# Appendix A

## CLIMATOLOGY AND METEOROLOGY

This appendix is supportive of Section 1.2, Subsection 5, Climatology and Meteorology, which contains additional discussion.

The meteorological facility (Environmental Data Station) began operation in April 1971 at a site about 4,000 feet southwest of the plant at an elevation of 750 feet MSL, or 50 feet above plant grade (figure A-1). The facility consists of a 300-foot steel tower with an instrument building near the tower base. The data collected and processed by a high-speed digital computer system include (1) wind direction and wind speed at 33 and 300 feet; (2) atmospheric turbulence (sigma-y and sigma-z) at 33 and 300 feet; (3) temperature at 4, 33, 150, and 300 feet; (4) solar radiation, rainfall, and atmospheric pressure at 4 feet; and (5) dew point at 4 feet.*

Interrogation (or scanning) impulses from the sensors are processed by a data logger system consisting of three basic components: (1) analog to digital converter; (2) scanner; and (3) mini-type digital computer, Nova Model by Data General, with 8K memory.

Data display at the instrument building consists of hourly teletypewriter and paper punch tape printouts. When the plant becomes operational, selected meteorological data, along with other environmental monitoring data, will be remoted from the meteorological facility over land line for computer processing and display in the reactor control

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*Additional dew point sensors will be installed at 33 and 300 feet when appropriate equipment becomes available. The 4-foot sensor is primarily for biological use.

room. Meteorological data will include 33- and 300-foot wind direction, wind speed, sigma-y, sigma-z, 33- to 300-foot temperature gradient; and 4-foot temperature. These data will be displayed on analog strip charts and/or in digital form.

The operational phase of the meteorological program includes those procedures and responsibilities involved with activities beginning with the initial fuel loading and continuing through the life of the plant. The meteorological data collection program will be continuous without major interruptions as required by AEC guidelines and Operational Quality Assurance Programs.

The terrain features of the region have some effect on the general climate. With the mountain ridge and valley terrain aligned northeast-southwest over eastern Tennessee, there is a definite bimodal upvalley-downvalley windflow in the lower 500 to 1,000 feet during much of the year. The high Cumberland Plateau terrain, 1,500 to 1,800 feet above the valley elevation, tends to dissipate many of the migratory storms which move from the west across the region. A detectable lake breeze circulation, resulting from discontinuities in differential surface heating between land and water is not expected because of the relatively narrow width of the Tennessee River as it flows southwestward through the Valley area.

1. Severe weather - Severe wind storms (frontal or air mass thunderstorms) may occur several times a year with winds reaching 35 mi/h and on occasion exceeding 60 mi/h. The highest wind speed recorded in Chattanooga was 82 mi/h in March 1947.[1] The highest

hourly wind speed recorded at the Sequoyah meteorological facility during the first 24 months of operation, April 2, 1971, through March 31, 1973, was 40 mi/h. High wind may accompany moderate-to-strong cold frontal passages about 20 to 30 times a year with the maximum frequency in March and April. High wind may also accompany thunderstorms about 56 times a year with maximum frequency in July.[1]

The probability of tornado occurrence is extremely low. Statistics show that during the period, 1916-73, no tornadoes were reported in the vicinity of the Sequoyah site.[1,2] Using the principles of geometric probability described by H.C.S. Thom,[3] the probability of a tornado striking any point in the plant site area is $8.4 \times 10^{-5}$, or about one in 11,905 years.

Tornadoes in the eastern Tennessee area generally move northeasterly and cover an average surface path 5 miles long and 100 yards wide (0.284 $mi^2$).[4] Winds of 150 to 200 mi/h are common in the whirl and are estimated to occasionally reach 300 mi/h.[4,5]

Days of high air pollution potential have been depicted by G. C. Holtzworth.[6] Over a 5-year period, his data show that there would be about 30 days, or about 6 days annually, that such conditions would likely affect the site area, with most of the days occurring in the fall.

The highest monthly average rainfall occurs during the winter and early spring months with March usually having the greatest amount. The maximum 24-hour rainfall reported near the plant site was 7.56 inches in August of 1954.[7] Other months with high precipitation are June and July when air mass thunderstorm activity is common. Minimum precipitation is normally in October when the Azores-Bermuda anticyclonic circulation is most predominant.

The occurrence of snow, freezing rain, and ice storms in the midwinter period is not uncommon. However, severe ice and snow storms causing appreciable damage to property and inconvenience to travel do not normally occur more often than once in 10 years.[4]

Hail storms of significant intensity are not likely to occur in the plant area.[4]

2. Local climatology and meteorology - Most of the data used in this climatological and meteorological description was collected at the onsite meteorological facility during the first full year of operation (April 2, 1971, through March 31, 1972). Included in the evaluation are the single-year summaries of wind, temperature, humidity, and atmospheric stability. The facility and its location with respect to the Sequoyah Nuclear Plant are shown in figure A-1.

Because of the limited 1-year of onsite data, long-term fog and snowfall trends as well as supplementary temperature information were obtained from 42 years of data collected at the National Weather Service Office at Lovell Field, Chattanooga,[1] located 14.5 miles south-southwest of the site (figure A-2). Normal precipitation trends were obtained from the 35-year record from TVA raingage station 685, Friendship School, Tennessee, located about 2.5 miles north-northeast of the plant site.[7]

With the limited onsite data, it is not possible to discuss normal and extreme values of meteorological parameters representative of the plant site; instead, the data should point toward typically mean values of the local meteorological parameters. Therefore, normal and extreme values of parameters measured offsite should be more

representative of the long-term regional trends, although local site influences on these trends may not be reflected.

(1) Wind direction - Data from the 33-foot (10-meter) wind instruments at the permanent meteorological facility for the first full year of operation (April 2, 1971, through March 31, 1972) should identify reasonably well the expected wind conditions in the plant site area. The monthly patterns (Tables A-1 through A-12) show predominant northeasterly and southwesterly wind components, which reflect the orographic channeling effects of the northeast-southwest aligned valley-ridge terrain. The month with the most pronounced valley regime is December with 42.57 percent of the wind being south-southwesterly or southwesterly and 31.89 percent north-northeasterly or northeasterly. This predominant northeasterly-southwesterly pattern becomes less pronounced in July, August, and September.

Tables A-8, A-10, and A-12, for the months of November, January, and March respectively, suggest a secondary maximum of prevailing wind from the northwest sector. This is most likely associated with post-cold-frontal wind during the optimum winter and early spring seasons of migratory low-pressure systems. A longer record of onsite wind conditions would most likely reveal this secondary maximum persisting continuously from late fall through early spring.

(2) Wind direction persistence - The wind direction persistence* analysis, based on data from the 33-foot tower,

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*Persistent wind is defined in this analysis as a continuous wind from one of the 22-1/2° sectors (e.g., north-northeast) except that the persistence is not considered to be interrupted if the wind departs from the sector for 1 hour and then returns, or if there are up to 2 hours of missing data followed by a continuation of the same directional persistence.

shown in Table 1.2-6, shows the persistence for periods 2 hours or more for the given wind directions. The four longest periods of persistence were 26, 21, 20, and 20 hours and are identified with south-southeast, north-northwest, north-northeast, and south-southwest winds, respectively. The analysis also shows that about 60 percent of the total persistence periods is equal to or greater than 3 hours, and about 3 percent is equal to or greater than 12 hours.

(3) Wind speed - The monthly and annual occurrences of wind speed at the 33-foot tower level for all wind directions are shown in Table 1.2-9 and in Tables A-1 through A-12. Calm conditions, i.e., wind speed less than 0.6 mi/h occur 3.18 percent of the time. The 0.6 to 3.4 mi/h wind has the greatest occurrence with 48.82 percent, and the 3.5 to 7.4 mi/h wind has the next greatest occurrence with 38.19 percent. The highest annual occurrence of the 0.6 to 3.5 mi/h wind with respect to direction are 8.47 percent (northeast) and 7.78 percent (north-northeast), respectively, and the highest occurrences of the 3.5 to 7.4 mi/h wind with respect to wind direction are 9.40 percent (southwest) and 6.88 percent (south-southwest). These predominant northeasterly-southwesterly winds again reflect the channeling effects of the local terrain. The preponderance of northeasterly winds with the 0.6 to 3.4 mi/h wind speed range is partly attributable to the associated light northeasterly (downvalley) wind in the fall when the stable anticyclonic circulation dominates the eastern Tennessee region. Also, the identification of the lowest wind speed range (calm and 0.6 to 3.4 mi/h) with stable anticyclonic flow is reflected in the high frequency of occurrence of this range in late summer and early fall (August, September, and October)--a period during

which stable anticyclonic conditions are most common. On the other hand, this lowest wind speed range occurs least often from midwinter through midspring (January, February, March, and April)--a period frequented by the passage of migratory low-pressure systems.

Moderate and high wind speed ranges (greater than 7.5 mi/h) occur only 9.81 percent of the time (Table 1.2-9). The highest annual occurrences of wind speeds greater than 7.5 mi/h with respect to direction are 2.31 and 2.08 percent and occur with southwest and south-southwest (upvalley) winds, respectively. These wind speed ranges occur least often with east-northeast, east, and east-southeast winds. The predominance of strong southwesterly winds may be attributable to the channeling of the southerly and southwesterly flow preceding the passage of cold fronts through the area. Winds greater than 7.5 mi/h occur most frequently from November through May, with a maximum of 18.51 percent in February; they occur least often from August through October.

(4) Temperature - A summary of the 1 year of onsite temperature data from the meteorological facility is shown in Table 1.2-2. The average annual temperature is 59.7°F with the annual monthly range from 40.1°F in February to 75.5°F in August. The extreme monthly maximum and minimum are 96.3°F and 2.9°F in June and January, respectively. Onsite temperature data compare reasonably well with the normal temperature records from the Chattanooga National Weather Service Office (Weather Bureau) for the 30-year period, 1931-60, shown in Table 1.2-1, although extremes of temperature from the 1 year of onsite data are somewhat conservative as compared to extremes for the 42-year period of record at Chattanooga.

(5) Atmospheric water vapor - The 1 year of onsite temperature and dew point data were used to compute mean and extreme values of absolute and relative humidity shown in Tables A-13 and A-14. The average annual absolute humidity is 9.7 $g/m^3$ with the annual monthly range from 16.2 $g/m^3$ in June to 4.2 $g/m^3$ in February. The extreme monthly maximum is 22.3 $g/m^3$ in June, and the extreme monthly minimum is 1 $g/m^3$ in February.

The average annual relative humidity is 66.5 percent with the annual monthly range from 50.6 percent in April to 78.4 percent in October and December. The extreme monthly maximum is 100 percent in March, June, September, November, and December, and the extreme monthly minimum is 17 percent in April.

(6) Precipitation - Precipitation patterns, based on a 20-year period (1948-67) of data collection at the TVA raingage station 685, 2.5 miles north-northeast of the plant site, are shown in Table 1.2-3. The data show that annually there are 117 days with 0.01 inch or more of precipitation. The average monthly precipitation is 4.81 inches, with the maximum 6.76 inches occurring in March and the minimum 2.86 inches occurring in October. The extreme monthly maximum and minimum are 16.58 inches in November and 0.09 inch in October, respectively.

Snowfall does not occur often in the Sequoyah site area. Chattanooga snowfall data in Table 1.2-4 are considered representative.[1] The average annual snowfall is 4.4 inches and occurs mostly in December through March. The maximum 24-hour snowfall reported was 8.9 inches in December 1963; the next highest was 8.7 inches in February 1960.

(7) Fog - No observations of the frequency and intensity of fogs have been made in the site area. However, National Weather Service (Weather Bureau Office) records[1] (Table 1.2-5) indicate that heavy fogs (visibility $\leq$ 1/4 mile) occur on 36 days annually with a maximum monthly frequency of 6 days in October and a minimum monthly frequency of 2 days from February through July.

(8) Atmospheric stability - One year (April 2, 1971, through March 31, 1972) of onsite temperature data collected from the 33- and 300-foot tower levels of the permanent meteorological facility were categorized into seven atmospheric stability groups (Pasquill classes A through G). Table A-15 shows that the Pasquill stability classes E, F, and G occur about 64 percent of the time. The most critical class, G, occurs 5.9 percent of the time, class F occurs 15.45 percent of the time, and class E, 42.24 percent of the time. The total occurrence of the least stable classes, A, B, and C, is about 3 percent of the time, while the neutral stability class, D, occurs 33.33 percent of the time.

Joint percent occurrences of wind speed for all wind directions for the Pasquill stability classes A through G are summarized in Tables A-16 through A-22. The most critical condition, class G, 0.6 to 3.5 (Table A-22), occurs 4.9 percent of the time, with class G, calm conditions, an additional 0.67 percent of the time. Stability category G is most often associated with north-northeast and northeast (downvalley) winds (1.77 percent of the total annual record) and slightly less often (1.57 percent of the total annual record) with

southwest and south-southwest (upvalley) winds. Annual frequencies for classes E and F (Tables A-20 and A-21) show respective frequencies for the 0.6 to 3.4 mi/h range and calm conditions of 22.0 and 1.07 percent and 11.93 and 1.18 percent.

## References for Appendix A


1. "Local Climatological Data with Comparative Data," 1972, Chattanooga, Tennessee, U.S. Department of Commerce; NOAA, EDS.

2. "Tornado Occurrences in Tennessee, 1916-1964," John V. Vaiksnoras, State Climatologist, U.S. Department of Commerce, Weather Bureau, Nashville, Tennessee, May 5, 1965.

3. "Tornado Probabilities," H.C.S. Thom, Monthly Weather Review, October-December 1963.

4. Communication with John Vaiksnoras, State Climatologist for Tennessee, Nashville, Tennessee, August 3, 1972, by TVA staff personnel.

5. Tornadoes of the United States, Snowden D. Flora, University of Alabama, November 1963.

6. "Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States," George C. Holtzworth, Division of Meteorology, Environmental Protection Agency, Preliminary Document, May 10, 1971.

7. Precipitation in the Tennessee River Basin, Tennessee Valley Authority, Division of Water Control Planning, Hydraulic Data Branch, period of record 35 years (1935-69).

Table A-1

PERCENT OCCURRENCE OF WIND SPEED*

FOR ALL WIND DIRECTIONS

Sequoyah Nuclear Plant

April 1971

| Wind Direction | Wind Speed (mph) 0.6-3.4 | 3.5-7.4 | 7.5-12.4 | 12.5-18.4 | 18.5-24.4 | ≥ 24.5 | Total |
|---|---|---|---|---|---|---|---|
| N | 1.63 | 1.93 | 0.45 | | | | 4.01 |
| NNE | 4.30 | 5.04 | 2.08 | | | | 11.42 |
| NE | 6.23 | 3.41 | 2.67 | | | | 12.31 |
| ENE | 2.67 | 0.15 | | | | | 2.82 |
| E | 0.45 | | | | | | 0.45 |
| ESE | 0.30 | 0.15 | | | | | 0.45 |
| SE | 0.45 | | | | | | 0.45 |
| SSE | 0.45 | 0.15 | | | | | 0.59 |
| S | 1.78 | 2.67 | 0.74 | | | | 5.19 |
| SSW | 3.26 | 6.38 | 3.71 | | | | 13.35 |
| SW | 4.15 | 12.61 | 12.46 | 0.59 | 0.15 | | 29.97 |
| WSW | 2.67 | 3.71 | 2.52 | 0.74 | 0.45 | | 10.09 |
| W | 0.45 | 0.15 | 0.59 | 0.45 | | | 1.63 |
| WNW | 0.59 | 0.74 | 1.34 | | | | 2.67 |
| NW | 0.45 | 0.30 | 0.89 | | | | 1.63 |
| NNW | 0.15 | 0.89 | 1.78 | | | | 2.82 |
| Total | 29.97 | 38.28 | 29.23 | 1.78 | 0.59 | | 99.85 |

Calm = 0.15

Lost Record = 6.39

*Wind Instrument 33 feet above ground.
Note: Total of all columns and calm (good observations) is 100 percent.

Table A-2

PERCENT OCCURRENCE OF WIND SPEED*

FOR ALL WIND DIRECTIONS

Sequoyah Nuclear Plant

May 1971

| Wind Direction | Wind Speed (mph) 0.6-3.4 | 3.5-7.4 | 7.5-12.4 | 12.5-18.4 | 18.5-24.4 | ≥24.5 | Total |
|---|---|---|---|---|---|---|---|
| N | 3.46 | 2.35 | 0.42 | | | | 6.23 |
| NNE | 7.34 | 5.12 | 0.83 | | | | 13.30 |
| NE | 6.65 | 5.26 | 0.55 | | | | 12.47 |
| ENE | 1.94 | 0.28 | | | | | 2.22 |
| E | 1.11 | | | | | | 1.11 |
| ESE | 0.69 | 0.14 | | | | | 0.83 |
| SE | 0.97 | 0.55 | | | | | 1.52 |
| SSE | 1.80 | 0.69 | 0.14 | | | | 2.63 |
| S | 3.32 | 2.49 | 0.97 | 0.55 | | | 7.34 |
| SSW | 5.26 | 8.59 | 3.32 | 0.42 | | | 17.59 |
| SW | 3.19 | 10.66 | 3.32 | 0.14 | | | 17.31 |
| WSW | 1.11 | 0.55 | 0.14 | | | | 1.80 |
| W | 0.14 | 0.14 | 0.28 | 0.14 | | | 0.69 |
| WNW | 0.69 | 0.55 | 0.28 | | | | 1.52 |
| NW | 0.83 | 1.80 | 1.11 | | | | 3.74 |
| NNW | 2.35 | 4.57 | 2.35 | 0.14 | | | 9.42 |
| Total | 40.86 | 43.77 | 13.71 | 1.39 | | | 99.72 |

Calm = 0.28

Lost Record = 2.96

*Wind Instrument 33 feet above ground.
Note: Total of all columns and calm (good observations) is 100 percent.

Table A-3

PERCENT OCCURRENCE OF WIND SPEED*

FOR ALL WIND DIRECTIONS

Sequoyah Nuclear Plant

June 1971

| Wind Direction | Wind Speed (mph) 0.6-3.4 | 3.5-7.4 | 7.5-12.4 | 12.5-18.4 | 18.5-24.4 | ≥24.5 | Total |
|---|---|---|---|---|---|---|---|
| N | 3.86 | 1.34 | 0.15 | | | | 5.34 |
| NNE | 7.72 | 2.82 | | | | | 10.53 |
| NE | 11.42 | 2.97 | | | | | 14.39 |
| ENE | 1.19 | 0.45 | | | | | 1.63 |
| E | 0.89 | | | | | | 0.89 |
| ESE | 0.15 | | | | | | 0.15 |
| SE | 1.34 | 0.74 | 0.15 | | | | 2.23 |
| SSE | 1.34 | 0.30 | 0.15 | | | | 1.78 |
| S | 4.15 | 2.08 | | | | | 6.23 |
| SSW | 6.97 | 10.24 | 0.30 | | | | 17.51 |
| SW | 6.08 | 11.57 | 1.34 | | | | 18.99 |
| WSW | 3.12 | 2.97 | 0.59 | | | | 6.68 |
| W | 1.78 | 0.74 | 0.15 | | | | 2.67 |
| WNW | 2.52 | 1.19 | | | | | 3.71 |
| NW | 1.19 | 0.59 | 0.30 | | | | 2.08 |
| NNW | 3.71 | 1.19 | | | | | 4.90 |
| Total | 57.42 | 39.17 | 3.12 | | | | 100.00 |

Calm = 0.30

Lost Record = 6.39

*Wind Instrument 33 feet above ground.
Note: Total of all columns and calm (good observations) is 100 percent.

Table A-4

PERCENT OCCURRENCE OF WIND SPEED*

FOR ALL WIND DIRECTIONS

Sequoyah Nuclear Plant

July 1971

| Wind Direction | Wind Speed (mph) 0.6-3.4 | 3.5-7.4 | 7.5-12.4 | 12.5-18.4 | 18.5-24.4 | ≥24.5 | Total |
|---|---|---|---|---|---|---|---|
| N | 3.02 | 0.71 | | | | | 3.73 |
| NNE | 6.22 | 1.60 | | | | | 7.82 |
| NE | 4.80 | 2.49 | | | | | 7.28 |
| ENE | 1.42 | | | | | | 1.42 |
| E | 0.53 | | | | | | 0.53 |
| ESE | 0.71 | 0.53 | | | | | 1.24 |
| SE | 0.89 | 0.18 | | | | | 1.07 |
| SSE | 3.02 | 0.36 | | | | | 3.37 |
| S | 5.33 | 6.57 | 0.36 | | | | 12.26 |
| SSW | 6.57 | 16.16 | 1.07 | | | | 23.80 |
| SW | 4.44 | 10.12 | 1.78 | | | | 16.34 |
| WSW | 1.95 | 2.31 | 1.07 | | | | 5.33 |
| W | 0.71 | 0.36 | | | | | 1.07 |
| WNW | 1.24 | 0.18 | | | | | 1.42 |
| NW | 1.78 | 1.42 | | | | | 3.20 |
| NNW | 6.22 | 1.95 | | | | | 8.17 |
| Total | 48.85 | 44.94 | 4.26 | | | | 98.05 |

Calm = 1.95

Lost Record = 24.33

*Wind Instrument 33 feet above ground.
Note: Total of all columns and calm (good observations) is 100 percent.

Table A-5

PERCENT OCCURRENCE OF WIND SPEED*

FOR ALL WIND DIRECTIONS

Sequoyah Nuclear Plant

August 1971

| Wind Direction | Wind Speed (mph) 0.6-3.4 | 3.5-7.4 | 7.5-12.4 | 12.5-18.4 | 18.5-24.4 | ≥24.5 | Total |
|---|---|---|---|---|---|---|---|
| N | 9.79 | 4.00 | | | | | 13.79 |
| NNE | 7.72 | 4.28 | | | | | 12.00 |
| NE | 4.14 | 0.41 | | | | | 4.55 |
| ENE | 0.83 | | | | | | 0.83 |
| E | 0.55 | | | | | | 0.55 |
| ESE | 0.41 | | | | | | 0.41 |
| SE | 1.93 | 0.14 | | | | | 2.07 |
| SSE | 1.93 | 0.97 | | | | | 2.90 |
| S | 4.41 | 2.34 | | | | | 6.76 |
| SSW | 6.48 | 5.24 | 0.97 | | | | 12.69 |
| SW | 3.86 | 6.62 | 0.97 | | | | 11.45 |
| WSW | 1.38 | 0.28 | | | | | 1.66 |
| W | 0.83 | 0.28 | | | | | 1.10 |
| WNW | 1.93 | 0.28 | | | | | 2.21 |
| NW | 3.31 | 0.55 | | | | | 3.86 |
| NNW | 12.97 | 4.14 | | | | | 17.10 |
| Total | 62.48 | 29.52 | 1.93 | | | | 93.93 |

Calm = 6.07

Lost Record = 2.55

*Wind instrument 33 feet above ground.
Note: Total of all columns and calm (good observations) is 100 percent.

Table A-6

PERCENT OCCURRENCE OF WIND SPEEDS*

FOR ALL WIND DIRECTIONS

Sequoyah Nuclear Plant

September 1971

| Wind Direction | Wind Speed (mph) 0.6-3.4 | 3.5-7.4 | 7.5-12.4 | 12.5-18.4 | 18.5-24.4 | ≥24.5 | Total |
|---|---|---|---|---|---|---|---|
| N | 7.16 | 4.06 | | | | | 11.22 |
| NNE | 6.38 | 3.87 | | | | | 10.25 |
| NE | 6.00 | 0.39 | | | | | 6.38 |
| ENE | 1.93 | 0.77 | | | | | 2.71 |
| E | 1.35 | | | | | | 1.35 |
| ESE | 1.35 | 0.19 | | | | | 1.55 |
| SE | 2.90 | 0.19 | | | | | 3.09 |
| SSE | 2.71 | 0.58 | | | | | 3.29 |
| S | 3.87 | 3.87 | 0.19 | | | | 7.93 |
| SSW | 4.45 | 6.96 | 0.39 | | | | 11.80 |
| SW | 2.51 | 4.45 | | | | | 6.96 |
| WSW | 1.35 | 0.19 | | | | | 1.55 |
| W | 0.77 | 0.77 | 0.39 | | | | 1.93 |
| WNW | 1.35 | 1.35 | 0.77 | | | | 3.48 |
| NW | 3.09 | 1.16 | 1.35 | | | | 5.61 |
| NNW | 10.44 | 3.87 | 0.19 | | | | 14.51 |
| Total | 57.64 | 32.69 | 3.29 | | | | 93.62 |

Calm = 6.38

Lost Record = 28.19

*Wind Instrument 33 feet above ground.
Note: Total of all columns and calm (good ovservations) is 100 percent.

