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JA Exhibit 2
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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of: Arizona Public Service Company, et al. (Palo Verde Nuclear Generating Station, Units 2 and 3)	Docket Nos. STN 50-529 STN 50-530

TESTIMONY OF DR. MORTON I. GOLDMAN

IDENTIFICATION AND QUALIFICATIONS

1. Q. Please state your name and address.

   A. My name is Morton I. Goldman and my address is 910 Clopper Road, Gaithersburg, Maryland 20878.

2. Q. By whom are you employed and in what capacity?

   A. I am employed by NUS Corporation in Gaithersburg, Maryland in the position of Senior Vice President and Technical Director.

3. Q. To what extent have you been involved in the Palo Verde project?

   A. NUS was engaged in mid-1972 to conduct a site selection study for the Arizona Nuclear Power Project

(ANPP) and I was the officer assigned by NUS to manage this work. I was intimately involved in all aspects of this study, including the formulation of site evaluation criteria, the selection of regions and sub-regions in Arizona to be evaluated, the data collection, including work required to obtain data, and the evaluation of more than 6 potential sites. The result of these efforts was the selection of the site where the Palo Verde Nuclear Generating Station (PVNGS) is now located.

Subsequently, NUS was given the responsibility for the development and preparation of the PVNGS Environmental Report - Construction Permit Stage (ER-CP) and the PVNGS Environmental Report - Operating License Stage (ER-OL), and I was the officer of NUS responsible for directing this work. In this connection I was one of applicant's witnesses on environmental matters, including questions relating to drift depositions, in the PVNGS construction permit hearings conducted in February, 1976.

4. Q. To what extent have you been involved in the proceedings now pending on issues raised by the intervenors on the effects of foliar depositions from drift from the PVNGS cooling towers?

A. I have served as a consultant on these matters. In that connection I have advised on the tasks which

should be undertaken to respond to the concerns raised by the intervenors, the scope of such tasks and the selection of other consultants, including Environmental Systems Corporation (ESC), Dr. William Dunn and the agronomists designated as the Review Board. Additionally, I participated in the review, and gave advice on the content and scope, of the proposal of the University of Arizona (UofA) to conduct greenhouse and field agricultural studies and attended most of the meetings of the Review Board. Also, NUS provided an expert in QA/QC matters to assist, under my direction, the UofA in the preparation of procedures to assure the proper documentation of the work undertaken in the UofA agricultural study.

I was also responsible for all of the work done in validating the NUS FOG computer model and in developing the current predictions of drift deposition from the PVNGS cooling towers which is the main subject of this testimony.

5. Q. Please describe your educational and professional background and experience.

A. I have prepared Exhibit G-1 attached to this testimony which summarizes my educational and professional background and experience and submit this exhibit in response to the question.

PURPOSE AND SUMMARY OF THE TESTIMONY

6. Q. Would you please describe the purpose and summarize the scope of your testimony.

A. The objectives of this testimony are (a) to present to the Board currently predicted drift deposition rates in the vicinity of PVNGS based on the most recent information about the nature and rate of emission of drift from the PVNGS cooling towers and other miscellaneous sources and (b) to describe the salt drift monitoring program. This information should be of assistance to the Board in judging the significance of the drift as a potential source of injury to crops grown in the vicinity of the plant.

The testimony reviews the drift projections made over the history of the project in the ER-CP and ER-OL; summarizes the independent review and validation of the NUS FOG computer model used to make the drift deposition estimates presented in those documents; describes the significance of the drift droplet size spectrum used in the modelling efforts and presents the spectrum resulting from the tests made in 1983 on one of the PVNGS towers as used in the current projections of drift deposition; summarizes the drift rate determinations made on the PVNGS tower and compares them to the vendor guarantee; and provides the most current

projections of drift deposition from PVNGS using the FOG model and one developed for the Electric Power Research Institute (EPRI).

EARLIER DEPOSITION ESTIMATES

7. Q. Please describe the basis and methodology used in developing the drift deposition rates reported in the ER-CP.

A. The ER-CP presented estimates of cooling tower drift emissions and deposition patterns based on assumed cooling tower design characteristics. Since at the time the ER-CP was filed in 1974, the type of cooling towers to be used at PVNGS had not been established, the use of such assumptions was unavoidable. Of the several alternative types of cooling towers discussed in the ER-CP, the alternative selected and assumed for the purpose of drift analyses consisted of three rectangular mechanical draft towers per unit, each containing 14 cells, with a drift loss rate of about 250 gallons per minute. With a circulating water flow rate of 620,000 gpm, this represented a drift loss rate of 0.04% [1]. The concentration of dissolved solids in the circulating water system (and the drift) was estimated to be 14,600 ppm [2]. These assumed design characteristics were selected because at the

time we considered that they could be met or improved upon with any reasonable alternative ultimately selected.

Starting then with such assumed design characteristics the drift deposition estimates presented in the ER-CP for both onsite and offsite areas [3] were developed using Gila Bend weather data and a droplet size spectrum provided by Research-Cottrell [4]. These estimates suggested that perhaps 130 acres of cultivated land might receive wet drift deposition at or above 50 pounds per acre-year and 3,850 acres would be subject to a total wet and dry drift particle deposition in excess of that value [5].

8. Q. Were these estimates subsequently revised?

A. Yes. During the ASLB hearing on the construction permit, evidence was introduced regarding the characteristics of and drift predictions for the round mechanical draft cooling tower design parameters selected for the plant [6]. The contract to purchase such towers, including their specifications, was signed only the week before the hearing [7]. These towers were one of the alternatives evaluated in the ER-CP [8], although with somewhat different operating parameters. The drift evaluations presented in the hearing were based on a drift rate

per unit of about 26 gpm or 0.0044% of the circulating water flow as guaranteed by the cooling tower vendor and a circulating water dissolved solids concentration of 16,000 ppm. The drift deposition patterns resulting from the new designs indicated no depositions offsite in excess of about 12 pounds per acre-year. Again, offsite meteorological data and the Research-Cottrell droplet size spectrum was used in the modelling effort.

The ER-OL largely repeated the same analysis as that performed for the CP hearing; a major difference involved the use of 5 years of onsite (PVNGS) meteorological data supplemented by Phoenix upper air data from the National Weather Service. In addition, a relatively slight change was made in the circulating water dissolved solids concentration from 16,000 to 15,000 ppm, despite a somewhat lower estimate of 12,000 ppm in the ER-OL [9]. The drift rate remained at about 26 gpm per unit, or 0.0044% of the circulating water flow and the droplet size spectrum was unchanged from that used earlier. The resulting deposition patterns were presented in the ER-OL [10], and again indicated maximum total deposition at the northeast corner of the site to be about 12 pounds per acre-year.

COMPUTER MODEL VALIDATION

9. Q. Would you please describe the work which was undertaken by NUS to validate the NUS FOG computer model?

A. As a result of the allegations by West Valley of inadequacies in the computer code (FOG) used by NUS to predict the drift deposition at PVNGS, NUS retained an independent consultant to evaluate that code. The consultant selected was Dr. William Dunn, Champaign, Illinois, who was co-author of a report of an earlier study of mathematical models for evaluating cooling tower salt drift deposition performed for the NRC [11], and was a principal contributor to the development of the most current computer models for prediction of cooling tower plume and drift behavior on behalf of EPRI [12]. The report on his evaluation of the FOG model [13] was provided to the parties on August 24, 1983 shortly after its receipt by the Applicant.

In summary, Dr. Dunn compared (a) the episodal predictions of FOG routines with the experimental field data collected during the Chalk Point Cooling Tower Project, as well as with the predictions of 11 other drift deposition models which had been evaluated in the earlier NRC-sponsored study; (b) the episodal predictions of FOG with field data

from the Pittsburg (California) study, as well as with the predictions of the EPRI model for those conditions; and (c) the seasonal/annual predictions of the FOG model for PVNGS with those of the EPRI model. With respect to (a) and (b), Dr. Dunn wrote: "The results of the Chalk Point Study revealed that for these limited data, the FOG model fell into a category of six out of twelve models which could be classified as 'better performing'. The results of the Pittsburg comparison were inconclusive due to limitations inherent in the measured data, although both the FOG and EPRI models gave reasonable predictions, in a subjective sense."

The evaluation of the FOG model and its comparison with the EPRI model for the PVNGS cooling towers included determining the effects on drift deposition patterns of using three different specifications of the drift droplet size spectrum which were provided to Dr. Dunn. The first of these was the spectrum as provided by Research-Cottrell (referred to as FOG73), divided into five size classes, or bins, and used in all of the ER evaluations for PVNGS beginning in 1973. The second and third specifications were both representative of one droplet size spectrum (referred to as FOG81) but subdivided that spectrum in one instance into 10

bins and in the other, into 38 bins. The latter spectrum was the default spectrum (i.e., a droplet size distribution to be used in the absence of tower-specific data) adopted by NUS in 1981 based on an evaluation of the technical literature on cooling tower drift studies, although it was not used for the evaluations reported in the ER-OL which was filed in 1979. These droplet spectra are presented in Exhibit G-2 attached to this testimony.

