UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of DUKE POWER COMPANY, et. al. (Catawba Nuclear Station, Units 1 and 2)	))))))	Docket Nos. 50-413 50-414

DIRECT TESTIMONY OF JOHN PURVIS
ON BEHALF OF CESG

Please state your name and business address.

John Purvis, Department of Natural Resources, State of South Carolina, 3803 Forest Drive, Columbia, South Carolina.

What is your position?

I am State Climatologist.

Do you have experience as a meteorologist?

Yes. I was director of inversion studies for the United States Weather Bureau in Columbia, South Carol na.

Are you acquainted with the meteorology of this region?

Yes.

How would you characterize it?

In the context of the relationship of the Catawba nuclear station to the City of Charlotte: The Catawba plant is precisely 17.6 miles directly southwest from the intersection of Trade and Tryon Streets, the center of the business section of Charlotte. The closest approach to the plant is a distance of 9.7 miles from the city limit in the $22\frac{1}{2}^{o}$ sector to the northeast of the plant. The prevailing winds are generally from a southwesterly direction. There is an unusually high incidence of atmospheric inversions. There is also more than average rainfall in Charlotte.

What is the incidence of winds from Catawba over the City of Charlotte?

The data are somewhat limited but they are fairly consistent. Based on observation made by Duke at the plant site at an elevation of 30 feet, June 30, 1971 to June 30, 1972, wind from SW has a probability of occurrence of 20.7%, from WSW of 8.7% and SSW of 5.6%. These winds carry over Charlotte. The total probability is 35.0%. If the wind blew at random, the probability would be 18.8%. This is significantly directional. It is confirmed by data reported by Duke for the period 1976-1977. From the data in Table ER 2.3.0-2 at 40m above ground the corresponding occurrences are: SW 13.5%, WSW 5.9% and and SSW 16.3% for a total of 35.7%. At 10m above ground, about 33 feet, the occurrences are: SW 13.5%, WSW 7.1% and SSW 13.8% for a total of 34.4%. These occurrences are compatible with and should relate to Charlotte weather Bureau records. The records for the period 1941-1970 show a prevailing wind direction from the SW at a mean speed of 7.5 miles per hour. For 8 months of the year the prevailing wind direction was either from the SW or from the SSW. In 1982, under the National Oceanic and Atmospheric Administration a different system was used for reporting wind direction. Direction was reported in 10° increments. SSW would correspond to 191.25 to 213.75° from north; SW to 213.25 to 236.25°; and WSW to 236.25 to 258.75° from north. The range of these three directions is very nearly from 190 to 260°. In 1982 for five months the prevailing wind direction fell within this sector. Resultant speeds for these months ranged from 0.5 miles per hour in March to 2.4 miles per hour in July. The maximum wind speeds during these months was 20 miles per hour. This indicates a pattern of directional changes, including reversals. The probability of a plume released at the Catawba plant being carried over Charlotte is about twice that of random chance. The wind speeds are such that the probable minimum time for a release to reach the city limit would be half an hour. As the mean wind speed is 7.5 miles per hour it would on the average take an hour and twenty minutes to reach the city limit, about two hours to reach city center. Under some circumstances a change in wind direction could carry the plume back over the path by which it arrived.

How frequent are calms in this region?

The Environmental Report indicates a 4.3% incidence of calms in

the period 1969-1973 and of 9.6% in 1976-1977. Observations made in 1976-1977 report an 8.77% occurrence of winds between 1.0 and 3.3 miles per hour at 40m; of 25.68% at 10m. To the extent that a plume deposits particulates, relatively still air results in a higher ground concentration of particulates. The length of exposure to radioactive gases in the plume would be increased, and the dilution by mixing of both gases and suspended particulates would be slowed. Calms are also the cause of inversions.

What are inversions?

Under normally windy conditions there is good mixing both horizontally and vertically of the atmosphere. As the temperature of the upper atmosphere is lower than that of the earth's surface, a negative temperature gradient results. That is, the higher above the earth's surface, the lower the temperature. Under conditions of low air flow the atmosphere near the surface is appreciably warmed. When, through heat loss by radiation, the earth cools more rapidly than the air above it, a positive temperature gradient results. The intersection of the lower positive gradient air with the higher negative gradient air is a barrier to the mixing of the lower air with the upper air. Warm air will, due to density differences rise in a negative gradient, decline in a positive gradient. Attachment A shows the behavior of plumes under six gradient conditions. By retarding vertical mixing, inversions further contribute to the maintenance of high concentrations in pollutant releases, exacerbating the problem of poor mixing and slow transport which I earlier referred to.

Are inversions frequent in the Catawba/Charlotte vicinity?

They are among the highest known in the United States. The thirty year weather record shows that this locality experiences on the average more than 350 inversions a year.. In contrast, Chicago is in the 50 a year zone. Inversions there were notorious because the amount of soot in the atmosphere was high enough to cause black days. A radioactive plume staying close to habitations will cause more exposure than one rising and mixing upward.