Table A-7

PERCENT OCCURRENCE OF WIND SPEED*

FOR ALL WIND DIRECTIONS

Sequoyah Nuclear Plant

October 1971

| Wind Direction | Wind Speed (mph) 0.6-3.4 | 3.5-7.4 | 7.5-12.4 | 12.5-18.4 | 18.5-24.4 | ≥24.5 | Total |
|---|---|---|---|---|---|---|---|
| N | 5.34 | 1.40 | 0.42 | | | | 7.16 |
| NNE | 15.45 | 4.49 | 0.14 | | | 0.14 | 20.22 |
| NE | 16.01 | 4.49 | | 0.28 | | | 20.79 |
| ENE | 3.23 | 0 70 | | | | | 3.93 |
| E | 0.28 | 0.28 | | | | | 0.56 |
| ESE | 0.84 | | | | | | 0.84 |
| SE | 0.42 | | | | | | 0.42 |
| SSE | 1.40 | | | | | | 1.40 |
| S | 2.95 | 0.28 | | | | | 3.23 |
| SSW | 5.20 | 1.83 | 0.28 | | | | 7.30 |
| SW | 3.93 | 5.06 | 0.14 | | | | 9.13 |
| WSW | 3.37 | 1.97 | 0.14 | | | | 5.48 |
| W | 2.25 | 0.28 | | | | | 2.53 |
| WNW | 0.56 | 0.28 | | | | | 0.84 |
| NW | 0.98 | 0.84 | | | | | 1.83 |
| NNW | 3.79 | 2.53 | 0.98 | | | | 7.30 |
| Total | 66.01 | 24.44 | 2.11 | 0.28 | | 0.14 | 92.97 |

Calm = 7.03

Lost Record = 4.30

*Wind Instrument 33 feet above ground.
Note: Total of all columns and calm (good observations) is 100 percent.

Table A-8

PERCENT OCCURRENCE OF WIND SPEED*

FOR ALL WIND DIRECTIONS

Sequoyah Nuclear Plant

November 1971

| Wind Direction | Wind Speed (mph) 0.6-3.4 | 3.5-7.4 | 7.5-12.4 | 12.5-18.4 | 18.5-24.4 | ≥24.5 | Total |
|---|---|---|---|---|---|---|---|
| N | 1.83 | 1.67 | | | | | 3.50 |
| NNE | 5.50 | 4.50 | 1.17 | | | | 11.17 |
| NE | 9.33 | 8.33 | 1.00 | | | | 18.67 |
| ENE | 1.17 | 0.33 | | | | | 1.50 |
| E | 0.50 | | | | | | 0.50 |
| ESE | 0.50 | | | | | | 0.50 |
| SE | 1.00 | | | | | | 1.00 |
| SSE | 0.67 | 0.33 | | | | | 1.00 |
| S | 3.00 | 3.67 | 0.83 | | | | 7.50 |
| SSW | 3.50 | 11.50 | 1.67 | | | | 16.67 |
| SW | 5.33 | 9.50 | 1.67 | | | | 16.50 |
| WSW | 2.00 | 1.00 | 0.0 | | | | 3.00 |
| W | 1.50 | 0.33 | | | | | 1.83 |
| WNW | 1.00 | 0.67 | 0.17 | | | | 1.83 |
| NW | 0.83 | 2.17 | 0.50 | 0.17 | | | 3.67 |
| NNW | 2.50 | 3.50 | 2.83 | 0.33 | | | 9.17 |
| Total | 40.17 | 47.50 | 9.83 | 0.50 | | | 98.00 |

Calm = 2.00

Lost Record = 16.67

*Wind Instrument 33 feet above ground.
Note: Total of all columns and calm (good observations) is 100 percent.

Table A-9

PERCENT OCCURRENCE OF WIND SPEED*

FOR ALL WIND DIRECTIONS

Sequoyah Nuclear Plant

December 1971

| Wind Direction | Wind Speed (mph) 0.6-3.4 | 3.5-7.4 | 7.5-12.4 | 12.5-18.4 | 18.5-24.4 | ≥24.5 | Total |
|---|---|---|---|---|---|---|---|
| N | 1.55 | 0.77 | 0.15 | | | | 2.48 |
| NNE | 7.12 | 4.95 | 1.08 | | | | 13.16 |
| NE | 7.59 | 10.84 | 0.31 | | | | 18.73 |
| ENE | 0.77 | | | | | | 0.77 |
| E | 0.93 | | | | | | 0.93 |
| ESE | 0.62 | | | | | | 0.62 |
| SE | 0.93 | | | | | | 0.93 |
| SSE | 0.93 | | | | | | 0.93 |
| S | 3.41 | 0.93 | 2.17 | | | | 6.50 |
| SSW | 6.97 | 8.36 | 4.33 | 0.62 | | | 20.28 |
| SW | 9.44 | 9.60 | 3.25 | | | | 22.29 |
| WSW | 2.17 | 1.08 | 0.15 | | | | 3.41 |
| W | 0.62 | 0.62 | | | | | 1.24 |
| WNW | 0.93 | 0.93 | | | | | 1.86 |
| NW | 0.46 | 0.31 | 0.15 | | | | 0.93 |
| NNW | 1.70 | 1.08 | 0.46 | | | | 3.25 |
| Total | 46.13 | 39.47 | 12.07 | 0.62 | | | 98.30 |

Calm = 1.70

Lost Record = 13.17

*Wind Instrument 33 feet above ground.
Note: Total of all columns and calm (good observations) is 100 percent.

Table A-10

PERCENT OCCURRENCE OF WIND SPEED*

FOR ALL WIND DIRECTIONS

Sequoyah Nuclear Plant

January 1972

| Wind Direction | Wind Speed (mph) 0.6-3.4 | 3.5-7.4 | 7.5-12.4 | 12.5-18.4 | 18.5-24.4 | >24.5 | Total |
|---|---|---|---|---|---|---|---|
| N | 3.00 | 1.95 | 0.60 | | | | 5.56 |
| NN | 6.16 | 5.86 | 1.20 | | | | 13.21 |
| NE | 6.31 | 2.70 | 0.90 | | | | 9.91 |
| ENE | 1.65 | 0.30 | | | | | 1.95 |
| E | 0.75 | | | | | | 0.75 |
| ESE | 0.30 | | | | | | 0.30 |
| SE | 0.90 | | | | | | 0.90 |
| SSE | 0.90 | 0.45 | | | | | 1.35 |
| S | 2.55 | 2.25 | 0.45 | | | | 5.26 |
| SSW | 2.40 | 6.31 | 3.75 | 0.45 | | | 12.91 |
| SW | 6.01 | 13.81 | 3.00 | 0.45 | | | 23.27 |
| WSW | 3.45 | 3.15 | 0.30 | | | | 6.91 |
| W | 0.60 | 1.50 | 0.45 | | | | 2.55 |
| WNW | 0.45 | 0.90 | 0.15 | | | | 1.50 |
| NW | 0.90 | 1.35 | 0.45 | | | | 2.70 |
| NNW | 3.60 | 3.00 | 3.90 | 0.15 | | | 10.66 |
| Total | 39.94 | 43.54 | 15.17 | 1.05 | | | 99.70 |

Calm = 0.30

Lost Record = 10.48

*Wind Instrument 33 feet above ground.
Note: Total of all columns and calm (good observations) is 100 percent.

Table A-11

PERCENT OCCURRENCE OF WIND SPEED*

FOR ALL WIND DIRECTIONS

Sequoyah Nuclear Plant

February 1972

| Wind Direction | Wind Speed (mph) 0.6-3.4 | 3.5-7.4 | 7.5-12.4 | 12.5-18.4 | 18.5-24.4 | ≥24.5 | Total |
|---|---|---|---|---|---|---|---|
| N | 1.79 | 1.64 | 0.60 | | | | 4.03 |
| NNE | 7.16 | 7.31 | 0.75 | | | | 15.22 |
| NE | 10.45 | 5.97 | 0.60 | | | | 17.01 |
| ENE | 3.28 | 0.30 | | | | | 3.58 |
| E | 1.49 | | | | | | 1.49 |
| ESE | 0.45 | | | | | | 0.45 |
| SE | 0.60 | | | | | | 0.60 |
| SSE | 0.30 | | | | | | 0.30 |
| S | 1.49 | 0.90 | | | | | 2.39 |
| SSW | 2.69 | 2.99 | 1.64 | | | | 7.31 |
| SW | 4.18 | 12.39 | 5.07 | | | | 21.64 |
| WSW | 3.28 | 5.07 | 0.60 | | | | 8.96 |
| W | 0.75 | 1.04 | 0.60 | | | | 2.39 |
| WNW | 0.90 | 1.34 | 2.24 | | | | 4.48 |
| NW | | 1.04 | 3.58 | 0.45 | | | 5.07 |
| NNW | 1.64 | 1.04 | 0.94 | 0.45 | | | 5.07 |
| Total | 40.45 | 41.04 | 17.61 | 0.90 | | | 100.00 |

Calm = 0

Lost Record = 3.74

*Wind Instrument 33 feet above ground.
Note: Total of all columns and calm (good observations) is 100 percent.

Table A-12

PERCENT OCCURRENCE OF WIND SPEED*

FOR ALL WIND DIRECTIONS

Sequoyah Nuclear Plant

March 1972

| Wind Direction | Wind Speed (mph) 0.6-3.4 | 3.5-7.4 | 7.5-12.4 | 12.5-18.4 | 18.5-24.4 | >24.5 | Total |
|---|---|---|---|---|---|---|---|
| N | 2.05 | 2.49 | 0.44 | | | | 4.98 |
| NNE | 7.91 | 4.98 | | | | | 12.88 |
| NE | 6.88 | 4.98 | 0.59 | | | | 12.45 |
| ENE | 3.81 | 0.73 | | | | | 4.54 |
| E | 1.32 | | | | | | 1.32 |
| ESE | | | | | | | |
| SE | 0.29 | 0.29 | | | | | 0.59 |
| SSE | 0.88 | 0.29 | | | | | 1.17 |
| S | 1.32 | 1.32 | 1.02 | 0.15 | | | 3.81 |
| SSW | 4.25 | 4.39 | 2.64 | 0.15 | | | 11.42 |
| SW | 3.51 | 12.01 | 2.93 | 0.15 | | | 18.59 |
| WSW | 1.61 | 2.78 | 1.35 | | | | 5.71 |
| W | 0.73 | 1.02 | 1.17 | | | | 2.93 |
| WNW | 0.29 | 1.17 | 1.90 | 0.15 | | | 3.51 |
| NW | 1.32 | 1.61 | 3.51 | 0.15 | | | 6.59 |
| NNW | 2.34 | 5.86 | 1.17 | 0.15 | | | 9.52 |
| Total | 38.51 | 43.92 | 16.69 | 0.88 | | | 100.00 |

Calm = 0

Lost Record = 8.20

*Wind Instrument 33 feet above ground.
note: Total of all columns and calm (good observations) is 100 percent.

Table A-13

ABSOLUTE HUMIDITY*

Sequoyah Nuclear Plant

April 2, 1971-March 31, 1972

| Month | Avg. A.H. $g/m^3$ | Avg. Max. A.H. $g/m^3$ | Avg. Min. A.H. $g/m^3$ | Extreme Max. A.H. $g/m^3$ | Extreme Min. A.H. $g/m^3$ |
|---|---|---|---|---|---|
| Dec. | 7.6 | 9.3 | 6.0 | 15.0 | 1.2 |
| Jan. | 5.4 | 7.1 | 3.8 | 15.4 | 1.1 |
| Feb. | 4.2 | 5.2 | 2.7 | 12.2 | 1.0 |
| Winter | 5.7 | 7.2 | 4.2 | 15.8 | 1.0 |
| Mar. | 5.9 | 8.0 | 4.3 | 12.7 | 1.5 |
| Apr. | 6.3 | 7.8 | 5.0 | 12.2 | 2.7 |
| May | 9.6 | 11.7 | 7.8 | 17.3 | 3.3 |
| Spring | 7.3 | 9.2 | 5.7 | 17.3 | 1.5 |
| June | 16.2 | 18.7 | 14.2 | 22.3 | 9.9 |
| July | 14.1 | 15.8 | 12.6 | 18.5 | 10.0 |
| Aug. | 13.9 | 15.9 | 12.2 | 19.6 | 8.7 |
| Summer | 14.7 | 16.8 | 13.0 | 22.3 | 8.7 |
| Sept. | 14.6 | 17.2 | 12.0 | 21.8 | 8.0 |
| Oct. | 12.4 | 14.7 | 10.3 | 19.6 | 5.6 |
| Nov. | 6.4 | 8.4 | 5.2 | 18.2 | 2.1 |
| Fall | 11.1 | 13.4 | 9.2 | 21.8 | 2.1 |
| Annual | 9.7 | 11.7 | 8.0 | 22.3 | 1.0 |

*Computed from dry bulb and dew point temperature measurements 4 feet above ground.

Table A-14

RELATIVE HUMIDITY*

Sequoyah Nuclear Plant

April 2, 1971-March 31, 1972

| Month | Avg. a.H. g/m3 | Avg. Max. A.H. g/m3 | Avg. Min. A.H. g/m3 | Extreme Max.A.H. g/m3 | Extreme Min. A.H. g/m3 |
|---|---|---|---|---|---|
| Dec. | 78.4 | 89.6 | 62.6 | 100.0 | 34.8 |
| Jan. | 65.0 | 79.9 | 50.1 | 93.9 | 22.5 |
| Feb. | 59.8 | 74.2 | 43.5 | 95.3 | 22.1 |
| Winter | 67.7 | 81.2 | 52.1 | 100.0 | 22.1 |
| Mar. | 63.8 | 83.4 | 43.4 | 100.0 | 21.9 |
| Apr. | 50.6 | 75.8 | 26.8 | 86.6 | 17.0 |
| May | 62.2 | 82.5 | 40.9 | 95.1 | 18.4 |
| Spring | 58.9 | 80.5 | 37.0 | 100.0 | 17.0 |
| June | 74.4 | 90.1 | 51.3 | 100.0 | 34.5 |
| July | 64.3 | 73.7 | 51.6 | 78.8 | 37.2 |
| Aug. | 63.3 | 72.7 | 47.2 | 85.3 | 33.8 |
| Summer | 67.3 | 78.8 | 50.0 | 100.0 | 33.8 |
| Sept. | 73.1 | 84.0 | 53.2 | 100.0 | 32.1 |
| Oct. | 78.4 | 89.0 | 61.7 | 99.3 | 37.8 |
| Nov. | 65.3 | 79.6 | 50.4 | 100.0 | 28.0 |
| Fall | 72.2 | 84.2 | 55.1 | 100.0 | 28.0 |
| Annual | 66.5 | 81.2 | 48.6 | 100.0 | 17.0 |

*Computed from dry bulb and dew point temperature measurements 4 feet above ground.

Table A-15

PERCENT OCCURRENCE OF ATMOSPHERIC STABILITY*

Sequoyah Nuclear Plant

April 2, 1971-March 31, 1972

| Pasquill Stability Class | Vertical Temperature Difference | Percent Occurrence |
|---|---|---|
| A | $\Delta T \leq -1.9^{\circ}$ C/100 m | 0.60 |
| B | $-1.9 < \Delta T \leq -1.7^{\circ}$ C/100 m | 0.57 |
| C | $-1.7 < \Delta T \leq -1.5^{\circ}$ C/100 m | 1.67 |
| D | $-1.5 < \Delta T \leq -0.5^{\circ}$ C/100 m | 33.33 |
| E | $-0.5 < \Delta T \leq 1.5^{\circ}$ C/100 m | 42.24 |
| F | $1.5 < \Delta T \leq 4.0^{\circ}$ C/100 m | 15.45 |
| G | $\Delta T > 4^{\circ}$ C/100 m | 5.90 |
| Total | | 100.00 |

*Temperature instruments 33 and 300 feet above ground.

Table A-16

PERCENT OCCURENCE OF WIND SPEED*

FOR ALL WIND DIRECTIONS

STABILITY CATEGORY A

Sequoyah Nuclear Plant

April 2, 1971-March 31, 1972

Wind Speed (mph)

| Wind Direction | 0.6-3.4 | 3.5-7.4 | 7.5-12.4 | 12.5-18.4 | 18.5-24.4 | ≥24.5 | Total |
|---|---|---|---|---|---|---|---|
| N | 0.04 | | | | | | 0.04 |
| NNE | 0.04 | 0.02 | | | | | 0.06 |
| NE | 0.05 | 0.04 | | | | | 0.09 |
| ENE | | | | | | | |
| E | | | | | | | |
| ESE | | 0.01 | | | | | 0.01 |
| SE | | 0.01 | | | | | 0.01 |
| SSE | | | | | | | |
| S | 0.02 | 0.04 | | | | | 0.06 |
| SSW | | 0.01 | 0.04 | | | | 0.05 |
| SW | 0.01 | 0.10 | 0.02 | | | | 0.13 |
| WSW | | | | | | | |
| W | 0.01 | | | | | | 0.01 |
| WNW | | | 0.01 | | | | 0.01 |
| NW | 0.01 | | 0.04 | | | | 0.05 |
| NNW | 0.03 | | | | | | 0.03 |
| Total | 0.22 | 0.24 | 0.10 | | | | 0.60** |

Calm = 0.04

Lost Record = 0.01

*Temperature instruments 33 and 300 feet above ground.
Wind instrument 33 feet above ground.
**Total includes all columns and calm (good observation).

Table A-17

PERCENT OCCURRENCE OF WIND SPEED*

FOR ALL WIND DIRECTIONS

STABILITY CATEGORY B

SEQUOYAH NUCLEAR PLANT

April 2, 1971-March 31, 1972

| Wind Direction | Wind Speed (mph) 0.6-3.4 | 3.5-7.4 | 7.5-12.4 | 12.5-18.4 | 18.5-24.4 | ≥24.5 | Total |
|---|---|---|---|---|---|---|---|
| N | | 0.03 | 0.03 | | | | 0.05 |
| NNE | 0.01 | 0.03 | 0.01 | | | | 0.05 |
| NE | 0.06 | 0.09 | 0.01 | | | | 0.17 |
| ENE | | | | | | | |
| E | 0.01 | | | | | | 0.01 |
| ESE | | | | | | | |
| SE | | | | | | | |
| SSE | | | | | | | |
| S | | 0.01 | | | | | 0.01 |
| SSW | | 0.03 | 0.04 | | | | 0.06 |
| SW | 0.01 | 0.09 | 0.03 | | | | 0.13 |
| WSW | | 0.03 | | | | | 0.03 |
| W | | | | | | | |
| WNW | | | | | | | |
| NW | | | 0.04 | | | | 0.04 |
| NNW | 0.01 | | | 0.01 | | | 0.03 |
| Total | 0.11 | 0.29 | 0.15 | 0.01 | | | 0.57** |

Calm = 0

Lost Record = 0.02

*Temperature instruments 33 and 300 feet above ground.
Wind instrument 33 feet above ground.
**Total includes all columns and calm (good observations).

Table A-18

PERCENT OCCURRENCE OF WIND SPEED*

FOR ALL WIND DIRECTIONS

STABILITY CATEGORY C

Sequoyah Nuclear Plant

April 2, 1971-March 31, 1972

| Wind Direction | Wind Speed (mph) 0.6-3.4 | 3.5-7.4 | 7.5-12.4 | 12.5-18.4 | 18.5-24.4 | ≥24.5 | Total |
|---|---|---|---|---|---|---|---|
| N | 0.01 | 0.04 | 0.03 | | | | 0.08 |
| NNE | 0.05 | 0.13 | 0.04 | | | | 0.22 |
| NE | 0.10 | 0.23 | 0.03 | | | | 0.36 |
| ENE | 0.01 | 0.01 | | | | | 0.03 |
| E | | 0.01 | | | | | 0.01 |
| ESE | | | | | | | |
| SE | 0.01 | 0.03 | | | | | 0.04 |
| SSE | | 0.01 | | | | | 0.01 |
| S | 0.01 | 0.04 | | | | | 0.05 |
| SSW | 0.03 | 0.10 | 0.11 | | | | 0.24 |
| SW | 0.01 | 0.17 | 0.05 | | | | 0.23 |
| WSW | | 0.04 | 0.03 | | | | 0.06 |
| W | | 0.01 | 0.03 | | | | 0.04 |
| WNW | | | | | | | |
| NW | | 0.03 | 0.04 | 0.01 | | | 0.08 |
| NNW | | 0.03 | 0.15 | 0.03 | | | 0.20 |
| Total | 0.24 | 0.87 | 0.50 | 0.04 | | | 1.67** |

Calm = 0.03

Lost Record = 0.03

*Temperature instruments 33 and 300 feet above ground.
Wind instrument 33 feet above ground.
**Total includes all columns and calm (good observations).

Table A-19

PERCENT OCCURRENCE OF WIND SPEED*

FOR ALL WIND DIRECTIONS

STABILITY CATEGORY D

Sequoyah Nuclear Plant

April 2, 1971-March 31, 1972

| Wind Direction | Wind Speed (mph) 0.6-3.4 | 3.5-7.4 | 7.5-12.4 | 12.5-18.4 | 18.5-24.4 | ≥24.5 | Total |
|---|---|---|---|---|---|---|---|
| N | 0.52 | 1.11 | 0.21 | | | | 1.84 |
| NNE | 1.32 | 2.00 | 0.41 | | | 0.01 | 4.74 |
| NE | 2.57 | 3.14 | 0.31 | 0.03 | | | 6.05 |
| ENE | 0.34 | 0.26 | | | | | 0.59 |
| E | 0.12 | 0.03 | | | | | 0.14 |
| ESE | 0.10 | 0.03 | | | | | 0.13 |
| SE | 0.23 | 0.13 | | | | | 0.36 |
| SSE | 0.34 | 0.14 | 0.01 | | | | 0.49 |
| S | 0.49 | 0.75 | 0.18 | 0.04 | | | 1.46 |
| SSW | 0.83 | 3.04 | 0.92 | 0.09 | | | 4.87 |
| SW | 0.93 | 3.50 | 1.07 | 0.08 | | | 5.58 |
| WSW | 0.28 | 0.84 | 0.25 | | | | 1.37 |
| W | 0.14 | 0.45 | 0.18 | 0.01 | | | 0.79 |
| WNW | 0.10 | 0.35 | 0.41 | 0.01 | | | 0.88 |
| NW | 0.28 | 0.43 | 0.63 | 0.04 | | | 1.38 |
| NNW | 0.54 | 1.12 | 0.76 | 0.05 | | | 2.48 |
| Total | 9.14 | 18.31 | 5.35 | 0.35 | | 0.01 | 33.33** |

Calm = 0.17

Lost Record = 1.32

*Temperature instruments 33 and 300 feet above ground.
Wind instrument 33 feet above ground.
**Total includes all columns and calm (good observations).

Table A-20

PERCENT OCCURRENCE OF WIND SPEED*

FOR ALL WIND DIRECTIONS

STABILITY CATEGORY E

Sequoyah Nuclear Plant

April 2, 1971-March 31, 1972

| Wind Direction | Wind Speed (mph) 0.6-3.4 | 3.5-7.4 | 7.5-12.4 | 12.5-18.4 | 18.5-24.4 | ≥24.5 | Total |
|---|---|---|---|---|---|---|---|
| N | 1.74 | 0.71 | 0.04 | | | | 2.49 |
| NNE | 3.10 | 1.47 | 0.04 | | | | 4.61 |
| NE | 2.47 | 0.69 | | | | | 3.15 |
| ENE | 0.45 | 0.09 | | | | | 0.54 |
| E | 0.34 | | | | | | 0.34 |
| ESE | 0.23 | 0.01 | | | | | 0.25 |
| SE | 0.44 | 0.03 | | | | | 0.47 |
| SSE | 0.65 | 0.18 | 0.01 | | | | 0.84 |
| S | 1.64 | 1.23 | 0.34 | 0.03 | | | 3.23 |
| SSW | 2.29 | 3.39 | 0.84 | 0.05 | | | 6.57 |
| SW | 2.26 | 4.19 | 1.01 | 0.05 | | | 7.51 |
| WSW | 1.41 | 0.81 | 0.14 | | | | 2.37 |
| W | 0.67 | 0.28 | 0.06 | | | | 1.02 |
| WNW | 0.71 | 0.49 | 0.10 | | | | 1.31 |
| NW | 0.88 | 0.65 | 0.21 | 0.01 | | | 1.74 |
| NNW | 2.71 | 1.65 | 0.35 | 0.01 | | | 4.73 |
| Total | 22.00 | 15.87 | 3.14 | 0.16 | | | 42.24** |

Calm = 1.07

Lost Record = 0.97

*Temperature instruments 33 and 300 feet above ground.
Wind instrument 33 feet above ground.
**Total includes all columns and calm (good observations).

