Thomas D. Gatlin
Vice President, Nuclear Operations
803.345.4342

SCE&G®
A SCANA COMPANY

January 14, 2016
RC-16-0006

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555-0001

Attn: S. A. Williams

Dear Sir / Madam:

Subject: VIRGIL C. SUMMER NUCLEAR STATION (VCSNS) UNIT 1
DOCKET NO. 50-395
OPERATING LICENSE NO. NPF-12
LICENSE AMENDMENT REQUEST – LAR-12-04269
LICENSE BASIS CHANGES IN STEAM GENERATOR TUBE RUPTURE ANALYSIS RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

References: 1. SCE&G Letter from Thomas D. Gatlin to NRC Document Control Desk, License Amendment Request – LAR-12-04269, "License Basis Changes in Steam Generator Tube Rupture Analysis," dated August 27, 2014 [ML14245A408]

2. NRC Letter from Shawn A. Williams to Thomas D. Gatlin, "Virgil C. Summer Nuclear Station, Unit No. 1 - Request for Additional Information Regarding License Basis Changes in Steam Generator Tube Rupture Analysis (CAC NO. MF4699)," dated December 1, 2015 [ML15320A338]

South Carolina Electric & Gas Company (SCE&G), acting for itself and as agent for South Carolina Public Service Authority pursuant to 10 CFR 50.90, submitted License Amendment Request (LAR) per Reference 1 concerning license basis changes in the steam generator tube rupture analysis. NRC review of this request determined that additional information was required and a request for additional information (RAI) was issued per Reference 2. This submittal's attachment contains SCE&G's response to the RAI dated December 1, 2015.

There are no regulatory commitments associated with this response.

If you have any questions regarding this submittal, please contact Mr. Bruce L. Thompson at (803) 931-5042.

A001
NRR

I certify under penalty of perjury that the foregoing is correct and true.

1-14-2016
Executed on

Thomas D. Gatlin

TS/TDG/wm

Attachment 1: VCSNS Response to Request for Additional Information
Attachment 2: Dames & Moore, "Recommendations Concerning Meteorological Data Adjustments Based on Heat Dissipation Study Effects of the Monticello Reservoir at Virgil C. Summer Nuclear Station," dated November 23, 1993

Enclosure: PAVAN Input Data for VCSNS – Compact Disk

c: K. B. Marsh
S. A. Byrne
J. B. Archie
N. S. Carns
J. H. Hamilton
J. W. Williams
W. M. Cherry
L. D. Wert
S. A. Williams
NRC Resident Inspector
S. E. Jenkins
Paulette Ledbetter
K. M. Sutton
NSRC
RTS (CR-12-04269)
Files (813.20)
PRSF (RC-16-0006)

VIRGIL C. SUMMER NUCLEAR STATION (VCSNS) UNIT 1
DOCKET NO. 50-395
OPERATING LICENSE NO. NPF-12

ATTACHMENT 1

VCSNS RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

The U.S. Nuclear Regulatory Commission (NRC) staff reviewed the Virgil C. Summer Nuclear Station (VCSNS) License Amendment Request (LAR), dated August 27, 2014 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML14245A408). Based on supplements dated September 10, 2015 (ADAMS Accession No. ML15258A021) and November 5, 2015 (ADAMS Accession No. ML15313A023) the NRC staff has determined that the following requests for additional information (RAI) are required to complete the review.

RAI-MET-1:

Background: In the Updated Final Safety Analysis Report (UFSAR), Section 2.3.3.2, "Operational Program," the licensee discusses the influence of Monticello Reservoir on the atmospheric dispersion in the site vicinity, especially for wind directions impacting the reactor site at the east end of the reservoir. The licensee proposes correction factors for X/Q for those cases where the atmospheric parameters collected at the meteorological tower might underestimate dispersion. The licensee indicates that these factors are necessary for the estimation of short-term diffusion characteristics to plant personnel and the factors would be applicable to all distances from the release points to the Low Population Zone (LPZ). However, the licensee provides no detail about how these correction factors were produced or applied in the latest calculations in the Steam Generator Tube Rupture (SGTR) licensee amendment request (LAR) and the RAI responses. Although the UFSAR states that Section 2.3 is being retained for historical purposes only, the NRC staff believes that the basis for these factors is still valid and should be taken into consideration for the calculation of the X/Q values in the STGR analysis.

Request: Please provide all relevant bases and calculations used to produce the correction factors for atmospheric dispersion. Please update the analyses to include the 2012-2014 meteorology data. Alternatively, provide staff with written justification that no correction factors were needed or used.

SCE&G Response

Section 2.3 of the Final Safety Analysis Report (FSAR) was designated as historical, as it was provided in the original FSAR to meet the requirements of 10 CFR 50.34(b), and was not expected to change with time. Subsequent changes were to be evaluated on a case-by-case basis. The general content of the section remains valid; however, the RAI question pertains to specific correction factors described in the section. The two correction factors, one for the general terrain and the other for the projected effects of the Monticello Reservoir, are addressed below.

Terrain Correction Factor

The discussion of the terrain correction factor for long-term diffusion in FSAR section 2.3 is also found in sections 5.1.4 and 6.1.3 of the Operating License Environmental Report (OLER). OLER Equation 6.1-3 includes the χ/Q terrain correction factor, T, the same factor in FSAR Equation 2.3-3. In both the FSAR and OLER, the T values reflect open terrain and are from

Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors." Therefore, the open terrain correction factors continue to be used in the PAVAN analysis.