With respect to the comparison of the predictions of the FOG and EPRI models for PVNGS, Dr. Dunn wrote: "The comparison of the seasonal/annual predictions using the Palo Verde site data indicated that the FOG and EPRI models gave similar predictions for two drop spectra with appreciable fractions of large drops. For a third spectra devoid of larger drops, the predictions were qualitatively different although of similar magnitude in the offsite areas. Overall, the comparisons were remarkably similar in light of the major difference between the methodologies of the two models. The sensitivity studies revealed that model performance is degraded as the detail of the input data is reduced and that predictions are affected by the choice of user-selected model parameters."

PVNGS DRIFT DROPLET SIZE SPECTRUM

10. Q. What other conclusions can be drawn from the Dunn study?

A. Findings of major significance in Dr. Dunn's evaluation, apart from the validation of drift deposition segment of the FOG model, were the importance to the resulting patterns of drift deposition of both (a) the drift droplet size spectrum and (b) the number of bins into which that spectrum was divided. The significance of those effects are clearly represented in Figures 13 through 18 of the Dunn Report for both the EPRI and the FOG models which figures are attached to this testimony as Exhibits G-3a through G-3f. These figures show that there is a significant difference between the patterns predicted (by either model) based on the 5-bin FOG73 droplet spectrum and those predicted with either the 10-bin or 38-bin FOG81 spectrum. Further, although the patterns are similar (for either model) between the 10-bin and 38-bin spectra, the latter does provide a somewhat more uniform distribution. It seems clear at this point that the 5-bin spectrum did not produce deposition patterns which would represent those to be expected from the PVNGS towers.

CURRENT PVNGS DRIFT DEPOSITION PREDICTIONS

11. Q. Since the ER-OL was prepared, have any more current evaluations been made of predicted drift depositions, and if so, would you please describe them and provide the parameters.

A. Two independent evaluations of drift deposition patterns were made within the past 2 years using the most directly applicable information currently available. One was performed by Dr. Dunn using the EPRI model, and the other by NUS using the FOG model. In both instances the input parameters were identical: 5 years of PVNGS site meteorological data (a prior examination had indicated that using nine years of available meteorological data added nothing to the precision of the results while nearly doubling the cost of the computer runs); the PVNGS tower performance characteristics, including the measured drift rate and a 16-bin droplet spectrum discussed below; and, a circulating water concentration of 12,000 ppm as presented in the ER-OL [9].

12. Q. You have explained why 5 years of meteorological data was selected. Would you also explain the bases for the other two parameters that were used in these current predictions?

A. The earlier predictions reported in the construction permit hearings and subsequently in the ER-OL were both developed using the vendor's guaranteed drift rate of 0.0044% of the circulating water flow and the 5-bin droplet size spectrum.

Because the intervenors originally challenged the validity of basing predictions on the unverified vendor's guarantee, APS engaged Environmental Systems Corporation (ESC) to make measurements of the actual drift emissions from the operation of one of the PVNGS cooling towers. This work was completed by ESC in 1983 and the report of the measurements has been given to the Board and the other parties. Mr. Wilber's testimony fully describes the manner in which such measurements were made and the results. However, for purposes of my testimony, ESC measurements show that the actual drift rate at PVNGS is substantially lower than the guaranteed rate, measured by either of the two techniques used. The first technique employed direct liquid measurements using Sensitive Paper devices; the second involved mineral flux measurements using an isokinetic sampler from which drift rates were inferred. The direct measurement technique indicated a drift rate of 0.0002%, whereas the inferred technique indicated a drift rate of 0.0012%. In

view of the judgment by Mr. Wilber, [15] that the inferred drift rate based on the mineral flux measurement is conservative due to the occurrence in the ambient air during the test periods of the magnesium used as a tracer for the mineral flux, the drift rate based on direct liquid measurements, 0.0002%, was adopted as the most reasonable value for use in subsequent drift deposition predictions.

With respect to the use of the 16-bin spectrum, the work performed by Dunn demonstrated the importance of both the spectrum of droplet sizes selected and the degree of subdivision of that spectrum used as input to the predictive model. Consequently, in the recent deposition predictions, the droplet size spectrum determined in the studies of the PVNGS tower by ESC [14] was divided into 16 bins. This value represents a compromise between the slightly degraded precision of estimates obtained with 10 bins as compared to 38 bins, and the considerably longer computer running time (and cost) associated with the greater number of bins. In my opinion the use of 38 bins would not have changed the predictions significantly. The PVNGS spectrum and its 16-bin representation as used in subsequent drift deposition modelling are also shown in Exhibit G-2 attached to this testimony.

13. Q. What are the current predictions of drift depositions from the operation of the Palo Verde cooling towers?

A. The results of these analyses are presented graphically in the attached Exhibits G-4 and G-5 for the FOG and EPRI models, respectively. In each of these figures the contours represent annual average deposition rates in units of pounds per acre-year. It can be noted that the patterns of deposition predicted by each of these models are quite similar, and the magnitude of the deposition predictions agree within about a factor of two, with the FOG model being the more conservative, i.e., higher, of the two.

The maximum deposition is predicted (by both models) to occur at the nearest site boundary to the west of Unit 2, and to approximate 60 pounds per acre-year. The maximum drift deposition predicted at the nearest point of the cultivated land closest to the cooling towers, about 1.25 miles northwest of the Unit 2 towers, is predicted to range between 1.5 (EPRI) and 3 (FOG) pounds per acre per year.

OTHER POTENTIAL SOURCES OF DRIFT

14. Q. What is your evaluation of other potential sources of drift originally raised by the intervenors, specifically the spray ponds and evaporation ponds?

A. Drift from the spray ponds can occur only when they operate as heat sinks during periods when units are shut down and the cooling towers are not operating. The liquid drift rate from the spray ponds is about 27 gpm, and the circulating water dissolved solids concentration is about 357 ppm [16]. Since the guaranteed cooling tower liquid drift rate is about the same value (26 gpm) but the circulating water dissolved solids content is about 12,000 ppm, the emission rate of mineral salts in drift droplets during the infrequent periods of spray pond operation is only about 3% of that for the towers. Further, the spray pond droplet size distribution is much more weighted toward large diameter droplets (98% of the spray volume is contained in droplets with diameters greater than 600 microns) than is the cooling tower drift, and the maximum height of the pond sprays is only about 12 feet above the nozzles [17]; thus, there is little likelihood of any drift being carried offsite.

In any event, basing offsite drift deposition predictions on the operation of the units at full

power 100% of the time with cooling tower drift 30 times richer in salt content produces a more conservative result than the alternative assumption of 11 months of cooling tower operation and 1 month of spray pond operation.

The evaporation ponds will not be a source of windborne dust since the sum of the liquid discharged to the (approximately) 250 acre first-phase evaporation pond [18] from the plant systems at a plant capacity of 60% or more (2870 acre-feet per year) [19] and the natural precipitation (125 acre-feet per 6 inches per year) [20] will be greater than the natural evaporation rate of 1600 acre-feet per year [21]. As this pond fills, additional ponds will be placed in service, but except for the very beginning of pond service, there will not be a 'dry' bottom capable of being eroded by wind forces. Thus, the evaporation ponds are not capable of adding in any significant way to the drift released from the operation of the cooling towers and, hence, to the offsite deposition of such materials.

CONCLUSIONS RESPECTING PREDICTED DRIFT DEPOSITIONS

15. Q. Would you please summarize the conclusions you have reached?

A. In summary, the FOG computer model used by NUS to predict the deposition pattern of drift emitted by the cooling towers at PVNGS has been validated by an independent evaluation of the code's ability to match experimental field data, and by comparison with the prediction of a current state-of-the-art (EPRI) computer code. Site specific data on meteorology, tower drift rate and droplet size spectra have been used as input to the FOG code and the EPRI code, and the predictions of these two codes agree well as to the shape and the magnitude of drift deposition patterns. There are no other sources of 'salt' drift on the PVNGS site which are expected to contribute to offsite drift deposition.

For perspective, it can be noted that monitoring of deposition in the vicinity of the PVNGS over the period May 1983 - June 1984 has indicated average cumulative deposition values for sodium, potassium, calcium and magnesium at monitoring stations on cultivated lands of about 9, 10, 25 and 7 pounds per acre, respectively. [22] These can be compared to predicted deposition values from 3 unit tower operation at the nearest farm of 0.8, 0.05, 0.1 and 0.04 pounds per acre-year, for the same ions, respectively.

SALT DRIFT MONITORING PROGRAM

16. Q. Would you please describe the plan which is currently in effect for monitoring drift from the Palo Verde cooling towers?