Table A-21

PERCENT OCCURRENCE OF WIND SPEED*

FOR ALL WIND DIRECTIONS

STABILITY CATEGORY F

Sequoyah Nuclear Plant

April 2, 1971-March 31, 1972

| Wind Direction | Wind Speed (mph) 0.6-3.4 | 3.5-7.4 | 7.5-12.4 | 12.5-18.4 | 18.5-24.4 | ≥24.5 | Total |
|---|---|---|---|---|---|---|---|
| N | 1.14 | 0.11 | | | | | 1.26 |
| NNE | 2.54 | 0.06 | | | | | 2.60 |
| NE | 2.05 | 0.03 | | | | | 2.10 |
| ENE | 0.61 | 0.01 | | | | | 0.62 |
| E | 0.18 | | | | | | 0.18 |
| ESE | 0.13 | 0.01 | | | | | 0.14 |
| SE | 0.25 | | | | | | 0.25 |
| SSE | 0.31 | | | | | | 0.31 |
| S | 0.68 | 0.10 | | | | | 0.78 |
| SSW | 1.26 | 0.33 | | | | | 1.59 |
| SW | 1.07 | 1.08 | 0.04 | | | | 2.19 |
| WSW | 0.31 | 0.18 | | | | | 0.48 |
| W | 0.15 | 0.05 | | | | | 0.20 |
| WNW | 0.18 | 0.06 | | | | | 0.24 |
| NW | 0.11 | 0.06 | 0.01 | | | | 0.19 |
| NNW | 0.96 | 0.17 | | | | | 1.12 |
| Total | 11.93 | 2.27 | 0.05 | | | | 15.45** |

Calm = 1.18

Lost Record = 0.01

*Temperature instruments 33 and 300 feet above ground.
Wind instrument 33 feet above ground.
**Total includes all columns and calm (good observations).

Table A-22

PERCENT OCCURRENCE OF WIND SPEED*

FOR ALL WIND DIRECTIONS

STABILITY CATEGORY G

Sequoyah Nuclear Plant

April 2, 1971-March 31, 1972

| Wind Direction | Wind Speed (mph) 0.6-3.4 | 3.5-7.4 | 7.5-12.4 | 12.5-18.4 | 18.5-24.4 | ≥24.5 | Total |
|---|---|---|---|---|---|---|---|
| N | 0.17 | 0.01 | | | | | 0.18 |
| NNE | 0.74 | | | | | | 0.74 |
| NE | 1.03 | | | | | | 1.03 |
| ENE | 0.49 | | | | | | 0.49 |
| E | 0.26 | | | | | | 0.26 |
| ESE | 0.03 | | | | | | 0.03 |
| SE | 0.08 | | 0.01 | | | | 0.09 |
| SSE | 0.09 | | | | | | 0.09 |
| S | 0.35 | 0.03 | | | | | 0.37 |
| SSW | 0.57 | 0.04 | | | | | 0.61 |
| SW | 0.76 | 0.19 | | | | | 0.96 |
| WSW | 0.19 | 0.04 | | | | | 0.23 |
| W | 0.04 | | | | | | 0.04 |
| WNW | 0.03 | | | | | | 0.03 |
| NW | 0.01 | | | | | | 0.01 |
| NNW | 0.06 | 0.01 | | | | | 0.08 |
| Total | 4.90 | 0.32 | 0.01 | | | | 5.90** |

Calm = 0.67

Lost Record = 0

*Temperature instruments 33 and 300 feet above ground.
Wind instrument 33 feet above ground.
**Total includes all columns and calm (good observations).

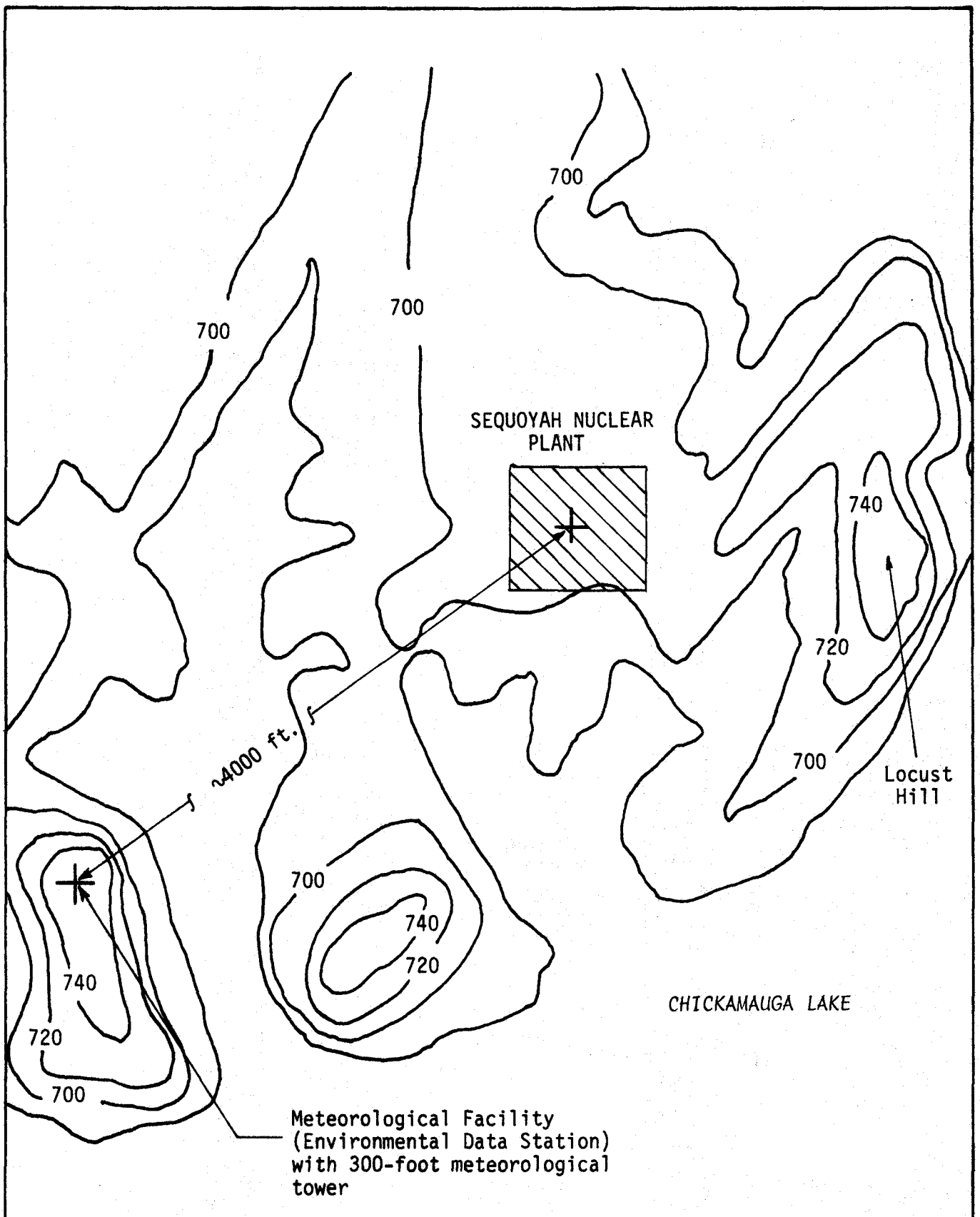



Figure A-1

METEOROLOGICAL FACILITY (ENVIRONMENTAL DATA STATION)

SEQUOYAH NUCLEAR PLANT

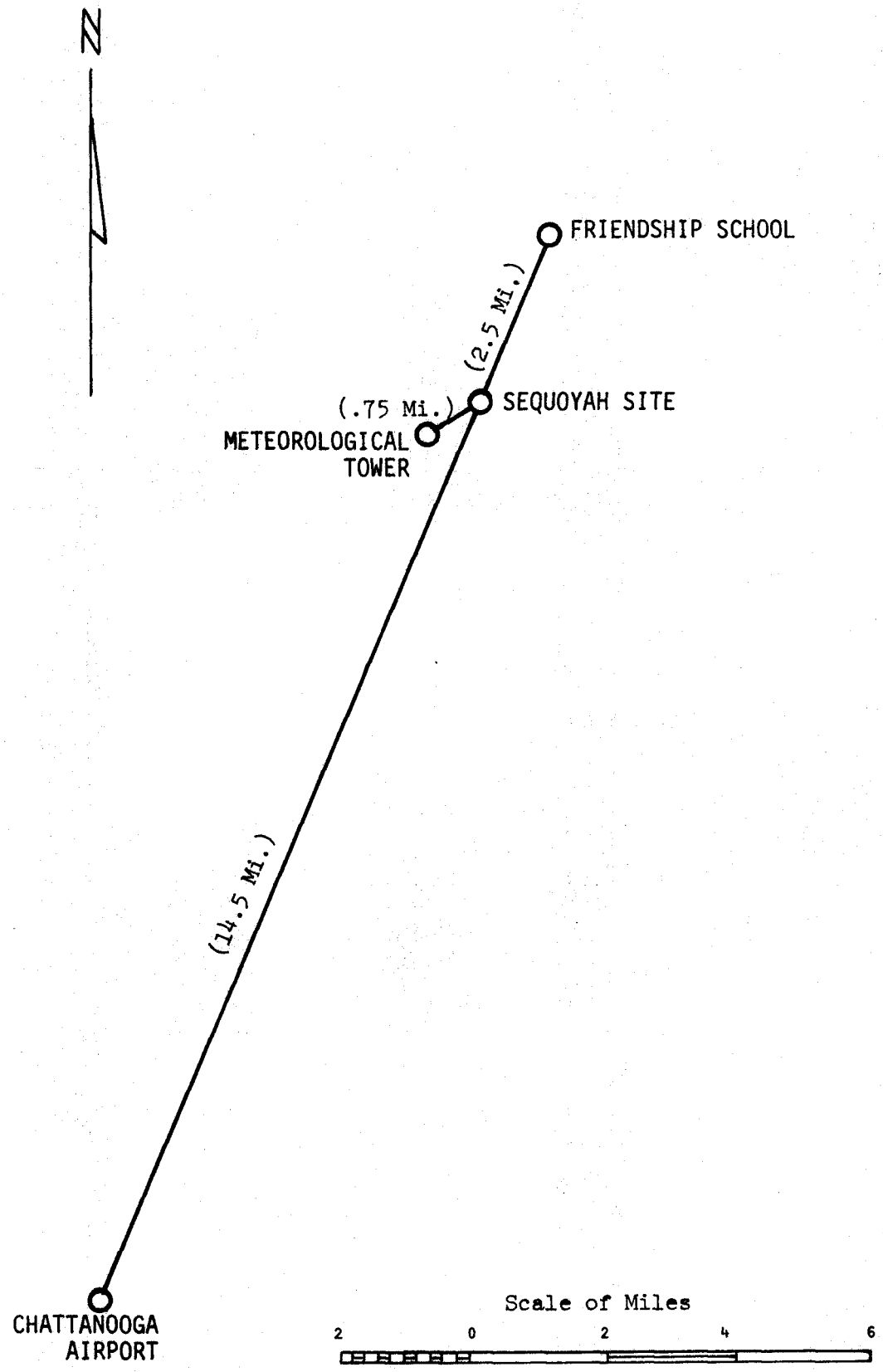



Figure A-2
CLIMATOLOGICAL DATA SOURCES
SEQUOYAH NUCLEAR PLANT

Appendix B

## FISHERY RESOURCES

The fisheries resources of Chickamauga Reservoir have been surveyed since impoundment in 1940. An intensive study during 1942, and a series of cove rotenone samples conducted by TVA during 1957-59 constitute the historical data discussed in this report. Routine preoperational monitoring data have been collected quarterly since 1970 by TVA fisheries biologists. These data are the bases for these discussions.

A species list (Table B-1) was erected to show the occurrence of species in Chickamauga Reservoir, both historically and currently. Some species, particularly the smaller percids, cyprinids, and other "minnows", are poorly sampled by gill and trap nets and may occur in the reservoir. The two sturgeon species have probably been extirpated since 1942. The yellow perch, apparently spreading downstream from two north Georgia impoundments (Chatuge and Nottely), has invaded Chickamauga Reservoir since 1959. Recent unpublished reports document the spread to Melton Hill (upstream) and Nickajack (downstream) reservoirs.

Cove rotenone samples were taken in Chickamauga Reservoir in years 1970-72. The 1970 samples consisted of three coves in each of four areas (figure B-1). Area I is the farthest upstream, area III contains the plant (although the three coves are upstream from the plant), and area IV is below the plant. Three coves in area II, the mouth of the Hiwassee River, were sampled in 1970, but not in 1971 or 1972. In 1971-72 three coves (two in area IV and one in area III) sampled in 1970 were resampled. A new cove in area I was sampled in 1971 and 1972. A total of 49 species

belonging to 12 families were found by cove sampling (Table B-1). Average standing crop per acre is estimated at 182 pounds based on the 12 coves sampled in 1970.

Total numbers and weights per acre in each year were tabulated (Table B-2) and then broken down into percent compositions for individual species. Numbers in all years are dominated by threadfin and gizzard shad, assorted minnows, and bluegill. The biomass found in the coves was largely composed of gizzard shad, carp, buffalo, and drum. Of the sport fish found in the coves, bluegill, redear, and longear sunfish were prominent, as were largemouth and spotted bass.

As part of the preoperational monitoring program, gill net samples were taken quarterly at each of four stations beginning in 1971. Two of the stations are located below the plant, one at Tennessee River Mile (TRM) 483.6, immediately below the plant, and the other at TRM 472.6 some 10 miles below the plant. Stations are also located at TRM 496.5 and in the mouth of the Hiwassee River (TRM 499), both above the plant site. Results of part of the gill net sampling (fall 1971 to summer 1972) are presented in Table B-3. Each net fished overnight is termed a "net-night."

Trap net sampling was also conducted each quarter at three stations: TRM 496, 483, and 472. At each station two 5-foot double crib, Wisconsin-type trapnets were fished in the overbank areas of the reservoir. Initially each net was to be lifted 5 times, but this was changed to 6 in winter, 1972. The total number of each species caught in all lifts of each net are presented (Table B-4), for a 1-year period (fall 1971 to summer 1972).

As expected, the catch in both types of sampling varies according to season. Within a given season, however, the catch varies from station

to station. As shown by both tables, no sauger or walleye were caught below this plant (TRM 472) and the catch of both species was highest above the plant. Spotted bass appeared to be most abundant at the plant site, although they were caught at all stations. Redear were most abundant at or above TRM 483, while white crappie and bluegill appeared to be spread all over the lake.

Of the commercially important species, blue and flathead catfish, smallmouth buffalo, drum, and carp were caught most often above the plant. Channel catfish were caught at all stations, but appeared to be most abundant at TRM 483 and 472.

The commercial harvest of fish from Chickamauga Reservoir was estimated to be 144,000 pounds in 1965, but has risen to 373,000 pounds by 1972. Of the 1972 total an estimated 258,000 pounds were sold. Catfish, buffalo, and carp were predominant in the catch although drum and spoonbill (Polyodon) were also taken.

Table B-1

TAXONOMIC LIST OF FISH SPECIES COLLECTED IN CHICKAMAUGA RESERVOIR

Entries Listed by Date and Method of Capture

| Species | 1957-59 Cove Samples | 1970-72 Cove Samples | 1942 Gill Net Samples | 1971-72 Gill Net Samples | 1971-72 Trap Nets |
|---|---|---|---|---|---|
| Family Acipenseridae | | | | | |
| Shovelnose sturgeon - *Scaphirhynchus platophynchus* | | | X | | |
| Lake sturgeon - *Acipenser fulvescens* | | | X | | |
| Family Lepisosteidae | | | | | |
| Spotted gar - *Lepisosteus oculatus* | | X | | X | X |
| Longnose gar - *L. osseus* | | X | X | X | X |
| Shortnose gar - *L. platostomus* | | | | X | |
| Family Polyodontidae | | | | | |
| Spoonbill - *Polyodon spathula* | | | X | | X |
| Family Clupeidae | | | | | |
| Skipjack herring - *Alosa chrysochloris* | X | X | X | X | |
| Gizzard shad - *Dorosoma cepedianum* | X | X | | X | X |
| Threadfin shad - *D. petenense* | X | X | | | X |
| Mooneye - *Hiodon tergisus* | X | X | X | X | X |
| Family Cyprinidae | | | | | |
| Carp - *Cyprinus carpio* | X | X | X | X | X |
| Golden shiner - *Notemigonus crysoleucas* | | X | | | |
| Emerald shiner - *Notropis atherinoides* | | X | | | |
| Spotfin shiner - *N. spilopterus* | | X | | | |
| Bluntnose minnow - *Pimephales notatus* | | X | | | |
| Goldfish - *Carassius auratus* | | X | | | |

Table B-1

TAXONOMIC LIST OF FISH SPECIES COLLECTED IN CHICKAMAUGA RESERVOIR
(Continued)

Entries Listed by Date and Method of Capture

| Species | 1957-59 Cove Samples | 1970-72 Cove Samples | 1942 Gill Net Samples | 1971-72 Gill Net Samples | 1971-72 Trap Nets |
|---|---|---|---|---|---|
| Family Catostomidae | | | | | |
| River carpsucker - *Carpiodes carpio* | | X | X | X | X |
| Quillback - *C. cyprinus* | X | X | X | | X |
| Highfin - *C. yelifer* | | | | | X |
| Smallmouth buffalo - *Ictiobus bubalus* | X | X | X | X | X |
| Bigmouth buffalo - *I. cyprinellus* | X | X | X | X | X |
| Black buffalo - *I. niger* | X | X | | | |
| Hogsucker - *Hypentelium nigricans* | X | X | | X | |
| Spotted sucker - *Minytrema melanops* | X | X | | X | X |
| Black redhorse - *Moxostoma duquesnei* | | X | X? | | |
| River redhorse - *M. carinatum* | X | X | | X | |
| Golden redhorse - *M. erythrurum* | X | X | | X | X |
| Shorthead redhorse - *M. macrolepidotum* | | X | | | X |
| Family Ictaluridae | | | | | |
| Blue catfish - *Ictalurus furcatus* | X | X | X | X | X |
| Black bullhead - *I. melas* | | X | | X | |
| Yellow bullhead - *I. natalis* | | | X? | | |
| Channel catfish - *I. punctatus* | X | X | | X | X |
| Flathead catfish - *Pylodictis olivaris* | X | X | X | X | X |
| Family Cyprinodontidae | | | | | |
| Blackstripe topminnow - *Fundulus notatus* | | X | | | |
| Family Poeciliidae | | | | | |
| Mosquitofish - *Gambusia affinis* | | X | | | |

Table B-1

TAXONOMIC LIST OF FISH SPECIES COLLECTED IN CHICKAMAUGA RESERVOIR
(Continued)

Entries Listed by Date and Method of Capture

| Species | 1957-59 Cove Samples | 1970-72 Cove Samples | 1942 Gill Net Samples | 1971-72 Gill Net Samples | 1971-72 Trap Nets |
|---|---|---|---|---|---|
| Family Atherinidae | | | | | |
| Brook silverside - *Labidesthes sicculus* | | X | | | |
| Family Percichthyidae | | | | | |
| White bass - *Morone chrysops* | X | X | X | X | X |
| Yellow bass - *M. mississippienis* | | X | | X | X |
| Family Centrarchidae | | | | | |
| Redbreast - *Lepomis auritus* | | | | X | |
| Green sunfish - *L. cyanellus* | X | X | | | |
| Warmouth - *L. gulosus* | X | X | | | |
| Orangespotted sunfish - *L. humilis* | X | X | | | |
| Bluegill - *L. macrochirus* | X | X | | X | X |
| Longear sunfish - *L. megalotis* | X | X | | X | X |
| Redear sunfish - *L. microlophus* | X | X | | X | X |
| Smallmouth bass - *Micropterus dolemieui* | X | X? | | | |
| Spotted bass - *M. punctulatus* | X | X | X | X | X |
| Largemouth bass - *M. salmoides* | X | X | X | X | X |
| White crappie - *Pomoxis annularis* | X | X | X | X | X |
| Black crappie - *P. nigromaculatus* | X | X | X | X | X |
| Rock bass - *Ambloplites rupestris* | | X | X | | |
| Family Percidae | | | | | |
| Yellow perch - *Perca flavescens* | | X | | | X |
| Fantail darter - *Etheostoma flabellare* | | X | | | |
| Redline darter - *E. rufilineatum* | | | | | |
| Logperch - *Percina caprodes* | | X | | | |
| Sauger - *Stizostedion canadense* | X | X | X | X | X |
| Walleye - *Stizostedion vitreum* | | | | X | X |
| Family Scianidae | | | | | |
| Freshwater drum - *Aplodinotus grunniens* | X | X | X | X | X |

Table B-2

PERCENT COMPOSITION OF 1970-72 COVE ROTENONE SAMPLES TAKEN

IN CHICKAMAUGA RESERVOIR

| | Numbers | | | Numbers | | |
|---|---|---|---|---|---|---|
| | 1970 | 1971 | 1972 | 1970 | 1971 | 1972 |
| Totals (per acre) | 3,345 | 2,845 | 5,804 | 182 | 195 | 282 |
| Species | Percent Composition | | | | | |
| Threadfin shad | 29.9 | 37.7 | 49.7 | 3.2 | 2.6 | 10.3 |
| Gizzard shad | 27.6 | 8.4 | 5.1 | 29.0 | 24.8 | 35.3 |
| Carp | 0.1 | 0.3 | 0.1 | 3.2 | 17.6 | 8.8 |
| Assorted minnows* | 12.2 | 14.4 | 14.9 | 0.6 | 0.6 | 1.0 |
| Smallmouth buffalo | 0.4 | 0.5 | 0.2 | 23.7 | 23.7 | 13.9 |
| Bigmouth buffalo | 0.1 | - | - | 8.8 | - | - |
| Golden redhorse | 0.1 | 0.1 | t | 1.6 | 1.8 | 1.2 |
| Channel catfish | 0.2 | 0.4 | 0.3 | 1.7 | 4.1 | 2.8 |
| Blue catfish | 0.1 | - | t | 0.9 | - | 0.3 |
| White bass | 0.5 | t | - | 0.1 | t | - |
| Bluegill | 15.3 | 26.6 | 20.2 | 5.7 | 7.4 | 6.5 |
| Longear sunfish | 1.0 | 2.4 | 2.0 | 0.6 | 1.0 | 0.7 |
| Redear sunfish | 0.8 | 1.5 | 0.9 | 1.2 | 1.9 | 2.4 |
| Spotted bass | 1.7 | 1.2 | 0.8 | 0.3 | 0.4 | 0.3 |
| Largemouth bass | 3.3 | 1.3 | 0.6 | 2.4 | 2.6 | 2.6 |
| White crappie | 0.9 | 0.4 | 0.4 | 1.4 | 1.3 | 0.8 |
| Drum | 5.2 | 3.4 | 3.4 | 13.7 | 7.5 | 9.1 |
| Yellow perch | 0.2 | 0.4 | 0.2 | 0.1 | 0.2 | 0.2 |
| Total percent | 99.6 | 99.0 | 98.8 | 98.2 | 97.5 | 96.2 |

