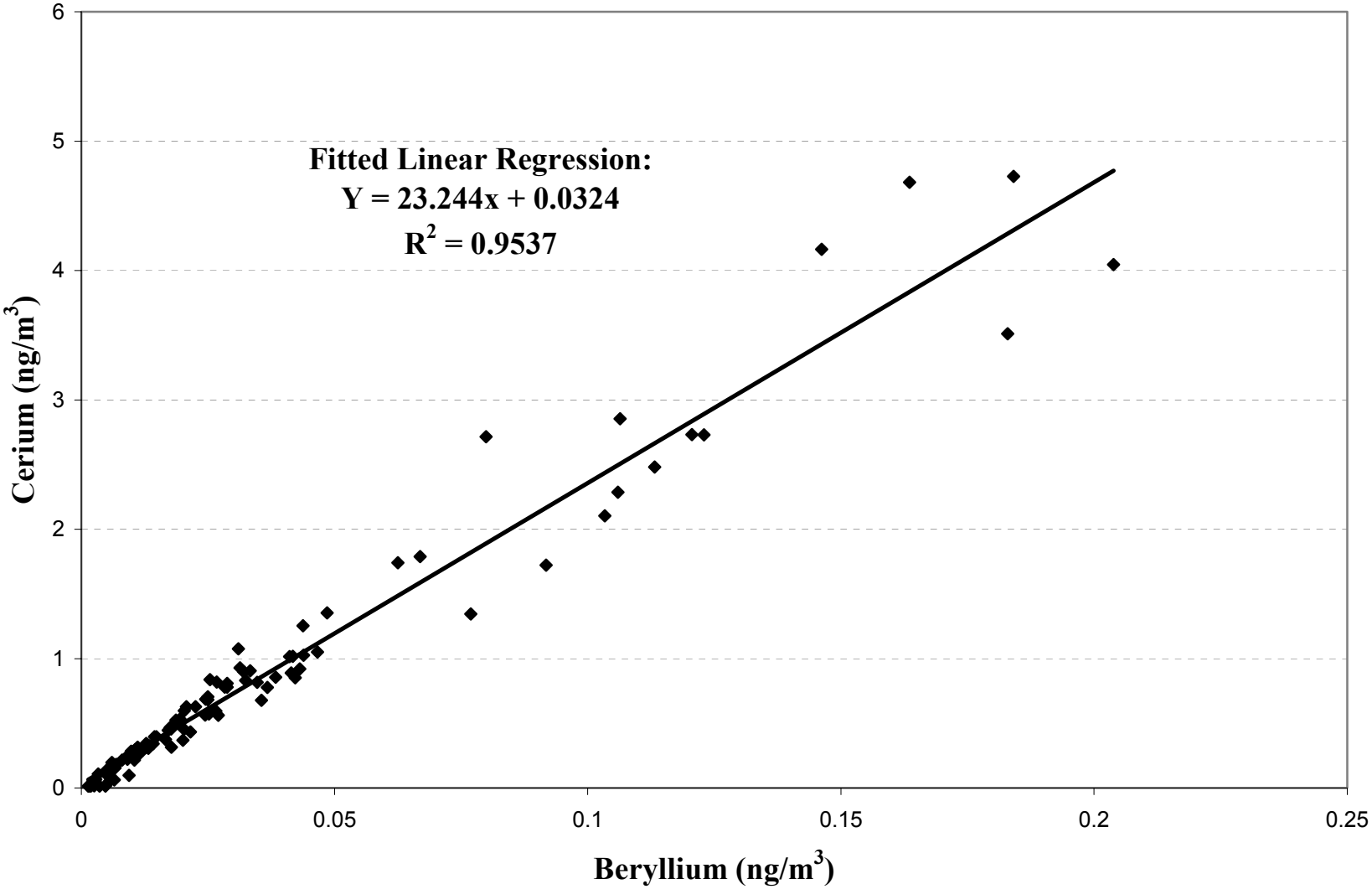
Quarterly Beryllium and Uranium-234 Concentrations for 2001