Monticello Correction Factor

The RAI question suggests that new correction factors for the effects of the Monticello Reservoir are being proposed in Section FSAR 2.3.3.2. These are not new correction factors. These factors continue to be regarded but are not applied directly to χ/Q values used in the ODCM for effluent accountability. These correction factors, derived prior to the study of the effects of the heated reservoir by Dames and Moore (the original provider of meteorological information in the FSAR), suggested that under certain conditions the reservoir could influence meteorological measurements making it appear that release conditions were more favorable than would be achieved during a release. Specifically, the FSAR states that the affected conditions are night time with wind speeds less than 3 miles per hour with winds from the north-northwest through northeast and during periods of atmospheric stabilities D, E, and F. In practice, the application of the factors is through modification of the favorable meteorological criteria discussed below.

Gaseous effluent dose calculations use annual average χ/Q values. To ensure that actual release conditions are no worse than annual average χ/Q, minimum wind speed criteria were developed for the 10-meter wind speed elevation for each stability class and provided in FSAR Table 2.3-120.

Note that the χ/Q correction factor criteria are for wind speeds less than three miles per hour. Originally, the FSAR specified a minimum wind speed of 2.6 miles per hour to meet favorable meteorology conditions for D stability, but the value was revised after 1988 following a review of the FSAR χ/Q adjustment Factors. The favorable meteorology criteria were added to Table 3.1-2 of the Offsite Dose Calculation Manual (ODCM, Revision 29) and to the System Operating Procedure for Waste Gas Processing, and criteria added for use with wind speeds measured at 61 meters. These criteria are still being used today to control waste gas releases.

A study of the effects of Monticello Reservoir on meteorological tower measurements was performed and specific recommendations were provided concerning adjustment of meteorological measurements in 1993 (Attachment 2 of this submittal). The study found that atmospheric stability measurement was significantly affected by onshore flows during warm water/cold land conditions. Specific adjustment procedures detailed in the study included the following adjustment schedule for onshore winds (from 349 degrees to 360 to 79 degrees):

(Temp atm –Temp water)	Delta T Correction
-5 to -10 degrees F	0.37
< -10	0.79

This adjustment procedure has been added to Emergency Plan Procedure, "Offsite Dose Calculation," (EPP-005, Revision 21) and the emergency dose assessment software (MIDAS).

The impact on the ODCM was evaluated with the conclusion that the effect of the heated reservoir does not necessitate any changes to the dispersion values used in the ODCM based on specific pathway locations. Corrected χ/Q values using a conservative correction methodology were found to be within 8 percent of the χ/Q value used for controlling effluents. The dispersion values for the controlling organ dose pathway were found to remain valid since the controlling dispersion value for the location is the sector-averaged relative deposition (D/Q), which does not use atmospheric temperature measurements.

The limited applicability of these correction factors will have similarly limited effects on dose consequences. However, in order to conservatively bound the dose consequences of the SGTR, an augmentation factor proposed in the response to RAI-MET-3 question, will be applied to these dose consequences.

RAI-MET-2:

Background: **The NRC staff carried out an audit-type analysis of the MET files and the Excel data provided by the licensee. The staff noted several apparent inconsistencies in the meteorology data provided, including:**

- **In late June of 2012, there are 10 hours, in 3 separate periods where the average temperature was 30 °C, while the readings for the hours in question were -17 °C. For the same hours, dew point readings averaged about +17 °C.**

- **There are a significant number of records where dew point exceeds ambient temperature by a small amount, generally less than 0.2 °C.**

- **Bad data in the Excel file appeared as either "99" or "-99", and would also appear as bad data for an identical period in the corresponding MET files. However, some bad data identified only in the MET files by "99" or "9999" was not correspondingly tagged as bad data in the Excel file. In these instances, the data in the Excel file were fixed values for the time period of the bad-tagged data in the MET file. The origin of these fixed values substituted into the Excel file could not be determined by the NRC staff. Table 1 indicates the periods of long runs of constant values in the Excel file that were identified either from a Run-Length Encoding (RLE) analysis or manual inspection.**

Table 1. Results of the RLE and visual analysis of the meteorology data in the Licensee's Excel spreadsheet showing the continuous periods (i.e., hours) over which either the data is shown to be bad (i.e., marked by -99) or the data are constant.***

Start Time	End Time	Consecutive Hours	Notes
3/11/12 2:00	3/12/12 8:00	30	All constants within each column
8/6/12 11:00	8/7/12 13:00	26	All constants within each column
8/13/12 0:00	8/13/12 10:00	11	All constants within each column
8/21/12 13:00	8/22/12 9:00	21	All Constants within each column*
10/23/12 14:00	10/30/13 8:00	163	-99 in all columns
11/3/12 10:00	11/4/12 8:00	23	All constants within each column
11/20/12 15:00	11/26/12 10:00	140	-99 in all columns
2/2/13 3:00	2/4/13 11:00	57	All constants within each column
4/30/14 2:00	5/10/14 18:00	257	-99 in all columns**
5/14/14 17:00	5/15/14 9:00	17	-99 in all columns**
5/18/14 14:00	5/22/14 21:00	103	-99 in all columns**
6/11/14 10:00	6/12/14 8:00	23	-99 in all columns**
7/2/14 13:00	7/4/14 9:00	44	-99 in all columns**
9/7/14 14:00	9/11/14 14:00	97	-99 in all columns**

***except one row of data**
****(except two columns)**
*****fewer than 10 consecutive hours are omitted from the table.**

<u>Request</u>: Please describe the overall meteorology data collection program and its use in calculating onsite and offsite atmospheric dispersion factors; including procedures, standards, different towers and heights and selection of parameters from each, and other applicable criteria. Also, please identify whether these data issues are isolated incidents or are indicative of a larger quality assurance and control issue.