16. A. The program currently in effect for monitoring the deposition of drift from the PVNGS cooling towers is substantially the same as that described in the "Salt Deposition and Impact Monitoring Plan" dated February 1983 which was forwarded to the Board and the parties in March 1983. The program generally consists of seven elements:

a. Measurement of monthly deposition of ions and total suspended solids from wet and dry particulates at 44 sites using ASTM dustfall jars;

b. Measurement of soil chemical parameters potentially affected by drift deposition at 44 sites twice per year (July-August and February-March) and, at 13 sites of the 44 which are located on cultivated lands, a third sampling after cotton defoliation;

c. Semi-annual sampling of indigenous vegetation and analyses of species richness and relative cover as well as measurements of tissue loading of drift constituents at six locations;

d. sampling of crops grown at the 13 agricultural monitoring locations twice during the growing season for measurements of tissue loading and for cotton yield at the end of the growing season;

e. Infrared aerial photography of crops and native vegetation within a five mile radius of PVNGS during the peak vegetative growth season to detect and document vegetative stresses of any origin, then confirmed by field inspection;

f. Airborne salt measurement by chemical analyses of monthly composites of filters from six low-volume air particulate samplers used as part of the radiological monitoring program; and

g. Quarterly sampling and analyses of cooling tower basin water to confirm the chemical composition of the drift emissions.

Samples collected in the field are forwarded to selected laboratories for analyses of constituents expected to be prominent in the drift from the PVNGS towers (see ER-OL Table 3.6-1) which include sodium, calcium, magnesium, potassium, chloride, sulfate and nitrate.

In addition to these measurements for the salt drift monitoring program, meteorological data from the PVNGS meteorological tower are analyzed specifically for this program to compare the deposition patterns expected to result from plant operations with those determined from field measurements.

Dustfall and soils are sampled at all locations which are shown in the attached Exhibit G-6; the locations of the native vegetation and crop sampling sites are shown in the attached Exhibit G-7. Both Exhibits are taken from current version (Revision 4) of the "Salt Deposition and Impact Monitoring Plan," dated May, 1985.

17. Q. How is the monitoring data reported?

A. Reports of data covering a calendar quarter are provided as soon as analytical results have been received from the laboratories, reviewed for consistency and converted to values related to the context of the samples represented (e.g., ion concentrations in dustfall jar water samples must be converted to deposition rates per unit area). Annual reports are prepared which include evaluations of the data relative to plant operations and predictions based on meteorological parameters during

the reporting period, as well as analyses of any changes from the baseline data collected during the preoperational period, or other prior operational periods.

18. Q. Is the program you have described any different from that which was distributed to the Board and the parties on March 28, 1983, and, if so, please explain the differences?

A. As stated earlier, the program is essentially the same as that described in the program plan referred to, although a number of relatively minor modifications have been made over the past two years based on experiences in the field:

a. Site 5 was subject to a grass-fire that destroyed the native vegetation community being monitored and was replaced by another of the same type of vegetative community as control site at location 44;

b. Soil sampling protocol was modified to separate the 12 inch soil cores into upper and lower segments (equal segments in the case of agricultural soils, and based on the depth to a textural change for uncultivated soils), to provide a greater sensitivity to surficial deposition and permit detection of any vertical migration of salts;

c. At each location, sampled soils were initially characterized by textural analyses, and a third sampling period was added at cultivated sites following the defoliation of cotton fields;

d. A few locations were shifted due to changes in access or land uses which made maintenance of those sites either impossible or the results of dubious value to the program. For example, at one agricultural site, the monitoring site access was precluded by the addition of fencing to control cattle; at another, collectors were washed away by a flash flood; at others the sample sites were moved to escape contributions of traffic- and field-generated dustfall so great as to overwhelm any other source;

e. Aerial infrared photography was performed twice in 1983 several months apart and was returned to once per annum for 1984 and subsequent years because of the lack of distinction between the results in 1983.

f. Foliar deposition monitoring (i.e., leaf rinsate and leaf area measurements) has been discontinued effective with the 1985 crop sampling season. These samples, taken twice

during the 200+ day growing season in both 1983 and 1984, are not representative, being affected both by the weather and by nearby agricultural machinery operations in the period immediately prior to sampling.

All of these changes have been incorporated in Revision 4 of the Salt Deposition and Impact Monitoring Plan, dated May, 1985.

19. Q. When was this program placed into effect?

A. Sampling was begun in May of 1983.

20. Q. How is this program dealt with in the operating license for PVNGS Unit 1?

A. The Facility Operating License (No. NPF-34) for PVNGS, Unit 1 includes an Environmental Protection Plan (Non-Radiological) as Appendix B which, in Section 4.2.2 Terrestrial Ecology Monitoring, requires that the monitoring program commence by the onset of commercial operation and that it continue for a minimum of three full years after the onset of operation of all three PVNGS Units, or until the licensees can demonstrate that program objectives have been fulfilled.

The Environmental Protection Plan also requires that procedures affecting program objectives require prior NRC approval. Other changes require notification of the NRC within 30 days after their

implementation. Annual monitoring reports are required to be submitted to the NRC for review.

21. Q. In your opinion is this program adequate for detecting cooling tower drift in the environment and effects, if any, on agricultural crops?

A. In my opinion this program will detect cooling tower drift in the environment at levels below those currently measured from sources other than PVNGS operations, as well as effects, if any, attributable to that drift on agricultural crops.

REFERENCES

1. Environmental Report CP Stage, Table 3.4-1
2. Ibid, Table 3.6-1
3. Ibid, Figures 5.1-14 to 5.1-19
4. Lefevre, M.R., Hamon Cooling Tower Division, Research Cottrell to NUS Corp, July 1971
5. ER-CP, Table 5.4-1
6. CP Hearing Transcript pp. 788-789, 1047-1049
7. " " " 428
8. ER-CP, Section 10.1
9. ER-OL, Table 3.6-1
10. Ibid, Figures 5.1-2 through 5.1-4 for dry particle, wet droplet and total drift deposition, respectively
11. A. J. Policastro, W. E. Dunn, M.L. Breig and J.P. Ziebarth, "Evaluation of Mathematical Models for Characterizing Plume Behavior from Cooling Towers. Volume 2. Salt Drift from Natural Draft Cooling Towers", NUREG/CR-1581. Vol. 2, U.S. NRC, 1980
12. W. E. Dunn, et al, "Studies on Mathematical Models for Characterizing Plume and Drift Behavior from Cooling Towers", Report CS-1683, Electric Power Research Institute 1981.

13. W. E. Dunn, "Evaluation of NUS/FOG Computer Model for Predicting Cooling Tower Drift Deposition Rates", prepared for NUS Corporation, July 15, 1983

14. Environmental Systems Corporation, "Development of a Drift Source Term - Palo Verde Nuclear Power Plant Circular Mechanical Draft Cooling Tower", Report No. TIN 83-1082, July 1983

15. Wilber, K. R., Vice President, ESC, letter of July 11, 1983 to Dr. Mort Goldman, NUS Corporation

16. ER-OL, Table 3.4-4 and Figure 3.3-1

17. Shah, Arvind M., "Droplet Size Spectrum Tests Report For: SPRACO Type 1751, The Spray Pond Cooling Nozzle", SPRACO Inc., New Hampshire, undated

18. ER-OL, Section 3.6.3.1

19. Ibid, Figure 3.3-1

20. Ibid, Table 2.3-19

21. C. R. Smith, R. M. White, W. C. Jacobs, "Weather Atlas of the United States," U.S. Dept. of Commerce, reprinted 1975 by Gale Research Company, Book Tower, Detroit, Michigan

22. "Annual Report for the PVNGS Salt Deposition Monitoring Program, May 1983- June 1984", Table 52, NUS-4683, NUS Corporation, March, 1985

Exhibit G-1

~~Exhibit 9~~

MORTON I. GOLDMAN

SENIOR VICE PRESIDENT
TECHNICAL DIRECTOR

EDUCATION

Massachusetts Institute of Technology, Sc.D., 1960
M.S., Nuclear Engineering, 1958
M.S., Sanitary Engineering, 1950
New York University, B.S., Civil Engineering, 1948

REGISTRATION

Professional Engineer: South Carolina, 1982; California, 1977; Arizona, 1974; Maryland, 1972; District of Columbia, 1965; New York, 1955

EXPERIENCE

Since 1961 with NUS Corporation in a series of positions from Technical Associate to Senior Vice President, Environmental Systems Group, involved with performing and managing work in safety and environmental areas, including site selection and evaluation, safety analyses for commercial, military and aerospace nuclear applications, waste management systems evaluations, environmental assessments and impact analyses for nuclear and fossil-fueled power plants and industrial facilities. Currently Technical Director of NUS, responsible for auditing and guiding the Corporation's technical capabilities, serving as senior corporate spokesman on environmental and nuclear safety issues, and providing senior level consulting and project direction for selected clients.

Earlier assignments, apart from management of a large number of site selection/environmental report/licensing support activities, included, in 1968, serving as U.S. representative to, and chairman of an IAEA expert panel on Radioactive Waste Management at Nuclear Power Plants, resulting in IAEA Safety Series No. 28 of that title; from 1972 to 1975, serving as consultant to and witness for the Consolidated Utility Group in the AEC/NRC rulemaking hearing on "as low as practicable" radioactive waste discharge standards; from 1975 to 1977 as consultant to and witness for the GESMO Utility Group party to those proceedings; from 1979 through 1982, expert witness for Duke Power Co. on the Table S-3 radon issue in the Perkins proceeding and subsequently for a consolidated utility group on its appeal. In addition, has appeared as an expert witness on environmental issues in more than two dozen administrative proceedings for nuclear and non-nuclear power plants, including cooling tower impact issues for the Trojan, Davis Besse, Perry and Palo Verde Generating Stations.

