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A STUDY OF THE ANPP DRIFT DEPOSITION MONITORING PROGRAM AFTER FOUR YEARS OF PVNGS OPERATION

REVISION 2

Prepared for

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1.0 INTRODUCTION

NUS Corporation is conducting a salt deposition and impact monitoring program in the vicinity of the Palo Verde Nuclear Generating station (PVNGS) for the Arizona Nuclear Power Project (ANPP). This program began operation in May 1983 and is intended to meet the commitment of the monitoring program called for in the PVNGS Environmental Report, Construction Permit Stage (PVNGS, 1974, Section 5.2.5), and to satisfy the requirements of the PVNGS Units 1, 2, and 3 Environmental Protection Plans, Sections 4.2.2 and 5.4.1 (Appendix B of Facility Operating Licenses NPF-41, NPF-51, and NPF-74). The objective of this program is to determine the environmental impact on salt drift emissions from the operation of the PVNGS round mechanical draft cooling towers.

This report presents the proposed modified design to this monitoring program including a statistical comparison between preoperational and operational drift deposition, as well as a discussion of drift rate versus measured deposition. Section 2.0 contains a discussion of the program background, Section 3.0 presents the data analysis, and Section 4.0 outlines the conclusions reached. Recommended program modifications are contained in Section 5.0.

2.0 PROGRAM BACKGROUND

As described in the Salt Deposition and Impact Monitoring Plan, Revision 5 (NUS, 1987b), the monitoring program was designed to (1) determine levels of airborne salt deposition; (2) define physical and chemical properties of surficial soils; (3) estimate species richness and cover and measure the salt loading of agricultural crops and indigenous plant communities in the vicinity of PVNGS; and (4) estimate cotton crop yield.

Forty-four monitoring locations ranging from 0.4 mile to 19.0 miles from PVNGS were initiated in May 1983. Eleven of these locations are onsite and thirteen are agricultural fields. Four background locations were established as control sites at distances (greater than 15 miles) where PVNGS cooling tower operations would have no impact and to measure any long-term natural changes. Airborne drift deposition measurements and soil sampling are performed at all 44 locations. Native vegetation sampling is performed at four onsite and three offsite locations (including two control sites). Agricultural vegetation sampling is performed at those fields which are planted in any given year. Six sites have low-volume air samplers for measuring airborne drift.

Prior to the onset of commercial operation at PVNGS, a baseline monitoring period was established to measure preoperational (background) levels for all the media sampled in the monitoring program. The preoperational period for the sites in this report is from May 1983 through December 1985. Significant drift from the Unit 1 cooling towers began in January 1986, from Unit 2 in May 1986, and December 1987 for Unit 3.

Annual reports have been issued since 1983 which describe the program results for each of the sampled media, as well as a comparison of measured and predicted drift deposition using the FOG model.

3.0 DATA ANALYSIS

Yearly analyses of data from the monitoring program since the inception of commercial operation at PVNGS have demonstrated the existence of drift deposition at a number of onsite sampling locations, and in one year at one offsite location (19) 2.3 miles from the Unit 2 cooling towers. However, in that four-year period, no drift deposition has been detected at distances of 2.5 miles or more, nor have cooling tower effects been detected in other media sampled at any distance.

A reassessment of the Drift Deposition Monitoring Program at PVNGS was performed to determine the feasibility of achieving the program objectives without maintaining the sites five miles or greater from PVNGS. For comparison purposes, two groups of sites were studied; those at a distance of 2.5 to 4.9 miles from PVNGS and those 5 miles or greater from PVNGS. Twelve sites are included in the first group (sites 12, 13, 17, 18, 21, 22, 24, 28, 30, 31, 32, and 41) and 16 in the second (sites 7, 15, 25, 26, 33-40, 42-45).

Statistical comparisons were made for each group between preoperational data and the 1986-1989 operational years. Comparisons were made for those major ionic constituents present in the cooling tower basin water. These selected ions of sodium, potassium, calcium, magnesium and nitrate constitute the most significant portion of the salt drift from the cooling towers which have been measured in deposition samples.

