# 1.0 ONSITE GROSS ALPHA IN AIR

In 1996, because of continuing budget decreases, an experiment was performed to determine if expensive plutonium analyses could be replaced by a surrogate, specifically gross alpha analyses. After the analysis of several hundred air samples for both plutonium and gross alpha, it was determined that gross alpha was not a surrogate for the presence of plutonium in air samples. However, this experiment did indicate that there were alpha emitters in the air of the Nevada Test Site (NTS) that were not related to either plutonium or radon progeny. Therefore it was decided to initiate a program for routine monitoring of gross alpha levels in air samples. The intent of this new monitoring program is to economize by only performing chemical separations when the gross alpha levels suggest that alpha emitting radionuclides are present at the NTS at levels above background. Monitoring of gross alpha in air levels at the NTS commenced in June of 1996.

Thirty-nine air sampling locations on the NTS were chosen to monitor for gross alpha levels. These are the same sampling locations as used for gross beta monitoring, except that the radiological waste management sites were not used for gross alpha. Gross alpha was measured on the same filters as used for gross beta measurements. The sampling units were equipped with glass-fiber filters and had an air flow rate of 140 L/min (5 cfm). The filters were changed after approximately one week of operation. The glass-fiber filters were analyzed by gamma spectroscopy and, after a five to seven day delay for radon progeny decay, for gross alpha, then gross beta.

Gross alpha in air sampling locations, sampling dates, measured concentrations, analytic standard deviations, and analytic detection limits for 1996 appear in Attachment 1.1. (All figures, tables, and attachments are located at the end of each chapter in that order.) The locations of NTS air sampling stations are shown in Figure 1.1. The names of the operational areas are the numbers in the middle of each area. Area 13 is not identified in Figure 1.1. It is located northeast of Area 15 and includes the Project 57 sampling station. Figure 1.1 also does not include Area 52, the location of the last three sampling sites listed in Attachment 1.1. These sampling locations are approximately 27 miles north of the northwest corner of Area 20. Area 52 contains three air sampling locations: the DOUBLE TRACKS and two CLEAN SLATE locations. Air monitoring at the DOUBLE TRACKS and CLEAN SLATE III locations began in December of 1995; monitoring at CLEAN SLATE I commenced in August of 1996.

Descriptive statistics for the results from individual stations are given in Table 1.1. None of the computed results are negative. The statistics for all stations combined appear at the foot of Table 1.1. For comparison purposes, the median detection limit is $0.54 \times 10^{-15}$ µCi/mL, and 23 of the 821 results, or 2.8 percent, are less than their individual detection limits. A comparison of the station means in Table 1.1 to the median detection limit shows that the means are usually three or more times the median detection limit. It should be emphasized that since data collection began in mid year, the statistics in Table 1.1 only approximate annual exposure levels.

Figure 1.2, a normal probability plot, shows that the alpha in air data can be assumed to have a lognormal statistical distribution. This figure shows three segments with most of the data in the middle segment and about nine values in each of the lower and upper tail segments. The middle segment is reasonably approximated by a straight line, indicating that this data is lognormally distributed. The highest value, a result of $31.9 \times 10^{-15}$ from the sample collected at the DOUBLE TRACKS location on June 13, 1996, was collected during cleanup activities and thus does not reflect environmental levels. Note that the lower and upper segments have approximately the same slope, which is distinct from the slope of the middle segment. This situation is statistically consistent with two subsets of the data that have about the same mean but different variances. The upper and lower segments in Figure 1.2 then could represent the subset of the data with the larger variance. An examination of the sampling locations and dates represented in the upper and lower segments showed no patterns, and since these data encompass only 2 percent of the total data, the segmentation was assumed to be of no practical consequence.

Figure 1.3 is a time series plot of all the alpha in air sampling locations combined. The high value from the DOUBLE TRACKS location has been excluded from this plot. Note that the time span of this plot is the last half of 1996. The line passing through the approximate middle of the data points is a "locally weighted scatterplot smoother" line, a statistical device that approximates any trends in the time series data. This plot shows an obvious downward trend. A linear regression on this data indicated that this trend is statistically very significant. The F-value for regression is 249 with 1 and 818 degrees of freedom. Since this is the first six months of gross alpha in air data collection, there is no historical data base to compare for pattern in the data, and no correlations with other radiological levels or activities at the NTS could be found. Thus at this time, the significant trend in 1996 has been found but its interpretation and practical significance must wait until a historical data base is established.