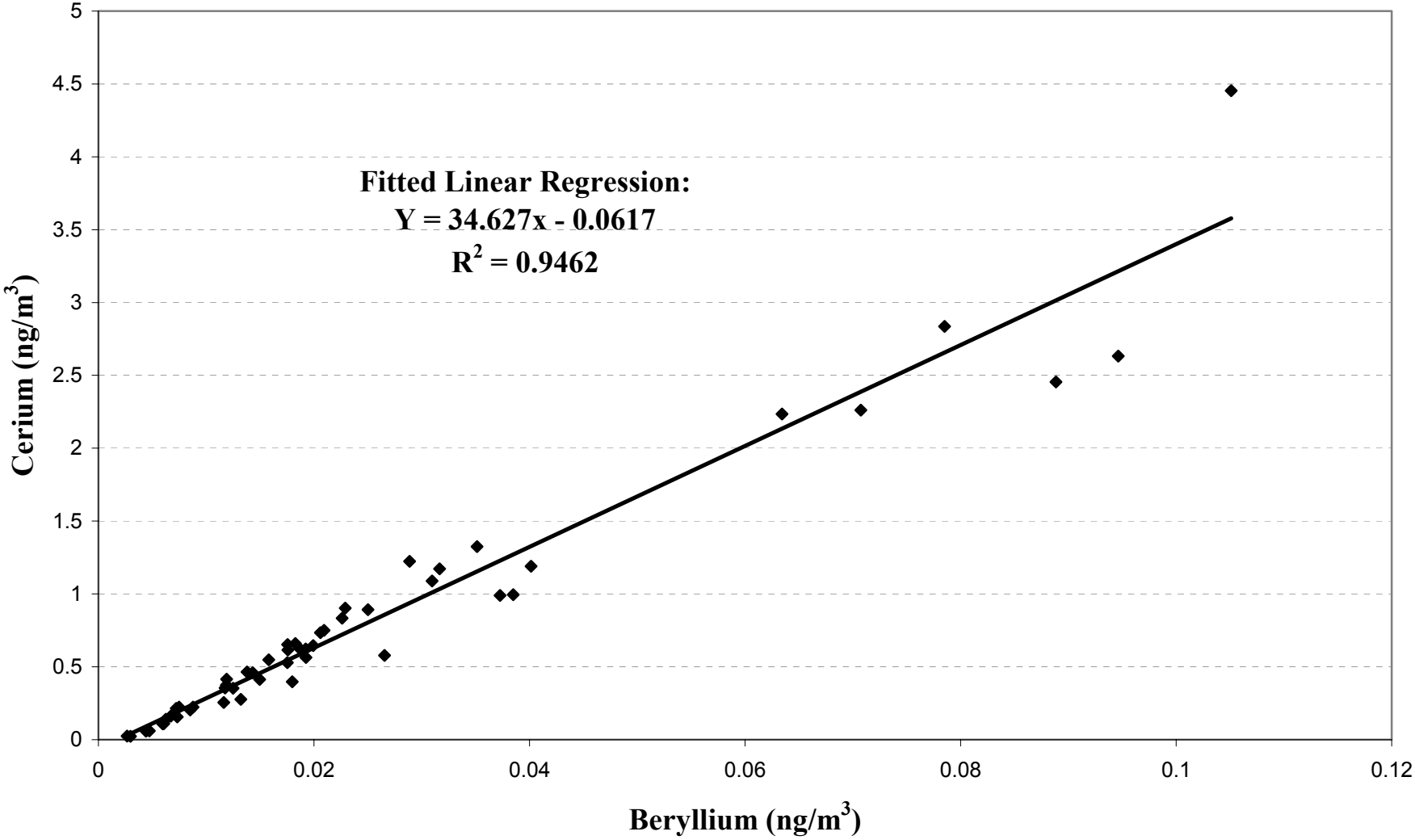
Quarterly Beryllium and Cerium Concentrations for 1999



Quarterly Beryllium and Cerium Concentrations for 2000



Quarterly Beryllium and Cerium Concentrations for 2001



7.0 APPENDICES

A. Determination of Expected Natural Be Concentrations in Ambient Air
B. 1989-93 Summary Be Data
C. 1994-2001 Detailed Be Data

Appendix A

Determination of Expected Natural Be Concentrations in Ambient Air

If the concentration of Be in soil and the total suspended particles (TSP) in air are both known, a good estimate of the expected airborne Be concentration from soil particles can be derived. This appendix develops such an estimate.