The statistical significance of differences in the means of each constituent between the preoperational period and the 1986-1989 operational years was determined using the two sample t-test. Depending on the differences in the variances between the two means, the calculation of the t-statistic assumed either the pooled-variance t-test or the separate-variance t-test. The pooled-variance t-test was used when the variances of the data sets were statistically equal at the 95 percent confidence level. The separate-variance estimate was used when the two variances were unequal statistically at the 95 percent confidence level.

Table 3-1 presents the means of sodium, potassium, calcium, magnesium, and nitrate, for the preoperational period and the 1986-1989 operational years for sites between 2.5 and 4.9 miles from PVNGS. Statistically significant

Table 3-1. Comparisons of mean annual deposition (lb/acre-yr) (means ± standard errors) of drift constituents for monitoring sites between 2.5 and 4.9 miles from PVNGS for the preoperational and 1986 - 1989 operational years

Constituent	Preoperational	1986	1987	1988	1989
Sodium	6.9 ± 0.3	6.4 ± 0.3	6.2 ± 0.2	5.2 ± 0.2[a]	4.6 ± 0.3[a]
Potassium	5.9 ± 0.2	3.6 ± 0.2[a]	5.3 ± 0.4	3.6 ± 0.4[a]	3.9 ± 0.4[a]
Calcium	17.7 ± 0.7	15.4 ± 1.0	19.5 ± 1.2	24.3 ± 2.1[a]	22.2 ± 1.8[a]
Magnesium	4.0 ± 0.2	2.7 ± 0.2[a]	3.4 ± 0.3	5.1 ± 0.7	4.9 ± 0.5
Nitrate	2.2 ± 0.1	2.0 ± 0.1[a]	1.6 ± 0.1[a]	1.3 ± 0.1[a]	0.8 ± 0.1[a]

NOTE: For each ion, means for the years 1986-1989 with a superscript letter a are significantly different at the 95 percent level.

changes occurred in one or more operational years when compared to the preoperational period for sodium, potassium, magnesium and nitrate. However, all these changes were significant <u>decreases</u> in deposition from preoperational values. Only calcium in 1988 and 1989 showed statistically significant increases in deposition over preoperational values. Since sodium decreased during this period and is present in the cooling tower basin water in concentrations an order of magnitude higher than calcium these increases are likely attributable to agricultural activity and not associated with cooling tower operation.

Table 3-2 presents similar data for those sites five miles or greater from PVNGS. With the exception of calcium in 1988, all of the statistical differences are <u>decreases</u> in deposition from preoperational values. As with the 2.5-4.9 mile samples in Table 3-1, this calcium increase is also likely due to agricultural activity and not attributable to cooling tower operation.

Figures 3-1 and 3-2 present graphs of the average quarterly drift rate calculated from the plant circulating water flow rate, TDS data, thermal generation, and number of cooling tower fans operating. The graphs illustrate the steady increase in drift rate coinciding with the onset of commercial operation of Unit 2 in May 1986 and Unit 3 in December 1987. The peak quarterly drift rate of 0.46 pounds per minute occurred in the fourth quarter of 1988 when all 3 units were operating at near full power. Figure 3-1 also presents the average quarterly drift deposition of sodium as measured at those sites 2.5 to 4.9 miles from PVNGS. Figure 3-2 contains the average quarterly drift deposition of sodium as measured at those sites 5 miles or greater from PVNGS (but not including the four control sites). A plot of the average quarterly drift deposition of sodium for the four control sites is included on both figures.