SCE&G Response

<u>Meteorological Data Collection Program Description</u>

The Environmental Assurance (EA) system upgrade, started in 2004, was prompted by aging and degradation of the original equipment. The station has one new tower that erected essentially at the location of the original tower, and is shown in Figure 1. Instrument booms are located at 10, 40, and 61 meters along the axis of the tower. Data communications between the tower and the Control Room is facilitated by fiber optic cable.

Section 2.3 of the Final Safety Analysis Report (FSAR) was designated as historical, as it was provided in the original FSAR to meet the requirements of 10 CFR 50.34(b), and was not expected to change with time. Subsequent changes were to be evaluated on a case-by-case basis.

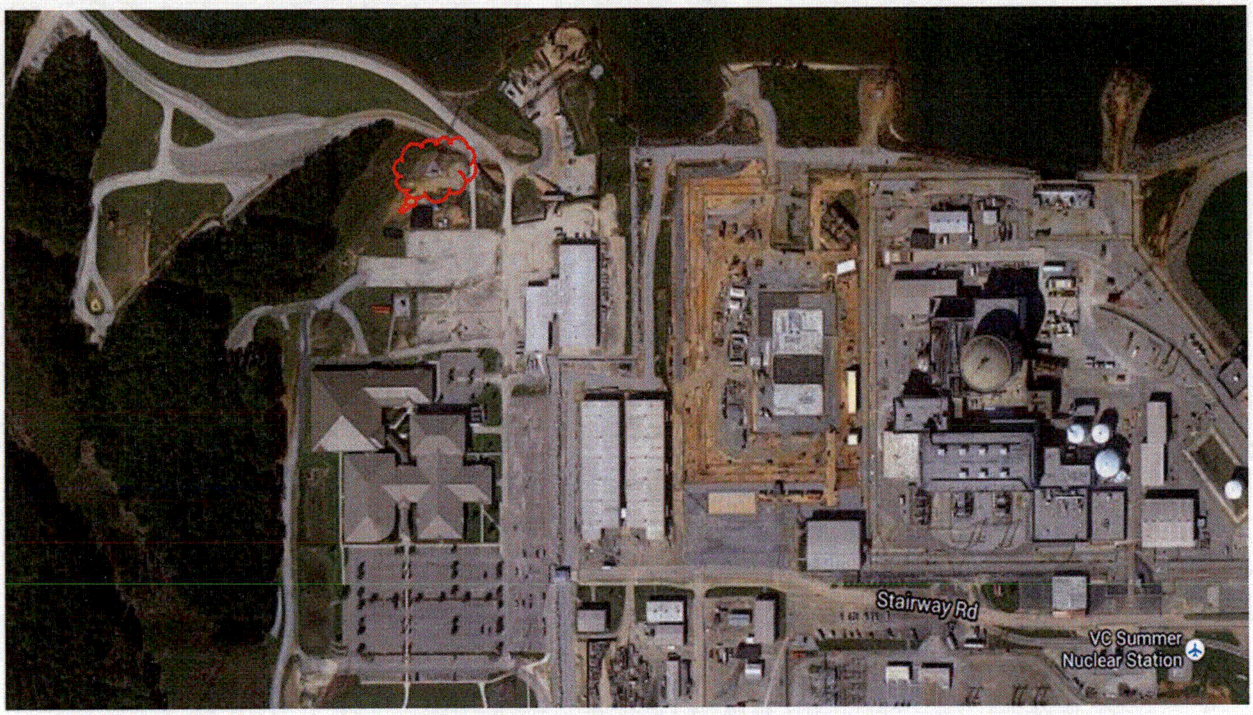

Figure 1 Meteorological Tower Location

The Vaisala MAWS301 Automatic Weather Station is at the center of the sensor array and weather station-to-plant computer data communications. It replaced the original analog system as part of the upgrade, and collects or computes data using its associated sensors and processors. FSAR Table 2.3-85 shows the sensors, parameters, and accuracies that meet Regulatory Guide 1.23 Revision 0, "Meteorological Monitoring Programs for Nuclear Power Plants (Safety Guide 23)," accuracy requirements to which the plant was licensed.

The meteorological data collection program is implemented by Instrumentation and Control Procedure (ICP-300.060), "Meteorological Bi-Weekly Data Verification." The procedure periodically verifies the operability of the monitoring equipment, retrieving the data collected by the equipment, and restoring equipment to its original configuration. Surveillance Test Procedure (STP-393.005), "Met Tower Instrumentation Calibration," verifies sensor calibration per the requirements of Technical Specification Table 4.3-5. This table stipulates a daily channel check, and a semi-annual recalibration.

<u>Data Issues</u>

Three questions on data quality were raised and responses provided:

a. *In late June of 2012, there are 10 hours, in 3 separate periods where the average temperature was 30 °C, while the readings for the hours in question were -17 °C. For the same hours, dew point readings averaged about +17 °C.*

A review of the June 2012 data shows that on 6/29/2012 from 1600 to 1900, and again on 6/30/2012 from 1500 to 1900, and finally on 7/1/2012 at 1400, ambient temperatures were abnormally low (-17 to -16 degrees Celsius) for the time of year. These are considered aberrant, and a specific cause could not be determined. However, these are considered isolated, as no other similar instances occurred in the 2012-2014 period.

b. *There are a significant number of records where dew point exceeds ambient temperature by a small amount, generally less than 0.2 °C.*