*Primarily family Cyprinidae

t = Less than 0.05%

Table B-3

RESULTS OF GILLNET SAMPLING ON CHICKAMAUGA RESERVOIR
FROM FALL 1971 TO SUMMER 1972

| | Fall 1971 | | | | Winter 1972 | | | | Spring 1972 | | | | Summer 1972 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 499 | 496 | 483 | 472 | 499 | 496 | 483 | 472 | 499 | 496 | 483 | 472 | 499 | 496 | 483 | 472 |
| Net-Nights | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| Spotted gar | - | - | - | - | - | - | - | - | 1 | 4 | 3 | - | 1 | 1 | - | - |
| Longnose gar | - | - | - | - | - | - | - | - | 8 | 1 | 1 | 1 | 6 | 2 | 3 | 1 |
| Shortnose gar | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - |
| Skipjack herring | 25 | 26 | 33 | 39 | 16 | 2 | 36 | 11 | 8 | 21 | 16 | 207 | 75 | 103 | 12 | 88 |
| Gizzard shad | 102 | 86 | 205 | 226 | 12 | 19 | 73 | 69 | 78 | 28 | 64 | 47 | 344 | 417 | 62 | 330 |
| Mooneye | - | 15 | 1 | 1 | 25 | 29 | - | - | 2 | - | 7 | - | 24 | 19 | 7 | 6 |
| Carp | 3 | - | 1 | - | - | - | - | - | - | 4 | - | - | 6 | - | - | - |
| River carpsucker | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - |
| Smallmouth buffalo | 1 | - | 3 | - | 1 | - | 1 | - | 1 | - | - | - | 1 | - | 1 | - |
| Bigmouth buffalo | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - |
| Hogsucker | - | 1 | - | - | - | 2 | - | 1 | - | - | - | 1 | - | - | - | - |
| Spotted sucker | 2 | - | 1 | - | 1 | 10 | 3 | 1 | 22 | 24 | 5 | 4 | 3 | - | 1 | 2 |
| River redhorse | - | - | - | - | - | - | - | 1 | - | 1 | - | - | - | - | - | - |
| Golden redhorse | 2 | 2 | 1 | - | - | 9 | - | 2 | 1 | 14 | 1 | 1 | 2 | 1 | 2 | 1 |
| Blue catfish | 5 | - | 30 | 1 | 23 | - | 30 | 2 | 12 | - | 54 | 16 | 12 | 13 | 10 | 3 |
| Channel catfish | 11 | 20 | 25 | 9 | 26 | 6 | 9 | 5 | 19 | 16 | 34 | 33 | 59 | 41 | 62 | 14 |
| Flathead catfish | 1 | 3 | - | - | 1 | - | - | - | - | - | 1 | - | 5 | 3 | 2 | 1 |
| White bass | 6 | 7 | - | 8 | 1 | 1 | 2 | - | - | - | 1 | - | 10 | 14 | 8 | 2 |
| Yellow bass | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | 1 | - |
| Bluegill sunfish | - | 3 | 3 | - | - | - | - | - | - | 14 | 4 | - | 10 | 5 | 2 | 4 |
| Redear sunfish | 4 | 8 | 2 | - | 4 | 7 | 6 | 2 | 19 | 36 | 21 | 6 | 33 | 8 | 5 | 9 |
| Spotted bass | 2 | 8 | 5 | 6 | 2 | 3 | 15 | 6 | 2 | 4 | 15 | 9 | 4 | - | 5 | 2 |
| Largemouth bass | - | - | 2 | - | 2 | 1 | 1 | 1 | 1 | 2 | 2 | - | - | - | 2 | 1 |
| White crappie | 14 | 25 | 27 | 31 | 9 | 4 | 17 | 6 | 12 | 12 | 31 | 18 | 21 | 17 | 8 | 3 |
| Black crappie | - | - | - | 1 | 1 | - | 1 | - | 1 | - | 1 | 1 | 5 | - | 1 | - |
| Sauger | 1 | - | 2 | - | 5 | - | 2 | - | 1 | - | - | - | 1 | - | 2 | - |
| Walleye | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - |
| Drum | 48 | 1 | 19 | 3 | 22 | 2 | 14 | - | 22 | 1 | 11 | 1 | 80 | 57 | 51 | 1 |
| Total Fish | 227 | 205 | 360 | 325 | 152 | 95 | 210 | 109 | 211 | 182 | 272 | 345 | 706 | 701 | 247 | 468 |

Table B-4

TRAP NETTING RESULTS FROM CHICKAMAUGA RESERVOIR, 1971-72

| | Fall 1971 | | | | | | Winter 1972 | | | | | | Spring 1972 | | | | | | Summer 1972 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 496 | | 483 | | 472 | | 496 | | 483 | | 472 | | 496 | | 483 | | 472 | | 496 | | 483 | | 472 | |
| Net | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 |
| No. Lifts | 4 | 5 | 5 | 5 | 4 | 5 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 5 | 6 | 6 | 6 | 6 | 6 |
| Paddlefish | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - | - | - | - | - |
| Longnose gar | - | - | - | - | - | - | - | - | - | - | - | - | - | 6 | - | - | - | - | - | 1 | - | - | - | - |
| Skipjack herring | - | 13 | - | - | - | 1 | 1 | 2 | - | 1 | - | - | 1 | 9 | - | 5 | - | 2 | - | - | - | - | - | - |
| Gizzard shad | 95 | 163 | 11 | - | 12 | 86 | 168 | 218 | - | 24 | 2 | 4 | 26 | 82 | 5 | 33 | 2 | 62 | - | 86 | 59 | 77 | 26 | 11 |
| Threadfin shad | - | - | - | - | - | - | - | - | - | 3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Mooneye | 10 | 36 | - | - | - | - | - | 83 | - | - | - | - | - | 5 | - | - | - | - | - | 4 | - | - | 1 | - |
| Carp | 1 | 1 | 2 | - | - | 1 | - | 1 | - | - | - | - | 4 | 5 | - | 2 | 3 | 3 | - | - | 3 | 3 | 1 | - |
| River carpsucker | 1 | 4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Highfin carpsucker | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Smallmouth buffalo | 9 | 109 | - | - | - | 1 | 1 | 11 | - | 1 | - | - | 26 | 24 | - | 5 | 2 | 3 | - | - | 2 | 1 | 2 | 1 |
| Bigmouth buffalo | - | - | - | - | - | - | - | 2 | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - |
| Spotted sucker | - | 4 | - | - | - | - | 1 | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - |
| Golden redhorse | 1 | 11 | - | - | - | - | 6 | - | - | - | - | - | 1 | - | - | - | - | - | - | 1 | - | - | - | - |
| Shorthead redhorse | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - |
| Blue catfish | - | 2 | 4 | - | 1 | 1 | 1 | 29 | 3 | 24 | 6 | 6 | 3 | 2 | 5 | 1 | - | 12 | - | 1 | 3 | 4 | 1 | - |
| Channel catfish | 11 | - | 7 | - | - | 21 | 5 | 16 | 20 | 1 | 28 | 22 | 8 | 24 | 13 | 9 | 14 | 26 | - | 2 | 15 | 12 | 33 | 10 |
| Flathead catfish | - | 3 | 1 | - | - | 1 | - | - | - | - | - | - | 2 | 4 | 7 | 7 | 2 | 2 | - | 4 | 3 | 3 | 1 | 2 |
| White bass | 7 | 36 | 1 | 19 | 13 | 85 | 7 | 12 | - | 12 | 1 | 2 | 3 | 30 | - | 25 | 1 | 7 | - | 10 | 27 | 13 | 23 | 2 |
| Yellow bass | - | - | - | 6 | - | - | 7 | 4 | - | 1 | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - |
| Bluegill sunfish | 14 | 23 | 40 | 44 | 7 | 128 | 13 | 10 | 13 | 8 | 348 | 49 | 48 | 161 | 25 | 95 | 36 | 188 | 8 | 86 | 119 | 420 | 17 | 31 |
| Longear sunfish | - | - | - | - | - | - | - | - | - | - | 4 | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| Redear sunfish | 79 | 142 | 4 | 6 | 12 | 32 | 32 | 15 | 4 | 23 | 46 | 4 | 23 | 32 | 15 | 2 | 2 | 17 | 2 | 18 | 17 | 46 | 2 | 6 |
| Spotted bass | 1 | - | - | 1 | 3 | 5 | - | 1 | - | 4 | 1 | 1 | 4 | 1 | 5 | - | 2 | - | - | - | 1 | 1 | - | - |
| Largemouth bass | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | 5 | 1 | 1 | - | - |
| White crappie | 178 | 428 | 184 | 13 | 25 | 185 | 10 | 1 | 263 | 30 | 160 | 315 | 604 | 448 | 143 | 352 | 139 | 487 | 1 | 170 | 110 | 151 | 53 | 52 |
| Black crappie | 1 | 1 | - | 1 | - | 2 | 2 | 1 | 2 | 1 | 5 | - | 7 | 16 | 5 | 4 | 6 | 46 | - | 1 | - | - | - | 3 |
| Sauger | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | 1 | - | - | - | - |
| Walleye | - | 1 | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Yellow perch | - | - | - | - | - | - | 4 | 3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Drum | 2 | 29 | 41 | - | 2 | 12 | 6 | 108 | 8 | 7 | 23 | 13 | 16 | 13 | 6 | 6 | 7 | 11 | - | 14 | 101 | 53 | 15 | 10 |

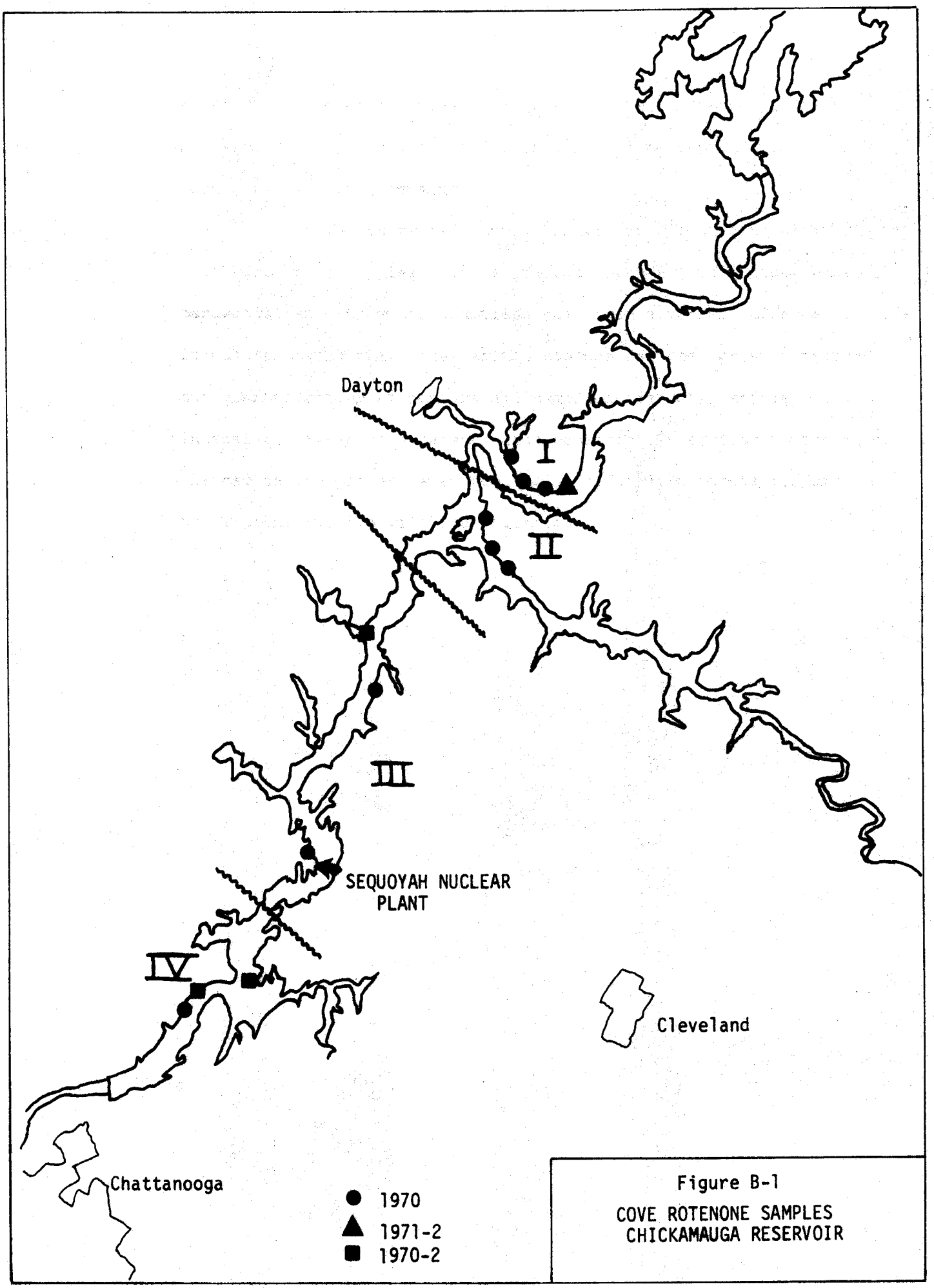



Figure B-1

COVE ROTENONE SAMPLES
CHICKAMAUGA RESERVOIR

# Appendix C

## SEQUOYAH VEGETATION

Prior to nuclear plant construction the Sequoyah Peninsula was 94 percent forested (figure C-1). Pasture constituted 3 percent of total cover and old field and right of way the remainder. Shortleaf pine (*Pinus echinata*) and Virginia pine (*Pinus virginiana*) were the dominant coniferous species on the area and the pine type accounted for 285 acres or 54 percent of the total area (Table C-1). Pine-hardwoods consisted primarily of the two pines mentioned above and oaks, hickories, beech and other typical ridge and Valley deciduous species. In this type pines generally comprise 25-50 percent of all mature trees. Thirty-eight acres or 7 percent of the area was typed as hardwoods, 3 percent pasture, 2 percent old field and 2 percent right of way (power line). Based on cursory field investigations of wooded lands off but adjacent to the project site, dominant project area mature hardwood species were white oak (*Quercus alba*), post oak (*Quercus stellata*), black oak (*Quercus velutina*), southern red oak (*Quercus falcata*), shagbark hickory (*Carya ovata*), mockernut hickory (*Carya tomentosa*), yellow poplar (*Liriodendron tulipifera*) and beech (*Fagus grandifolia*).

Construction activities necessitated clearing 237 acres of vegetation or 45 percent of the total land base. Figure C-2 shows areas affected by construction and the remaining vegetation. This report does not account for acreage that might be affected by future construction. Tables C-2 and C-3 give vegetation type composition after construction and the magnitude of loss due to clearing. Post construction

vegetation presently consists largely of pine, 59 percent, and pine-hardwood, 29 percent. About 288 acres or 55 percent of the original 525 acres of vegetation remains.

Little can be said about changes in wildlife populations due construction activities. Those species dependent upon pine, pine-hardwoods, and hardwoods doubtless have been adversely affected. It can be stated that total animal biomass has been greatly reduced but quantification of numbers and magnitude is not possible. Intensive surveys on adjacent lands ecologically similar to the lands cleared on the project area would give a fairly accurate picture of the preconstruction wildlife situation.

Table C-1

PRECONSTRUCTION VEGETATION

| Type | Acres | Percent Cover |
|---|---|---|
| Pine | 285 | 54 |
| Pine-Hardwood | 170 | 32 |
| Hardwood | 38 | 7 |
| Pasture | 16 | 3 |
| Old Field | 8 | 2 |
| Right of Way | 8 | 2 |
| Total | 525 | 100 |

Table C-2

POST CONSTRUCTION VEGETATION*

| Type | Acres | Percent Cover |
|---|---|---|
| Pine | 169 | 59 |
| Pine-Hardwood | 84 | 29 |
| Hardwood | 18 | 6 |
| Pasture | 9 | 3 |
| Old Field | 8 | 3 |
| Total | 288 | 100 |

*Does not include losses that will occur if cooling towers are built.

Table C-3

VEGETATION LOSS DUE TO ONSITE CONSTRUCTION*

| Type | Acres | | Percent Change |
|---|---|---|---|
| | Before | After | |
| Pine | 285 | 169 | 59 |
| Pine-Hardwood | 170 | 84 | 49 |
| Hardwood | 38 | 18 | 47 |
| Pasture | 16 | 9 | 56 |
| Old Field | 8 | 8 | 0 |
| Right of Way | 8 | 0 | 100 |
| Total | 525 | 288 | 55 |

*Does not include access ROW to site from Highway 27, offsite power line ROW'S, etc.

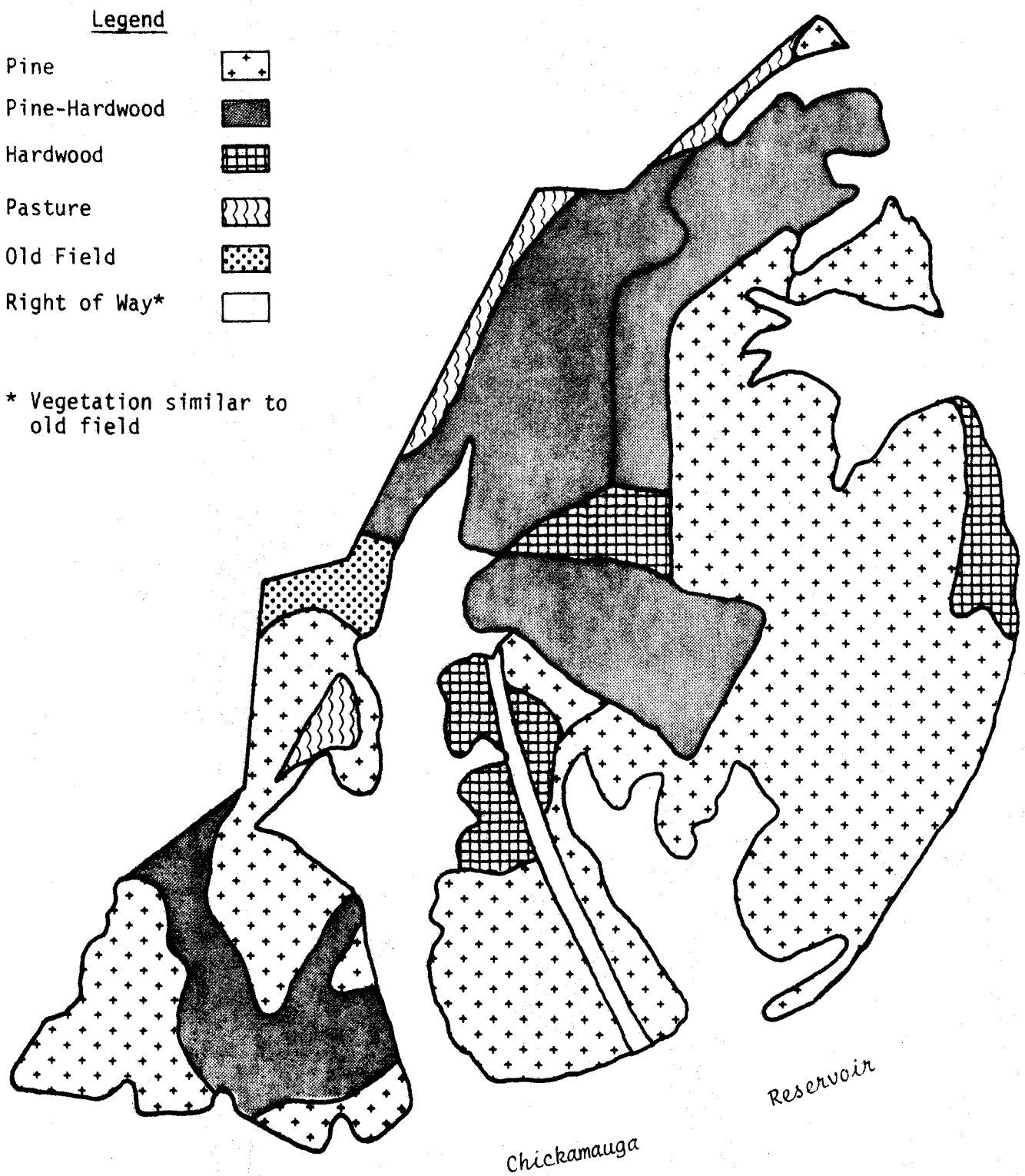



Figure C-1

PRECONSTRUCTION VEGETATION

SEQUOYAH NUCLEAR PLANT

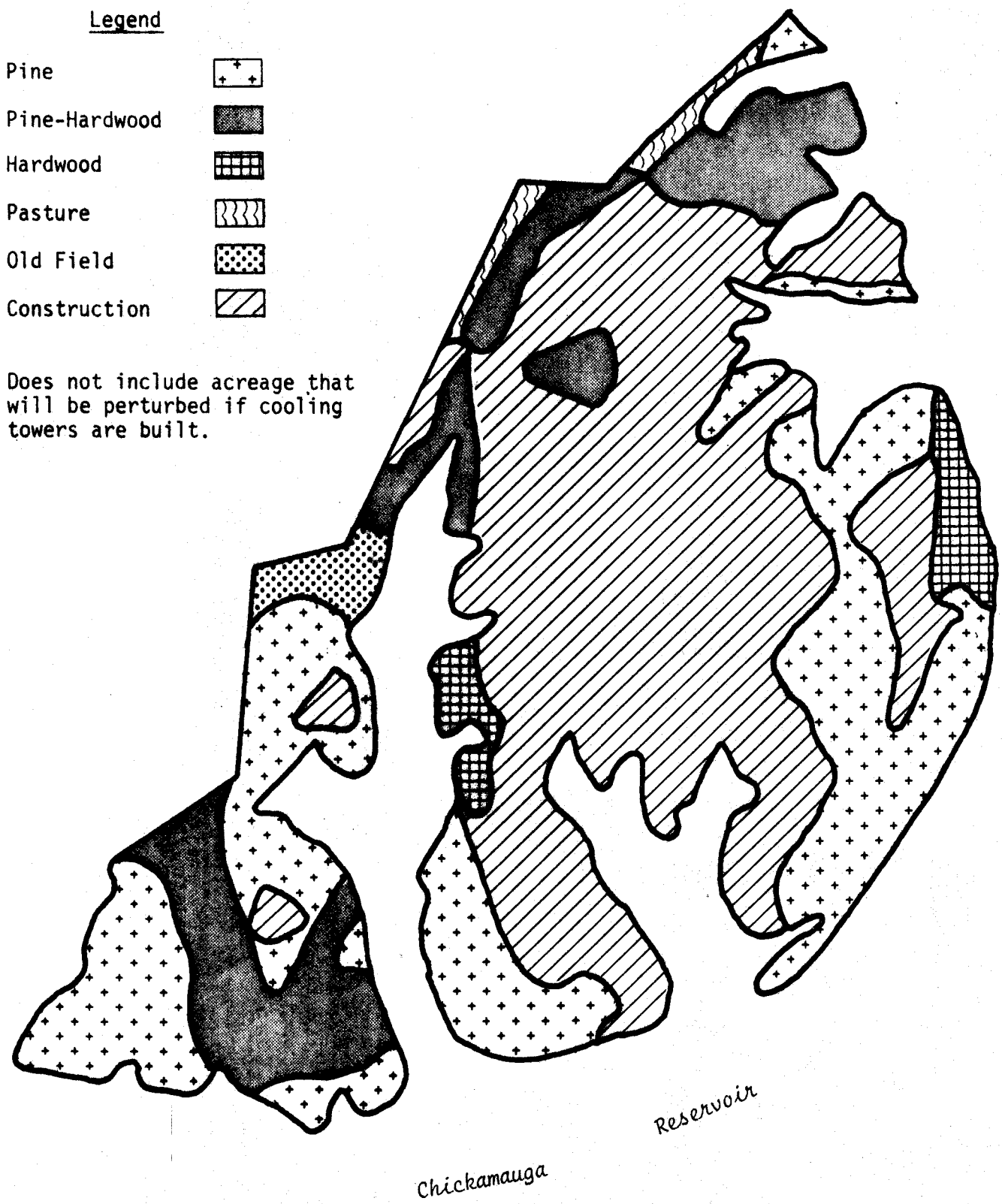



Figure C-2

POST CONSTRUCTION VEGETATION

SEQUOYAH NUCLEAR PLANT

Appendix D

## RADIOLOGICAL ANALYSIS FOR TRANSPORTATION OF SPENT FUEL AND RADIOACTIVE WASTE

1. Normal shipment - The direct external radiation dose from the normal shipment of irradiated fuel elements and radioactive waste has been estimated.

Three cases are considered. These cases are: (1) the dose rate versus distance from a stationary shipping container under normal conditions; (2) the dose to an individual from the passing shipping container; and (3) the population dose due to the passage of the shipping container (see figure D-1).

The dose rates and doses are estimated by considering the source to be an isotropic point source located at the centerline of the shipping container. Under normal conditions the dose rate shall not exceed 10 mrem/h at 6 feet from the container surface. The source strength, I, produces 10 mrem/h at 6 feet + $R_c$, where $R_c$ is the container half thickness. The average gamma-ray energy is calculated to be about 1 MeV.

The dose rate as a function of distance from the shipping container is calculated by

$$DR = \frac{I\, e^{-\mu r}\, B(E, Z, \mu r)}{r^2} , \qquad (1)$$

where

I = source output, $\left(\frac{\text{mrem-ft}^2}{\text{h}}\right)$ ,

r = source to receptor distance, (ft),

$\mu$ = linear attenuation coefficient, $(ft^{-1})$, = $2.5 \times 10^{-3}\ ft^{-1}$,

$B(E, Z, \mu r)$ = linear buildup factor for air and is given by

$$1 + K\mu r \quad , \tag{2}$$

where

$$K = \frac{\mu - \mu_{en}}{\mu_{en}}$$

and $\mu_{en}$ is the linear energy-absorption coefficient. The results of the dose rate calculations for a stationary shipping container are shown in figure D-2.

The total dose delivered to an individual at a given distance from the centerline of the right of way by a passing shipping container passing with a constant speed of 20 mi/h is calculated by

$$D(d) = \int_{-\infty}^{\infty} DR\ dt \quad , \tag{3}$$

where

$$dt = \frac{dx}{v} \quad ,$$

and

$x$ = the distance along the shipping route, (ft),

$v$ = the velocity, $\frac{ft}{h}$ ,

therefore,

$$D(d) = \frac{2I}{v} \int_{0}^{\infty} \frac{e^{-\mu r}}{r^2} B(E, Z, \mu r) dx \quad , \tag{4}$$

where

$I$ = source output, $\left(\frac{mrem\text{-}ft^2}{h}\right)$ ,

$r = (x^2 + d^2)^{1/2}$, (ft),

d = the distance normal to the centerline of the container's line of travel at which a person is located, (ft),

B(E, Z, ur) and u are as defined for equation 1.