Beryllium in Soil

Measurements of Be in dry soil have been taken and reported in LANL ESRs. The 2000 ESR provides a wealth of soil Be data from a wide range of locations in northern New Mexico. The 2000 ESR gives the range of Be in LANL and regional soils as 0.41-1.2 μg/g of soil. The 2000 ESR also references a 1979 paper by Ferenbaugh, et al, (LA-11941-MA) where the average Be level in an undisturbed soil area at Sigma Mesa ranged from 1.1 to 3.3 μg/g and averaged 1.9 μg/g of soil. It appears that differing methods were used to make these Be determinations and some, such as the leaching method apparently used for the 2000 ESR measurements, may underestimate the total Be content of soil. The Ferenbaugh paper references other general studies of Be in the earth's crust that give values of 2-7 μg/g. Based on these studies, it seems reasonable to estimate that the normal Be soil concentration near LANL and in the region is in the range of about 0.5 to 2 μg/g of soil. Assuming higher soil values would give higher expected airborne Be concentrations.

Total suspended Particles in Air

Based on total suspended particles (TSP) measurements taken during 1986-89 and reported in the LANL ESR for those years, the annual geometric mean for TSP near LANL is typically about 20-30 $\mu g/m^3$. During any 24-hour period, it ranged from 50-150 $\mu g/m^3$. LANL is relatively remote and has a higher vegetation level than many other parts of New Mexico, such as Espanola and Santa Fe. Therefore, it would be reasonable to assume that those higher traffic, more dusty areas would have a higher TSP than typically around LANL. However, no TSP measurements for those areas were readily available for this analysis. Thus, based on the available TSP measurements, we postulate that, in the absence of very abnormally dusty (or clean) circumstances, a quarterly average TSP for locations in northern NM could typically be in the range of 10-50 $\mu g/m^3$. Assuming a higher TSP values would give higher expected airborne Be concentrations. Note that AIRNET samplers also collect TSP; however, the mass of particles on AIRNET filers is not normally determined.

Airborne Be Calculation

Using the above soil and TSP measurements, calculating the range of expected airborne Be is straight forward:

1. For the lower TSP and soil values:
   Given, TSP = 10 $\mu g/m^3$and Be in soil = 0.5 μg/g or 0.5 pg/μg
   Then, 10 $\mu g/m^3$* 0.5 pg/μg * 10^{-3} ng/pg = **0.005 ng/ m^3**

2. For the higher TSP and soil values:

   Given, TSP = 50 μg/m^3 and Be in soil = 2 μg/g or 2 pg/μg

   Then, 50 μg/m^3* 2 pg/μg * 10^{-3} ng/pg = **0.1 ng/ m^3**

Therefore, the range of Be that would normally be expected in air in the region would be about 0.005-0.1 ng/m^3. (Note unit change from μg to ng.) The typical range of Be in air is about 0.005-0.02 ng/m^3 at AIRNET stations around or on LANL property. The high-traffic, dusty landfill station 32 is typically 0.1 ng/m^3. Santa Fe station 03 is typically closer to 0.035 ng/m^3, while Espanola station 01 is typically close to 0.03 ng/m^3. Thus, the measured values in the region are very close to the expected range of 0.005-0.1 ng/m^3.

Appendix B

1989-93 Summary Be Data

This Appendix B contains the quarterly Be concentrations for each AIRNET station. Note that all data for 1998-1993 are "gross" measurements. "Gross" means that the very small amount of Be contamination normally present on a clean air filter has *not* been subtracted from the measurement. There appear to be some transcribing errors in the original data. They are shown in **BOLD**.