The mean quarterly drift deposition of sodium for those sites 2.5 to 4.9 miles from PVNGS indicates a trend, as shown in Figure 3-1, to follow the station drift rate during the third and fourth quarters of 1986. During this period, Unit 1 operated with a fraction of the drift eliminator bays damaged by high winds in an August thunderstorm. Through 1987 and the period of maximum drift rate (1988), the mean sodium deposition closely paralleled that of the control sites. The indication of a trend for deposition to follow the

Table 3-2. Comparisons of mean annual deposition (lb/acre-yr) (means ± standard errors) of drift constituents for monitoring sites between 5 miles or greater from PVNGS for the preoperational and 1986 - 1989 operational years

Constituent	Preoperational	1986	1987	1988	1989
Sodium	6.4 ± 0.2	4.6 ± 0.1[a]	5.5 ± 0.2[a]	4.0 ± 0.1[a]	3.0 ± 0.1[a]
Potassium	5.9 ± 0.3	3.1 ± 0.2[a]	4.1 ± 0.2[a]	2.9 ± 0.3[a]	2.7 ± 0.2[a]
Calcium	12.8 ± 0.5	11.3 ± 0.6[a]	11.8 ± 0.5	16.4 ± 1.2[a]	12.8 ± 0.6
Magnesium	3.3 ± 0.2	2.3 ± 0.2[a]	2.0 ± 0.2[a]	3.4 ± 0.4	3.0 ± 0.3
Nitrate	1.9 ± 0.1	1.6 ± 0.05[a]	1.2 ± 0.04[a]	0.9 ± 0.05[a]	0.7 ± 0.04[a]

NOTE: For each ion, means for the years 1986-1989 with a superscript letter a are significantly different at the 95 percent level.