The dose to an individual at varying distances d from a passing shipping container is given below.

| d (ft) | Dose (mrem) |
|---|---|
| 100 | $2.9 \times 10^{-4}$ |
| 200 | $1.0 \times 10^{-4}$ |
| 350 | $5.9 \times 10^{-5}$ |
| 600 | $9.7 \times 10^{-6}$ |
| 1,000 | $1.5 \times 10^{-6}$ |
| 1,500 | $2.6 \times 10^{-7}$ |
| 2,200 | $5.4 \times 10^{-8}$ |

The population dose within 1/2 mile of the route of travel is calculated by considering the integrated dose at 6 intervals between 100 and 2,640 feet from the right of way centerline. The computation is based on the assumption that 100 people per square mile are uniformly distributed along the route of travel. An actual population dose may be computed by multiplying the population dose based on 100 persons per square mile by the ratio of the actual population density to the assumed population density. Using these assumptions a population dose of $1.59 \times 10^{-6}$ man-rem/mi per shipment is calculated.

In these calculational estimates, the attenuation due to manmade structures, trees, and other scatterers and/or absorbers is not considered.

2. Transportation accident - The principal potential environmental effects from an accident involving irradiated fuel are those from direct radiation resulting from increased radiation levels and from gaseous release of noble gases and iodine.

The direct external radiation dose rate from a transportation accident has been evaluated. Under accident conditions the dose rate shall not exceed 1,000 mrem/h at 3 feet from the container surface. The dose rate is estimated using equation 1 and a source strength which produces 1,000 mrem/h at 3 feet + $R_c$. The results are shown in figure D-3.

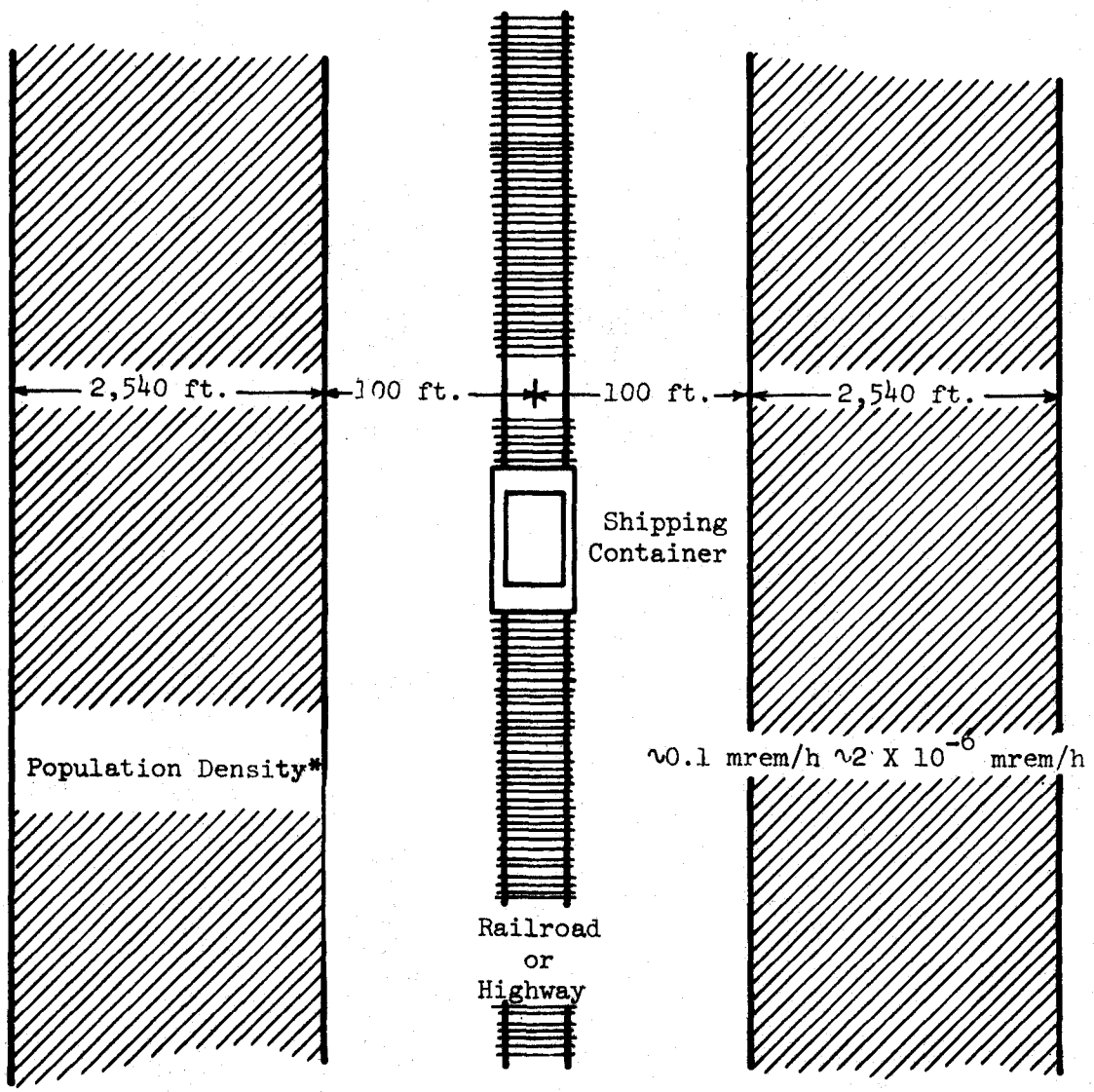
It is assumed that there would be no gaseous releases without a substantial quantity of decay heat in the shipping container plus the addition of external heat such as from a fire. Thus, it is assumed that the thermal currents surrounding the container carry any released fission gases to a height of 10 meters before they are dispersed in the environment. Doses to the whole body, skin, and thyroid have been calculated and are plotted vs. distance in figure D-4. These dose curves represent the envelope of the doses for Pasquill stability conditions A through F with a wind speed of 1 m/s. For a specific accident (with a wind speed of 1 m/s and for one particular Pasquill stability condition) the maximum doses would be equal to the "plateau" doses shown in figure D-4, but the "plateau" doses would not prevail over the entire range of distance between 50 and 1,300 feet. For wind speeds in excess of 1 m/s the doses would be lower than shown in figure D-4 by a factor equal to the reciprocal of the wind speed. Assuming a person stands 50 feet from the cask during the entire accident, the resulting whole-body dose is about 2 mrem, the skin dose is about 86 mrem, and the thyroid dose is about 5 rem. Assuming an average population density of 100 persons per square mile, the whole body dose due to gaseous releases is 0.07 man-rem, the population skin dose is 2.5

man-rem, and the iodine inhalation population dose is 150 man-rem. TVA considers the average population to be the most realistic number to use in analyzing transportation accidents because of the small fraction of the total distance traveled in high population density areas and because accidents in such areas generally occur at lower speeds and therefore would be less severe.

Doses to a truck driver who remains near the truck during a transportation accident are about 2 mrem to the whole body, about 86 mrem to the skin, and about 5 rem to the thyroid. The whole-body dose to the driver due to direct radiation from the shipping cask can be estimated from figure D-3.

Consideration has been given to the radiological impact of the shipment of tritiated water. The low-energy direct radiation from tritium will be shielded by the shipping container and will not be a source of radiation exposure during normal transportation. Calculations have been performed for an accidental release of the entire contents of a 3,700-gallon container of tritiated water with a tritium concentration of 2.5 uCi/cc. A conservative upper limit for the resulting radiation dose is computed by assuming that all of the tritium evaporates into the atmosphere and is blown directly to an individual who remains at the maximum dose point for the entire period of release to the atmosphere. With these assumptions the maximum whole-body dose is computed to be 440 mrem, which is less than the annual dose limit to an individual in the general public specified in 10 CFR Part 20. This dose decreases rapidly with distance, as shown in figure D-5, and at 600 feet is 23 mrem. Figure D-5 has been prepared assuming Pasquill stability condition

F and a wind speed of 1 m/s. For Pasquill stability condition A through E and wind speeds of 1 m/s, the dose at 50 feet from the cask will be about the same as shown in figure D-5 (440 mrem), but the doses at downwind distances beyond 50 feet would be lower than shown in the figure. For wind speeds above 1 m/s, doses may be predicted by multiplying the doses calculated for a wind speed of 1 m/s by a factor equal to the reciprocal of the wind speed. If a uniform average population density of 100 persons per square mile is assumed, the population dose within 50 miles is less than 0.10 man-rem.




When Container is moving at 20 mph:

Maximum Individual Exposure = 0.00029 mrem/trip
Average Individual Exposure = 0.000016 mrem/trip

* Assume 100 persons/mi$^2$ for spent fuel shipments and for radioactive waste shipments.

Figure D-1

Spent Fuel and Radioactive Waste Shipments Population Exposure Distribution

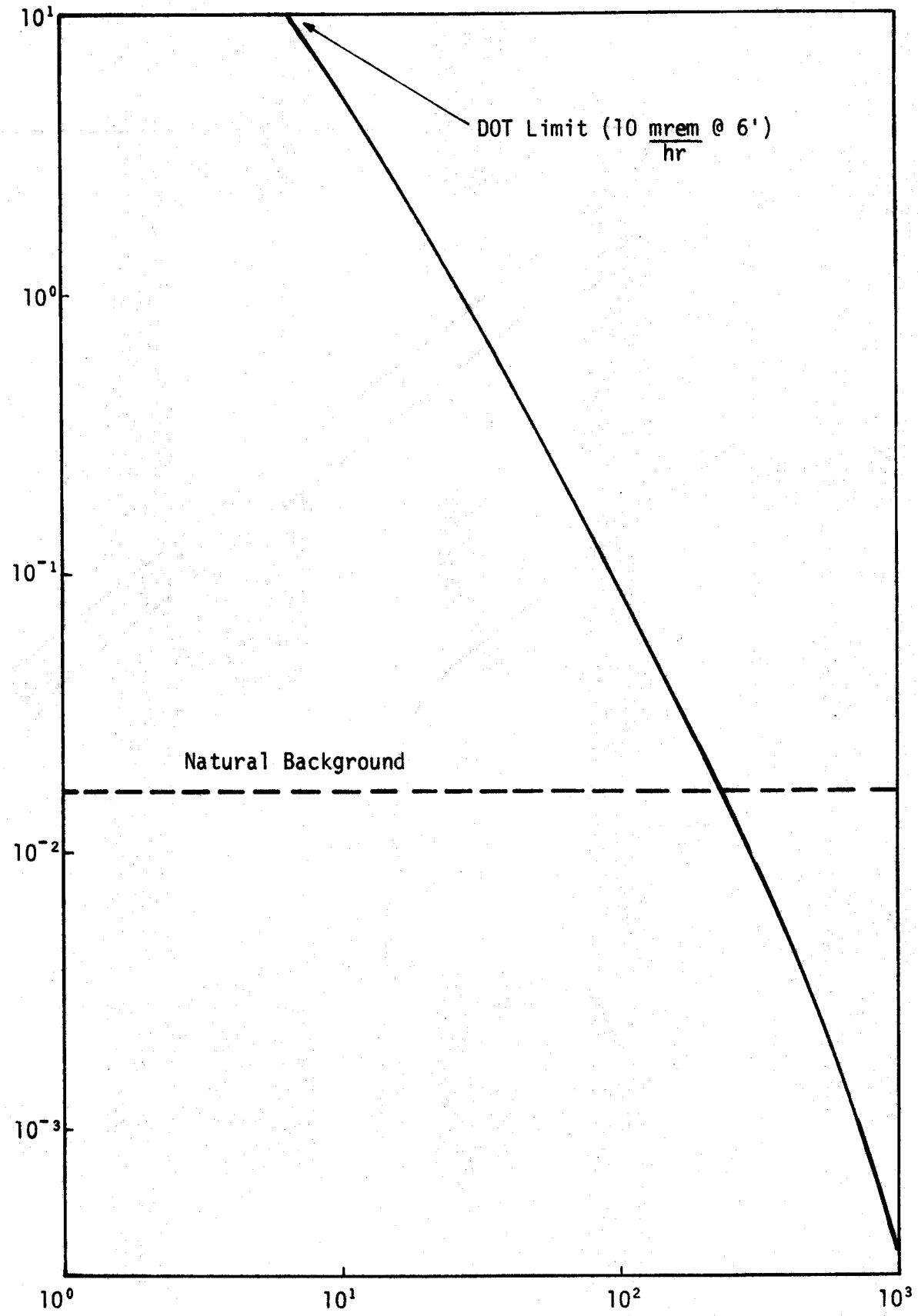



Figure D-2

Dose Rate vs Distance from a Stationary Shipping Container, Normal Conditions

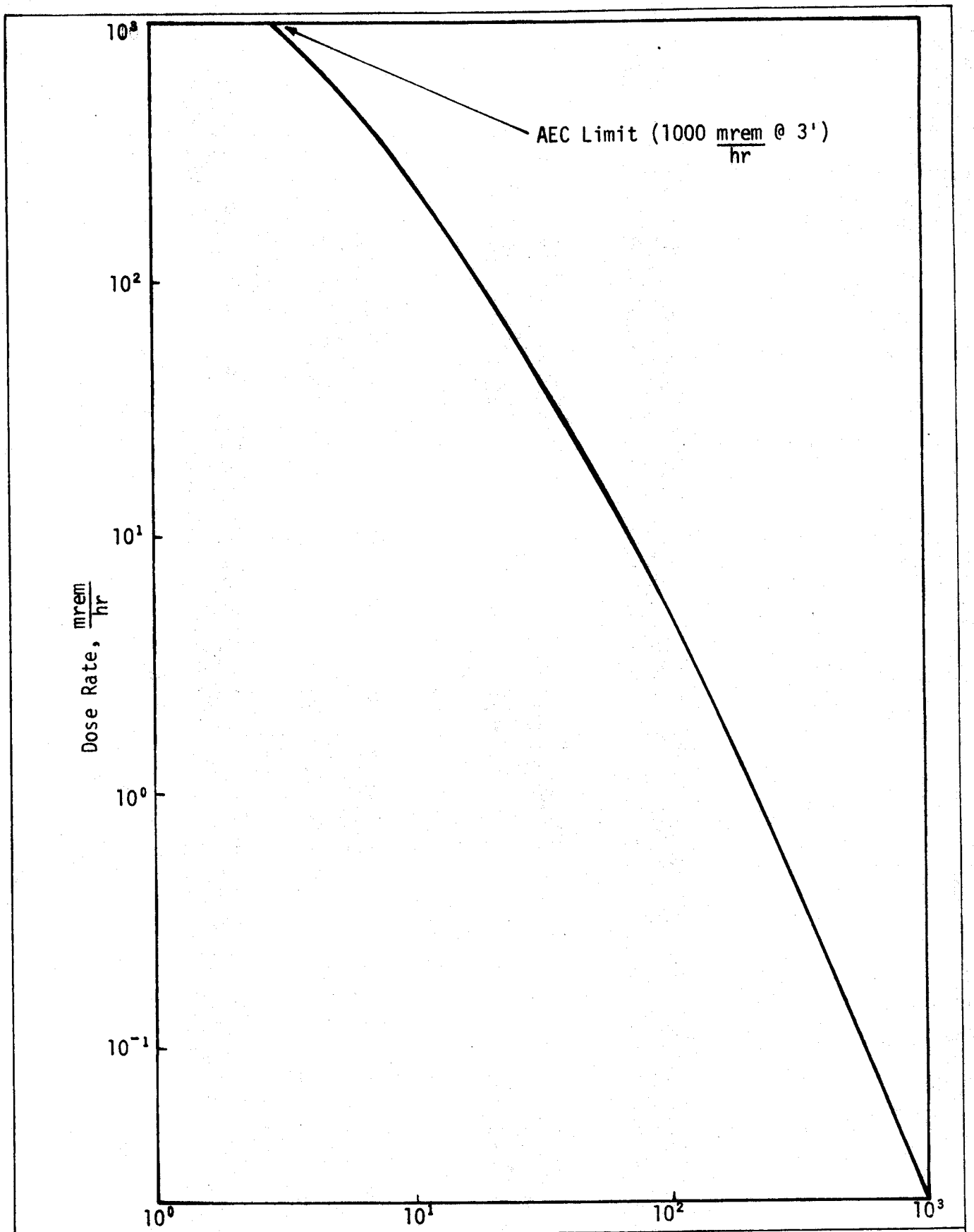



Figure D-3

Dose Rate vs Distance from a Stationary Shipping Container, Accident Conditions

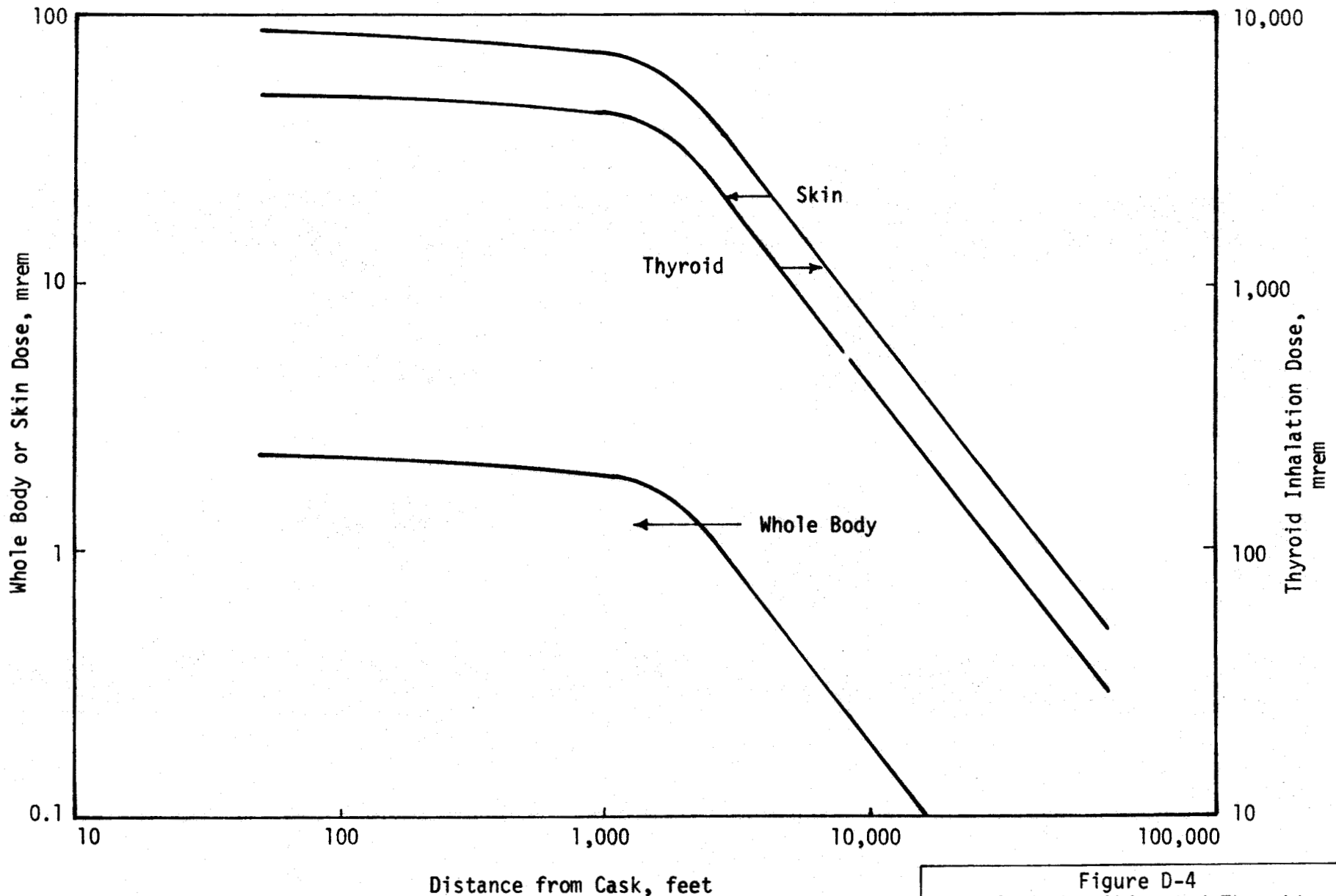



Figure D-4
Whole Body, Skin, and Thyroid Inhalation Doses vs Distance for Release of 1000 Ci of Noble Gases and 10 Ci of I-131 During a Spent Fuel Transportation Accident

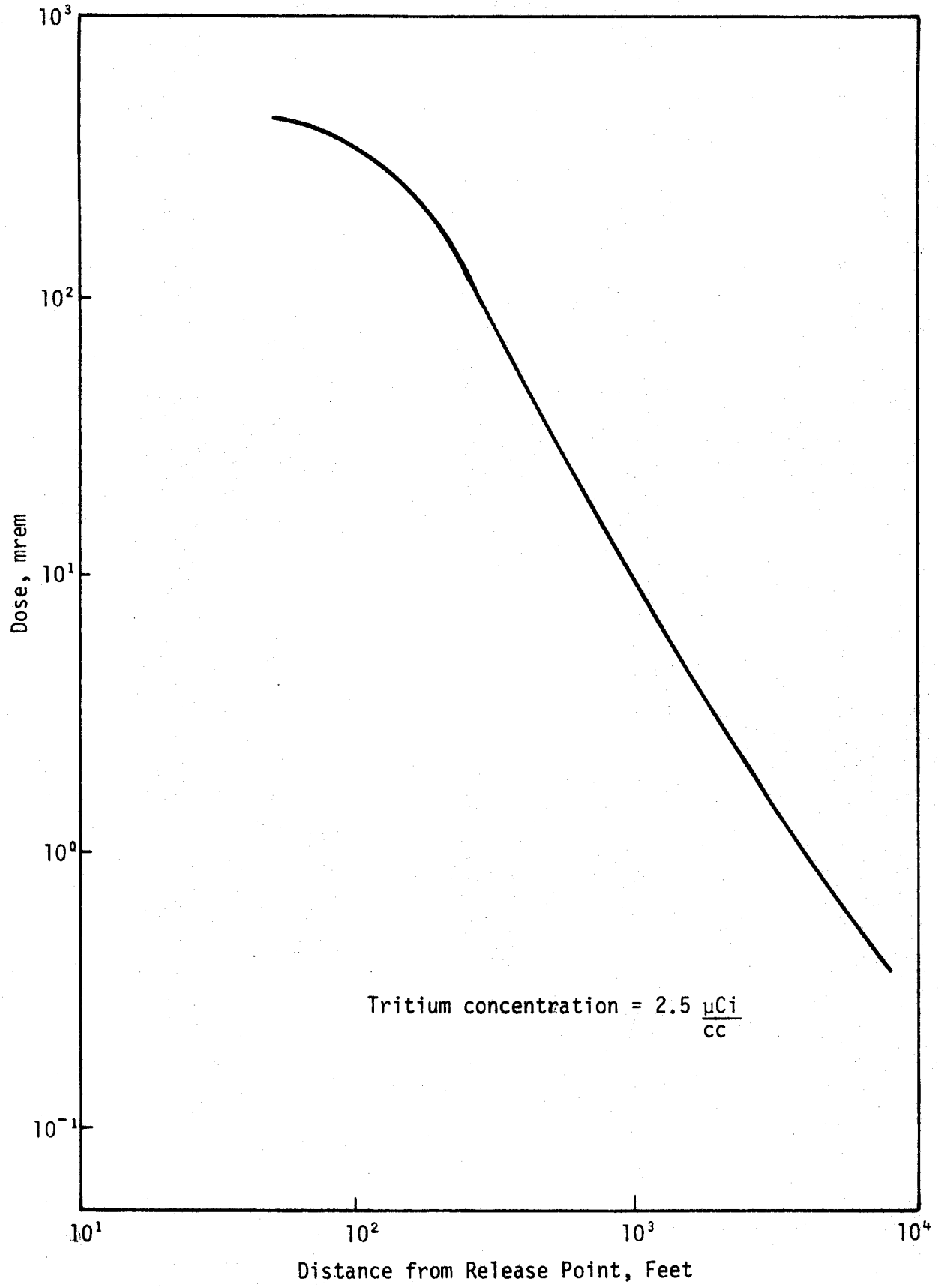



Figure D-5
Whole Body Dose vs Distance for Release of 3,700 Gallons of Tritiated Water During Transportation Accident

# Appendix E

## RELATION OF 10 CFR PART 71 ACCIDENT REQUIREMENTS TO ACTUAL SHIPPING ENVIRONMENT

1. Performance requirements of 10 CFR Section 71.36 - The domestic transportation of radioactive materials is regulated at the Federal level by both the Atomic Energy Commission and the Department of Transportation. The primary aim of the regulations is, of course, to protect the public by rigorously restricting the amount of radiation to which people are exposed. The regulations given in 10 CFR Section 71.36 are written in terms of performance specification requirements for hypothetical accident conditions.