Current assignments include oversight of cooling tower impact predictions, crop studies and drift deposition monitoring programs for the PVNGS; cooling tower impact predictions for the Vogtle Electric Generating Plant; and

direction of the NUS Savannah River Center programs in support of the DOE-Savannah River Operations Office, including determining the feasibility and impacts of alternative cooling systems for production reactors and steam plants, review and evaluation of present and proposed hazardous and radioactive waste management systems and techniques, and assistance in planning and conduct of emergency preparedness exercises.

Other activities include chairman, Atomic Industrial Forum Ad Hoc Committee on the Clean Air Act and member of Steering Group, AIF Committee on Environment; member Standards Committee ANS-2 "Site Evaluation"; and member and former chairman, Nuclear Effects Committee, Environmental Engineering Division, ASCE.

Before joining NUS Corporation, served for 11 years with U.S. Public Health Service, Division of Radiological Health, in a variety of assignments, including serving as training instructor; conducting research on disposal of radioactive wastes at ORNL and at MIT; participating in working group responsible for radioactivity standards in 1960 USPHS Drinking Water Standards; and providing technical consultation and assistance to state and federal agencies on health and safety problems of nuclear facilities.

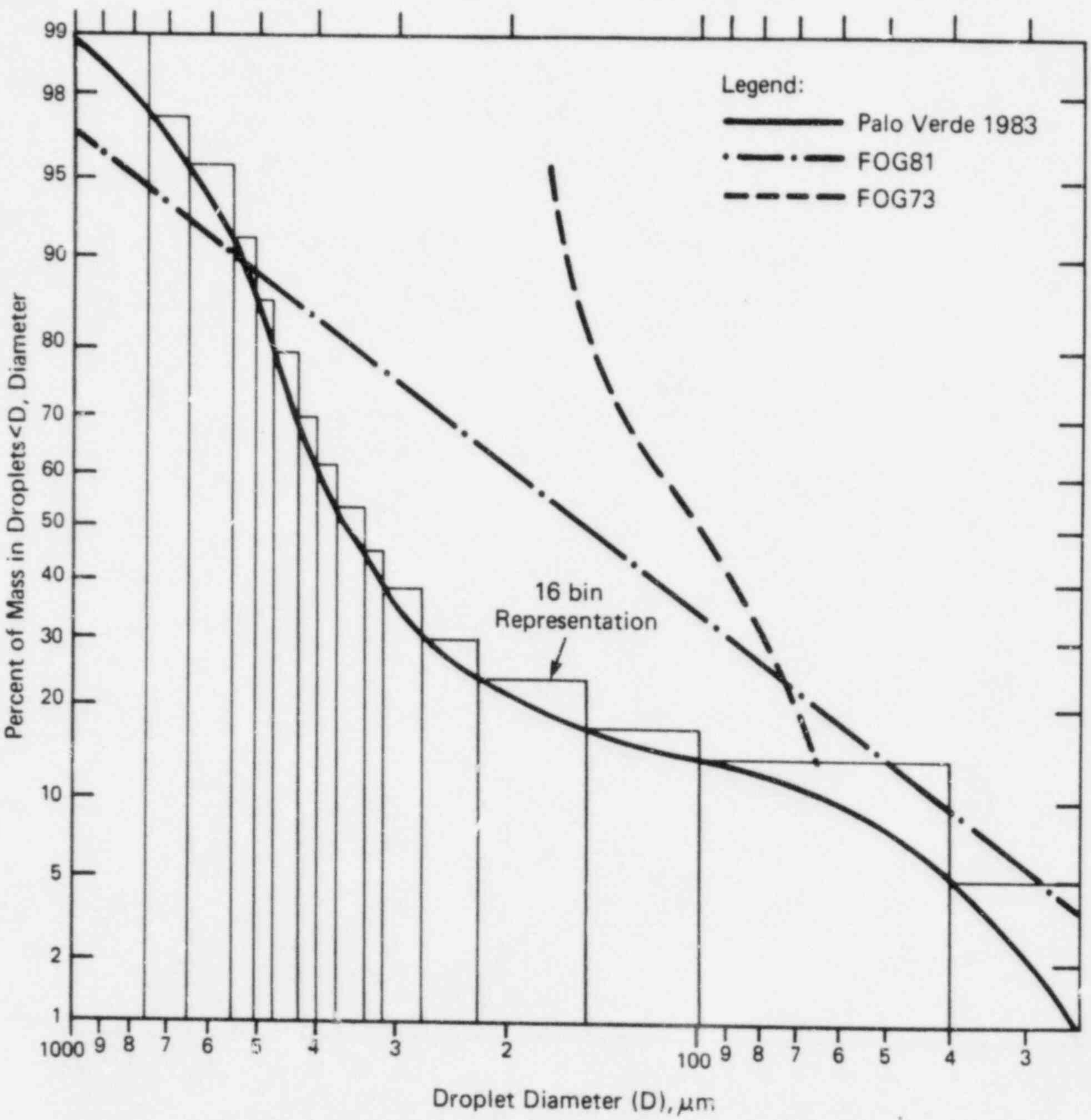
MEMBERSHIPS

American Society of Civil Engineers
American Nuclear Society
American Academy of Environmental Engineering (Diplomate)

2/85

Exhibit G-2

MECHANICAL DRAFT TOWER
DRIFT DROPLET SIZE SPECTRA



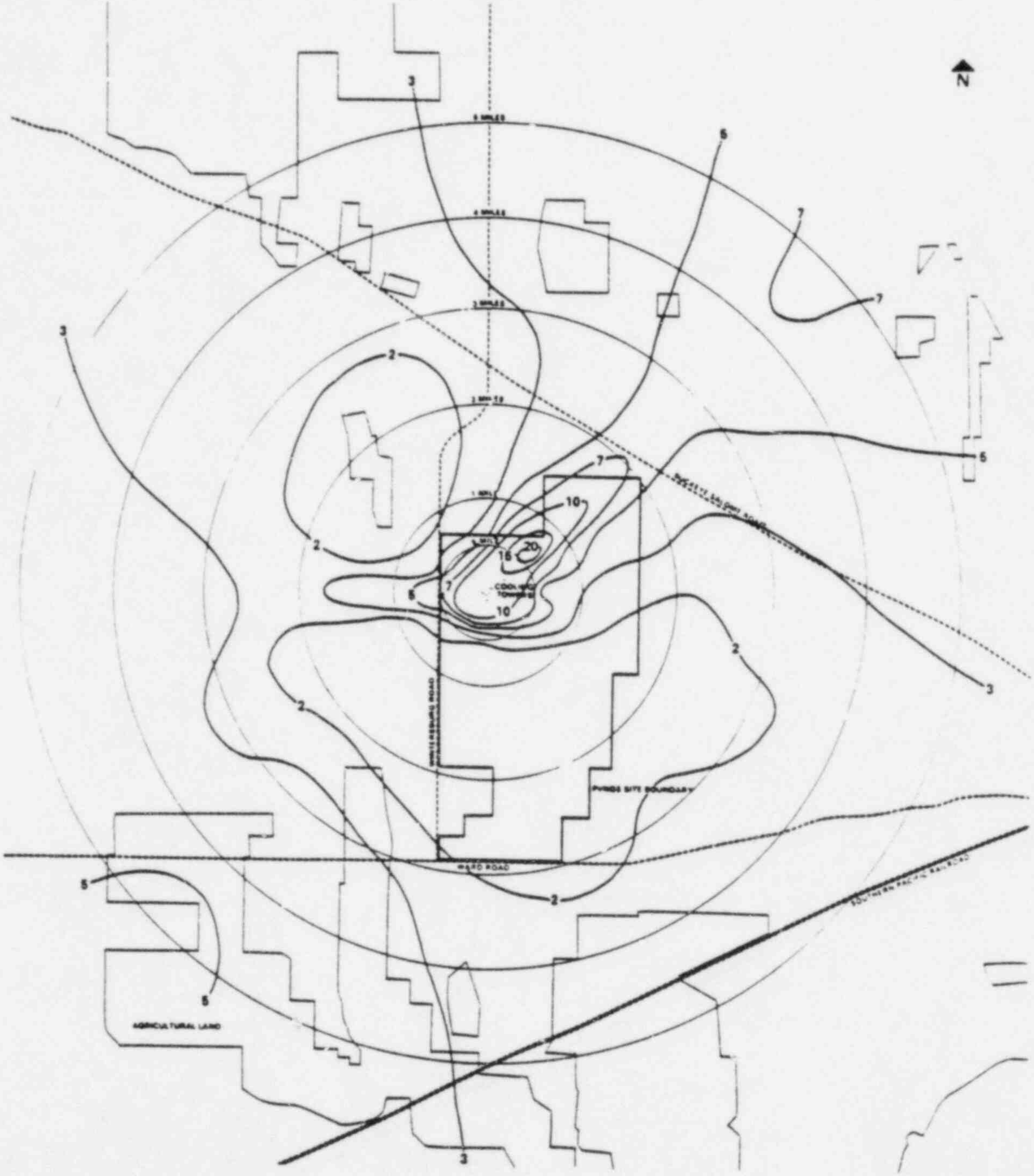


Figure 13. Annual Salt Deposition Rate Predictions of the NUS/FOG Computer Model for the 5-bin Drop Spectrum. (Contour values are pounds per acre per year.)