Table 1.2 and Figure 1.4 summarize the gross alpha in air data by NTS operational area. Table 1.2 gives descriptive statistics for each area. Note that several of the areas have zero samples, which indicates that no gross alpha in air samples were collected in these areas. Samplers are usually located where there is potential exposure of personnel. The areas with zero samples are mostly those with minimal operational activities and thus are rarely visited by workers. Figure 1.4 is a thematic map of average gross alpha in air levels. The pattern within the areas indicates the average levels, and the ranges of values are given at the right side of the figure. The areas with no pattern are those with no samples. The ranges were determined as five evenly spaced intervals between the minimum and maximum area averages. The areas with the highest values are approximately those in which atmospheric testing was performed; thus, they have some residual plutonium in soils.

The pattern of averages in Figure 1.4 leads to a statistical test to see if the differences in averages are statistically significant. This situation suggests a two way analysis of variance (ANOVA), with monitoring locations nested within operational areas and date of sampling used as a covariate. This covariate will account for the effect of the trend seen in Figure 1.3. However, the data is rank deficient for this ANOVA model, which approximately means that there is not enough data in some of the operational areas to compute the ANOVA model coefficients. A simplified ANOVA, that is possible, is a one-way analysis for differences between operational areas. This analysis is less powerful than the one adjusting for the effects of the covariate and for the effects of individual stations, but if significant differences are found, they would also be found with higher significances by the two way analysis. The ANOVA was performed using the natural logarithms of the data values, since the data is lognormally distributed. This one way analysis found a statistically very significant difference between area averages ($p=8.4 \times 10^{-6}$). The average of the logarithms of the data values is an estimator of the medians of the data for lognormally distributed data. A Tukey's multiple comparison test was used to determine the pattern of differences between the areas. When the area average logarithms are ordered by rank, a gradual increase from the lowest value to the highest value is seen. There are no dichotomies in the sequence of values. The Tukey's test only finds that the lowest value is different from the highest value; thus, no useful pattern was found.

The conclusions of the statistical test on the gross alpha levels in air data can be summarized as follows. A very significant downward trend over time was found, but no significant covariate other than time could be identified. The interpretation of this trend must wait upon additional years of data.  A very significant difference between operational area levels was found.  These differences are not due to any grouping of values by areas, but rather are due to statistically significant differences between the highest and lowest values.

## HISTORICAL TRENDS

Gross alpha in air measurements were made in the years of the first NTS annual reports.  The results were usually reported qualitatively, and so they are of no comparative value today.  The first annual report was released in August 1964 and covered measurements made during the period of January to June 1964.  This report simply states that only normal radon progeny products were detected.  The second NTS annual report covered the time period from July 1964 to June 1965 or the fiscal 1965 period.  This report states that the maximum gross alpha in air measured was $1.0 \times 10^{-12}$ µCi/mL, which is almost two orders of magnitude above the typical values seen in 1996.  However, in the 1965 report, it is not clear if this maximum includes or excludes the radon progenys.  The fiscal 1965 report gives the approximate detection limit for gross alpha in air as $2.9 \times 10^{-15}$ µCi/mL.  This is over five times higher than the median detection limit in 1996, and thus the comparability of levels between then and now should be considered more qualitative than quantitative.  The fiscal 1966 and 1967 reports only state that "detectable alpha activity values for air during this period occurred infrequently."  The fiscal 1967 report repeats the 1996 statement about gross alpha levels.  The fiscal 1968 report and subsequent reports, until the present, do not mention gross alpha in air.

## CONCLUSION

Gross alpha in air sampling was initiated in mid 1996 after some experimentation to establish a plutonium surrogate indicated that there are measurable levels of gross alpha in air at the NTS.  These experiments found that gross alpha in air is not a plutonium surrogate; however, this experiment also indicated that there were alpha emitters in the air of the NTS.  Gross alpha in air was reported in the 1964 and 1965 reports.  The average gross alpha in air levels for the entire NTS for the last half of 1966 is $2.06 \times 10^{-15}$ µCi/mL.  The most notable finding is a statistically significant linear decrease in gross alpha in air levels over the seven months of data collection in 1996.