Airborne Be Concentrations 1989-93 at LANL
(without background correction)

Master ID	Recent Station #	Description	Air Vol, m^3	# Samples	1989 Gross Concentrations (ng/m^3) Max	Min	Mean
147	02	Pojoaque	53366	3	0.0400	0.0300	0.0300
112	04	Barranca School	71141	4	**0.0100**	**0.0400**	**0.0200**
149	07	48th Street	68559	4	**0.0100**	**0.0100**	**0.0300**
150	10	Gulf/Exxon/Shell Station	67227	4	0.0800	0.0100	0.0400
121	13	Pajarito Acres	69362	4	**0.2000**	**0.0100**	**0.0100**
198	P	Perimeter Group Annual Summary		16	0.0800	0.0100	0.0200
148	19	TA-5/52	80783	4	0.0200	0.0100	0.0100
145	20	TA-16 S-Site	49234	3	0.0100	0.0100	0.0100
152	22	TA-54	37676	2	0.0700	0.0100	0.0400
158	26	TA-16-450	77756	4	0.0100	0.0100	0.0100
199	OS	On Site Stations, Controlled Areas Group Annual Summary		13	0.0700	0.0100	0.0200

Master ID	Recent Station #	Description	Air Vol, m^3	# Samples	1990 Gross Concentrations (ng/m^3) Max	Min	Mean
147	02	Pojoaque	56543	3	0.0500	0.0200	0.0400
112	04	Barranca School	53112	3	0.0300	0.0200	0.0200
149	07	48th Street	62572	3	0.0900	0.0100	0.0400
150	10	Gulf/Exxon/Shell Station	59919	3	0.0400	0.0300	0.0400
121	13	Pajarito Acres	57802	3	0.0200	0.0100	0.0100
198	P	Perimeter Group Annual Summary		12	0.0900	0.0100	0.0300
148	19	TA-5/52	60476	3	0.0100	0.0100	0.0100
145	20	TA-16 S-Site	57834	3	0.0200	0.0100	0.0100
152	22	TA-54	58821	3	0.0300	0.0200	0.0200
158	26	TA-16-450	63075	3	0.0100	0.0100	0.0100
199	OS	On Site Stations, Controlled Areas Group Annual Summary		12	0.0300	0.0100	0.0100

Note: **BOLD** data may be transcribing errors in the ESR.

Airborne Be Concentrations 1989-93 at LANL
(without background correction)

Master ID	Recent Station #	Description	Air Vol, m^3	# Samples	1991 Gross Concentrations (ng/m^3) Max	Min	Mean
147	02	Pojoaque	22288	2	0.0400	0.0300	0.0400
197	R	Regional Group Annual Summary		2	0.0400	0.0300	0.0400
112	04	Barranca School	60004	3	0.0200	0.0200	0.0200
149	06	48th Street	70737	3	0.0200	0.0100	0.0100
150	07	Gulf/Exxon/Shell Station	67584	3	0.0400	0.0100	0.0200
121	14	Pajarito Acres	70949	3	0.0200	0.0100	0.0100
133	17	Bandelier Fire Lookout	37528	2	0.0100	0.0100	0.0100
198	P	Perimeter Group Annual Summary		14	0.0400	0.0100	0.0200
148	23	TA-5/52	69689	3	0.0600	0.0100	0.0300
145	24	TA-16 S-Site	74668	3	0.0200	0.0200	0.0200
158	25	TA-16-450	43139	2	0.0100	0.0100	0.0100
170	27	TA-54 Area G (by QA)	28872	1	0.0400	0.0400	0.0400
171	31	TA-3	39586	2	0.0100	0.0100	0.0100
199	OS	On Site Stations, Controlled Areas Group Annual Summary		11	0.0600	0.0100	0.0200

Note: **BOLD** data may be transcribing errors in the ESR

Airborne Be Concentrations 1989-93 at LANL
(without background correction)