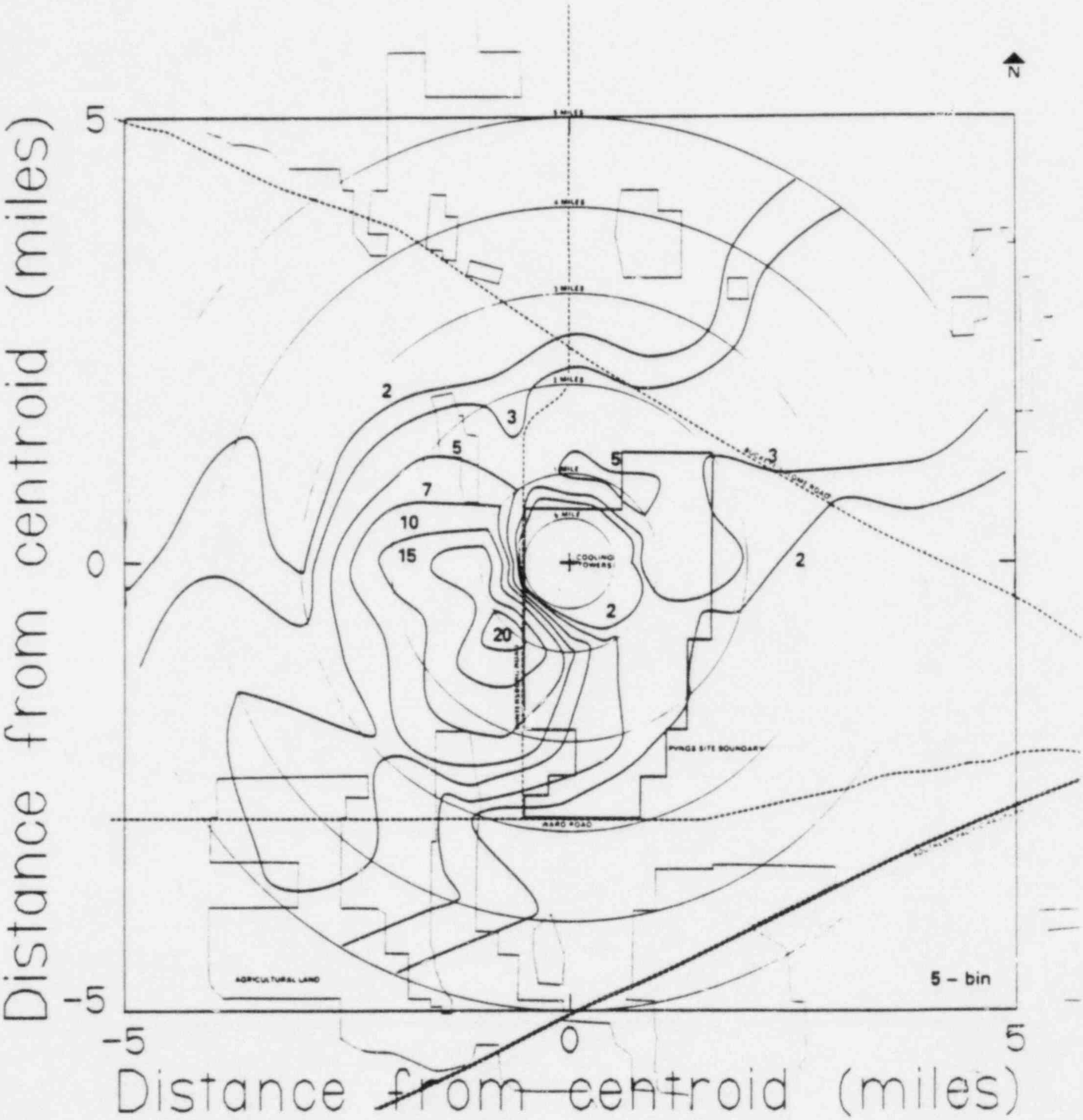


Figure 14. Annual Salt Deposition Rate Predictions of the EPRI Computer Model for the 5-bin Drop Spectrum. (Contour values are pounds per acre per year.)

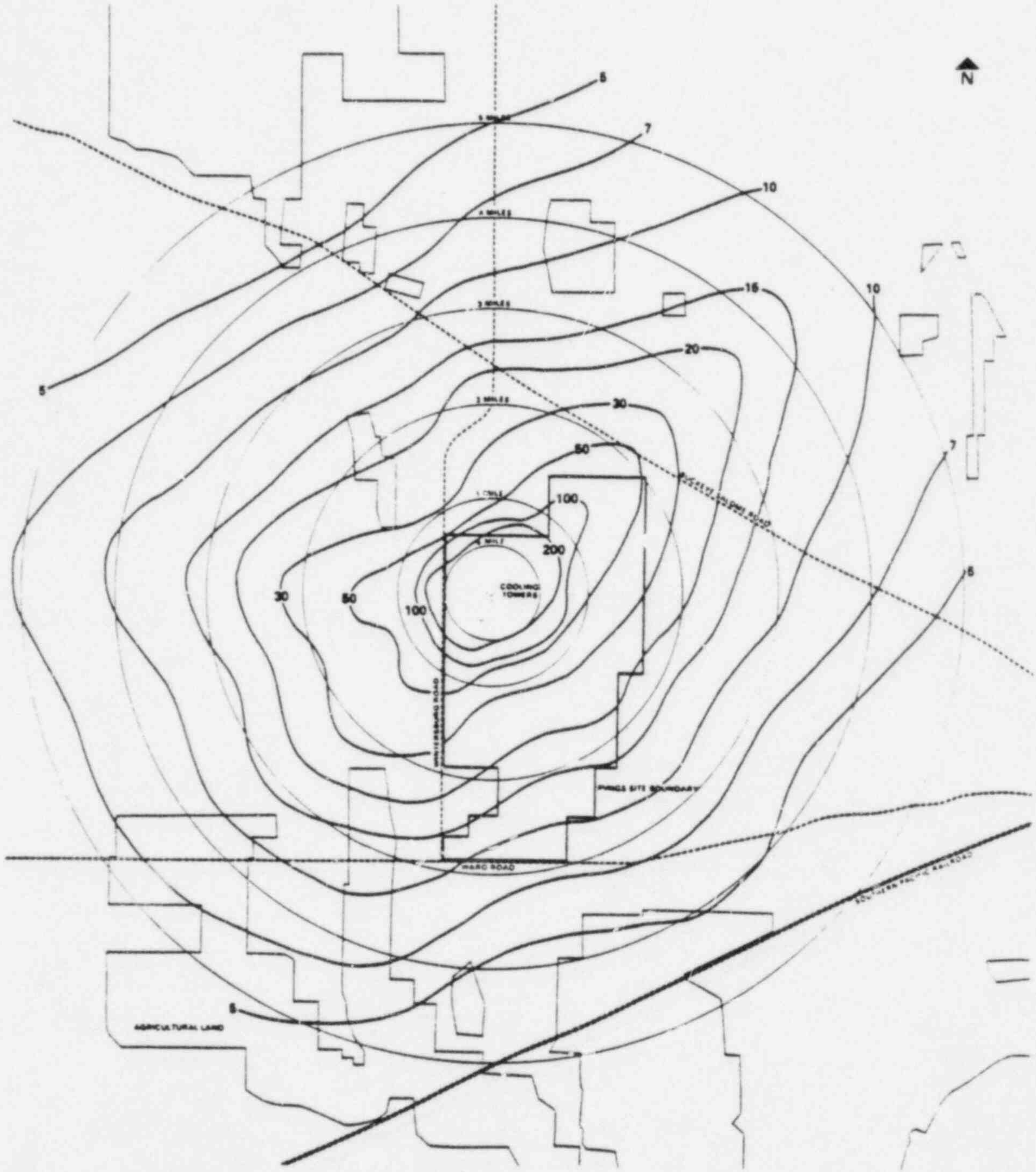


Figure 15. Annual Salt Deposition Rate Predictions of the NUS/FOG Computer Model for the 10-bin Drop Spectrum. (Contour values are pounds per acre per year.)