Dew point temperature, TD, is a computed value, using air temperature and relative humidity. The equation used for calculating TD is:

$$TD = \frac{c \times b}{c \times \frac{a}{2} + b} - 273.15$$

Where:

$$a = ln\frac{100}{RH}$$

$$b = 15.0 \times a - 2.1 \times TA + 2711.5$$

$$c = TA + 273.15$$

TA = actual air temperature, deg C

RH = actual relative humidity, %

The small (<0.2 degree Celsius) exceedances of dew point over ambient temperature can be expected due to timing differences between the data acquisition and the completion of the computation, as well as the record writing time. Further, the exceedance is within the acceptable uncertainty for dew point (0.9 degree Fahrenheit or 0.5 degree Celsius) from Regulatory Guide 1.23.

c. *Also, please identify whether these data issues are isolated incidents or are indicative of a larger quality assurance and control issue.*

Table 1 addresses the third question regarding additional data issues. The significant data gaps (>140 hours) were associated with plant activities. Only three instances do not have plausible explanations, and one of those (3/11/2012) is likely related to a communications condition determined later (8/21/2012 and 11/3/2012). From the table, a total of 1,012 hours of questionable (constant value) or bad data occurs during the monitoring period. Along with the 10 hours of abnormally low ambient temperatures from (RAI-MET-2 Section a), the total represents approximately 4 percent of the total time of the 2012-2014 monitoring period. This still demonstrates 90 percent data recovery, which is set in FSAR section 2.3.3.2.4. In conclusion, there is not a larger quality assurance or control issue.

Table 1 Meteorological Tower Data Gaps and Explanations

Start Time	End Time	Consecutive Hours	Observations	Reason
3/11/12 2:00	3/12/12 8:00	30	All constants within each column	Unknown, possibly related to August 2012 instances.
8/6/12 11:00	8/7/12 13:00	26	All constants within each column	See 8/21/2012 entry
8/13/12 0:00	8/13/12 10:00	11	All constants within each column	See 8/21/2012 entry
8/21/12 13:00	8/22/12 9:00	21	All constants within each column	Discovered that data not updating. This was found to be due to a communications protocol failure. This was resolved by a reset of the Open Platform Communications (OPC) server.
10/23/12 14:00	10/30/12 8:00	163	-99 in all columns	Refueling Outage 20. Performance test PTP-160.023, Train A AC and DC Breaker Exercise Test (With Inverters 5901 and 5902 Started on DC Power Only), conducted.
11/3/12 10:00	11/4/12 8:00	23	All constants within each column	During this time period, an investigation revealed the recurrence of the OPC server issue. This was resolved by the installation of an updated version of the communication program.
11/20/12 15:00	11/26/12 10:00	140	-99 in all columns	Integrated Plant Computer (IPCS) showed suspect data due to a recent IPCS modification. The condition was corrected and Special Report 2012-002 was submitted.
2/2/13 3:00	2/4/13 11:00	57	All constants within each column	Unknown. Data had stopped updating. Was restored within 7 days.

Start Time	End Time	Consecutive Hours	Observations	Reason
4/30/14 2:00	5/10/14 18:00	257	-99 in all columns	Bus 1DA Out of Service for NFPA 805 implementation.
5/14/14 17:00	5/15/14 9:00	17	-99 in all columns	Met Tower de-energized for lighting work.
5/18/14 14:00	5/22/14 21:00	103	-99 in all columns	Refueling Outage 21.
6/11/14 10:00	6/12/14 8:00	23	-99 in all columns	Unknown
7/2/14 13:00	7/4/14 9:00	44	-99 in all columns	Fiber optic cable between plant and Met Tower inadvertently cut.
9/7/14 14:00	9/11/14 14:00	97	-99 in all columns	Transformer XTF5053 found grounded.

RAI-MET-3:

Background: The licensee supplied sufficient information for the NRC staff to recreate licensee PAVAN results for identical parameter inputs. The NRC staff's review showed that the licensee's calculations employed only 7 wind-speed categories. The NRC's confirmatory analysis using the same meteorological data but employing 12 wind-speed categories lead to χ/Q values approximately 20% higher than the licensee's results in some instances, allowing for a possible non-conservatism in the licensee's analyses. Section 4.6 of the PAVAN user's manual (NUREG/CR-2858) suggests that wind speed should have a large number of categories; e.g., calm, 0.5, 0.75, 1.0, 1.25, 1.5, 2.0, 3.0, 4.0, 5.0, 6.0, 8.0 and 10.0 meters per second.

Request:

Provide the PAVAN input data set that was provided informally via e-mail on November 17, 2015. Please justify using 7 wind-speed categories, when a finer grouping of wind speed would affect the offsite atmospheric dispersion factors. Alternatively, provide the results of a revised PAVAN analysis using a Joint Frequency Distribution table based on finer wind-speed categories.

SCE&G Response

The PAVAN input data set provided informally on November 17, 2015, is included in the attached CD in order to formalize the transfer.

For the second part of the question, a 12 wind speed group PAVAN analysis was performed to assess the impact of the more refined wind speed categorization. The resulting χ/Q values for the 12 wind speed group calculations are tabulated below (Table 2), along with the 7 wind speed group χ/Q values previously provided and located in the Current Licensing Basis (CLB). It is evident that the effect of having more wind speed groups is mixed when compared against the CLB and the corresponding 7-group data for 2012-2014. For the Exclusion Area Boundary (EAB), the new 12-group χ/Q values exceed those of the CLB and the 7-group data for 2012-2014. However, for the Low Population Zone (LPZ), the 12-group χ/Qs exceed all of the current χ/Qs, but do not exceed any of the 2012-2014 7-group χ/Qs.

Table 3 shows the percent differences in χ/Q between the two groups. To accommodate the variation with respect to the dose acceptance criteria, the 18 percent difference observed at the EAB will be increased further to 20 percent. V.C. Summer proposes to apply this factor to the dose consequences at the EAB and the LPZ for the SGTR. This will also address any concerns relative to the Monticello Reservoir correction factors discussed in the response to RAI-MET-1 because it will be applied under all daytime wind speed, wind direction, and stability factors. Even with this augmentation factor, the dose consequences of this event will remain within the acceptance limits.