Master ID	Recent Station #	Description	Air Vol, m^3	# Samples	1992 Gross Concentrations (ng/m^3) Max	Min	Mean
147	02	Pojoaque	68874	4	0.0300	0.0100	0.0200
197	R	Regional Group Annual Summary		4	0.0300	0.0100	0.0200
112	04	Barranca School	63526	4	0.0500	0.0100	0.0300
149	06	48th Street	31327	2	0.0200	0.0100	0.0100
150	07	Gulf/Exxon/Shell Station	60763	4	0.0300	0.0200	0.0200
157	10	East Gate	17777	1	0.0200	0.0200	0.0200
151	12	Royal Crest	13782	1	0.0200	0.0200	0.0200
119	13	White Rock - Pinon School	38965	2	0.0100	0.0100	0.0100
121	14	Pajarito Acres	25893	2	0.0200	0.0100	0.0200
133	17	Bandelier Fire Lookout	25853	2	0.0200	0.0100	0.0200
198	P	Perimeter Group Annual Summary		18	0.0500	0.0100	0.0200
135	19	TA-21 DP Site	37193	2	0.0100	0.0100	0.0100
169	20	TA-21 Area B	24837	2	0.0300	0.0200	0.0200
136	22	TA-53 LAMPF	36459	2	0.0200	0.0200	0.0200
148	23	TA-5/52	26710	2	0.0200	0.0100	0.0200
145	24	TA-16 S-Site	12793	1	0.0200	0.0200	0.0200
158	25	TA-16-450	34601	2	0.0100	0.0100	0.0100
124	26	TA-49	36809	2	0.0200	0.0100	0.0200
171	31	TA-3	24200	2	0.0200	0.0100	0.0100
199	OS	On Site Stations, Controlled Areas Group Annual Summary		15	0.0300	0.0100	0.0200

Note: **BOLD** data may be transcribing errors in the ESR.

Airborne Be Concentrations 1989-93 at LANL
(without background correction)

Master ID	Recent Station #	Description	Air Vol, m^3	# Samples	1993 Gross Concentrations (ng/m^3) Max	Min	Mean
147	02	Pojoaque	11200	3	0.1000	0.0300	0.0500
112	04	Barranca School	42600	3	0.0800	0.0100	0.0400
149	06	48th Street	46100	3	0.0400	0.0000	0.0200
121	14	Pajarito Acres	22700	2	0.0400	0.0400	0.0400
133	17	Bandelier Fire Lookout	42100	3	**0.0600**	**0.0000**	**0.0800**
198	P	Perimeter Group Annual Summary		11	0.0800	0.0000	0.0300
148	23	TA-5/52	48200	3	0.0400	0.0100	0.0300
145	24	TA-16 S-Site	46400	3	0.0400	0.0100	0.0200
171	31	TA-3	24700	2	0.0100	0.0100	0.0100
199	OS	On Site Stations, Controlled Areas Group Annual Summary		8	0.0400	0.0100	0.0200

Note: **BOLD** data may be transcribing errors in the ESR.

Appendix C

1994-2001 Detailed Be Data

This Appendix C contains the quarterly Be concentrations for each AIRNET station. Note that the 1994-1995 data (shown in **bold**) are "gross" measurements, and the later data are "net." "Gross" means that the very small amount of Be contamination normally present on a clean air filter has *not* been subtracted from the measurement. "Net" means the small amount of Be on the clean filter *has* been subtracted from the measurement.