The following discussion is directed toward relating the 10 CFR Part 71 accident conditions to similar conditions which might be experienced as a result of a transportation accident.[1]

It should be noted that there is a wide margin of safety in the container design itself. The container is required to withstand the accident conditions imposed pursuant to 10 CFR Part 71 with only relatively minor damage to the container and no release of the contents except for a small amount of coolant and a small quantity of noble gases. For example, the IF-300 shipping cask is designed to absorb the total effects of the impact with only minor deformation of the outer fins that have been provided for impact protection. No credit is taken for deformation of the outer steel shell. Thus, because of the relative strength of the shell as opposed to the impact energy-absorbing fins, there is a wide margin between the damage that would

be experienced by the cask in absorbing the energy of the 30-foot free fall and that which would be required to breach the container such that there could be a release of the radioactive contents. It is estimated that the amount of energy involved to sustain a significant breach would be from five to ten times that which the cask experiences in a 30-foot free fall.

Thus, as pointed out below, it is unlikely that the casks will experience conditions as severe as those imposed by the 10 CFR Part 71 requirements, and in any event, conditions far more severe than those would be required to result in a substantial breach of a container. As shown in the analysis below, the proposed tests are representative of conditions at least as severe as those which would be experienced by containers in transport. Further, since the tests are required to be applied to the containers in sequence, the cumulative severity of conditions to which the containers are subjected in all probability far exceeds that to which the containers would ever be subjected as a result of an accident in the course of transportation. It is highly improbable that a container would be subjected to conditions as severe as even one of these conditions, let alone all three in the sequence provided for the test.

(1) <u>30-foot free fall</u> - The shipping cask is required to withstand a 30-foot free fall onto an essentially unyielding surface. This requires that all the energy of the impact be absorbed by deformation of the container. In addition, the container impact must be considered from all possible orientations to assure that the impact protection provided is adequate regardless of the orientation of

the fall. Based on previous design experience, it is estimated that a shipping cask will decelerate (stop) on impact within a distance of 2 to 8 inches.[2] To provide a basis for this comparison it has been assumed that a shipping cask would decelerate completely within 6 inches after impact with the unyielding surface. Table E-1 shows a comparison of the various forces which would be generated by the stopping of the shipping cask, an overweight truck, or an automobile traveling at various speeds on striking an unyielding surface.

As indicated in the table, a 45,000-pound shipping cask traveling at 30 mi/h, which is the terminal velocity following a 30-foot free fall, would create 2,700,000 pounds of force if stopped within a distance of 6 inches. A 130,000-pound cask, which is equivalent to the IF-300, would generate about 7,800,000 pounds of force. A loaded truck, weighing 75,000 pounds and traveling at 60 mi/h, coming in contact with the unyielding surface is assumed to decelerate within 10 feet. Under these conditions, the truck would generate a maximum of 900,000 pounds of force, or about one-third of the force that would be generated by the 45,000-pound cask as a result of the 30-foot free fall. Likewise, a 5,000-pound automobile traveling at 80 mi/h hitting an unyielding surface is assumed to stop in only 5 feet, which would generate about 220,000 pounds of force. Thus, it is seen that typical objects which the cask might encounter would generated substantially less force than the shipping cask because of the relatively weaker sections of their structures and the greater distance required to decelerate those bodies.

A second area of concern is the shipping cask colliding with stationary objects such as bridge abutments, etc. In this regard, it should be noted that even heavily loaded trucks contacting such stationary objects generally severely damage the object and displace it by some measurable amount. Therefore, these stationary objects generally cannot be considered as unyielding surfaces for the purposes of assessing the effects of a shipping cask impact. As demonstrated in Table E-1, the force developed by the shipping cask would be far greater than that developed by even a loaded truck, and thus the displacement of the "stationary objects" would be even greater than that encountered in a truck-type accident. Additionally, these impacts with the shipping cask assume that the shipping cask contacts the surface with the center of gravity directly behind the point of impact and in the line of travel such that the maximum force is exerted on the cask. In all likelihood, a shipping cask contacting such surfaces would strike a glancing blow in which case the energy required to be absorbed by the shipping cask would be greatly diminished over that which would result from a direct impact.

The required analysis of a 30-foot drop onto an essentially unyielding surface adequately provides for force to which a cask might be subjected as a result of a transportation accident. Therefore, as a result of these conditions and the ruggedness of the cask, the possibility of encountering a transportation accident of sufficient severity to result in rupture of the container has an extremely low, if not incredible, probability.

(2) <u>40-inch drop test</u> - The 40-inch puncture test requires that the cask be dropped from a height of 40 inches,

with the center of gravity directly above the point of impact, onto a 6-inch diameter pin of sufficient length to puncture the container but without allowing the puncture of even the outer shell of the vessel. The formula for analysis of this condition was developed at Oak Ridge National Laboratories[2] and other places based on extensive testing of steel and lead shipping containers.

In regard to the relationship of this test to the transportation environment, it was originally intended that the 6-inch diameter pin would approximate that of the end of a rail for rail transportation accidents. It should be noted that the puncture so specified would require that the cask hit the pin exactly perpendicular to the cask surface. Any deviation from this would result in a substantially reduced loading on the side of the cask and enhance chances of deflection. Further, the pin must be long enough to penetrate through the walls of the container, which would require damage to the contents. In most cases this would require that the pin be approximately 12 to 18 inches in length. However, if the pin is much longer than this, it becomes doubtful that the column strength of the pin is sufficient to rupture the container without buckling of the proposed pin.

It should be noted that the containers are required to pass the puncture test without rupture of even the outer shell. As generally there is a heavy outer shell backed up by several inches of shielding material followed by an inner steel shell, there is a wide margin between the damage that the container would sustain as a result of the required puncture test and that which would be required to rupture the inner vessel such that there could be dispersal

of the radioactive contents. This test provides conditions at least as severe as those to which a container would be subjected as a result of a transportation accident.

(3) 30-minute fire test - The 30-minute fire test was proposed as that to which a container would be subjected as a result of large open burning of petroleum such as diesel or jet fuel. In this regard it should be noted that the test conditions require that it be assumed that the cask is perfectly surrounded by a uniform heat flux corresponding to a thermal emissivity of 0.9 at a temperature of 1475°F. In actuality, the cask will most likely be lying on the ground near the cooler part of the flames such that it is not surrounded completely by the fire environment. Further, while there may be individual flame temperatures hotter than the proposed 1475°F, the average flame temperatures will not exceed these values. It is unlikely that a container the size of a large shipping cask would be completely engulfed in flames due to lack of the required quantities of combustible materials, winds which tend to blow the flames away from the container, and other factors which act to reduce the idealized conditions assumed for compliance with the 10 CFR Part 71 requirements. It is felt that the test conditions proposed in the regulations provide adequate, if not more severe, simulation of the fire conditions to which a container might be subjected during the course of transportation.

(4) Conclusion - In summary, the casks are designed to meet the requirements of applicable regulations, and it is unlikely that accident conditions more severe than those postulated in the regulations would be encountered.

## REFERENCES FOR APPENDIX E

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2. Cask Designers Guide. Oak Ridge National Laboratory, ORNL-NSIC-68.

Table E-1

IMPACT ACCIDENT COMPARISON

| Object | Weight (lb) | Initial Velocity (mi/h) | Stopping Distance (ft) | G's | Deceleration Force (lb) |
|---|---|---|---|---|---|
| Cask | 45,000 | 30 | 0.5 | 60 | 2,700,000 |
| Cask | 130,000 | 30 | 0.5 | 60 | 7,800,000 |
| Truck | 75,000 | 60 | 10.0 | 12 | 900,000 |
| Car | 5,000 | 80 | 5.0 | 44 | 220,000 |

# Appendix F

## OZONE PRODUCTION AND ITS POTENTIAL EFFECTS

This appendix summarizes and references the literature on the characteristics of ozone and its potential effects on plants, animals, and man. Natural sources of ozone are compared with reference values of the quantities measured during tests on EHV transmission lines. Ozone quantities are also compared with the "Community Air Quality Guides"[1] and the "National Primary and Secondary Ambient Air Quality Standards"[2] for oxidants.

1. Ozone characteristics and potential effects on plants, animals, and man - The characteristic pungent odor of ozone can be detected at very low concentrations (0.02 to 0.05 ppm depending on individual acuity). At somewhat higher concentrations (0.05 to 0.10 ppm) the odor becomes more pronounced and disagreeable. Ozone is one of the most powerful oxidizing substances known and combines readily with many materials.

Ozone is not considered to be injurious to vegetation, animals, and humans unless concentrations exceed about 0.05 ppm over prolonged periods.[1] Extremely sensitive varieties of tobacco can be injured after about 8 hours of exposure to 0.05 ppm ozone or a 1-hour exposure of 0.07 ppm.[1,3] Most other vegetation, however, can withstand exposures exceeding 0.10 ppm for 8 hours without injury.[1,3] Mice exposed to ozone levels of 0.08 ppm in the laboratory for 3 hours which were then infected with streptococcus experienced a 23 percent increase in mortality rate.[4] TVA is not aware of any similar correlation studies

of reduced tolerance to diseases versus ozone exposure which may have been made for humans. Most humans generally experience discomfort from ozone's unpleasant odor by the time concentrations approach 0.05 ppm.[4] Spectrograph operators who have experienced intermittent exposures of ozone concentrations in the range of 0.10 to 1.00 ppm over a 2-week period complained of shortness of breath and continuous headaches.[4] The visual acuity of humans can be reduced by prolonged exposures of 0.20 to 0.50 ppm.[3] Technical literature dealing with possible ozone-induced chromosome aberrations extrapolated from animal studies indicated that presently permitted ozone exposure would be expected to result in break frequencies that are orders of magnitude greater than those resulting from permitted radiation exposures.[5] The recent "Community Air Quality Guide,"[1] issued for ozone by the American Industrial Hygiene Association after consideration of the radiomimetic nature of ozone and the need for a realistic limit, recommended an upper concentration limit of 0.05 ppm for not more than 1 to 2 hours per day to protect very sensitive plants, and an exposure limit of 0.1 ppm/h/d on the average during any year if human health is not to be significantly impaired during a lifetime of exposure. By projecting observed impacts from experimental ozone exposures of Chinese hamsters, one observer estimates that even these levels could possibly produce about 1,270 times more lymphocyte chromosome breaks than the maximum permitted occupational radiation exposure.[5]

2. Natural ozone sources - Ozone is formed in nature by the dissociation action of solar ultraviolet radiation below 2,450A on the oxygen molecules present in the atmosphere. Peak

natural-formed concentrations of ozone as high as 11 ppm or more have been measured in the stratosphere; however, chemical, photochemical, and catalytic reactions tend to destroy the major portion of the ozone at ground levels where peak natural-formed concentrations would be expected to exceed 0.05 ppm only under rare circumstances, i.e., about 1 percent of the time.[1] Average ground-level concentrations of naturally formed ozone is estimated to be about 0.01 ppm in the United States.[4]

The actual instantaneous values for any specific location can vary from less than 0.01 ppm to over 0.05 ppm, depending on altitude, meteorological factors, geographical latitude, time of day, and time of year. Figure F-1 illustrates how ozone concentrations vary with altitude; however, vertical air currents constantly change the distribution, pattern, and magnitude of peak concentrations from those indicated. Similarly, figures F-2 and F-3 illustrate the magnitude of the diurnal variations which can occur between daytime ozone levels produced by the sun and nighttime levels when ozone tends to dissociate to its original oxygen form. The implications of figure F-2 will be discussed in greater detail later as it relates to the environmentally insignificant levels of ozone produced by transmission lines. Lightning is another natural phenomenon which produces large instantaneous quantities of extremely localized ozone; however, this accounts for very little of the total ozone existing in nature.

3. <u>Ozone generation by transmission facilities and other potential sources</u> - Ozone may be generated by any corona or electrical discharge in air or other oxygen medium. Quantities produced are dependent on the quantity of oxygen in the energy envelope. Ozone

may, therefore, be generated in undetermined quantities by motors, circuit breakers, electric welding torches, plasma sources, ultraviolet and fluorescent lamps, applicances, switches, transmission lines, or any other device which produces corona or electrical discharges.

Corona discharges can increase as a result of abrasions, foreign particles or sharp points on electrical conductors and electric equipment, or incorrect design which produces excessively high potential gradients. However, the design and construction of TVA transmission facilities minimize corona discharges and arcing. TVA specifications require that transmission line hardware and electrical equipment for operation at 500,000 volts be factory tested to assure as near corona-free performance as possible up to maximum operating voltage levels.

An extensive field-test program of detection of ozone in the vicinity of 765-kV lines has recently been completed, and full details and conclusions were incorporated in papers submitted for presentation at the 1972 IEEE Summer Power Meeting, San Francisco, July 1972.[6,7] Tests were conducted by Battelle Memorial Institute at 20 locations and under a variety of meteorological conditions, including several tests in which the instruments were placed as close as 6 meters downwind from the energized 765-kV conductors, at the conductor height. Ozone, $NO_x$, and corona-loss measurements were simultaneously conducted, under contract to AEP, at the Westinghouse EHV Laboratory at Trafford to measure the rates of ozone and $NO_x$ production from full-scale conductor bundles which could be operated at 765 kV.[8] Diffusion models developed from these tests agreed closely with the actual transmission

line measurements. No ozone contribution to the natural ozone levels was detected which could be attributed to the transmission lines.

Under these tests sponsored by the Electric Research Council and jointly financed by the Edison Electric Institute and the Bonneville Power Administration, the General Electric Company[9,10,11,12] is conducting transmission research in the 1,000-kV to 1,500-kV range. As a result of questions posed about the possible levels of ozone generation from the UHV configurations, ozone was monitored at the project. Figure F-2 shows ozone concentrations during the time the UHV test line was energized and deenergized over a 2-week period and graphically illustrates the following conclusions:

> From the results, it was evident that sunlight on a clear day is a more efficient producer of ozone than UHV lines, and any amounts created by the lines were so small that they were lost in the background produced by the sun's radiation.[13]

4. Conclusion - No significant adverse effects on vegetation, animals, or humans are expected to result from possible levels of ozone production attributable to transmission facilities for transmission voltages up to 765 kV. It is concluded that any level of ozone that can reasonably be expected to be generated by TVA's transmission facilities (500-kV maximum voltage), either resulting from normal transmission operation or following breaker or switching operations for the periods and the levels that they could be expected to persist, are environmentally inconsequential to humans, animals, or vegetation.

## REFERENCES FOR APPENDIX F


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3. Heggested, H. E., "Consideration of Air Quality Standards for Vegetation with Respect to Ozone," Journal of the Air Pollution Control Association.

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8. Roach, J. F., Chartier. "An Estimate of Ozone and $NO_x$ Concentrations Near Extra High Voltage Transmission Lines Based on Laboratory Measurements of Ozone and $NO_x$ Production Rates for Four Conductor Bundles," Westinghouse Research Laboratories Research Report 71-7E8-COZOM-R1, December 31, 1971.

9. Letter and attachments, J. M. Schanberger to Dr. G. W. Walkins, dated November 15, 1971. "Report to the Electrical Research Council RP-68 UHV Transmission Research Project."

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13. "UHV Transmission Research Project Extended for Additional Two Years," Edison Electric Institute Bulletin, January-February 1972.

14. Ripperton, L. A., L. Kornreich, and J. Worth. "Nitrogen Dioxide and Nitric Oxide in Nonurban Air," Air Pollution Control Association Journal, Volume 20, No. 9 (September 1970), pp. 589-592.

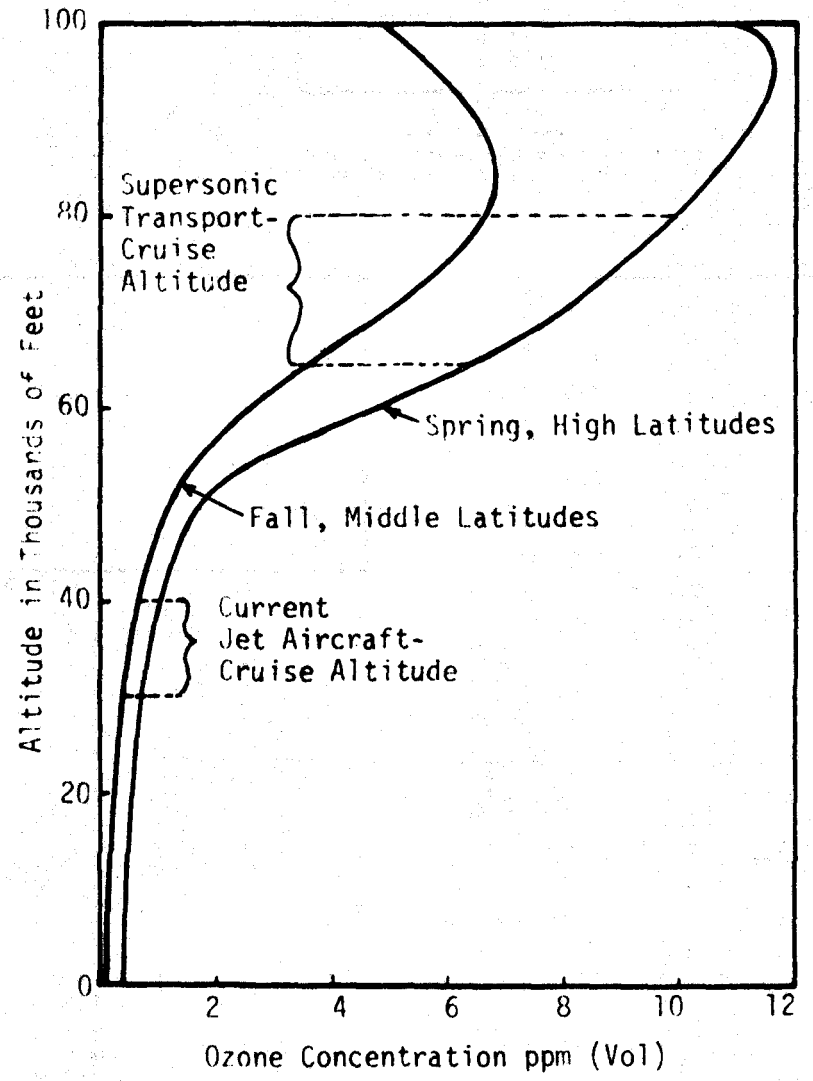



Figure F-1

Ozone Distribution
Northern Hemisphere

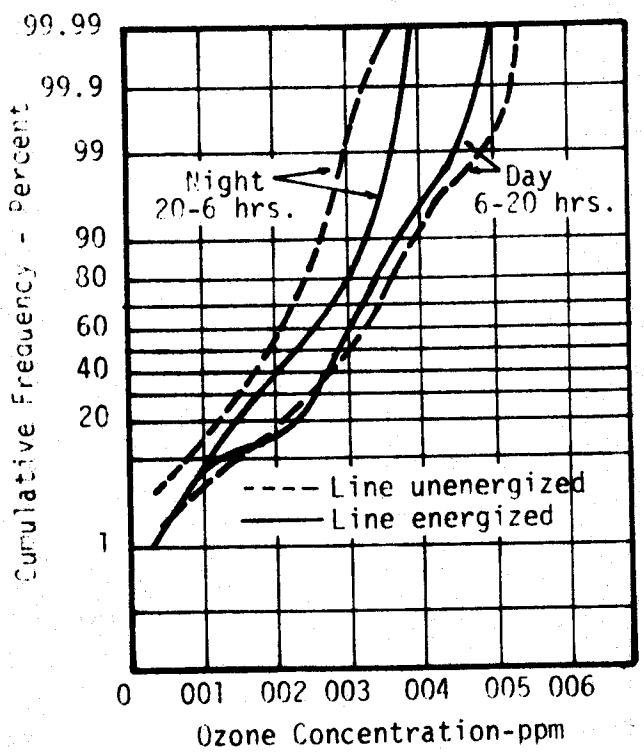



Figure F-2
Ozone Statistic obtained near UHV Test Line during 8 days of Energization and 10 days without Energization

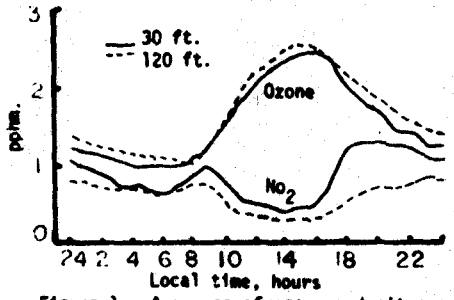
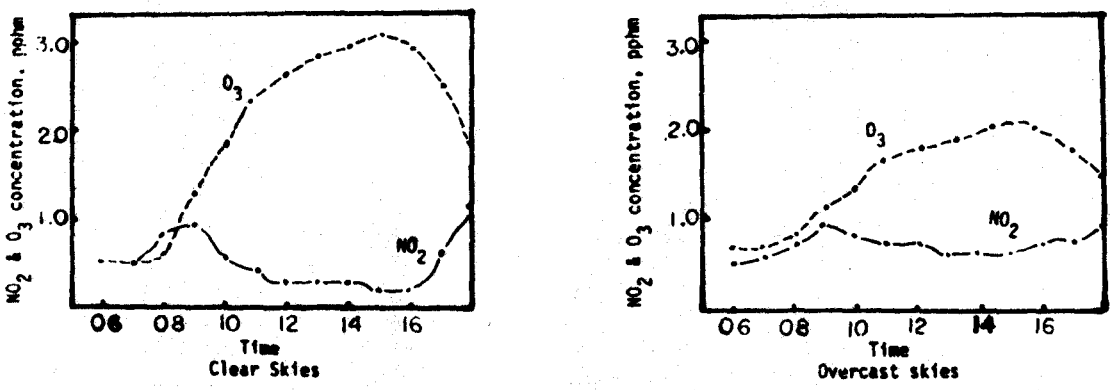



Figure 1. Averages of ozone and nitrogen dioxide for five months(Sept. 1966-Jan. 1967)



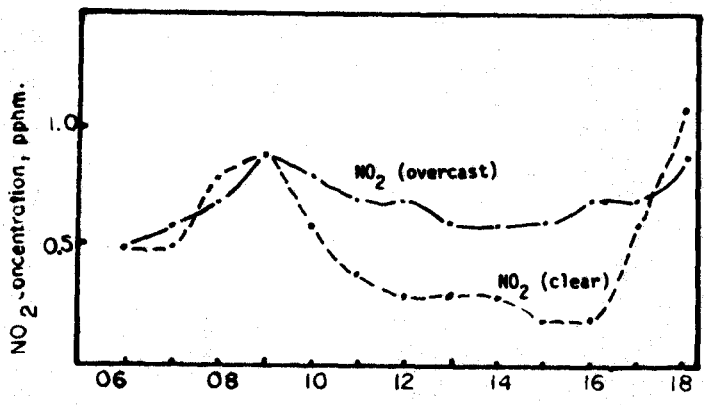




Figure 2. Nitrogen dioxide on clear and overcast days (Sept. 1966-Jan. 1967)

Figure F-3

FUNCTIONAL RELATIONSHIPS OF OZONE AND NITROGEN DIOXIDE[14]

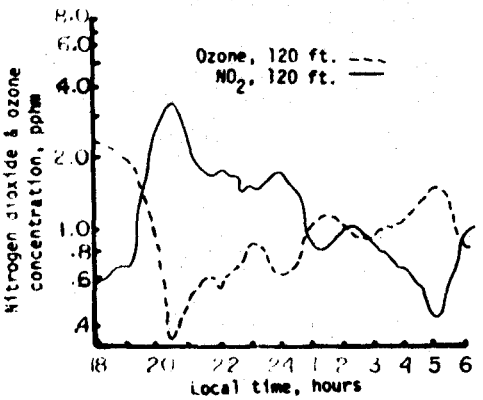



Figure 3. Nitrogen dioxide and ozone (1800-0600 hr on 11/24/66).

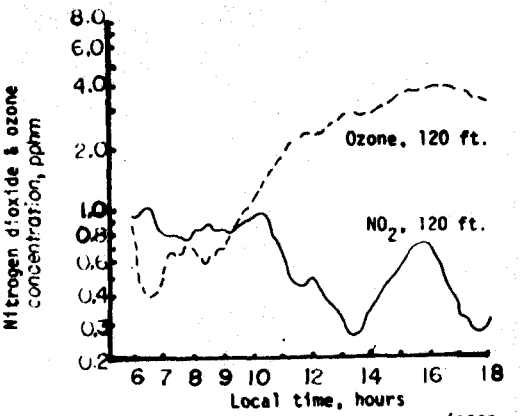



Figure 4. Nitrogen dioxide and ozone (0600 1800 hr on 11/25/66).