Table 2

Time Period	CLB – AST (s/m^3)		2012-2014 7 Wind Speed Groups (s/m^3)		2012-2014 12 Wind Speed Groups (s/m^3)	
	EAB	LPZ	EAB	LPZ	EAB	LPZ
0 – 2 hrs	1.24E-04	5.06E-5[a]	1.25E-4	5.97E-5[a]	1.53E-4	5.96E-5[a]
0 – 8 hrs	---	2.42E-5	---	2.91E-5	---	2.87E-5
8 – 24 hrs	---	1.68E-5	---	2.03E-5	---	1.99E-5
1 – 4 days	---	7.55E-6	---	9.30E-6	---	8.97E-6
4 – 30 days	---	2.40E-6	---	3.03E-6	---	2.91E-6

Table Note:
a. 0 to 2 hours LPZ χ/Q is used only for the Fuel Handling Accident.

Table 3

Time Period	Percent Differences: 7 vs. 12 Wind Speed Groups	
	EAB	LPZ
0 – 2 hrs	-18.3	0.2
0 – 8 hrs	---	1.4
8 – 24 hrs	---	2.0
1 – 4 days	---	3.7
4 – 30 days	---	4.1

VIRGIL C. SUMMER NUCLEAR STATION (VCSNS) UNIT 1
DOCKET NO. 50-395
OPERATING LICENSE NO. NPF-12

ATTACHMENT 2

DAMES & MOORE, "RECOMMENDATIONS CONCERNING METEOROLOGICAL DATA ADJUSTMENTS BASED ON HEAT DISSIPATION STUDY EFFECTS OF THE MONTICELLO RESERVOIR AT VIRGIL C. SUMMER NUCLEAR STATION," DATED NOVEMBER 23, 1993

RECOMMENDATIONS CONCERNING METEOROLOGICAL DATA ADJUSTMENTS BASED ON HEAT DISSIPATION STUDY EFFECTS OF THE MONTICELLO RESERVOIR AT VIRGIL C. SUMMER NUCLEAR STATION

NOVEMBER 23, 1993

DAMES & MOORE

SIX PIEDMONT CENTER, SUITE 500
3525 PIEDMONT ROAD
ATLANTA, GEORGIA 30305
Job No. 05182134201

DAMES & MOORE
SIX PIEDMONT CENTER, SUITE 500, 3525 PIEDMONT ROAD, ATLANTA, GEORGIA 30305
(404) 262-2915 FAX: (404) 233-2271

November 23, 1993

South Carolina Electric & Gas Company
Virgil C. Summer Nuclear Station
Nuclear Training Center
Highway 213
Jenkinsville, South Carolina 29065

Attention: Mr. Tim Riley

Re: Report
Recommendations Concerning
Meteorological Data Adjustments
Based On Heat Dissipation Study
Effects Of The Monticello Reservoir
At Virgil C. Summer Nuclear Station

Dear Mr. Riley:

Enclosed is the report Recommendations Concerning Meteorological Data Adjustments Based On Heat Dissipation Study Effects Of The Monticello Reservoir At Virgil C. Summer Nuclear Station. This report presents the results of our review of the Phase I and II heat dissipation effects studies of the Monticello Reservoir relative to implementation procedures for site-specific dispersion and transport assessments at the nuclear station. The recommended implementation procedures are considered appropriated to modify the routine and emergency radiological assessment processes to account for significant observed reservoir modifications of meteorological observations during plant operation.

We appreciate the opportunity to perform the Monticello Reservoir heat dissipation effects study and to provide the meteorological data adjustment recommendations. This report completes the authorized heat dissipation effects investigation for the V.C. Summer Nuclear Station. Please let us know if you have any questions concerning the work performed or the enclosed recommendations.

Sincerely,

DAMES & MOORE, INC.

Stanley J. Krivo

Stanley J. Krivo, CCM
Associate/Senior Meteorologist

SJK:sjm

Enclosures
cc: Ms. Laura Blake - SCE&G Palmetto Center Office Building
Mr. John W. Preston - SCE&G Palmetto Center Office Building

TABLE OF CONTENTS

RECOMMENDATIONS CONCERNING METEOROLOGICAL DATA ADJUSTMENTS BASED ON HEAT DISSIPATION STUDY EFFECTS OF THE MONTICELLO RESERVOIR AT VIRGIL C. SUMMER NUCLEAR STATION

1.0 INTRODUCTION

The following presents the results of a review of the Phase I and Phase II heat *dissipation effects studies of the Monticello Reservoir relative to implementation* procedures for site-specific dispersion and transport assessments at the Virgil C. Summer Nuclear Station (VCSNS). The Phase I heat dissipation study (Dames & Moore, 1982), analyzed the on-site meteorological data for post- and pre-reservoir conditions prior to the operation of the VCSNS to identify and quantify the meteorological parameters that were affected by the presence of the heat dissipation reservoir. The Phase II heat dissipation study (Dames & Moore, 1993) performed a similar analysis using reservoir and meteorological data acquired during the plant operation when waste heat was being discharged to the reservoir. The results of theses two studies, and subsequent implementation reports and procedures, were reviewed to define appropriate modifications in the routine and emergency assessments of radiological releases from the VCSNS plant to account for significant observed modifications of the meteorological observations.