1994-2001 AIRNET Be Data Set Sorted by Quarter

	Mstr ID	116	147	120	112	149	150	114	157	151	168
	Name	Espan	Poj	SF	Barranca	48th St	Shll Sta	LAArprt	Eastgate	RC Tr Pk	Naz Ch
	Site No.	01	02	03	04	06	07	09	10	12	16
PeriodID	**EndDate**										
94Q1	3/28/1994		**0.03178**		**0.01060**	**0.00358**	**0.01094**			**0.00214**	
94Q2	6/20/1994		**0.01049**		**0.00592**	**0.00599**				**0.00605**	
94Q3	9/26/1994		**0.00584**		**0.00731**	**0.00584**	**0.00585**			**0.00697**	
94Q4	1/3/1995		**0.00108**		**0.00109**	**0.00112**	**0.00582**			**0.00105**	
95Q1	3/27/1995		**0.01489**		**0.01385**	**0.01460**	**0.01549**			**0.02811**	
95Q2	6/20/1995		**0.06960**		**0.01485**	**0.01196**	**0.01200**			**0.01079**	
95Q3	9/25/1995		**0.01835**		**0.01477**	**0.01199**	**0.01450**			**0.01470**	
95Q4	1/3/1996		**0.03925**		**0.01878**	**0.01233**	**0.01764**			**0.01243**	
98Q1	3/30/1998	0.01622		0.02139	0.01912		0.01513	0.00585		0.00456	0.00511
98Q2	6/22/1998	0.02597		0.03058	0.02018		0.03254	0.01128		0.01255	0.00864
98Q3	9/28/1998	0.01870		0.02117	0.01209		0.01556	0.00755		0.00960	0.00575
98Q4	12/21/1998	0.01499		0.01150	0.00683		0.01049	0.00360		0.00372	0.00257
99Q1	3/29/1999	0.03300		0.01994	0.02349		0.03444	0.00928	0.01887	0.01662	0.01095
99Q2	6/21/1999	0.02845		0.05284	0.01660		0.02485	0.01315	0.02757	0.01278	0.00974
99Q3	9/27/1999	0.01475		0.02126	0.00835		0.04435	0.00503	0.00684	0.00751	0.00446
99Q4	12/20/1999	0.03782		0.03826	0.01700		0.12097	0.00981	0.01366	0.00778	0.00907
00Q1	3/27/2000	0.04256		0.02773	0.02357		0.11934	0.00895	0.01673	0.01315	0.00818
00Q2	6/19/2000	0.03212		0.06563	0.02385		0.18262	0.01832	0.03970	0.03126	0.02327
00Q3	9/25/2000	0.02032		0.02879	0.01871		0.04388	0.00944	0.01780	0.01242	0.01065
00Q4	12/18/2000	0.01327		0.01884	0.01099		0.02029	0.00362	0.00476	0.00652	0.00546
01Q1	3/26/2001	0.01924		0.01753	0.01250			0.00473	0.00877	0.00597	0.00721
01Q2	6/18/2001	0.03388		0.07720	0.03048			0.01076	0.01879	0.02385	0.01061
01Q3	9/24/2001	0.02057		0.02475	0.02566			0.00922	0.00975	0.01228	0.00635
01Q4	12/17/2001	0.02618		0.03646	0.01095			0.00878	0.01130	0.01243	0.00832
1998-2001 Avg		0.02488		0.03212	0.01752		0.05537	0.00871	0.01621	0.01206	0.00852
1998-2001 Max		0.04256		0.07720	0.03048		0.18262	0.01832	0.03970	0.03126	0.02327
1998-201 Min		0.01327		0.01150	0.00683		0.01049	0.00360	0.00476	0.00372	0.00257

1994-2001 AIRNET Be Data Set Sorted by Quarter

	Mstr ID	133	169	148	158/145	124	170	171	172	164	160
	Name	Bandel	TA21 B	TA5/52	TA16-450	TA49	TA54 G	TA3	Landfill	TA49 AB	TA54 G2
	Site No.	17	20	23	25	26	27	31	32	33	35
PeriodID	**EndDate**										
94Q1	3/28/1994	**0.00506**		**0.00491**	**0.03662**			**0.01576**			
94Q2	6/20/1994	**0.00605**		**0.00597**	**0.00597**			**0.00566**			
94Q3	9/26/1994	**0.00636**		**0.00563**	**0.02447**			**0.00932**			
94Q4	1/3/1995	**0.00192**		**0.00107**	**0.00117**			**0.00200**			
95Q1	3/27/1995	**0.01389**		**0.01607**	**0.01560**			**0.08203**			
95Q2	6/20/1995	**0.00978**		**0.01041**	**0.01242**			**0.01589**			
95Q3	9/25/1995	**0.01456**		**0.01357**	**0.02358**			**0.01624**			
95Q4	1/3/1996	**0.01220**		**0.03494**	**0.01245**			**0.01267**			
98Q1	3/30/1998			0.00856				0.00954	0.09153		
98Q2	6/22/1998			0.01124				0.00801	0.09952		
98Q3	9/28/1998			0.01071				0.00557	0.10945	0.01492	
98Q4	12/21/1998			0.00603				0.00373	0.08582	0.02539	
99Q1	3/29/1999			0.01011		0.00836	0.20352	0.00717	0.07794		0.05249
99Q2	6/21/1999			0.01331		0.01589	0.69307	0.00984	0.13558		0.03802
99Q3	9/27/1999			0.00751		0.00339	0.08160	0.00759	0.08503		0.01713
99Q4	12/20/1999			0.00845		0.00479	0.05963	0.01436	0.12756		0.04561
00Q1	3/27/2000			0.00935		0.00531	0.09071	0.02999	0.10525		0.04216
00Q2	6/19/2000			0.04735		0.02561	0.20264	0.02424	0.14470		0.03561
00Q3	9/25/2000			0.02497		0.00593	0.11323	0.02004	0.16356		0.03837
00Q4	12/18/2000			0.01049		0.00147	0.02659	0.00912	0.07991		0.02152
01Q1	3/26/2001		0.00670	0.00850		0.00454	0.01798	0.01432	0.06342		0.01320
01Q2	6/18/2001		0.01644	0.01946		0.01639	0.09345	0.02769	0.10373		0.03899
01Q3	9/24/2001		0.00836	0.00964		0.00709	0.01895	0.01140	0.09891		0.01759
01Q4	12/17/2001		0.01015	0.02218		0.00672	0.02355	0.01506	0.08064		0.02306
1998-2001 Avg			0.01041	0.01424		0.00879	0.13541	0.01360	0.10328		0.03198
1998-2001 Max			0.01644	0.04735		0.02561	0.69307	0.02999	0.16356		0.05249
1998-201 Min			0.00670	0.00603		0.00147	0.01798	0.00373	0.06342		0.01320