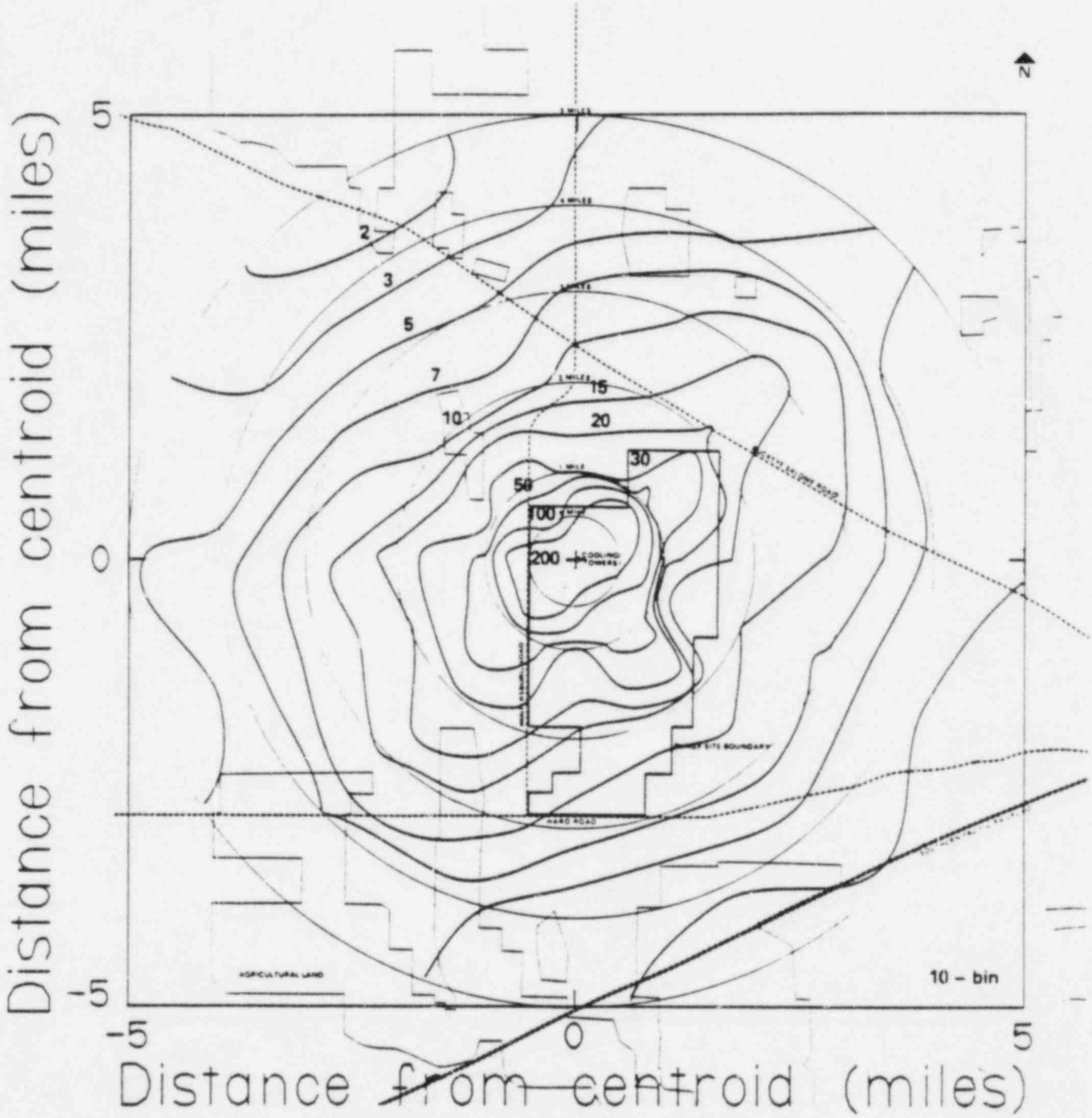


Figure 16. Annual Salt Deposition Rate Predictions of the EPRI Computer Model for the 10-bin Drop Spectrum. (Contour values are pounds per acre per year.)

Exhibit 10e

Exhibit G-3e

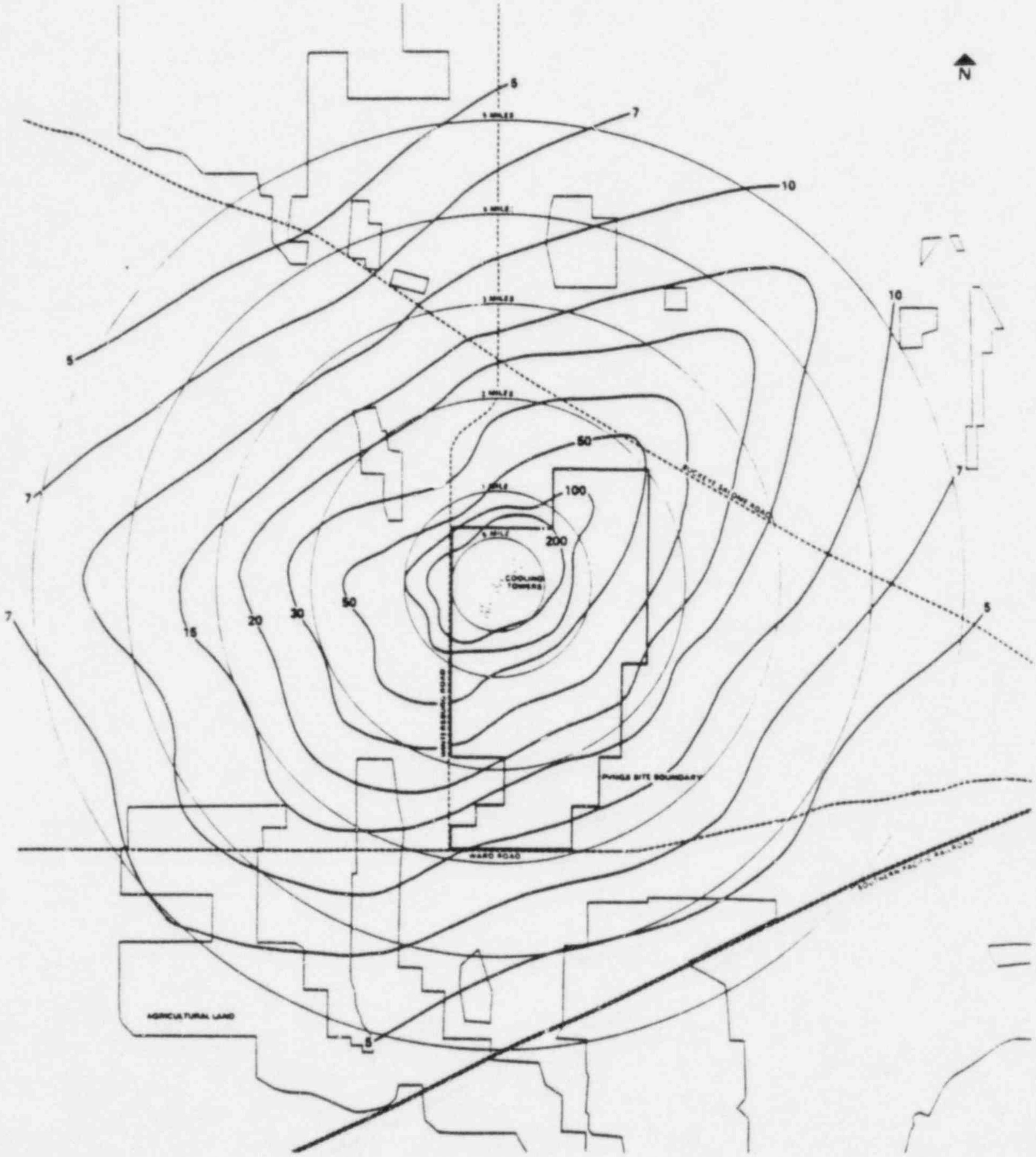


Figure 17. Annual Salt Deposition Rate Predictions of the NUS/FOG Computer Model for the 38-bin Drop Spectrum. (Contour values are pounds per acre per year.)