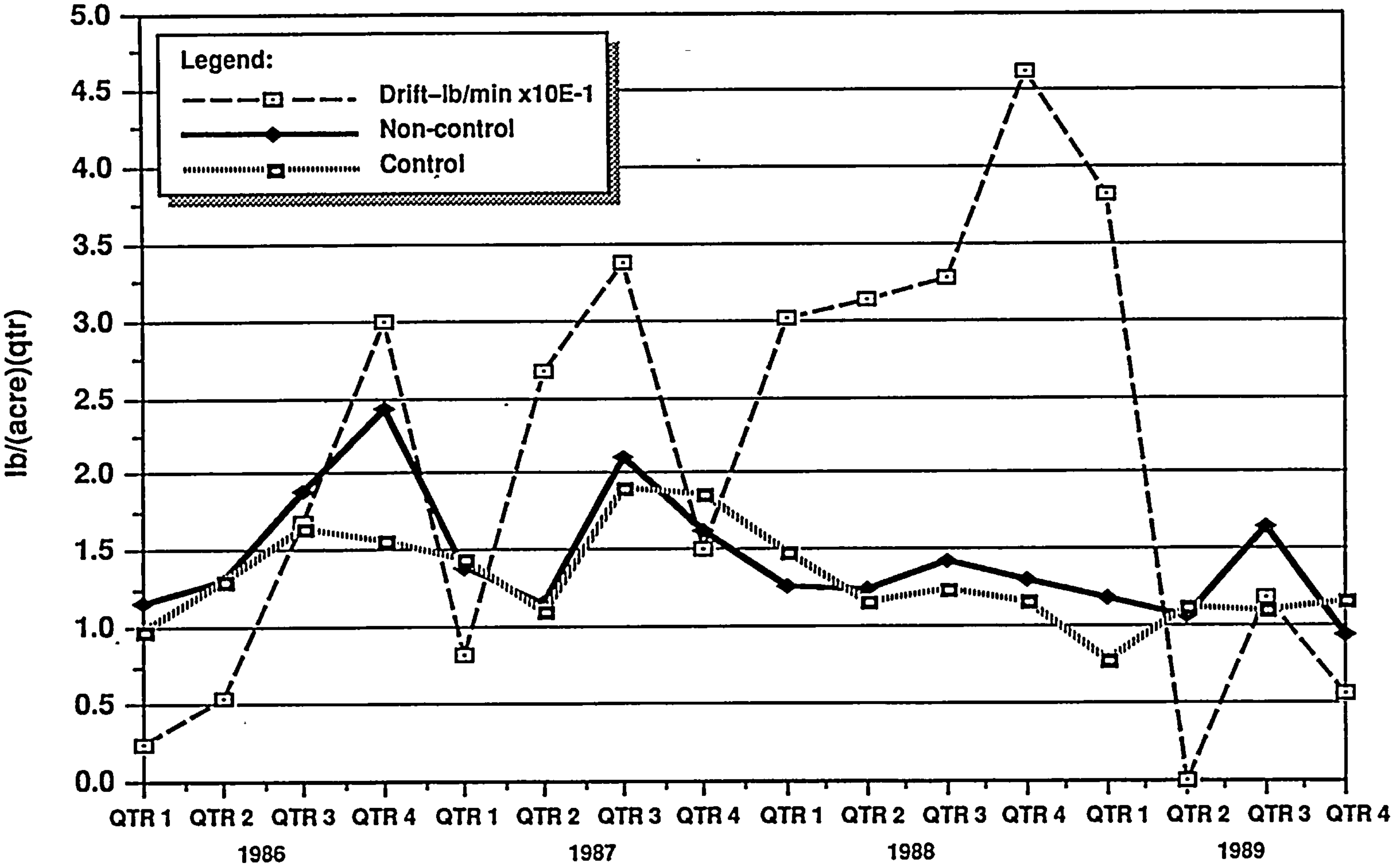

Figure 3-1. Mean concentrations of sodium for all non-control sites and control sites 2.5 to 4.9 miles from PVNGS and the corresponding cooling tower drift rate during PVNGS operation by quarter.