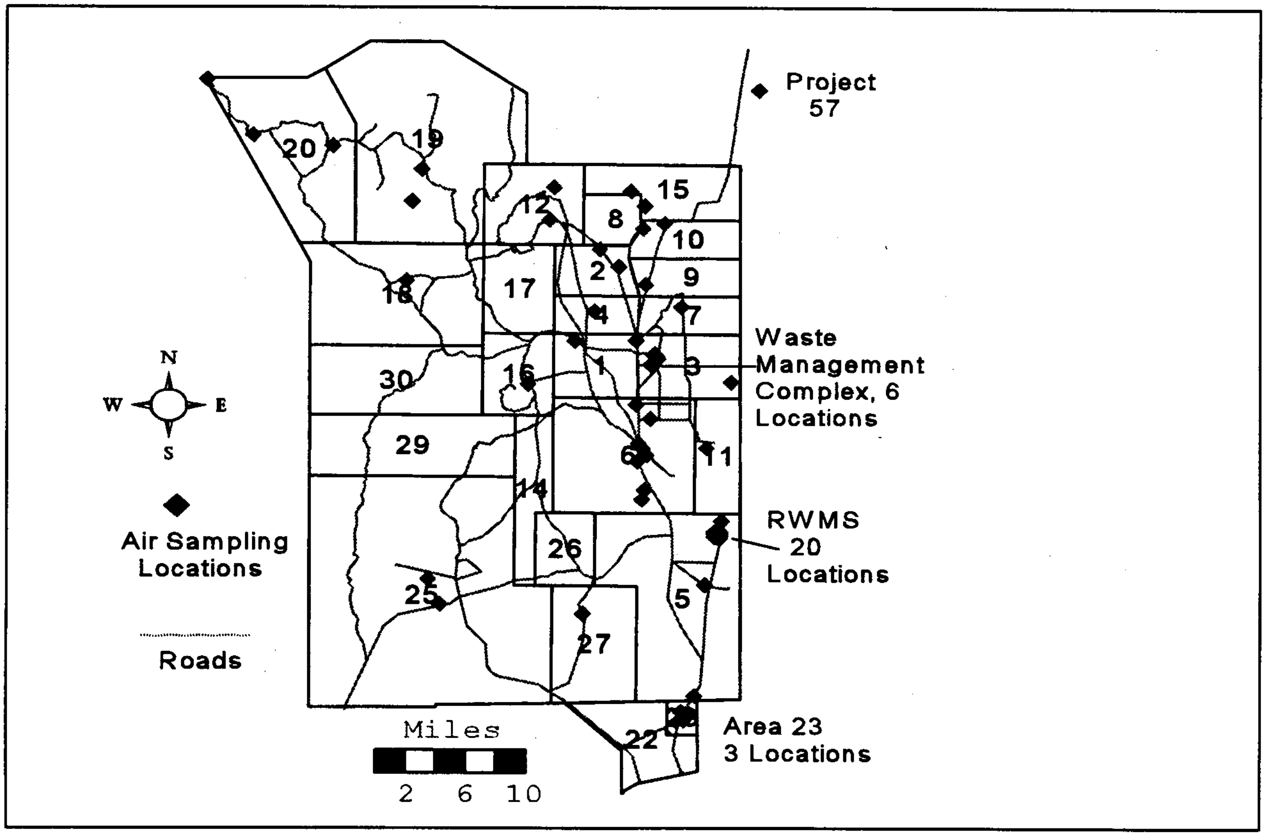


Figure 1.1 Locations of Air Sampling Stations on NTS

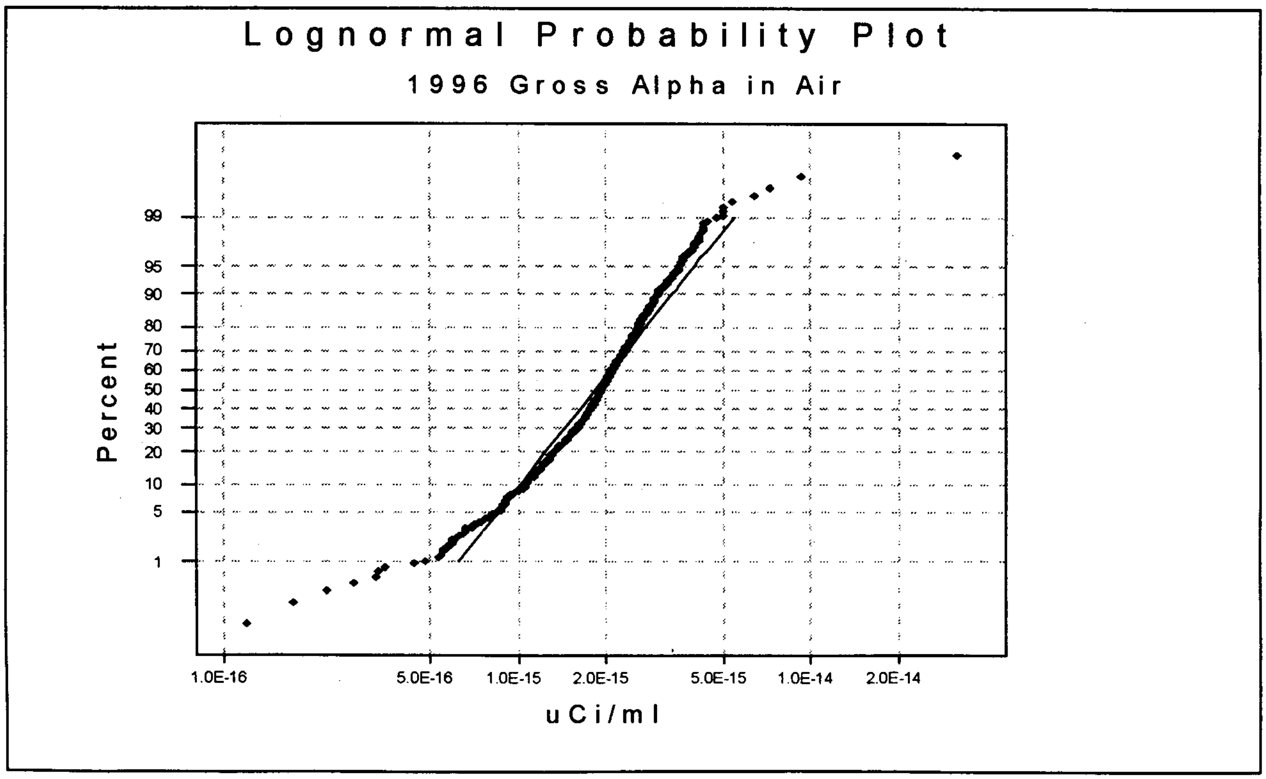


Figure 1.2 Probability Plot for All Data Combined

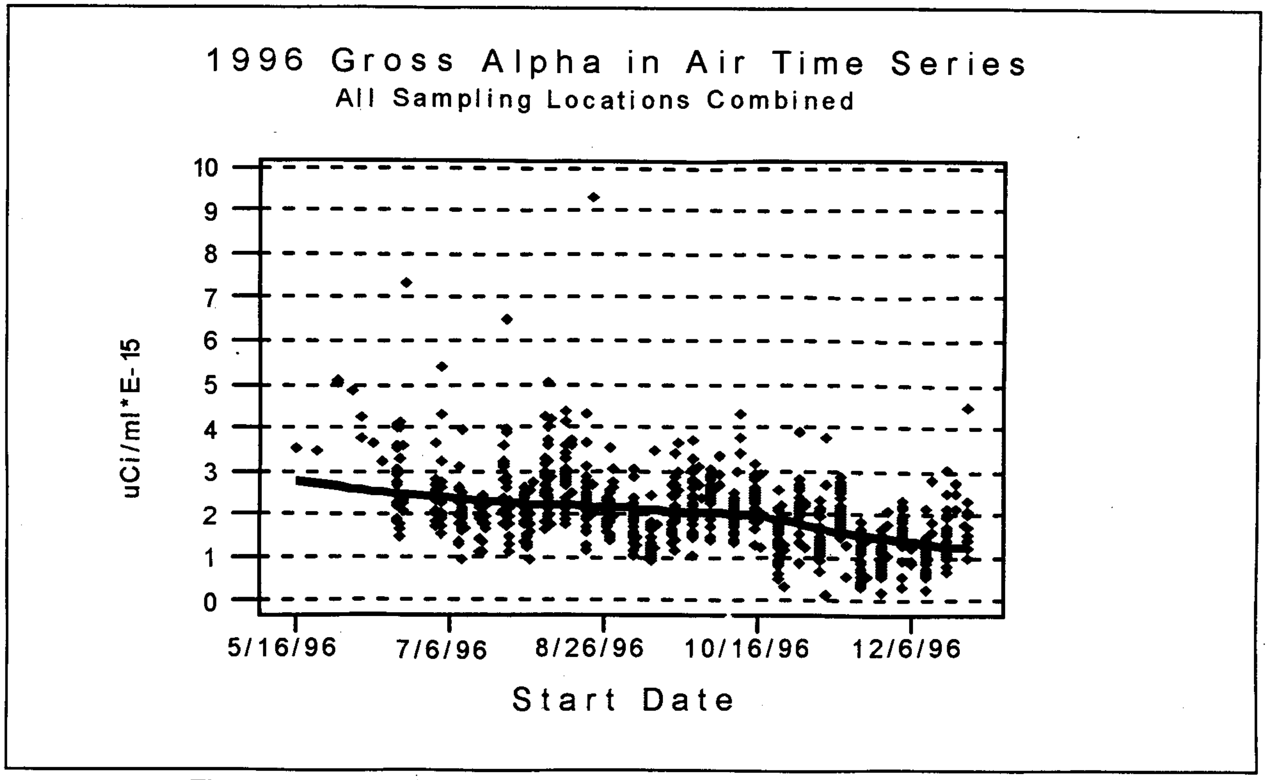


Figure 1.3 Time Series Plot of Gross Alpha in Air with LOWESS Line

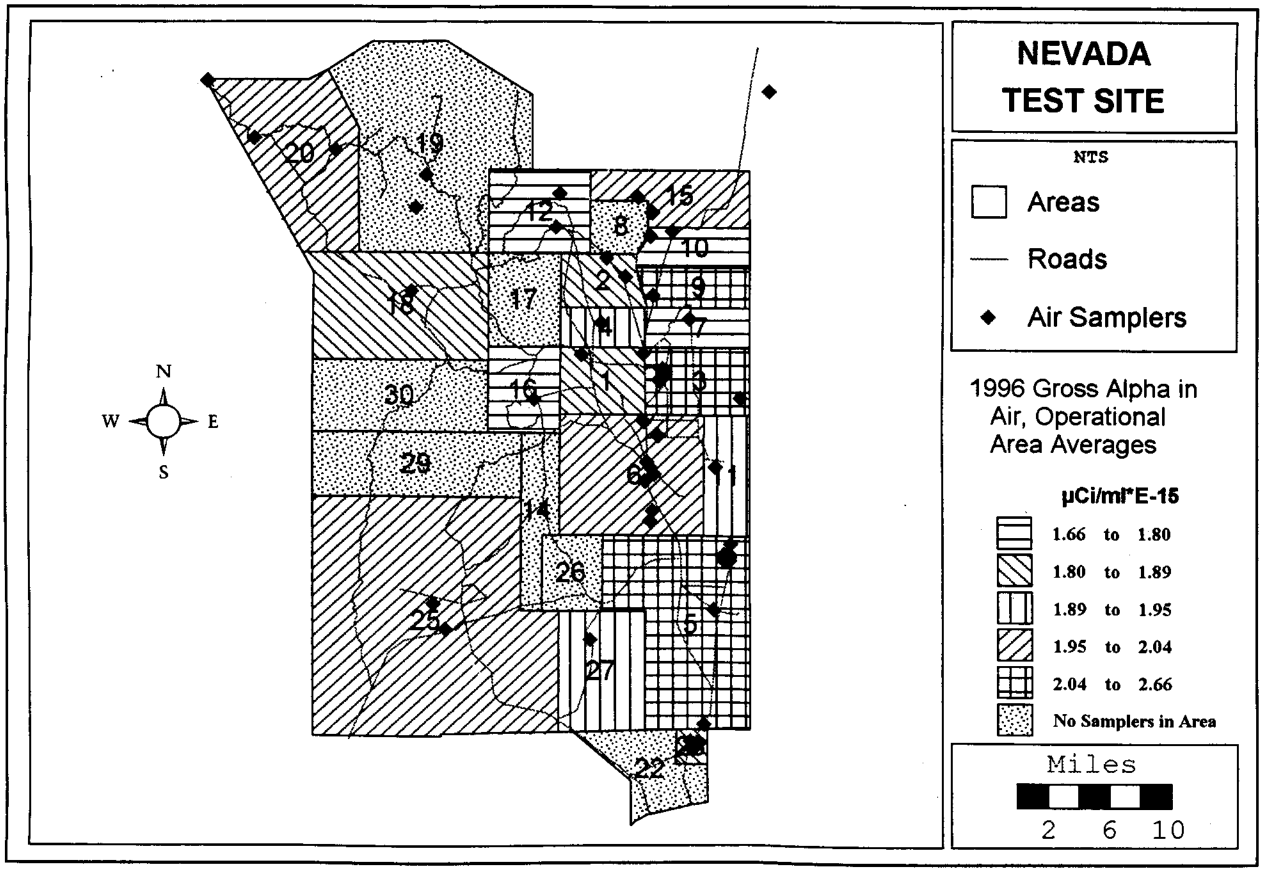


Figure 1.4 Thematic Map of 1996 Gross Alpha in Air

Table 1.1  Descriptive Statistic for Gross Alpha in Air by Sampling Location, µCi/mL × $10^{-15}$

| Station Name | Number of Samples | Mean | Median | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|---|---|
| BJY | 25 | 1.81 | 1.70 | 0.58 | 0.96 | 3.05 |
| Area 2, Camp | 26 | 1.94 | 1.89 | 0.63 | 0.81 | 3.67 |