2.0 SUMMARY OF PREVIOUS HEAT DISSIPATION STUDIES

2.1 UNHEATED RESERVOIR

The initial (Phase I) study of changes in the measured meteorological variables as a result of the Monticello Reservoir (Dames & Moore, 1982) was performed using two sets of data: 1) Meteorological data obtained prior to the existence of the reservoir (1975), and 2) Meteorological data and concurrent Monticello Reservoir temperature data subsequent to the reservoir construction and filling (1979). The following presents a summary of the results of this study:

1) The meteorological variables affected by the presence of the reservoir are wind speed, stability, ambient temperature, and dew-point temperature.

2) Wind speed increased on the downwind side of the reservoir for all stabilities. The magnitude of the increase was about 50 percent of the upwind values.

3) Stability shifted to more unstable and neutral conditions for on-shore flows after reservoir filling.

4) Ambient temperature downwind of the reservoir is modified. The magnitude of the change is dependent on the temperature difference between the reservoir surface and the air.

   Cold Water/Warm Land - Downwind temperatures were 5 to 6°F less than upwind values.

   Warm Water/Cold Land - Downwind temperatures were 2 to 4°F greater than the upwind values.

5) Dew-point temperatures downwind of the reservoir were 1 to 4°F greater than values upwind of the reservoir.

In a separate study (Dames & Moore, 1983A), procedures for the implementation of the above results into the real-time operation of the VCSNS's Emergency Assessment and Response System (EARS) were developed based on the above results. The following are the significant results and recommendations from this study.

1) Of the meteorological variables affected by the Monticello Reservoir, only wind speed and stability are important in the dispersion and transport assessments.

2) The VCSNS's emergency assessment system used a segmented plume model with defined receptor grids. A receptor grid to represent the area affected by the Monticello Reservoir was recommended. This grid would be used in

subsequent dispersion and transport assessments to address wind speed and stability modification factors.

3) The travel distance needed to have the atmospheric conditions modified because of changes in surface conditions was estimated to be 1.61 kilometers (1.0 mile). This distance is appropriate for both water-to-land and land-to-water flows.

4) A single wind speed correction factor was recommended for both on-shore and off-shore flows. The average increase of wind speed for over reservoir flow is 33 percent. Based on this adjustment factor, reservoir grids are needed for each wind direction because the affected grid receptors will be different for each direction.

5) The observed modifications in ambient 10-meter temperature were recommended for use in modifying the measured differential temperature measurements used to determine Pasquill atmospheric stability classes. Based on the observed Site 1 and Site 2 ambient temperature differences for on-shore flows, the following air versus water temperature dependent ambient 10-meter temperature modifications were recommended. (Note: "Differential temperatures" in this report refers only to the difference between two levels of air temperatures on the meteorological tower. The difference between air and water temperatures will be called "temperature difference.")

Absolute Magnitude of Air-Water Temperature Difference (°F)	Recommended Air or Differential Temperature Change (°F)
$(T_a - T_w) \leq 5°$	0.07
$5° < (T_a - T_w) \leq 10°$	0.37
$(T_a - T_w) > 10°$	0.79
On-shore Site 1/Cold Water	Subtract the appropriate change from the differential temperatures.
On-shore Site 1/Warm Water	Add the appropriate change to the differential temperatures.

Off-shore Site 1/Cold Water	Add the appropriate change to the differential temperatures.
Off-shore Site 1/Warm Water	Subtract the appropriate change from the differential temperatures.

To account for these changes, separate grids for each combinations of 16 directions and 3 air-water temperature differences were recommended.

A re-evaluation of the above two Phase I heat dissipation studies was performed to ensure that significant meteorological relationships are incorporated into the VCSNS's transport and dispersion assessments. (Dames & Moore, 1983B) This review resulted in a recommendation that only the reservoir effects on the atmospheric stability measurements be addressed in the site specific dispersion and transport assessments. The recommended stability adjustment procedure for the EARS based grid receptor system was different from the 1983A study because it was based on duplicating the stability distribution prior to the existence of the reservoir. Adjustments were suggested for air-water temperature differences greater than 10°F and less than -10°F.

In summary, the recommended meteorological data adjustment procedures developed from the unheated reservoir study were based on:

1) The grid based receptors associated with the segmented plume dispersion and transport EARS model. Only those meteorological variables affecting the dispersion and transport assessments from the VCSNS were addressed. The procedures recognized different adjustment factors for upwind, transition zones, and downwind receptors for on-shore, off-shore, and along-shore directions.

2) Wind speed effects:

- Dispersion - Occurs at release point; increased speed at release point causes decreased concentration.
- Transport - Wind speeds during transport only defines the time required for a release to reach specific receptors.

3) Established relationship between concurrently measured up- and down-wind values of temperatures and winds for specific wind directions and air minus water temperature differences.

2.2 HEATED RESERVOIR

The Phase II study of changes in the measured meteorological variables as a result of the Monticello Reservoir (Dames & Moore, 1993) was performed using a set of meteorological data and concurrent reservoir surface temperature data obtained during the operation of VCSNS (1991/92). During this one-year study period, waste heat from VCSNS was discharged to the reservoir. The following presents a summary of the results of this Phase II study:

1) The meteorological variables affected by the presence of the reservoir were the same as found in Phase I - wind speed, stability, ambient temperature, and dew-point temperature.

2) Wind speed increased on the downwind side of the reservoir for all stabilities. The magnitude of the increase was between 30-50 percent of the upwind values. The wind speed increase for the heated reservoir appeared to be smaller than those observed for the unheated reservoir.

3) Stability shifted to more unstable and neutral conditions for on-shore flows. The heated reservoir appears to have a greater decrease in stable occurrences.

4) Ambient temperatures downwind of the reservoir were modified. The magnitude of the change was dependent on the difference in temperatures between the reservoir surface and the air.