1994-2001 AIRNET Be Data Set Sorted by Quarter

	Mstr ID	161	163	173	185	226	234	246	247	248	211
	Name	TA54 G3	TA54GQA	TA49 QA	San I	SF wst	El Ranc	TA49AB2	TA49AB5	Jem Pue	LA Hosp
	Site No.	36	38	39	41	55	56	57	58	59	61
PeriodID	**EndDate**										
94Q1	3/28/1994										
94Q2	6/20/1994										
94Q3	9/26/1994										
94Q4	1/3/1995										
95Q1	3/27/1995										
95Q2	6/20/1995										
95Q3	9/25/1995										
95Q4	1/3/1996										
98Q1	3/30/1998				0.02745		0.01214				0.02169
98Q2	6/22/1998				0.02095		0.01993				0.03433
98Q3	9/28/1998				0.01975		0.01291	0.02612	0.00508		0.02734
98Q4	12/21/1998				0.01870		0.00570	0.01472	0.00284		0.01191
99Q1	3/29/1999	0.04978	0.17664	0.00649	0.03532	0.01293	0.02149			0.07461	0.02476
99Q2	6/21/1999	0.09782	0.31157	0.01350	0.03162	0.01574	0.02037			0.09615	0.01784
99Q3	9/27/1999	0.03258	0.06187	0.00362	0.01671	0.01474	0.00976			0.05803	0.01222
99Q4	12/20/1999	0.02563	0.05620	0.00453	0.03880	0.01161	0.01428			0.07628	0.03283
00Q1	3/27/2000	0.03459	0.10237	0.00494	0.04064	0.01011	0.02141			0.07529	0.02415
00Q2	6/19/2000	0.04112	0.18115	0.01946	0.02716	0.01100	0.03094			0.10450	0.03014
00Q3	9/25/2000	0.02707	0.12294	0.00485	0.01751	0.00982	0.01283			0.04662	0.01713
00Q4	12/18/2000	0.00940	0.03474	0.00252	0.01660	0.00284	0.00602			0.04145	0.01321
01Q1	3/26/2001	0.01163	0.02654	0.00626	0.01497	0.00749	0.00730			0.03848	0.01378
01Q2	6/18/2001	0.03610	0.08767	0.02176	0.02975	0.01748	0.02143			0.06926	0.01713
01Q3	9/24/2001	0.01193	0.02905	0.00933	0.01993	0.01077	0.01205			0.05785	0.01398
01Q4	12/17/2001	0.01011	0.02630	0.00684	0.04737	0.01139	0.02313			0.07738	0.01587
1998-2001 Avg		0.03231	0.10142	0.00867	0.02645	0.01133	0.01573			0.06799	0.02052
1998-2001 Max		0.09782	0.31157	0.02176	0.04737	0.01748	0.03094			0.10450	0.03433
1998-201 Min		0.00940	0.02630	0.00252	0.01497	0.00284	0.00570			0.03848	0.01191