| 2-1 Substation | 25 | 1.74 | 1.58 | 0.83 | 0.28 | 4.32 |
| Mud Plant | 25 | 2.34 | 2.06 | 1.08 | 0.70 | 4.31 |
| Well ER 3-1 | 27 | 2.17 | 1.93 | 0.89 | 0.87 | 4.48 |
| Bunker T-4 | 25 | 1.94 | 1.92 | 0.52 | 0.93 | 3.30 |
| WEF North | 3 | 2.16 | 1.93 | 0.59 | 1.72 | 2.83 |
| WEF South | 4 | 2.39 | 2.44 | 0.57 | 1.73 | 2.95 |
| RWMS No. 4 | 1 | 3.59 | – | – | – | – |
| RWMS No. 5 | 1 | 2.16 | – | – | – | – |
| RWMS No. 6 | 1 | 2.93 | – | – | – | – |
| DOD Yard | 27 | 2.07 | 2.10 | 0.70 | 0.90 | 4.00 |
| RWMS No. 3 | 1 | 3.49 | – | – | – | – |
| RWMS No. 1 | 1 | 2.97 | – | – | – | – |
| Well 5B | 27 | 2.15 | 2.11 | 0.62 | 0.88 | 3.60 |
| Yucca | 24 | 2.01 | 1.89 | 0.56 | 0.89 | 3.05 |