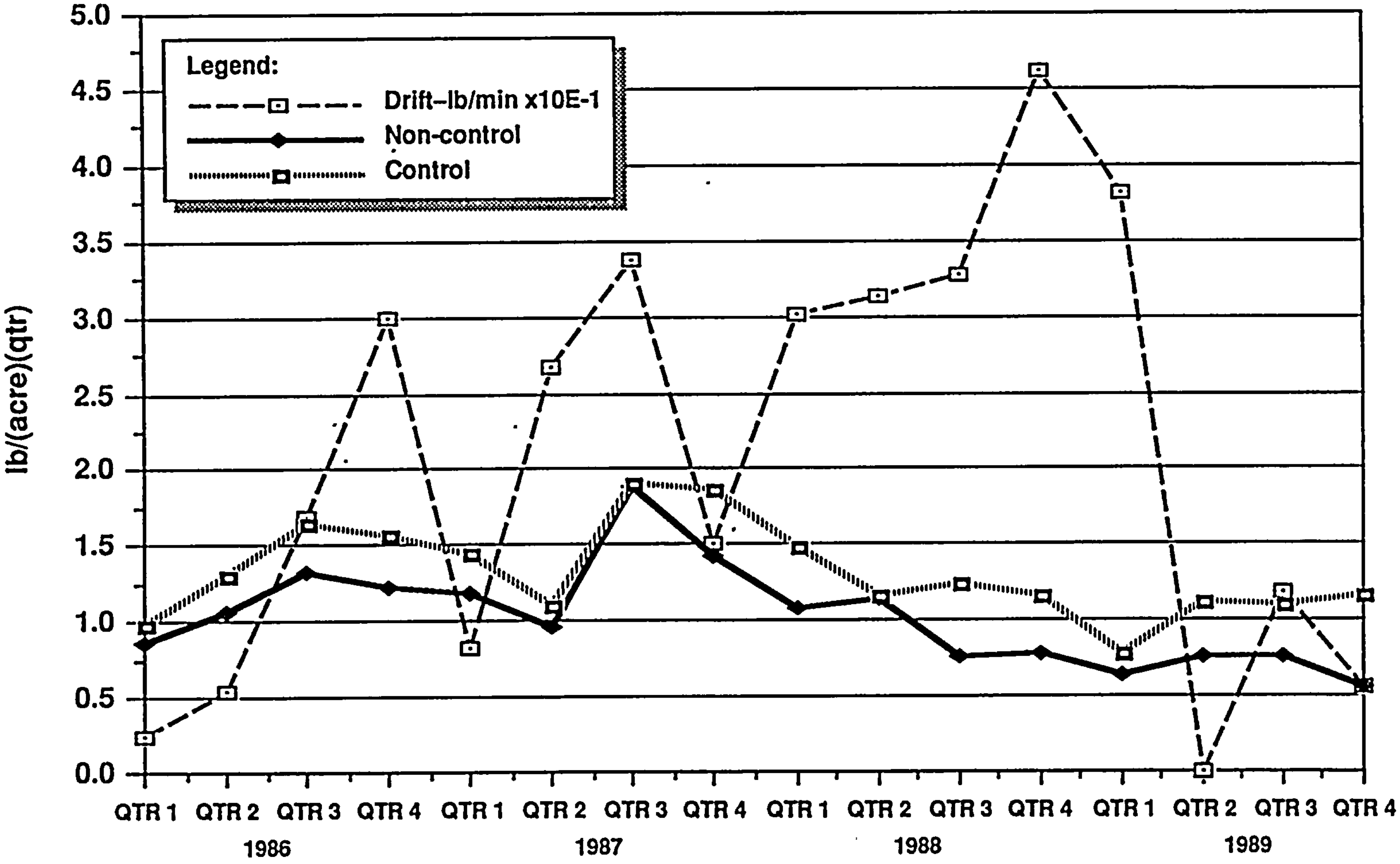

Figure 3-2. Mean concentrations of sodium for all non-control sites and control sites five miles or greater from PVNGS and the corresponding cooling tower drift rate during PVNGS operation by quarter.

drift rate reappears somewhat more weakly in the first and third quarters of 1989.

It is evident from Figure 3-2 that the increase or decrease of drift rate from the PVNGS cooling towers during the four-year operational period have had little or no impact on the deposition of sodium measured at those sites five miles or greater from PVNGS. The fluctuations in drift deposition at those sites are in response to area-wide factors as evidenced by the trends at the control sites, which are at sufficient distances as to not be affected by PVNGS cooling tower operation.

A similar trend is seen for potassium, calcium, magnesium, and nitrate but these have not been analyzed in detail because of their much smaller contribution to the total drift emissions from the towers.

In addition to the drift deposition measurements, airborne particulate salt concentrations have been determined at six offsite locations by analyzing monthly composites of weekly filters from low-volume air samplers used as part of the radiological monitoring program. As noted in the original monitoring plan,

> "the primary purpose of analyzing the filters for salt concentration is to determine if there is a correlation between salt deposition . . . . and the airborne concentration at a location. If a strong correlation exists based on the preoperational monitoring results, the salt concentrations from earlier filters may be usable for estimating baseline·salt deposition rates for the period prior to implementing the [salt] monitoring plan."

These filters have been analyzed for chemical drift constituents since 1984, and comparisons made between deposition and airborne concentrations at the six locations for four ions (sodium, calcium, nitrate and magnesium) present in detectable quantities in both samples. As indicated in the annual reports, no consistent or significant correlations between deposition and airborne concentrations have been identified. Table 3-3 presents the correlation coefficients, R, for the most prominent drift constituent, sodium, in drift and airborne samples measured at the 6 locations over the period 1984 - 1989.

Table 3-3. Correlation Values, R, Between Deposition and Airborne Concentrations of Sodium at Low-Volume Air Sampling Sites

Site	1984	1985	1986	1987	1988	1989
8	0.50	0.38	0.08	0.01	0.07	0.14
9	0.14	0.13	-0.42	0.18	-0.20	0.30
10	0.83	0.29	0.03	0.32	-0.16	0.06
20	0.53	-0.44	-0.24	0.72	-0.29	-0.29
21	0.59	-0.11	0.04	0.06	-0.02	0.50
27	0.45	0.06	-0.31	0.45	-0.42	-0.29

As this table indicates, the correlation value exceeded 0.50 on only four occasions, of which three occurred in 1984, before the cooling towers began to operate with a significant heat load. Since there is no pattern of correlation that has been observed in the six-year period, these measurements are not useful.