   Cold Water/Warm Land - The heated reservoir had downwind temperatures as much as 3°F colder than the upwind values. The unheated Phase I study had downwind temperatures 5 to 6°F less than upwind values.

Warm Water/Cold Land - Downwind temperatures for the heated reservoir were 2 to 5 °F greater than upwind values. These values are within the range of temperature change found for the unheated reservoir.

5) Dew-point temperatures downwind of the reservoir were 1 to 5 °F greater than values upwind of the reservoir. The dew-point temperature modifications were similar to those found for the unheated reservoir.

2.3 SUMMARY

Based on the results of the pre-reservoir, unheated reservoir, and heated reservoir studies, the Monticello Reservoir does have a modifying influence on the meteorological data measured at the VCSNS tower. The affected meteorological variables of importance to the dispersion and transport assessments at the VCSNS are wind speed and ambient 10-meter temperature. The latter because of its effect on atmospheric stabilities determined from measured differential temperatures. The observed differences between the heated and unheated reservoir findings are not believed to be significant enough to warrant different implementation procedures. If the same dispersion and transport assessment model is used, the recommended implementation procedures for the unheated reservoir should be applicable for conditions when the waste heat is discharged to the reservoir.

The major difference between the observations associated with heat loading on the reservoir and conditions when the reservoir has no waste heat discharge is the frequency of occurrence of cold water/warm land conditions. The frequency of cold water/warm land conditions decreased for both on-shore and off-shore flows by 0.38 to 0.54 times the unheated reservoir frequency. For all flow conditions, the frequency of warm water/cold land is 1.5 to 2.3 times larger than the unheated observations.

3.0 CURRENT VCSNS MONITORING AND ANALYSIS SYSTEMS

3.1 METEOROLOGICAL AND RESERVOIR MONITORING SYSTEMS

The meteorological monitoring system used to provide data for the for the emergency and routine radiological assessments at VCSNS has not changed significantly since the 1982 study. The current 60-meter Site 1 primary tower and measured meteorological variables are the same as was used in 1975, the earliest annual data record used in the heat dissipation study. The only significant changes in the monitoring system is the termination of the Site 2 meteorological data acquisition station. The Site 1 meteorological tower data, the surface temperatures from two reservoir monitoring stations, and circulating water intake temperature are the real-time data available for any radiological assessment program at VCSNS.

3.2 DISPERSION AND TRANSPORT ASSESSMENTS

3.2.1 Segmented Plume Model

At the time of the initial Phase I analysis, radiological assessments at VCSNS were performed used a segmented plume dispersion and transport computer model developed by Nuclear Data, Incorporated. The VCSNS computer system was called the Emergency Assessment and Response System (EARS). The subsequent implementation studies for Phase I were based on the receptor and input requirements of this model.

The EARS segmented plume model used grid based receptors to permit temporal and spatial variations in the calculations. The meteorological variables and appropriate adjustments could be varied at each grid receptor thereby permitting different values depending on receptor locations relative to upwind, downwind, or transition zones. The spatial grids changed with each hourly observation at the VCSNS meteorological tower.

3.2.2 Straight-Line Gaussian Model

Shortly after the development of the Phase I implementation recommendations, the use of the EARS was discontinued at VCSNS. A straight-line Gaussian dispersion and transport model is currently used at VCSNS. This type of model does not have the ability to incorporate temporal or spatial variations in the meteorological input data. It assumes a constant meteorological data field for all calculations. Thus, the straight-line Gaussian model is not conducive to making temporal or spatial wind speed and stability adjustments.

4.0 RECOMMENDATIONS

Based on the results of the Phase I and II heat dissipation studies, a number of meteorological variables are affected by the presence of the Monticello Reservoir. This section presents a review of affected meteorological variables as they relate to the dispersion and transport assessments at the VCSNS. It also provides recommended procedures to adjust these assessments to properly account for reservoir produced modifications to meteorological variables and assessment techniques to ensure reasonable concentration estimates are made in the vicinity of the plant due to releases from the VCSNS.

The issues of concern in developing the implementation procedures and recommended meteorological data adjustments are:

- Limitations and uncertainties associated with the basic Phase I and II studies (e.g., limited reservoir temperature data, variability in the correlation analyses, etc.). As indicated in the Phase I and II reports, sophisticated adjustment implementation procedures are not supported by the results.
- The calculated concentrations are not underestimated.
- Inclusion of observed reservoir effects that are significant to the radiological assessments.
- Adjustments and implementation procedures are compatible with the dispersion and transport assessment methodology.

The previous sections summarized the results of the Phase I and Phase II heat dissipation studies, defined the current meteorological and reservoir monitoring program, and described the dispersion and transport assessment technique used for the routine and emergency dispersion and transport assessments at VCSNS. The two meteorological variables affected by the reservoir and of importance in the radiological assessments are the wind speed and the 10-meter ambient temperature as it affects the determination of atmospheric stability.

4.1 WIND SPEED

The wind speeds at the VCSNS were found to increase as they pass over the smoother reservoir waters. Wind speeds on the downwind side of the reservoir are expected to be between 30-50 percent greater than speeds experienced upwind of the reservoir. In assessing the need to adjust the measured wind speed values when estimating the concentrations downwind of the VCSNS, the following were considered.