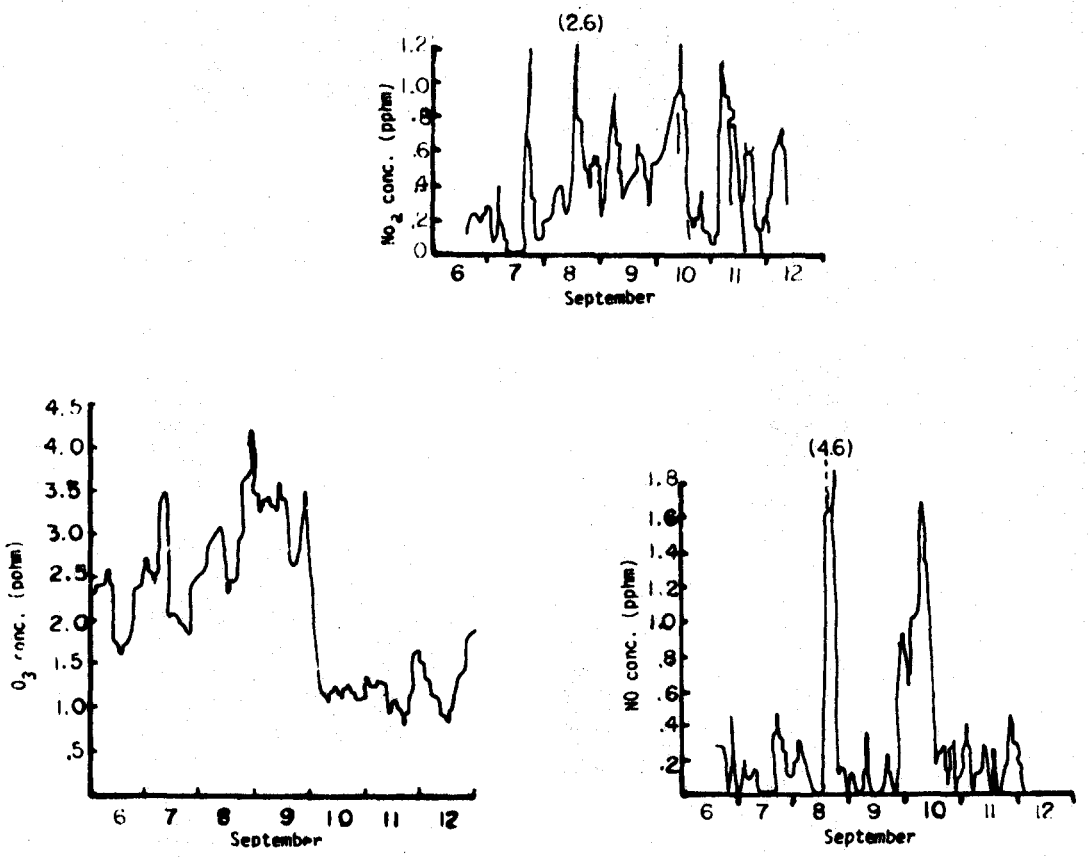



Figure 5. Diurnal averages for nitrogen dioxide and ozone at Green Knob. N. C. (Sept. 1965).

Figure F-3 (Cont'd)

FUNCTIONAL RELATIONSHIPS OF OZONE AND NITROGEN DIOXIDE[14]

Appendix F1

## PROGRAM FOR CHEMICAL TREATMENT OF TVA TRANSMISSION LINE RIGHTS OF WAY

Each year TVA submits for approval of the Federal Working Group on Pest Management a detailed report of its proposed program for chemical control of vegetation on transmission line rights of way. The report sets out the number of acres to be controlled, the chemicals to be used, and the method and rate of application. Tables F1-1 and F1-2 show the reports submitted in fiscal year 1972 by TVA.

The following pages and supporting information are TVA's justification for the use of chemical treatment of its transmission line rights of way.

**WGP Form No. 2 (Rev. 70) - Justification for the Use of 2,4,5-T Esters, Picloram 101, and 10K Pellets**

1. The Tennessee Valley Authority plans to use 2,4,5-T esters, picloram 101, and 10K pellets to control undesirable brush species in remote and problem areas on transmission line rights of way.
2. If the brush is not controlled it will grow into the lines and cause power interruptions. It is planned to use herbicides because the terrain is so rugged and remote that other methods are not feasible.
3. The Tennessee Valley Authority is planning to chemically treat approximately 3,600 acres of brush on transmission line rights of way. The chemicals will be applied from helicopters and ground equipment and by hand. The areas to be treated are sections of rights of way 100 feet in width and are not in close proximity to one another. They are in Tennessee, Alabama, Mississippi, North Carolina, and Kentucky and vary in size from 2 acres to 250 acres.
4. The Tordon 101 will be applied from helicopters at the rate of 10 pounds active per acre. Four gallons of the chemical will be mixed with 11 gallons of water and applied at the rate of 15 gallons total solution per acre. The 2,4,5-T will be applied as a basal, using handguns and treating the lower 18 inches of each stem. Three gallons of the chemical will be mixed in 97 gallons of diesel oil and applied at the rate of 100 gallons per acre, depending on the stem population. In general, the chemical will be applied at the rate of 12 pounds active per acre. The 10K pellets will be used in spot treatment and will be applied by hand. The rate per acre will be determined by the stem population; however, the total volume will not exceed 90 pounds per acre, which is 9 pounds active per acre.* The Tordon 101 is registered under U.S. Department of Agriculture registration number 464-306. The 10K pellets are registered under U.S. Department of Agriculture registration number 464-320. The Dow 2,4,5-T is registered under U.S. Department of Agriculture registration number 464-205.
5. The application of the herbicides will be directed by employees who are thoroughly trained in all phases of the work and have 20 years' experience. The aerial spraying will be done by pilots who have 8 years' experience in power line spraying.** The chemical mixture to be applied from helicopters will be thickened to eliminate fine droplets and to ensure on-target application. Spraying will not be done when the wind exceeds 2 miles per hour. The spray pattern will be observed; and when it begins to shift, the spraying will cease. The basal spraying will be done using low pressure, and the spray

---

*90 pounds per acre represents maximum application; as indicated for project No. P-3, the average application is 80 pounds per acre.

**Eight years represents the minimum experience of the pilots conducting the work; as indicated for project Nos. P-2 and P-5, some of the pilots have as much as 12 years' experience.

gun will be kept close to the ground at all times. Special precautions will be taken to prevent any of the chemicals from getting into streams and water sources. All necessary precautions will be taken to keep the chemicals from contaminating crops and other vegetation off the rights of way.

6. There are no other materials that will control the species of brush established in the areas scheduled for treatment. Mechanical methods are not economically feasible and will not render a long-enough control.
7. No other organizations are involved.
8. Extensive tests have been conducted on the materials to be used, and various technical reports about the impact on organisms in the environment are available. Therefore, no monitoring activities are planned.

**Justification for the Use of Tandex**

In 1968 TVA established a series of tests using the Tandex to determine its effectiveness in controlling brush. This work was done in conjunction with the U.S. Army. The material was applied at various rates to determine the most effective and economical rate. It was applied in solution from a helicopter. The evaluations were made at intervals during 1968 and 1969, and it was found that 15.2 pounds of active material per acre would control all species of brush. We were particularly interested in controlling ash since the other herbicides that are used in our program are not effective in controlling this species.

In May 1970 we sprayed 136 acres on sections of two of our lines near Monteagle, Tennessee. These sections were in rugged mountainous areas with limestone rock outcrop. There was a dense stand of ash ranging from 12 to 20 feet high. The ground cover was very sparse because of the tremendous canopy of the ash. Our evaluations have revealed that the material is the most effective herbicide on all species that we have used in our program.

Tandex is considered a soil sterilent; however, we have found that the sterilized condition is temporary, and that the second growing season many species of broadleaved seed-bearing plants become established. These plants are very beneficial to wildlife and have advantages in other ways. The grass also begins to come back the second growing season, and by the end of the third growing season the right of way has a beautiful dense ground cover of low-growing broadleaved plants and various grasses.

The areas that we propose to use the Tandex on are remote, and the terrain and ground conditions are so rugged that machines cannot be used to clear the right of way. The other alternative would be to use power saws, which would result in a very expensive operation.

The herbicides that we have used in the past will not be effective since a greater part of the right of way has a dense stand of ash, and the Tandex is the only chemical that will kill it. Since the Tandex will be applied on a 100-foot strip cross country in very rugged remote terrain, we do not believe that it would have any adverse effect on the environmental considerations that are now being promoted.

PHYSICAL, CHEMICAL, AND BIOLOGICAL CHARACTERISTICS OF SELECTED HERBICIDES
USED IN TRANSMISSION LINE RIGHT OF WAY MAINTENANCE
(Taken from Herbicide Handbook of the Weed Science Society of America

| | | | | | |
|---|---|---|---|---|---|
| **A. Nomenclature, Chemical and Physical Properties of the Pure Chemical** | | | | | |
| 1. Common name | -- | Picloram | Picloram | 2,4,5-T | Hychlor |
| 2. Trade name | Tandex | Tordon 101 | Tordon 10K pellets | -- | -- |
| 3. Molecular formula | $C_{14}H_{21}N_3O_3$ | $C_6H_3CL_3N_2O_2$ | | $C_8H_5CL_3O_3$ | -- |
| 4. Molecular weight | 279.4 | 241.5 | 279.5 | 255.5 | -- |
| 5. Physical state, color & odor | White crystalline solid | White powder, chlorine-like odor | Brown pellets | White solid | -- |
| 6. Melting point | 176 to 176.5 C | Decomposes before melting | Decomposes before melting | 154 to 155 C | -- |
| 7. Solubility at temperature given | Solvent @ 20C | Solvent @ 25C | Solvent @ 25C | Solvent | Moderately soluble in water at 25° C. |
| | Water 325 ppm | Acetone 19,800 ppm | Acetone 100 ppm | Ethyl or isoprophyl alcohol @ 50C 590 ppm | Metaborate portion is least soluble. |
| | Acetone 3% | Acetonitrile 1,600 ppm | Isopropanol 2,400 ppm | Water @ 30C 238 ppm | |
| | Xylene 3% | Benzene 200 ppm | Kerosene 100 ppm | | |
| | Isopropanol 3% | Carbon disulfide 50 ppm | Water 400,000 ppm | | |
| | Isophorone 3% | Diethyl ether 1,200 ppm | Xylene 100 ppm | | |
| | Dimethyl sulfoxide 20 to 25% | Ethanol (2B absolute) 10,500 ppm | | | |
| | Dimethyl formamide 20 to 25% | Isopropanol 5,500 ppm | | | |
| | | Kerosene 10 ppm | | | |
| | | Methylene Chloride 600 ppm | | | |
| | | Water 430 ppm | | | |
| **B. Herbicidal Use** | | | | | |
| 1. General | Control of annual and perennial broad-leaved weeds and grasses as well as woody species is provided. | For general woody plant control and control of most perennial broadleaf plants. Most grasses are resistant, and broadleaf weed control in grass crops is feasible. | For general woody plant control and control of most perennial broadleaf plants. Most grasses are resistant, and broadleaf weed control in grass crops is feasible. | For general control of woody plants, brush, and broadleaf weeds under a variety of conditions. | Nonselective - soil sterilant |
| 2. Application methods | Pre-emergence or post-emergence applications. | Granular formulations applied by hand or commercial granular applicators. Aerial application is recommended only with a drift control method. | Granular formulations applied by hand or commercial granular applicators. Aerial application is recommended only with a drift control method. | Mainly post-emergence but some pre-emergence spraying with conventional ground and aerial spraying. | Granular formulations, wettable powders and liquid spray. |
| 3. Rates | 2 to 4 lb/A - for annuals<br>4 to 8 lb/A - for perennials<br>8 to 20 lb/A - for woody species | 6 to 8 lb/A - for thick stands of brush<br>1 to 3 lb/A - for deep-rooted perennial weeds<br>0.25 oz/A - for annual weed control | 6 to 8 lb/A - for thick stands of brush<br>1 to 3 lb/A - for deep-rooted perennial weeds<br>0.25 oz/A - for annual weed control | 2 lb. A.E. in 25 gal. solution (rates of AI/acre is governed by density of brush stand) | |
| 4. Usual carrier | Water or herbicidal oil. | No. 2 diesel fuel. | Applied in pellet form. | Water, diesel or fuel oil, or an oil-water emulsion at volumes of 3 to 30 gpa. | Water or pellets |
| **C. Use Precautions** | | | | | |
| 1. Flammability | Not flammable. | Combustible with a TOC flash-point of 35 C. | Not flammable. | Not flammable. | Not flammable. |
| 2. Possible incompatibilities | Generally compatible. | Compatible with hard water and many liquid fertilizers. | -- | Esters cause little or no clogging in hard water. Amine salts may result in insoluble precipitates, depending upon degree of sequestration and water hardness. | Generally compatible but metaborate is least soluble portion. |
| 3. Corrosiveness | Noncorrosive. | -- | -- | Noncorrosive. | -- |
| 4. Storage stability | Stable. | 3 years | 3 years | Excellent | Highly stable, when dry. |

PHYSICAL, CHEMICAL, AND BIOLOGICAL CHARACTERISTICS OF SELECTED HERBICIDES
USED IN TRANSMISSION LINE RIGHT OF WAY MAINTENANCE
(continued)

| | TANDEX | TORDON 101 | TORDON 10K | 2,4,5-T | HYCHLOR |
|---|---|---|---|---|---|
| D. Physiological and Biochemical Behavior | | | | | |
| 1. Foliar absorption characteristics | The active ingredient is primarily absorbed through the roots. Does not vaporize. | Rapidly absorbed by both tops and roots. | Rapidly absorbed by both tops and roots. | Absorbed through roots and foliage. | Absorbed primarily through roots |
| 2. Translocation characteristics | -- | Translocates both up and down in plants. Kills new growth sprouting from stumps. | Translocates both up and down in plants. Kills new growth sprouting from stumps. | Through phloem tissue following foliar application. | Translocates both up and down |
| 3. Mechanism of action | Known to inhibit the Hill reaction. | -- | -- | Basic mechanism of action is unknown. Several modes of action have been shown. | Seems to be by causing defoliation, chlorosis and by die-back due to blockage of normal metabolism. |
| E. Behavior In or On Soils | | | | | |
| 1. Absorption and leaching in basic soil types | -- | Sorption by organic matter and certain clays has been demonstrated. Some leaching may occur in sandy soils low in organic matter. | Sorption by organic matter and certain clays has been demonstrated. Some leaching may occur in sandy soils low in organic matter. | Similar to those of 2,4-D | Will persist 10-18 months depending upon oil type. |
| 2. Microbial breakdown | -- | Degradation by soil microorganisms does occur. | Degradation by soil microorganisms does occur. | Broken down more slowly than 2,4-D, due to the addition of another Cl atom. | Very slow degradation. |
| 3. Loss from photo decomposition | -- | Breakdown occurs in UV light. Rate of breakdown is greatest in clear, moving water. | Breakdown occurs in UV light. Rate of breakdown is greatest in clear, moving water. | -- | -- |
| 4. Resultant average persistance at recommended rates | -- | Disappearance from soils varies with geographical location, climate, and rate of application. Disappearance is more rapid under warm, humid conditions in the south and slowest under cold, dry conditions in the north. | Disappearance from soils varies with geographical location, climate, and rate of application. Disappearance is more rapid under warm, humid conditions in the south and slowest under cold, dry conditions in the north. | -- | 10-18 months dependent upon soil and amount of precipitation. |
| F. Toxicological Properties | | | | | |
| 1. General toxicity to wildlife and fish | Nontoxic. | Has low order of toxicity to wildlife and fish. | Has low order of toxicity to wildlife and fish. | Negligible hazard to wildlife at recommended rates. | Bromacil relatively low toxicity, sodium chlorate toxic to fish, sodium metaborate relatively nontoxic. |
| 2. Acute toxicity ($LD_{50}$ Values) | Albino rats 3,000 mg/kg | Rats 8,200 mg/kg<br>Mice 2,000-4,000 mg/kg<br>Rabbits 2,000 mg/kg<br>Guinea pigs 3,000 mg/kg<br>Chicks 6,000 mg/kg<br>Sheep 1,000 mg/kg<br>Cattle 750 mg/kg | Rats 8,200 mg/kg<br>Mice 2,000-4,000 mg/kg<br>Rabbits 2,000 mg/kg<br>Guinea pigs 3,000 mg/kg<br>Chicks 6,000 mg/kg<br>Sheep 1,000 mg/kg<br>Cattle 750 mg/kg | Rats 300 mg/kg<br>Dogs 100 mg/kg<br>Bluegill 11 mg/kg | Bromacil<br>Rats oral 5,200 mg/kg<br>Rabbits dermal 5,000+ mg/kg<br>Sodium chlorate<br>Rats oral 5,500 mg/kg<br>Sodium metaborate<br>No data |
| 3. Chronic toxicity | -- | Rats - 90 days<br>1,000 ppm - no effect<br>3,000 ppm - liver effects noted. | Rats - 90 days<br>1,000 ppm - no effect<br>3,000 ppm - liver effects noted. | Low chronicity for livestock. | Bromacil<br>Rats - 2 years<br>>250 ppm but ≤1,250 ppm.<br>Dogs - 2 years<br>1,250 ppm - no effects<br>Sodium chlorate - unknown<br>Sodium metaborate - unknown |

PHYSICAL, CHEMICAL, AND BIOLOGICAL CHARACTERISTICS OF SELECTED HERBICIDES
USED IN TRANSMISSION LINE RIGHT OF WAY MAINTENANCE
(continued)

| | TANDEX | TORDON 101 | TORDON 10K | 2,4,5-T | HYCHLOR |
|---|---|---|---|---|---|
| 4. Toxicity to skin and possible danger through inhalation | The acute dermal $LD_{50}$ of AI to albino rats is 15,400 mg/kg of body weight. | Skin - mild irritation, not a skin sensitizer to humans. Not likely to be absorbed through skin. $LD_{50}$ for rabbits from skin absorption - 4,000 mg/kg.<br>Eyes - moderate irritation which heals readily. No corneal injury likely.<br>Inhalation - dusts may be irritating but not likely to cause illness. | Skin - mild irritation, not a skin sensitizer to humans. Not likely to be absorbed through skin. $LD_{50}$ for rabbits from skin absorption - 4,000 mg/kg.<br>Eyes - moderate irritation which heals readily. No corneal injury likely.<br>Inhalation - dusts may be irritating but not likely to cause illness. | -- | Guinea pigs - mild irritation of skin by Bromacil.<br>Skin irritation and ulceration of nasal septum by sodium chlorate - no irritation by sodium metaborate. |
| 5. Symptoms of poisoning | No human intoxication known. | Possible nausea from ingestion. | Possible nausea from ingestion. | -- | Sodium Chlorate<br>a. Oral - abdominal pain, nausea, vomiting, diarrhea, pallor, blueness, shortness of breath, unconsciousness, collapse<br>b. Inhalation - ulceration of nasal septum<br>c. Dermal - skin irritation<br>d. Eyes - irritation<br>Bromacil<br>a. Oral - no symptoms, low toxicity<br>b. Inhalation - may be irritating<br>c. Dermal - may irritate<br>d. Eyes - irritation<br>Sodium Metaborate - no data |

| WORKING GROUP ON PESTICIDES PEST CONTROL PROGRAM REPORT | DEPARTMENT/AGENCY: Tennessee Valley Authority | DATE SUBMITTED: October 13, 1971 |
|---|---|---|
| | DIVISION: Power System Operations | PERSON TO CONTACT/TELEPHONE NO.: S. I. Simon, 755-2461 |

*Refer to attached instructions before completing form. Be sure that entries are correctly aligned horizontally.*

| OBJECTIVE | PESTICIDE | APPLICATION | | | | | SENSITIVE AREAS[1] | REMARKS |
|---|---|---|---|---|---|---|---|---|
| (a) PROJECT NO. (b) TARGET PEST (c) PURPOSE | (a) COMMON NAME (b) % AI OR LB/GAL (c) REGISTERED USE AND REGISTRATION NO. (If available) | (a) FORM APPLIED (Dust, granule, emulsion, bait, solution, gas, etc.) (b) USE STRENGTH (%) OR MIX | LBS AI PER ACRE OR OTHER RATE | METHOD (Aircraft, ground, aerosol, ULV, LV, other) | (a) ACRES OR OTHER UNIT TO BE TREATED (b) NUMBER AND DESCRIPTION OF SITES | (a) SEASON OF YEAR (b) STATE OR REGION | (a) AREAS TO BE AVOIDED (b) AREAS TO BE TREATED WITH CAUTION [1]Croplands, lakes, streams, human, exposure, other | (a) PRECAUTIONS TO BE TAKEN (b) NO. OF APPLICATIONS (c) USE OF TRAINED/CERTIFIED PERSONNEL (d) MONITORING (e) OTHER |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| (a) P-1 (b) mixed species of hardwood brush on trans. line R/W. (c)to ensure continuous operation of trans. line | (a) 2,4,5-T esters (b) 4 lbs. A.E./gal. | (a) Solution (b) 97 gals. No. 2 diesel oil and 3 gals. 2,4,5-T esters | 12 lbs/A. | Ground basal-individual stem-lower 18 inches of stem | (a) 1,900 acres (b) numerous | (a) spring, summer, & fall (b)Alabama Kentucky Mississippi North Carolina Tennessee Georgia | (a)no spraying where mixture will get into water (b) croplands | (a)applied under low pressure (b)one application (c)highly trained personnel will be used |
| (a) P-2 (b)undesirable brush species in remote rough terrain where other methods and chemicals are not economically feasible (c) to ensure continuous operation of trans. line. | (a)Tordon 101 (b)2 lbs. 2,4-D Amine & 1/2 lb. Picloram Total 2-1/2 lbs/gal. | (a) Solution (b) 11 gals. $H_2O$ and 4 gals chemical with Vistik as thickening agent. | 10 lbs/A. | Aerial helicopter | (a)1,500 acres | (a)spring & summer (b)Alabama Kentucky North Carolina Tennessee | (a)croplands, lakes,streams & other water sources and residential areas. (b)No spraying within 100 feet of water. | (a)A thickener used. No spraying when wind velocity exceeds 2 miles per hour. (b)one application (c)highly trained personnel used. Pilots have 10 to 12 years experience in the application technique. |
| (a) P-3 (b)undesirable brush species in small are (c)to keep brush fro | (a) Tordon 10K pellets (b)10% active | (a) Pellets (b)80 lbs total per acre or 8 lbs active per acre | 8 lbs/A. | Ground spot treatment. Hand & cyclone spreader | (a) 200 acres | (a)spring & early summer (b)Alabama Kentucky Mississippi North | (a)croplands lakes,streams & other water sources. (b)no application within 100 feet of | (a)necessary precautions will be taken to keep the material out of water & crops (b)one application |



SP FORM 1 (9/71)

| WORKING GROUP ON PESTICIDES PEST CONTROL PROGRAM REPORT | DEPARTMENT/AGENCY: Tennessee Valley Authority | DATE SUBMITTED: October 13, 1971 |
|---|---|---|
| | DIVISION: Power System Operations | PERSON TO CONTACT/TELEPHONE NO.: S. I. Simon, 755-2461 |

*Refer to attached instructions before completing form. Be sure that entries are correctly aligned horizontally.*

| OBJECTIVE | PESTICIDE | APPLICATION | | | | | SENSITIVE AREAS[1] | REMARKS |
|---|---|---|---|---|---|---|---|---|
| (a) PROJECT NO. (b) TARGET PEST (c) PURPOSE | (a) COMMON NAME (b) % AI OR LB/GAL (c) REGISTERED USE AND REGISTRATION NO. (if available) | (a) FORM APPLIED (Dust, granule, emulsion, bait, solution, gas, etc.) (b) USE STRENGTH (%) OR MIX | LBS AI PER ACRE OR OTHER RATE | METHOD (Aircraft, ground, aerosol, ULV, LV, other) | (a) ACRES OR OTHER UNIT TO BE TREATED (b) NUMBER AND DESCRIPTION OF SITES | (a) SEASON OF YEAR (b) STATE OR REGION | (a) AREAS TO BE AVOIDED (b) AREAS TO BE TREATED WITH CAUTION [1] Croplands, lakes, streams, human, exposure, other | (a) PRECAUTIONS TO BE TAKEN (b) NO. OF APPLICATIONS (c) USE OF TRAINED/CERTIFIED PERSONNEL (d) MONITORING (e) OTHER |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| growing into conductors. | | | | | | Carolina Tennessee | water | (c) trained personnel will be used. |
| *(a) P-4 (b)Undesirable vegetation in substation yards, and various areas at steam & hydro plants (c)to create better maintenance & operation of facilities More economical than other methods. | (a) Hychlor (b) 93.6% active | (a) Granule (b) 93.6% active, sodium Metaborate, and Bromacil | 650/A | Ground mechanical spreader & by hand | (a) 135 acres (b) gravel rd. areas. Rip-raps, railroads, fences | (a)spring & summer (b)Alabama Georgia Kentucky Mississippi North Carolina Tennessee Virginia | (b)near water & crops | (a)The material will not be applied in areas where surface runoff will move it from target area. (b)one application (c)trained personnel will be used. |

*P-4 - Division of Power System Operations - 70 percent, Division of Power Production - 30 percent.