| CP-6 | 27 | 2.13 | 2.12 | 0.54 | 0.92 | 3.11 |
| Area 6, Well 3 | 26 | 1.98 | 2.00 | 0.66 | 0.63 | 3.26 |
| UE-7ns | 25 | 1.80 | 1.52 | 0.91 | 0.35 | 5.04 |
| Area 9, 9-300 | 27 | 2.63 | 2.45 | 1.18 | 0.87 | 6.51 |
| Gate 700 South | 26 | 1.68 | 1.68 | 0.63 | 0.59 | 3.27 |
| SEDAN Crater | 26 | 1.82 | 1.96 | 0.66 | 0.65 | 2.95 |
| Gate 293 | 26 | 1.95 | 1.92 | 0.56 | 0.93 | 3.39 |
| Area 12, Camp | 26 | 1.70 | 1.59 | 0.51 | 0.44 | 2.81 |
| Project 57 | 31 | 2.35 | 2.35 | 0.92 | 0.88 | 4.82 |
| EPA Farm | 26 | 1.96 | 1.92 | 0.96 | 0.59 | 5.39 |
| 3545 Substation | 25 | 1.66 | 1.59 | 0.80 | 0.17 | 4.34 |
| Well UE-18t | 26 | 1.90 | 1.81 | 0.73 | 0.54 | 3.42 |