- Only on-shore or off-shore wind flows are of concern. Along-shore winds are not affected by the reservoir.
- For off-shore winds (ESE-WNW), the wind speeds over the reservoir and at on-shore receptors within the shoreline transition zone are about 1.33 times those measured at the meteorological tower for all wind speeds and stabilities. The measured wind speed is appropriate for all other receptor locations downwind of the reservoir transition zone.
- For on-shore winds (N-ENE), the measured wind speeds are affected by the reservoir and, therefore, are appropriate for locations upwind and over the on-shore transition zone. The wind speeds further inland are about 75 percent of the measured values for all speeds and stabilities.
- The reactor is relatively close to the meteorological tower. The tower wind speed measurements are representative of those experienced at the release point. Because the dilution based on wind speed occurs at the release point, wind speed measured at the tower is appropriate to estimate relative concentrations.
- For the determination of time needed for a particular release to reach a downwind location during on-shore flows, the tower measured wind speed will typically underestimate times - shorter time periods for transport because of the higher reservoir affected wind speeds as compared to the overland values.

- Spatial dependent wind speeds can not be incorporated in the current straight-line Gaussian dispersion model used for routine and emergency assessments at VCSNS.

Based on the above considerations, only the measured wind speeds for on-shore wind directions are affected by the presence of the reservoir. The measured wind speeds are considered appropriate for all release conditions from the plant. No wind speed adjustments are recommended in calculating the routine or emergency concentrations at receptors of concern but the estimated 25 percent decrease in speeds as the plume moves inland should be considered when estimating times of transport to downwind receptors for on-shore directions.

4.2 ATMOSPHERIC STABILITY

The heat dissipation reservoir affects the tower measurements of 10-meter ambient temperature and thus, differential temperature. The reservoir affected stabilities during on-shore flows have been found to shift towards more neutral and unstable conditions. The shift from stable to more unstable conditions will generally result in smaller estimates of concentrations. The following are important issues considered in developing a recommended implementation procedure to account for the observed reservoir stability modifications.

- Only on-shore or off-shore wind flows are of concern. Along-shore winds are not significally affected by the reservoir.
- Only on-shore wind directions demonstrate significant changes in the distribution of stabilities associated with the reservoir.
- Measurements of differential temperatures during off-shore flows are not affected by the reservoir. The resultant stability values are appropriate for all locations with the possible exceptions of receptors over the reservoir and in the transition zones.
- Because atmospheric stabilities are expected to shift to more stable classes downwind during cold water (i.e., $(T_a\text{-}T_w) > 0.0\,°F$) off-shore flows, calculated downwind concentration using tower measured differential temperature values are expected to be underestimated. These conditions of cold water off-shore flow are expected to be relatively infrequent based on the 1991/92 data record.

- The other possible flow condition where the use of tower measured differential temperature values could underestimate concentrations is warm water (i.e., (T_a-T_w) < 0.0°F) on-shore flows. The tower measurements affected by the warmer reservoir temperatures will result in stabilities that are not representative of downwind conditions. The expected shift to more stable conditions inland will result in concentrations larger than those predicted using the tower measurements. The warm water conditions, based on the 1991/92 date record, are estimated to represent over 90 percent of the on-shore flows when the plant is in operation.

- Spatial dependent stabilities can not be incorporated in the current straight-line Gaussian dispersion model used for routine and emergency assessments at the VCSNS.

- Measurements of differential temperatures during on-shore flows are affected by the reservoir. The resultant stability values are only appropriate for locations over the reservoir and in the transition zones.

- The following table presents the maximum change in stability categories based on the U.S. Nuclear Regulatory Commission's (U.S. Nuclear Regulatory Commission, 1986) definition of Pasquill stability categories and the magnitude of the potential temperature adjustments (i.e., 0.37°F and 0.79°F):

Measured Pasquill Stability Class	Max. Possible Stability Class Change for ± 0.37°F Adjustment	Max. Possible Stability Class Change for ± 0.79°F Adjustment
A	D	
B	A or D	
C	A or D	Same as ± 0.37°F Adjustment
D	A or E	
E	D or F	
F	E or G	
G	F	

Unstable atmospheric conditions could change by up to 3 classes more stable (e.g., A to D Pasquill class). Stable conditions will only change by 1 class. A 3 class stability change can cause, depending on the distance, greater than 10-fold increase in the estimated concentrations.

Based on the above considerations, only stabilities during on-shore wind directions when the reservoir surface temperature is higher than the air temperature required adjustments. These are frequently occurring conditions under which the use of the as-measured, reservoir affected differential temperature values may underestimate the concentrations.

4.3 RECOMMENDED IMPLEMENTATION PROCEDURES

The following are the recommended implementation procedures for the VCSNS's routine and emergency radiological assessment systems to adjust for the reservoir modified stabilities measured at the Site 1 60-meter tower. These procedures take cognizance of the previous discussions and heat dissipation studies.

<u>Atmospheric Stability</u>

- Required monitoring data:
    - Differential temperature (60-10 meter), ambient 10-meter temperature, and wind direction measurements from the Site 1 60-meter tower.
    - Concurrent reservoir surface temperature measurements from the monitoring station that best represents the average surface temperatures of the reservoir.
- For on-shore wind directions: (Sectors N-ENE: 349-360-79 degrees)
    - Determine the difference between the 10-meter ambient temperature at Site 1 and the reservoir surface temperature (T_a-T_w).
    - For values of (T_a-T_w) less than -5° F but greater than or equal to -10° F, add 0.37° F to the differential temperature measurements to obtain the reservoir unmodified values.
    - For values of (T_a-T_w) less than -10° F, add 0.79° F to the differential temperature measurements to obtain the reservoir unmodified values.
    - Use the adjusted differential temperature values to determine the atmospheric stabilities for use in the relative concentration calculations.

Wind Speed

- No adjustments to the concentration calculations are recommended. For emergency assessments during on-shore flows (Sectors N-ENE: 349-360-79 degrees), any estimates of travel time to receptors of interest should take cognizance of the fact that the transport wind speed will be about 75 percent of the measured value for all wind speed classes and stabilities.

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