~~Exhibit 10f~~

Exhibit G-3f

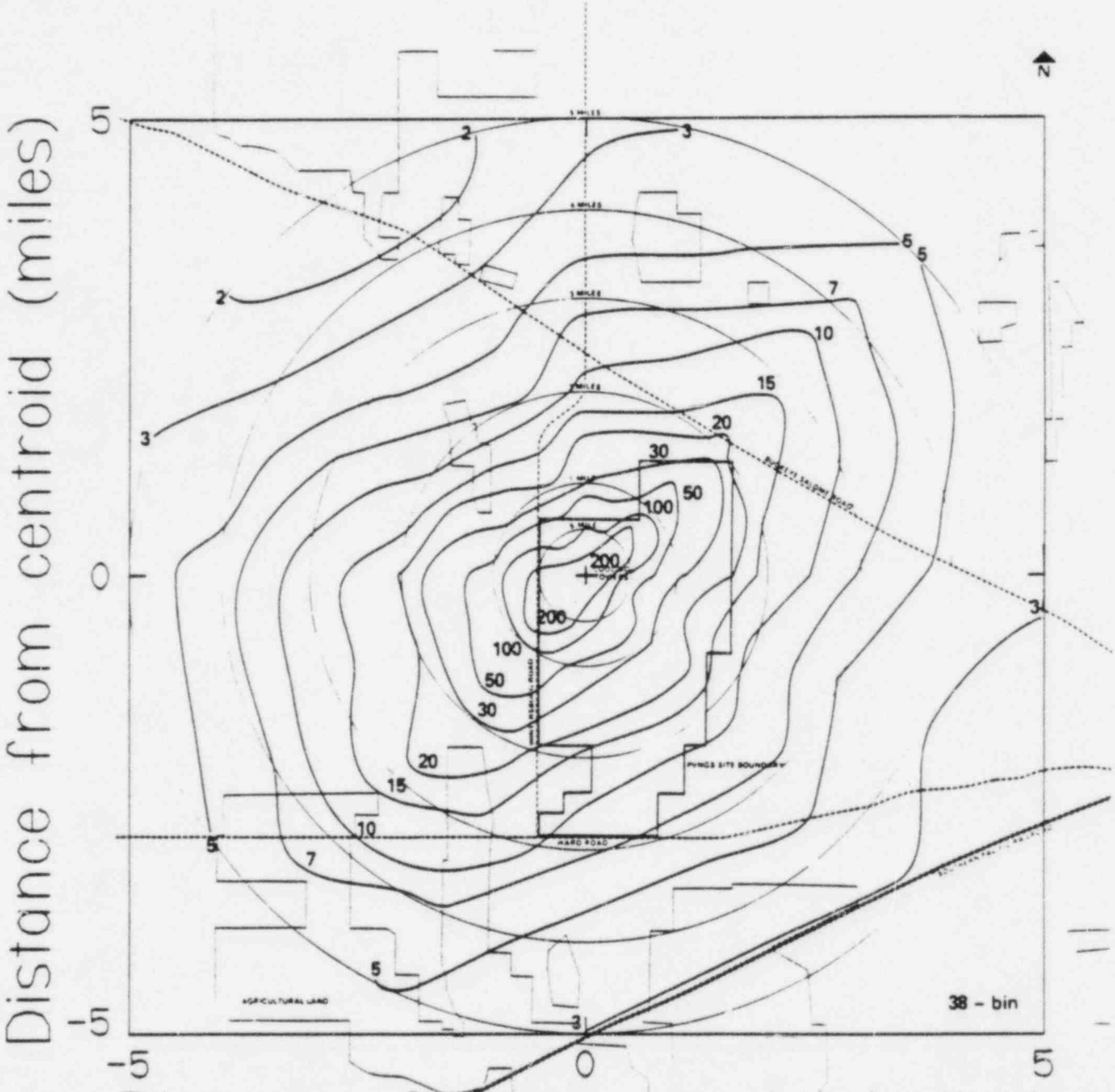
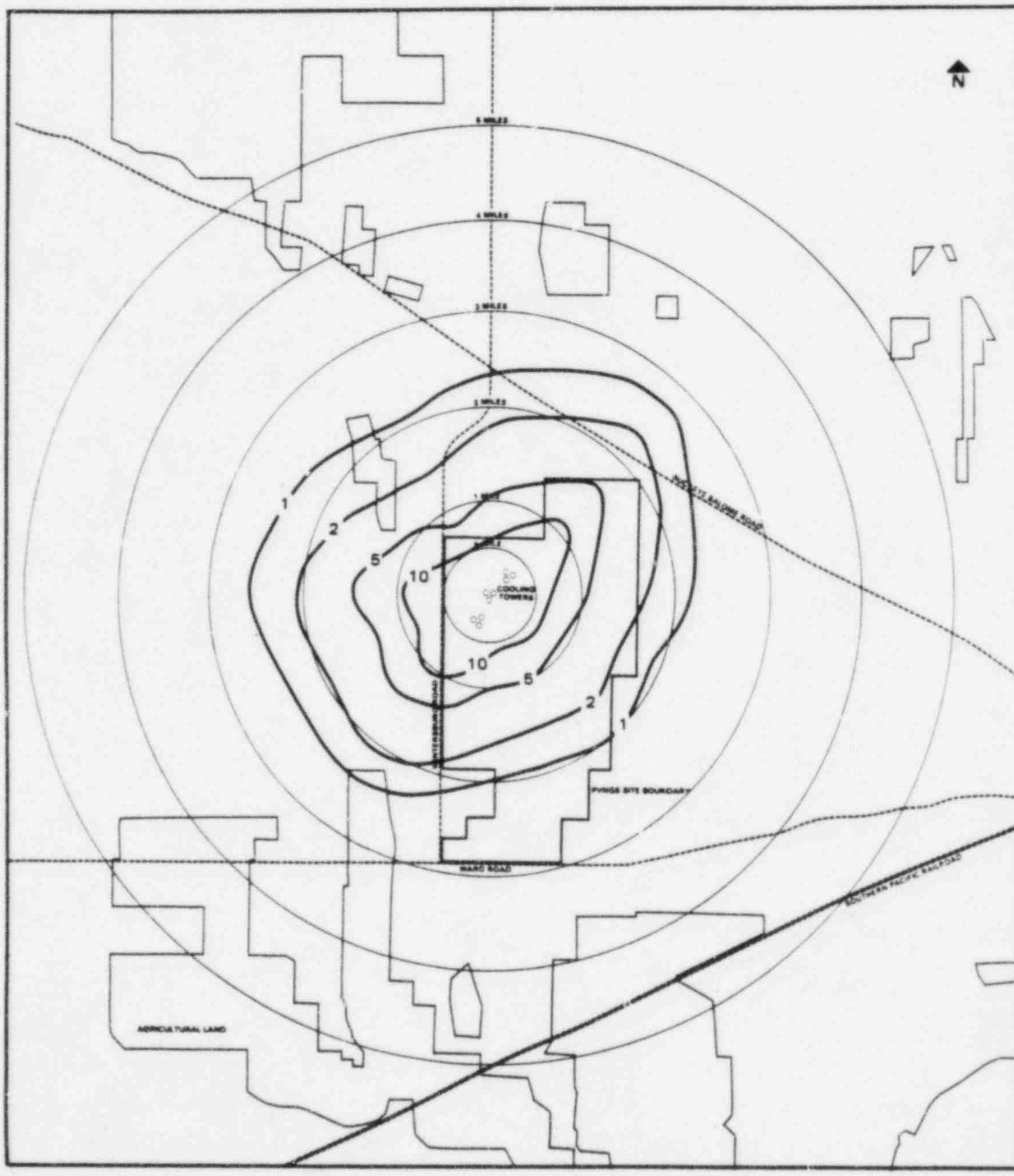


Figure 18. Annual Salt Deposition Rate Predictions of the EPRI Computer Model for the 38-bin Drop Spectrum. (Contour values are pounds per acre per year.)

Exhibit G-4

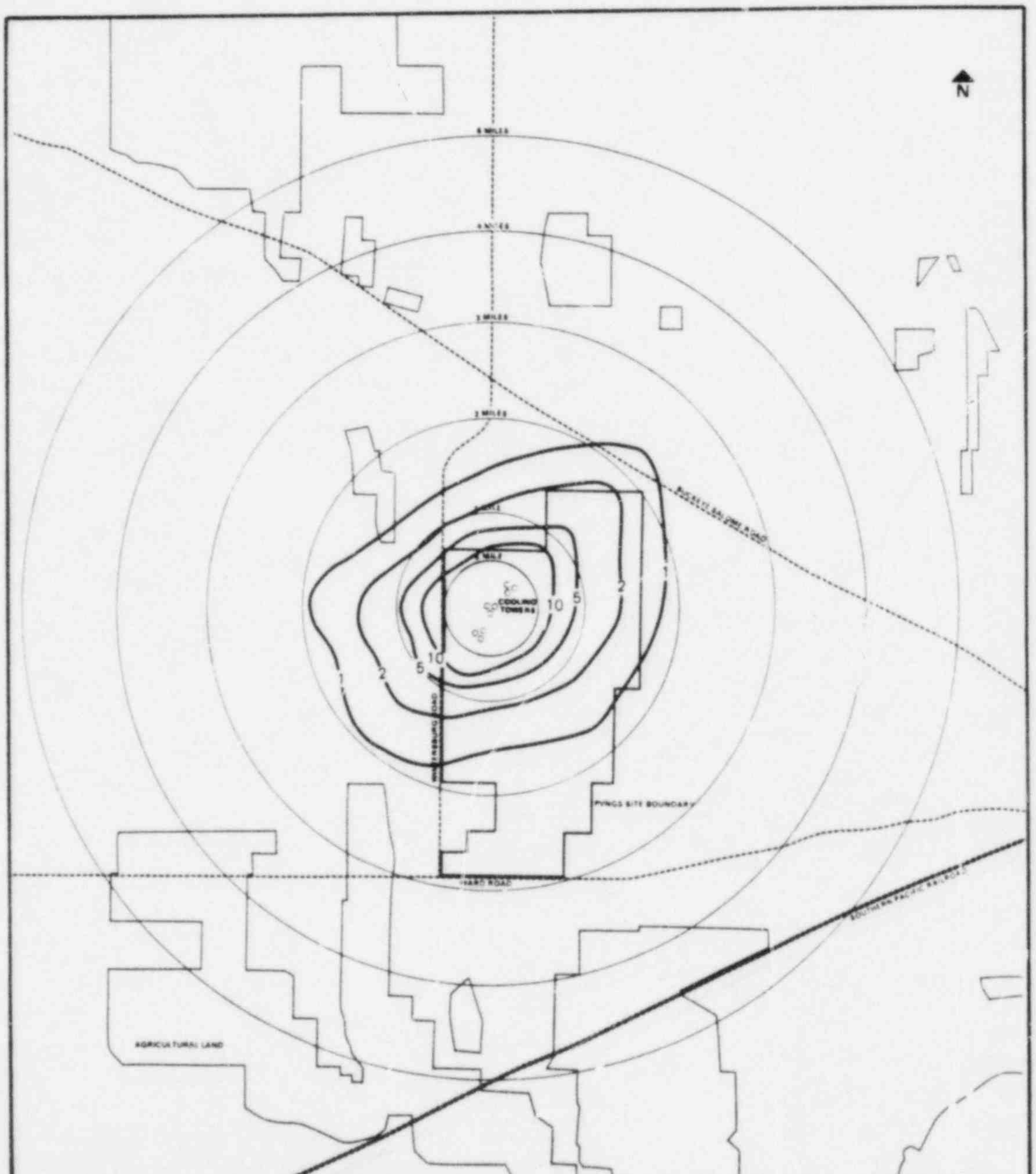
COOLING TOWER DRIFT DEPOSITION AT PVNGS–FOG MODEL



Notes: Drift Rate = 0.0002%
Circulating Water TDS= 12,000 ppm
Palo Verde 1983 Droplet Size
Spectrum; 16 bin
5 Year Meteorological Record