1994-2001 AIRNET Be Data Set Sorted by Quarter

	Mstr ID	250	253	257	262	290	176	177	178	179	180
	Name	TA54GX	LndfllEX	LA Inn S	TA3 Res	Apt Rd	TA21.01	TA21.02	TA21.03	TA21.04	TA21.05
	Site No.	64	65	66	67	68	71	72	73	74	75
PeriodID	**EndDate**										
94Q1	3/28/1994										
94Q2	6/20/1994										
94Q3	9/26/1994										
94Q4	1/3/1995										
95Q1	3/27/1995										
95Q2	6/20/1995						**0.01184**	**0.01122**	**0.01161**	**0.01250**	**0.01261**
95Q3	9/25/1995						**0.01485**	**0.01506**	**0.01467**	**0.01588**	**0.01438**
95Q4	1/3/1996						**0.01213**	**0.01307**	**0.01340**	**0.01216**	**0.01603**
98Q1	3/30/1998										
98Q2	6/22/1998										
98Q3	9/28/1998										
98Q4	12/21/1998										
99Q1	3/29/1999										
99Q2	6/21/1999										
99Q3	9/27/1999	0.03947									
99Q4	12/20/1999	0.04441									
00Q1	3/27/2000		0.16601								
00Q2	6/19/2000		0.18396								
00Q3	9/25/2000		0.10789	0.00968	0.06253						
00Q4	12/18/2000		0.06303								
01Q1	3/26/2001		0.04650				0.00606				
01Q2	6/18/2001		0.08937				0.01808				
01Q3	9/24/2001		0.06896				0.00801				
01Q4	12/17/2001		0.05970			0.01073	0.00804				
1998-2001 Avg			0.09818								
1998-2001 Max			0.18396								
1998-201 Min			0.04650								

1994-2001 AIRNET Be Data Set Sorted by Quarter

	Mstr ID	193	194	195	107	206
	Name	TA15-41	TA36IJ	TA15N	W Ariz	EgateBK
	Site No.	76	77	78	80	90
PeriodID	EndDate					
94Q1	3/28/1994					
94Q2	6/20/1994	**0.00942**	**0.01253**	**0.01593**		
94Q3	9/26/1994	**0.00694**	**0.00612**	**0.00581**		
94Q4	1/3/1995	**0.00120**	**0.00120**	**0.00120**		
95Q1	3/27/1995	**0.01735**	**0.01809**	**0.01758**		
95Q2	6/20/1995	**0.00990**	**0.00984**	**0.01137**		
95Q3	9/25/1995	**0.01480**	**0.01524**	**0.01431**		
95Q4	1/3/1996	**0.01491**	**0.01172**	**0.01196**		
98Q1	3/30/1998	0.00389	0.00401	0.00284		
98Q2	6/22/1998	0.00962	0.01323	0.00728		
98Q3	9/28/1998	0.00493	0.00652	0.00462		
98Q4	12/21/1998	0.00332	0.00422	0.00245		
99Q1	3/29/1999	0.00786	0.00828	0.00460		
99Q2	6/21/1999	0.01018	0.01060	0.00927		
99Q3	9/27/1999	0.00495	0.00837	0.00364		
99Q4	12/20/1999	0.00488	0.00767	0.00502		
00Q1	3/27/2000	0.00401	0.00584	0.00230		
00Q2	6/19/2000	0.01328	0.01643	0.01363		
00Q3	9/25/2000	0.00668	0.00802	0.00597		
00Q4	12/18/2000	0.00184	0.00179	0.00136		
01Q1	3/26/2001	0.00298	0.00440	0.00266		
01Q2	6/18/2001	0.01982	0.01441	0.01075		
01Q3	9/24/2001	0.00803	0.00750	0.00554	0.01330	0.01238
01Q4	12/17/2001	0.00805	0.00736	0.00485	0.02440	0.01148
1998-2001 Avg		0.00715	0.00804	0.00542		
1998-2001 Max		0.01982	0.01643	0.01363		
1998-201 Min		0.00184	0.00179	0.00136		