| SCHOONER | 26 | 1.98 | 2.08 | 0.80 | 0.56 | 3.58 |
| Area 20, Camp | 26 | 1.71 | 1.87 | 0.83 | 0.32 | 3.30 |
| CABRIOLET | 3 | 1.51 | 1.41 | 0.40 | 1.16 | 1.95 |
| Building 790 No. 2 | 27 | 1.81 | 1.72 | 0.71 | 0.76 | 3.23 |
| H & S Building | 27 | 1.82 | 1.80 | 0.72 | 0.22 | 3.07 |
| E-MAD North | 27 | 1.92 | 2.02 | 0.75 | 0.57 | 3.95 |
| NRDS | 27 | 2.01 | 1.92 | 0.77 | 0.65 | 4.25 |
| Area 27, Camp | 22 | 1.95 | 1.87 | 0.61 | 0.95 | 3.17 |
| DOUBLE TRACKS | 28 | 3.66 | 2.25 | 5.86 | 0.34 | 31.90 |
| CLEAN SLATE III | 29 | 2.51 | 2.31 | 1.05 | 1.18 | 5.05 |
| CLEAN SLATE I | 19 | 2.32 | 2.64 | 1.09 | 0.12 | 3.75 |
| All stations combined | 821 | 2.06 | 1.94 | 1.36 | 0.12 | 31.90 |