Exhibit G-5

COOLING TOWER DRIFT DEPOSITION AT PVNGS—EPRI MODEL



Notes: Drift Rate = 0.0002%
Circulating Water TDS = 12,000 ppm
Palo Verde 1983 Droplet Size
Spectrum; 16 bin
5 Year Meteorological Record

Exhibit G-6

~~Exhibit 13~~

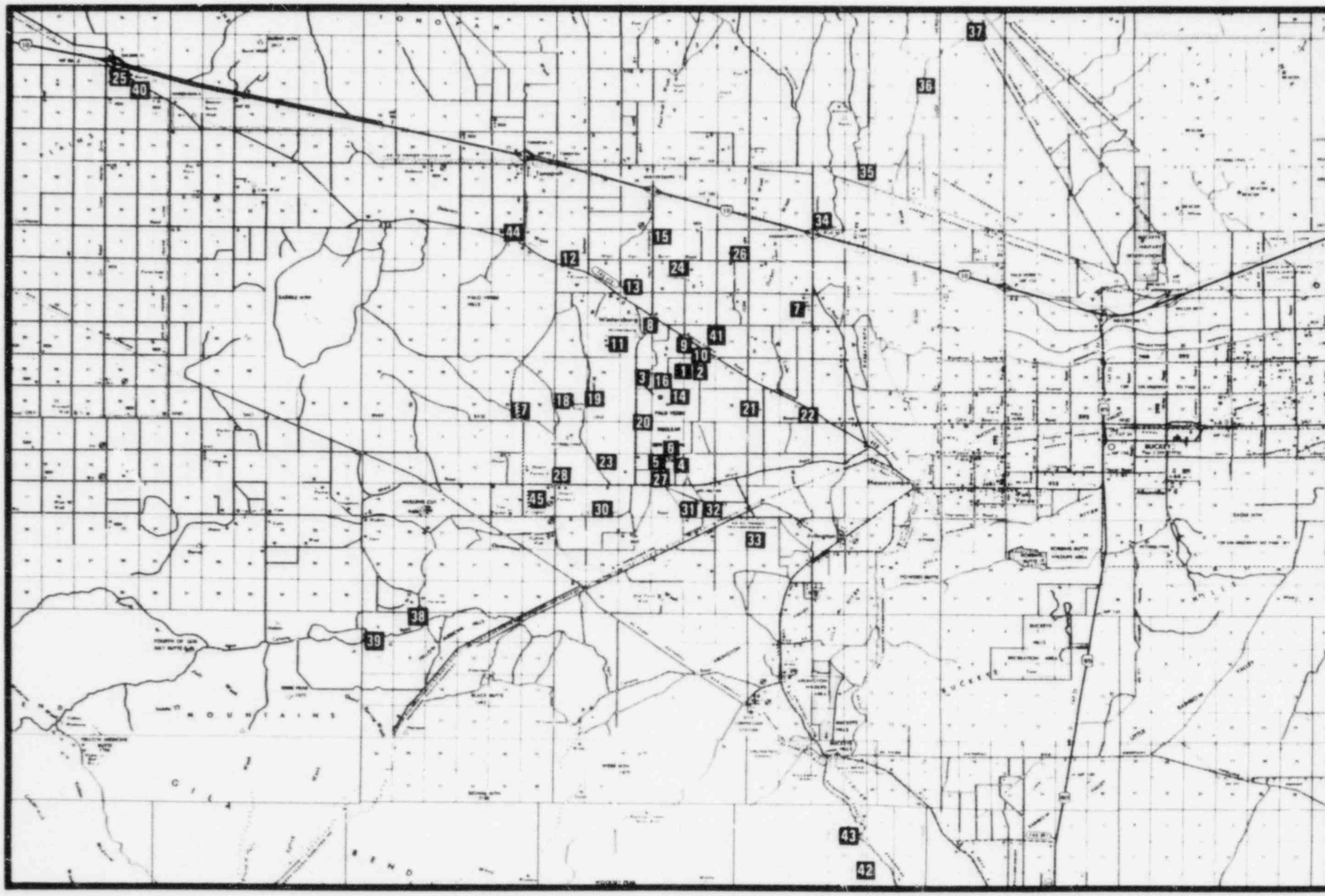


Figure 2-1
Distribution of Dustfall and Soil Sampling Locations

Exhibit G-7

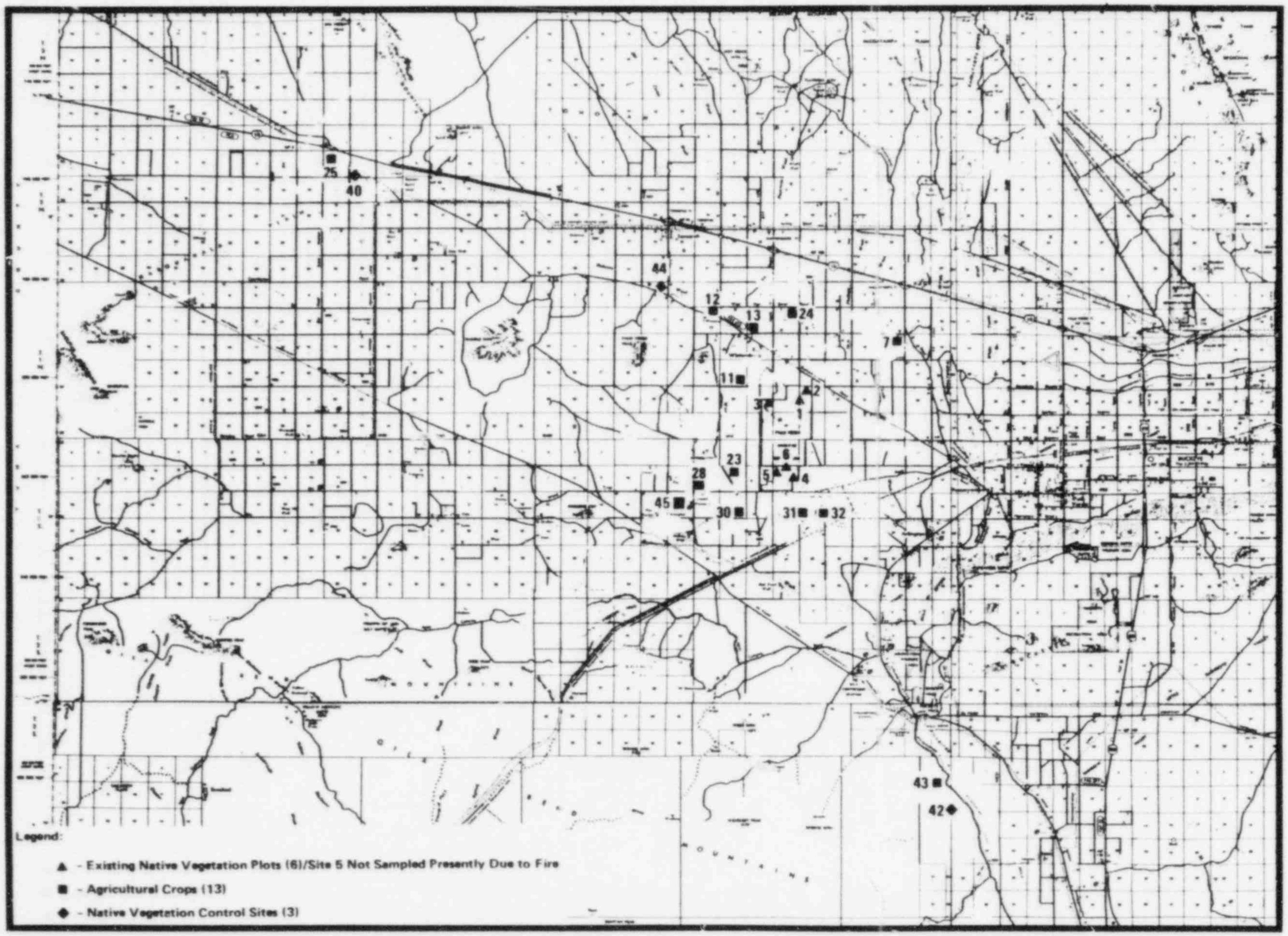


Figure 2-2
Distribution of Vegetation Sampling Locations