What effect does rainfall have on a plume?

Rain washes particulates out of the atmosphere and brings them to earth. Under dry conditions the particulates in a plume are brought down by gravity. Larger, denser particulates settle more rapidly than smaller, less dense particulates. We are all familiar with the conveyance of pollen and dust by the wind.

What do we know about the nature of the particulates in the release from a nuclear accident?

Very little. Assumptions are made about the particle size distribution. One can conceive of the particulates in an accident release differing with the nature of the accident. But of one thing we can be sure. In dry weather small particles will be borne farther from the release than large particles. If rain is encountered both large and small particles will be brought down at a distance nearer to the point of release than would otherwise have occurred and at a higher concentration because there will have been less opportunity for mixing.

What is the incidence of rainfall in the Charlotte area?

On the average there have been 112 days with recordable rain in Charlotte. In 1982 there were 120 days. This is one day in three.

How much rain falls in Charlotte?

The thirty year average is 42.72 inches water equivalent. This includes snow and ice pellets. In 1982 the total precipitation was 41.69 inches.

How does this compare to other parts of the country?

There is a listing of weather data from 29 weather stations of the rainfall in typical meteorological years in NUREG/CR-2239. The average of these values is 29.9 inches. Charlotte receives 43% more rain than the average station reported.

How heavy or light is this rainfall?

It covers the range from mists or drizzle to heavy. In a 30 year period the heaviest 24 hour fall was 5.34 inches. In 1982 the heaviest fall was 2.17 inches in 24 hours. A heavy enough rainfall will tend to wash away pollutants. The average Charlotte rainfall is 0.38 inches, hardly a cleansing downpour.

Are there any other weather factors in relation to an atmospheric release of radioactivity that you would call to our attention?

Yes. Snow would probably entrain particulates with about the same efficiency as rain. The larger surface to mass ratio of snow flakes would make them more efficient scavengers than spherical drops. There are strong attractive forces between small particles and larger masses; the snow would not need to have a moist surface to capture aerosol dimension particles. The particles would be immobilized where the snow fell. Depending on the rate of the thaw, there could be little or no runoff and efficient deposition of the particles on the ground and other snowed-on surfaces.

Is this the only effect snow would have?

Not necessarily. Dpending on the rate of fall, depth, wetness, etc., it could seriously impede automobile travel--in this context, evacuation.. Other severe weather conditions could interfere with communication by siren or bullhorn such as high winds and the noise background that would be generated.

Does this complete your testimony in regard to weather influences in the event of an accidental release of radioactivity into the atmosphere?

Yes.

How would you sum up your testimony?

The prevailing winds are such that Charlotte has twice a random chance of having a release from the Catawba plant come over it. Low wind speeds and frequent inversions would make for prolonged exposure in the event of such a release. The probability of rainout of particulates over Charlotte is about 40% more than for average reported national weather conditions. Insofar as meteorological conditions affect the consequences of an accidental release of radioactivity, Charlotte is substantially more at risk than a representative community of the same size at the same distance from a nuclear plant.

POLLUTANT CONCENTRATION VARIATION

D. B. Turner*

THE INFLUENCE OF VERTICAL TEMPERATURE STRUCTURE UPON STACK EFFLUENTS

The manner in which stack effluents diffuse is primarily a function of the stability of the atmosphere. Church (1949) has typed the behavior of smoke plumes into five classes. Hewson (1960) has added a sixth class taking into account inversions aloft.

LOOPING

Looping occurs with a superadiabatic lapse rate. Large thermal eddies are developed in the unstable air and high concentrations may be brought to the ground for short time intervals. Diffusion is good however when considering longer time periods. The superadiabatic conditions causing looping occurs only with light winds and strong solar heating. Cloudiness or high winds will prevent such unstable conditions from forming.

CONING

With vertical temperature gradient between dry adiabatic and isothermal, slight instability occurs with both horizontal and vertical mixing but not as intense as in the looping situation. The plume tends to be cone shaped hence the name. The plume reaches the ground at greater distances than with looping. Coning is prevalent on cloudy or windy days or nights. Diffusion equations are more successful in calculating concentrations for this type of plume than for any other.

FANNING

If the temperature increases upward the air is stable and vertical turbulence is suppressed. Horizontal mixing is not as great as in coning but still occurs. The plume will therefore spread horizontally but little if any vertically. Since the winds are usually light the plume will also meander in the horizontal. Plume concentrations are high but little effluent from elevated sources reaches the ground with this situation except when the inversion is broken due to surface heating, or terrain at the elevation of the plume is encountered. Clear skies with light winds during the night are favorable conditions for fanning.