Table 1.2 Descriptive Statistic for Gross Alpha in Air by Operational Area, µCi/mL × $10^{-15}$

| Area | Number of Samples | Mean | Median | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|---|---|
| 1 | 25 | 1.81 | 1.70 | 0.58 | 0.96 | 3.05 |
| 2 | 51 | 1.84 | 1.75 | 0.73 | 0.28 | 4.32 |
| 3 | 52 | 2.25 | 1.94 | 0.98 | 0.70 | 4.48 |
| 4 | 25 | 1.94 | 1.92 | 0.52 | 0.93 | 3.30 |
| 5 | 66 | 2.20 | 2.15 | 0.68 | 0.88 | 4.00 |
| 6 | 77 | 2.05 | 2.07 | 0.58 | 0.63 | 1.66 |
| 7 | 25 | 1.80 | 1.52 | 0.91 | 0.35 | 5.04 |
| 8 | 0 | | | | | |
| 9 | 27 | 2.63 | 2.45 | 1.18 | 0.87 | 6.51 |
| 10 | 52 | 1.75 | 1.83 | 0.64 | 0.59 | 3.27 |
| 11 | 26 | 1.95 | 1.92 | 0.56 | 0.93 | 3.39 |
| 12 | 26 | 1.70 | 1.59 | 0.51 | 0.44 | 2.81 |
| 13 | 31 | 2.35 | 2.35 | 0.92 | 0.88 | 4.82 |
| 14 | 0 | | | | | |
| 15 | 26 | 1.96 | 1.92 | 0.96 | 0.59 | 5.39 |
| 16 | 25 | 1.66 | 1.59 | 0.80 | 0.17 | 4.24 |
| 17 | 0 | | | | | |
| 18 | 26 | 1.90 | 1.81 | 0.73 | 0.54 | 3.42 |
| 19 | 0 | | | | | |
| 20 | 55 | 1.83 | 1.88 | 0.80 | 0.32 | 3.58 |
| 22 | 0 | | | | | |
| 23 | 54 | 1.81 | 1.74 | 0.70 | 0.22 | 3.23 |
| 25 | 54 | 1.97 | 1.98 | 0.75 | 0.57 | 4.25 |
| 26 | 0 | | | | | |
| 27 | 22 | 1.95 | 1.87 | 0.61 | 0.95 | 3.17 |
| 29 | 0 | | | | | |
| 30 | 0 | | | | | |
| 52 | 76 | 2.89 | 2.38 | 3.66 | 0.12 | 31.9 |