4.0 CONCLUSIONS

The analysis in Section 3.0 clearly illustrates that there has been virtually no impact on the environment from cooling tower drift beyond 2.5 miles from PVNGS during the first four years of operation. The only detectable influence at less than 5 miles offsite resulted during a period of operation with damaged drift eliminators. No trends are evident in the deposition at five miles or greater from PVNGS for the analytes which were not the result of background fluctuations.

Considering the large number of agricultural monitoring sites (7) that range from 2.5 to 4.9 miles from PVNGS, and the potential for impact if drift eliminators are damaged it is recommended that all of the monitoring sites in this range be maintained. Since no impact has been measured beyond 2.5 miles from PVNGS during two-unit operation, it is unlikely that a three-unit impact would be measured at twice that distance, or 5 miles. Therefore, all of the sites five miles or greater from PVNGS could be eliminated without affecting the ability of the program to detect and assess cooling tower drift. For background measurements, the two control sites southeast of PVNGS should be maintained as well as a native vegetation control site 6 miles northwest of PVNGS.

5.0 PROPOSED PROGRAM MODIFICATIONS

Based on the results of drift deposition monitoring around PVNGS during both the background period and during the first four years of commercial operation, the following program modifications are recommended:

- Eliminate all non-control soil and dustfall monitoring locations five miles or greater from PVNGS.

- Eliminate the two control sites (25, 40) approximately 19 miles northwest of the plant from all sampling.

- Eliminate all low-volume air sampling analyses for salt deposition. (Low-volume air sampling will be continued for the radiological monitoring program.)

- Eliminate all non-control agricultural vegetation sampling five miles or greater from PVNGS (affects only sites 7 and 45 which have been fallow since 1985)

- Reduce the native vegetation sampling frequency to annually due to cover loss from 7 years of semiannual sampling and drought. Eliminate saltbush sampling at Site 44 and maintain this site as a creosote-bush control site only.

Instituting all of these modifications would result in substantial savings while maintaining a program adequate to detect any environmental impact of PVNGS cooling tower operation. The five-mile radius around PVNGS would contain 28 monitoring sites of which 9 are agricultural vegetation sampling sites, 5 are native vegetation sampling sites, and the remainder are sites for dustfall and soil sampling only. Eleven of the 28 sites are located on PVNGS. Three control sites will be continued: Site 44 (6 miles NW of PVNGS) and Site 42 (16.6 miles SSE of PVNGS) for native vegetation and sampling Site 43 (15 miles SSE of PVNGS) for agricultural vegetation sampling.

6.0 REFERENCES

PVNGS (Palo Verde Nuclear Generating Station), 1974. Environmental Report, Construction Permit Stage, Docket Nos. STN-50-528/529/530, Phoenix, Ariz.

PVNGS (Palo Verde Nuclear Generating Station), 1979. Environmental Report, Operating License Stage, Docket Nos. STN-50-528/529/530, Phoenix, Ariz.

NUS Corporation, 1985. Annual Report for the Salt Deposition Monitoring Program, May 1983 - June 1984, NUS 4683, Gaithersburg, Md.

NUS Corporation, 1986a. Annual Report for the PVNGS Salt Deposition Monitoring Program, January - December 1985, NUS 4831, Gaithersburg, Md.

NUS Corporation, 1986b. Annual Report for the PVNGS Salt Deposition Monitoring Program, January - December 1984, NUS 4921, Gaithersburg, Md.

NUS Corporation, 1987a. Annual Report for the PVNGS Salt Deposition Monitoring Program, January - December 1986, NUS 4999, Gaithersburg, Md.

NUS Corporation, 1988. Annual Report for PVNGS Salt Deposition Monitoring Program, January - December 1987, NUS 5096, Gaithersburg, Md.

NUS Corporation, 1989. Annual Report for PVNGS Salt Deposition Monitoring Program, January - December 1988, NUS 5181, Gaithersburg, Md.

NUS Corporation, 1990. Annual Report for PVNGS Salt Deposition Monitoring Program, January - December 1989, NUS 5241, Gaithersburg, MD.

NUS Corporation, 1987b. Salt Deposition and Impact Monitoring Plan, Revision 5, Gaithersburg, MD.