LOFTING

Lofting occurs when there is a superadiabatic layer above a surface inversion. Under this condition diffusion is rapid upward but downward diffusion does not penetrate the inversion and so is damped out. With these conditions gases will not reach the surface but particles with appreciable settling velocities will drop through the inversion. Near sunset on a clear evening in open country is most favorable for lofting. Lofting is generally a transition situation and as the inversion deepens is replaced by fanning.

FUMIGATION

As solar heating increases the lower layers are heated and a super-adiabatic lapse rate occurs through a deeper and deeper layer. When the layer is deep enough to reach the fanning plume, thermal turbulence will bring high concentrations to the ground along the full length of the plume. This is favored by clear skies and light winds and is apt to occur more frequently in summer due to increased heating.

Another type of fumigation may occur in the early evening over cities. Heat sources and mechanical turbulence due to surface roughness causes a lapse condition in the lower layers of the stable air moving into the city from non-urban areas where radiation inversions are already forming. This causes a fumigation until the city loses enough heat so that the lapse condition can no longer be maintained.

TRAPPING

When an inversion occurs aloft such as a frontal or subsidence inversion a plume released beneath the inversion will be trapped beneath it. Even if the diffusion is good beneath the inversion such as a coning plume,

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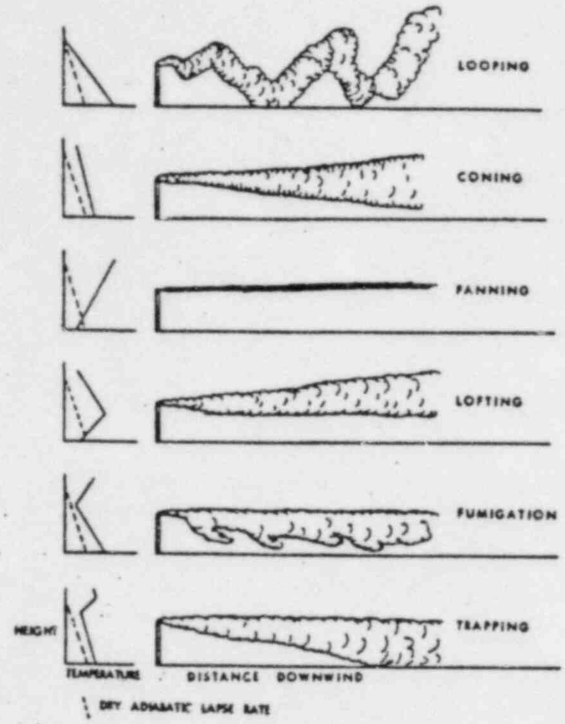
PA. ME. sd. 30a. 8. 62

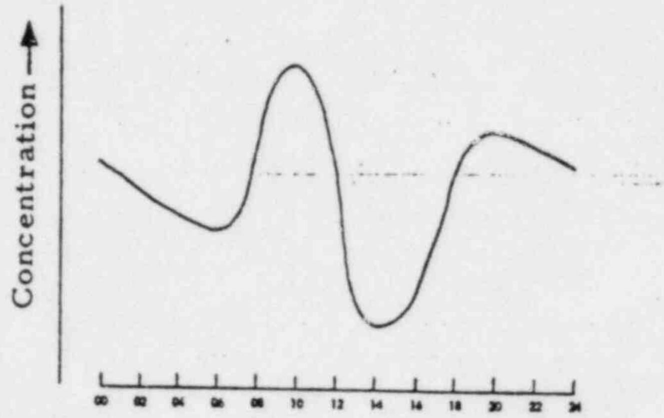
the limit to upward diffusion will increase concentration in the plume and at ground level.

The six plume classes are diagrammed in the accompanying figure.



VARIATION OF POLLUTANT COCENTRATIONS DUE TO METEOROLOGIC VARIATIONS

An example of the diurnal variation of pollutant concentrations is given in this figure. These are the concentrations some distance down-wind from a continuous elevated urban source on a day when stability reaches extremes, i. e., on a clear day with light winds. This shows only the variations on the order of an hour's duration rather that the rapid variations which may occur a few minutes duration.



Diurnal Variations of Ground-Level Concentrations from Elevated Urban Sources

The primary maximum around 10 AM is due to fumigation. The rapid decrease in concentration following this is due to the heating of a progressively deeper layer and mixing of pollutants through this layer.

The increase of concentrations during the late afternoon are due to the slight increase in stability after the period of maximum heating. During this period the lapse rate is generally changing from strong lapse to weak lapse.

The secondary maximum that occurs in the evening is a phenomena observed only in the urban area. During the late afternoon and early evening a radiation inversion begins to form at the earth's surface in the non-urban areas, i. e., the surrounding countryside. The air over the city, however, does not have a radiation inversion in the lower layers due to release of heat from the buildings and pavings of the city. However, later in the evening, an inversion above the weak lapse layer forms above the city and a mixing of the pollutants in this layer produces the higher concentrations. This has been described by Munn and Katz