DCF:RC

WGP FORM 1 (9/71)

Table F1-1 (Continued)

**WORKING GROUP ON PESTICIDES**
**PEST CONTROL PROGRAM REPORT**

| DEPARTMENT/AGENCY | DATE SUBMITTED |
|---|---|
| Tennessee Valley Authority | March 20, 1972 |
| **DIVISION** | **PERSON TO CONTACT/TELEPHONE NO.** |
| Power System Operations | S. I. Simon - 755-2461 |

*Refer to attached instructions before completing form. Be sure that entries are correctly aligned horizontally.*

| OBJECTIVE | PESTICIDE | APPLICATION | | | | | SENSITIVE AREAS[1] | REMARKS |
|---|---|---|---|---|---|---|---|---|
| (a) PROJECT NO.<br>(b) TARGET PEST<br>(c) PURPOSE | (a) COMMON NAME<br>(b) % AI OR LB/GAL<br>(c) REGISTERED USE AND REGISTRATION NO. (if available) | (a) FORM APPLIED (Dust, granule, emulsion, bait solution, gas, etc.)<br>(b) USE STRENGTH % OR MIX | LBS AI PER ACRE OR OTHER RATE | METHOD (Aircraft, ground, aerosol, ULV, LV, other) | (a) ACRES OR OTHER UNIT TO BE TREATED<br>(b) NUMBER AND DESCRIPTION OF SITES | (a) SEASON OF YEAR<br>(b) STATE OR REGION | (a) AREAS TO BE AVOIDED<br>(b) AREAS TO BE TREATED WITH CAUTION<br>[1] Croplands, lakes, streams, human, exposure, other | (a) PRECAUTIONS TO BE TAKEN<br>(b) NO. OF APPLICATIONS<br>(c) USE OF TRAINED/CERTIFIED PERSONNEL<br>(d) MONITORING<br>(e) OTHER |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| (a) P-5<br>(b) Dense stands of ash and other species of brush on transmission line rights of way<br>(c) To ensure continuous operation of transmission line in rugged mountainous terrain | (a) Tandex<br>(b) 80% wettable powder | (a) Suspension<br>(b) 19 lbs. of 80% wettable powder with 20 gals. of water | 15.2 lbs. per acre | Helicopter | (a) 1,393 acres | (a) Spring<br>(b) Alabama Georgia, and Tennessee | (a) Croplands, lakes, streams & other water sources and residential areas<br>(b) No spraying within 100 ft. of water | (a) Applied under ideal weather conditions with wind velocity not exceeding 3 miles per hour<br>(b) One application<br>(c) Highly trained personnel used. Pilots have 10 to 12 years of experience in the application technique |

WGP FORM 1 (9/71)

# Appendix G

## OUTLINE OF ACCIDENT ANALYSES

## SEQUOYAH NUCLEAR PLANT

1. Introduction - This appendix describes the evaluation of the environmental impact of postulated occurrences and accidents for the Sequoyah Nuclear Plant. This evaluation follows the guidelines given in the AEC Regulatory Guide 4.2, "Preparation of Environmental Reports for Nuclear Power Plants," issued on March 2, 1973 (Reference 1 of section 2.3). As shown in Table G-1, the results of this evaluation demonstrate that the consequences of the postulated accidents and occurrences have no significant adverse environmental effects.

The postulated events are divided into the nine accident classes as shown in Table 2.3-1. The events analyzed in each class are those identified in Regulatory Guide 4.2. Assumptions not specified have been selected on the basis of using the most realistic values consistent with the present state of knowledge.

In the following pages, the individual events are described with emphasis on the routes of escape of activity to the environment, and the equipment and structures which contain the activity. Indications of the probable frequency or probability of occurrences of the postulated events are provided to the degree possible. Detailed description of critical equipment and structures is provided in the preliminary safety analysis report (as amended), which also contains descriptions of very conservative analyses of many of these same events.

2. Evaluation of Class 1 and 2 events - Class 1 events are trivial incidents involving small releases due to normal operations. Class 2 events are small releases outside containment such as valve leakage, spills, etc. The releases from both Class 1 and Class 2 events are considered in the evaluation of routine releases.

3. Analysis of Class 3 events - Class 3 events include releases of radioactivity from the waste disposal systems as a result of equipment malfunction or a single operator error. The waste disposal system has been designed to collect, monitor, treat, and discharge or package for disposal liquid, solid, and gaseous wastes. Operations will be conducted in accordance with administrative procedures.

Waste releases and shipments are made on a batch basis which permits knowledge and control of anticipated releases before any action is undertaken to make the actual release. For the liquid and gaseous cases, the actual release is monitored by radiation detectors, and a permanent record of the activity release is recorded.

(1) Liquid radwaste - The bulk of the radioactive liquids discharged from the reactor coolant system are processed and retained inside the plant by the chemical and volume control system recycle train. This minimizes liquid input to the waste disposal system which processes relatively small quantities of generally low-activity level wastes. The processed water from waste disposal, which contains relatively little radioactive material, is discharged through a monitored line into the waste discharge pipe.

At least two valves must be manually opened to permit discharge of liquid or gaseous waste from the waste disposal

system. One of these valves is normally locked closed, and the other is interlocked so that it can be opened only if two out of three condenser circulating water pumps per unit are operating. A control valve will trip closed on a high effluent radioactivity level signal.

The system is controlled from a central panel in the auxiliary building. Malfunction of the system actuates an alarm in the auxiliary building and annunciates in the control room. All system equipment is located in or near the auxiliary building, except for the reactor coolant drain tank and drain tank pumps, and floor and equipment drain sump and pumps which are located in the containment buildings.

Leakage of liquid radwaste from tanks is caught in sumps in the auxiliary building. Therefore, leakage or rupture of a radwaste tank does not lead to a significant release to the river. Gaseous activity from such a spill would be picked up by the auxiliary building ventilation system.

The largest inventory of radioactivity outside the plant structures is the refueling water tank. There is one 350,000-gallon tank for each unit which might contain as much as 2,000 curies of tritium and 0.75 curies of other radionuclides. It is postulated that the tank ruptures, releasing its contents in about 1/2 hour. The released water would drain to the plant intake and be released to the reservoir via the diffuser pond and the diffusers.

(2) Solid radwaste - Because of the nature of solid radioactive wastes and specialized procedures and equipment provided for packaging and handling these wastes, significant accidental

releases of radioactivity from solid wastes is considered extremely unlikely.

(3) Gaseous radwaste - Several postulated Class 3 accidents were analyzed, and a major leak in a gas waste holdup tank was found to yield the greatest potential for release to the environment. Operating experience at Yankee-Rowe and Saxton indicates that the activity stored in the gas holdup tank consists of the noble gases released from the primary coolant and only negligible quantities of the less volatile isotopes. Any major leakage from these tanks would be processed through the filtration system in the auxiliary building ventilation systems to further reduce any potential release of particulates and iodines.

(4) Evaluation - The potential for environmental effects from Class 3 events is based on releases from a gaseous decay tank for gaseous releases and from a rupture of a refueling water storage tank.

The inventory in the gaseous radwaste tank is based on the accident occurring to the tank immediately after the coolant had been degassed during a reactor shutdown. The average inventory in each of the nine gaseous decay tanks will be much less than this.

Leakage from the gaseous radwaste system might be expected to occur during the lifetime of the plant. Complete failure of a radwaste tank (gas or liquid) is not expected to occur during the lifetime of the plant.

Subparagraph (1) above gives the volume and activity levels for the refueling water storage tank. The release of the contents of this tank has been analyzed as a gaseous accident in accordance with the assumptions of Regulatory Guide 4.2, and the results are listed under item 3.3 in Table G-1. The potential effect of such an accident was also evaluated assuming all the water enters the ground water at the site. The resulting dose commitment to people within 50 miles is less than a third of the dose commitment resulting from the treatment of the accident as a "gaseous" accident (9.8 man-rem versus 33 man-rem).

4. Analysis of Class 4 events - Class 4 accidents are events that release radioactivity into the primary coolant, including anomalous fuel failures as well as fuel failures which might result in an increased primary coolant activity which increases the activity of the fluids processed by the waste disposal system.

The fuel rods consist of uranium dioxide ceramic pellets contained in slightly cold-worked Zircaloy-4 tubing which is plugged and seal-welded at the ends to encapsulate the fuel. The manufacturing process is subject to an extensive quality assurance program which provides assurance that the resulting fuel rods satisfy the manufacturing tolerances and design specifications. Excessive heating or pressurization of the fuel rods could possibly cause perforation of the fuel element cladding and subsequent fission product release. Consequently, very conservative design margins are used for the fuel to further reduce the possibility of fuel damage.

Operating experience with Zircaloy cladding has demonstrated that the extent of anomalous fuel rod failures during normal operation will be less than 0.5 percent failed fuel* with administrative controls. (Administrative controls as defined in proposed standard ANS 3.2, "Standard for Administrative Controls for Nuclear Power Plants," are rules, orders, instructions, procedures, policies, practices, and designations of authority and responsibility written by management to obtain assurance of safety and high-quality operation and maintenance of a nuclear power reactor. Administrative controls are firm rules governing the actions of employees.) Therefore, 0.5 percent failed fuel is a conservative basis for evaluation of accidental releases since the releases occur over a long period of time.

Without protective systems, fuel failures are also possible as a result of certain abnormal operating transients. However, the plant design incorporates a reactor protection system which limits the postulated transients so that the design limits for the fuel will not be exceeded. Therefore, the fuel will not be damaged, and no activity will be released to the primary coolant as a result of an abnormal operating transient.

5. Analysis of Class 5 accidents - Class 5 accidents are events which result in the release of radioactive material to the environment via any secondary plant system. Primary protection against Class 5 accidents is afforded by coolant chemistry control and good steam generator design. With the exception of the steam-generator blowdown, the plant fluid systems are designed with an intermediate water

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*0.5 percent failed fuel is defined as small clad defects (holes) in fuel pins which produce 0.5 percent of the total core power.

system between any radioactive fluid and any water that is continually discharged to the environment. For example, the component cooling water system cools all of the heat exchangers which contain primary coolant, and the component cooling water is in turn cooled by raw cooling water in a separate heat exchanger. Consequently, a highly unlikely simultaneous failure of two heat exchangers would be required in order for the primary coolant to reach the environment. As an added precaution, the component cooling water loop is continuously monitored for radioactivity, providing timely indication of a leak into the component cooling water system from the primary system.

The other source of possible radioactive release is a primary-to-secondary leak in a steam generator which transports the fission products, released by cladding failures, into the main steam system. Indication of the occurrence will be afforded by:

1. A radiation monitor in the effluent line of the vacuum pump which monitors the activity of the noncondensable gases leaving the main condenser. When a predetermined activity level is reached, the monitor actuates an alarm in the control room.
2. The steam generator blowdown samples are monitored.

Processing of steam-generator blowdown is discussed in more detail in section 2.4. The most important environmental consequence of this event is the release of noble gases and iodines which are removed from the main condenser by the vacuum pump, and exhausted via a vent on the turbine building roof after passing through charcoal filters which remove most of the iodines. (Tritium in the condenser

offgas would amount to less than 1 curie per month.) Releases due to steam-generator tube leakage are included in the radioactive discharge section.

A hypothetical release due to an offdesign transient has been analyzed using the assumptions specified in Regulatory Guide 4.2, including the assumption that no credit be taken for filtration of condenser air ejector releases.

The steam generator tube rupture accident is defined as a complete severance of one steam generator tube. The accident results in an increase in the contamination of the secondary (steam) system.

The operator must identify and isolate the faulty steam generator in order to reduce the release of radioactivity to the atmosphere. The following characteristics of a tube rupture will enable the operator to rapidly identify the accident:

1. The pressurizer low-pressure and low-level alarms are actuated, and prior to the plant trip, charging pump flow increases in an attempt to maintain pressurizer level.
2. A steam flow/feedwater flow mismatch will exist as feedwater flow to the affected steam generator will be reduced.
3. The steam-generator blowdown liquid monitor and the vacuum pump radiation monitor will alarm indicating a sharp increase in radioactivity in the secondary system, and the blowdown valves will close.

The plant design incorporates the following features to protect the reactor during and following the postulated accident:

1. The reactor will trip on a low pressurizer pressure signal,
2. The safety injection signal is actuated by coincident low pressurizer pressure and level signals, and
3. The safety injection signal actuates the auxiliary feedwater system.

Plant recovery can be achieved and normal shutdown initiated in 30 minutes.

The rupture of a steam-generator tube would allow fission products that might be in the primary coolant to contaminate the secondary coolant, leading to releases of activity to the environment via the condenser offgas. The results of this postulated event are evaluated based on the release of 15 percent of the primary coolant to the secondary side of the steam generator. The activity in the secondary system before rupture of the tube is based on a primary-to-secondary leak rate of 20 gallons per day per reactor unit and a blowdown rate of 10 gal/min per unit. The normal blowdown rate is 30 gal/min per reactor unit. All noble gases and 0.1 percent of the iodines in the secondary system are assumed to be released to the environment.

The events analyzed in this class (offdesign transient and steam-generator tube rupture) are not expected to occur during the lifetime of the plant; however, steam-generator tube leakage may occur for short time periods several times during the plant lifetime, and therefore it is included as part of the routine radioactive releases.

6. Analysis of Class 6 events - Included in this class of accidents are fuel failures from any cause that occur during refueling operations inside the primary containment.

The reactor is refueled with equipment specially designed to handle the spent fuel underwater from the time it leaves the reactor vessel until it is placed in a cask for shipment from the site. Underwater transfer of spent fuel provides an effective radiation shield, as well as ensuring adequate cooling for the removal of decay heat. Boron added to the water as a neutron absorber ensures subcritical neutron multiplication during refueling.

The various components of the fuel-handling equipment are designed for failsafe operation utilizing interlocks and limit switches designed to preclude any occurrence which might damage a fuel assembly. Administrative procedures will ensure that the integrity of the equipment is maintained.

Detailed refueling procedures will be used to ensure a safe and orderly refueling. When fuel is being inserted, removed, or rearranged in the reactor core, licensed operators will be in the control room and on the refueling floor supervising the operations.

Detailed descriptions of fuel-handling equipment are given in the Sequoyah Nuclear Plant PSAR.

Accidents involving spent fuel after it has left the transfer tube are discussed in the following section as part of the Class 7 accidents.

In the event of an accident the containment ventilation systems will be isolated upon high containment activity. This effectively precludes the release of significant amounts of fission products to the environment since:

1. This accident is not accompanied by any containment pressure increase which could serve as a driving force for leakage.
2. Any leakage that does occur can be treated by the emergency gas treatment system.

Two events in this class are described by Regulatory Guide 4.2. TVA has analyzed these events using the Regulatory Guide 4.2 assumptions. It is assumed, however, that all activity released from the pool is exhausted to the purge exhaust filters where 99 percent of the iodines are removed.

Fuel-handling accidents have occurred in the past with both new and irradiated fuel. However, none has resulted in a substantial release of radioactivity to the environment. Therefore, while fuel element drops or other minor events may occur during the life of the plant, a fuel-handling accident leading to a significant release of activity from the fuel is not expected to occur during the lifetime of the plant, or in fact during several plant lifetimes.

7. Analysis of Class 7 accidents - Class 7 accidents are events initiated during refueling operations outside the primary containment or storage of spent fuel which result in a release of radioactivity to the environment.

The movement of the spent fuel is accomplished in accordance with strict administrative procedures to reduce the possibility of an accident to a minimal level. In fact, in over 50 reactor years of industry operating experience with Westinghouse PWR's, there

has not been a single fuel-handling incident in which either a new or spent fuel rod has sustained a cladding rupture. This is a result of conscientious fuel transport procedures and thorough engineering design of the fuel-handling equipment and facilities, such as:

1. The fuel pit is designed to ensure that the stored fuel is submerged in water and placed in a subcritical array at all times.
2. The spent fuel pit water is cooled to remove decay heat and purified to remove fission products and metallic ions which could cause corrosion of the fuel assemblies.
3. Safety features are incorporated into the fuel-handling crane which preclude dropping of the fuel shipping cask.
4. The spent fuel pit area is normally ventilated with outside air at the rate of five volume changes per hour and maintained at a slight negative pressure. The exhaust is routed via the auxiliary building exhaust vent system which contains radioactivity monitors and filter trains which are automatically aligned in the event of an accident. These filters remove essentially all particulates and at least 99 percent of the iodines.

The three events analyzed in this class are (1) fuel element drop, (2) heavy object dropped off fuel storage rack, and (3) fuel cask drop accident. The releases from the fuel element drop accident are based on the release of 1 percent of the fission product activity in 17 fuel pins (one row) after 7 days' decay time. The releases from the heavy object drop accident are based on the release of 1 percent of the fission product activity from the fuel pins in

one fuel assembly after 30 days' decay time. For both these events, 99.9 percent of the iodines are assumed to remain in the spent fuel pool water.

The results of the fuel cask drop accident have been estimated assuming one fuel assembly is damaged releasing 1 percent of the contained noble gas activity inside the auxiliary building. In all three events, it is assumed that 99 percent of the iodines in the exhaust from the building are removed by charcoal filters. Because of the design of the fuel cask and cask-handling equipment, no significant releases of radioactivity to the environment are expected, nor is fuel damage a likely result of a hypothetical cask drop. However, the results for damage to one assembly are presented for illustrative purposes. The number of assemblies carried in a cask depends on the specific cask design as well as the mode of transportation.

With the exception discussed above, events in this class are expected to have the same probability as those discussed for Class 6.

8. Class 8 accidents - Those accidents chosen as design basis accidents are included in Class 8. The postulated accidents considered in this class are:

1. Loss-of-coolant accidents
2. Control rod ejection accident
3. Steamline rupture accidents

These accidents have a very low probability of occurring; however, several engineered safety features are incorporated in the plant design to minimize any significant radioactivity release

associated, should any of the accidents occur. Each of the design basis accidents is discussed below.

(1) Loss-of-coolant accident - A loss-of-coolant accident may result from a rupture of a reactor coolant system (RCS) component or of any line connected to that system up to the first closed valve which results in loss of coolant at a rate which exceeds the capability of the makeup system.

The severity of the accident is a function of the primary coolant leakage rate and consequently the size of the pipe rupture. The most severe postulated accident is a result of the hypothetical "double-ended" rupture of the largest RCS pipe.

The design of the plant includes several safety features designed to minimize the effects of a loss-of-coolant accident. These features include:

1. A free-standing steel primary containment vessel surrounded by a concrete shield building to prevent the leakage of fission products (double containment).
2. The ice condenser system which prevents a high pressure in the containment and thus reduces the potential for the escape of fission products from the containment. The ice melt, which contains sodium borate, also removes iodines from the primary containment atmosphere.
3. The emergency core cooling system which provides core cooling following the accident to minimize fuel element failure.

4. The emergency gas treatment system which filters the leakage from the primary containment before releasing it to the plant vent.
5. The auxiliary building gas treatment system which filters any leakage to the auxiliary building before release to the atmosphere.

If a postulated loss-of-coolant accident should occur, the RCS will rapidly depressurize. The reactor trip will actuate when the pressurizer low-pressure set point is reached. The emergency core cooling system is actuated by the pressurizer low-pressure or by the high-containment pressure signal. These countermeasures will limit the consequences of the accident in two ways:

1. Reactor trip and borated water injection by the emergency core cooling system supplement void formation in causing rapid reduction of the nuclear power to a residual level corresponding to the fission product decay heat.
2. Injection of borated water ensures sufficient flooding of the core to prevent excessive temperatures.

For short-term core cooling, passive protection is provided by four accumulator tanks pressurized with nitrogen which rapidly discharge their borated water to the RCS when the RCS pressure decreases below the accumulator pressure. In addition, borated cooling water is injected by high-head charging pumps and low-head safety injection pumps.

For long-term core cooling, water spilled from the ruptured reactor coolant system and containment spray and ice

condenser drainage are collected, cooled, and recirculated through the core. This recirculated water is delivered by low-head pumps when the reactor system pressure is low.

The decay heat generated in the core is removed for an indefinite period of time by this recirculation flow which is cooled by two residual heat exchangers.

Fission products which are released from failed fuel as a result of a loss of coolant are released to the primary coolant where some of the iodines and most of the particulate fission products are trapped. Of the iodine released to the primary containment, most is removed from the containment atmosphere by the ice bed and melt water.

Fission products leaking from the primary containment to the annulus (region between primary containment and shield building) are held up for a long period of time. The release from this volume is through the filters of the emergency gas treatment system to atmosphere. The assumptions specified in Regulatory Guide 4.2 were used to estimate releases.

A primary containment leak rate of 0.25 percent per day and a shield building inleakage rate of 100 percent per day were used in the analysis. Since the shield building pressure is always less than atmospheric throughout the transient, no release occurs which is not filtered.

(2) Control rod ejection accident - The design basis reactivity transient is the postulated ejection of a rod control cluster assembly (RCCA). Such an ejection could result from a

complete rupture of a control rod mechanism housing. The possibility of such an ejection is minimized by:

1. Shop testing each housing at 4,100 $lb_f/in^2$ and again at 3,750 $lb_f/in^2$ upon installation. (Normal primary system pressure is 2,250 $lb_f/in^2$.)
2. The housings are designed to withstand plant transients and the design basis earthquake.

If the postulated accident should occur, a power transient would result, causing a reactor scram; fuel failures may occur as a result of this transient. The fission products in the coolant as a result of 0.5 percent failed fuel are assumed expelled from the reactor vessel through the broken control rod housing into the primary containment. Some iodines are removed from the containment by melted ice in the ice condenser and by the containment spray water. The airborne and gaseous fission products, along with the remaining iodines, may leak into the secondary containment (shield building) after which they are exhausted via the emergency gas treatment system where further filtration reduces the iodine concentration. As far as activity releases are concerned, this event is a small loss-of-coolant accident and is analyzed according to the guidance in Regulatory Guide 4.2.

(3) Main steamline rupture accident - A rupture of a steamline would result in an uncontrolled steam release from a steam generator. However, this only results in a significant radioactive material release when the reactor is being operated with: (a) primary-to-secondary leak in a steam generator, and (b) fuel failures (cladding perforations).

The accident is initiated by a postulated failure in the main steamline system outside the containment which could cause depressurization of the steam generator in that loop. The following plant systems mitigate the consequences of a steam pipe rupture:

1. Emergency core cooling activation from one of several signals
2. The overpower reactor trips
3. Redundant isolation of the main feedwater lines
4. Trip of the fast-acting main steamline stop valves

The analysis of a steamline rupture does not yield any core damage so that the radioactivity release will be a function of the secondary system activity at the time of the accident.

The initial secondary system activity is based on a primary-to-secondary leak rate of 20 gallons per day per unit and a 10 gal/min per unit blowdown rate. The guidance given in Regulatory Guide 4.2 is followed in the analysis. However, since the halogen reduction factor for releases from the primary system is taken to be 0.5 for both the "large" and "small" break, the two accidents yield identical calculated results.

9. Evaluation of Class 9 accidents - Class 9 accidents are described as hypothetical sequences of successive failures which are more severe than those postulated as design-basis accidents whose results are summarized in safety analysis reports by applicants requesting construction permits and operating licenses from AEC for nuclear power plants. Although the consequences of Class 9 accidents

could be severe, the probability of their occurrence is so small that their environmental risk is extremely low.

These accidents would require the occurrence of multiple failures of the plant's engineered safety features with each failure even more severe than the postulated design-basis accidents, which have extremely low probabilities of occurrence.

Conservative design; diverse and redundant physical barriers, protection systems, and engineered safety features; extensive quality assurance; and control of operations dictate such a probability of occurrence that the environmental risk associated with Class 9 accidents is negligible as compared to that of the other classes of accidents.

10. Dispersion conditions - TVA has had a site meteorological investigation program under way at Sequoyah since April 1971. This data has been analyzed and can be found in Chapter 2 of the PSAR. The analysis shows that dispersion conditions more severe than a Pasquil type F and a wind speed of 0.25 meters per second occur less than 5 percent of the time. This dispersion condition (which results in dispersion values about four times higher than those given in AEC Regulatory Guide No. 1.4 (Reference 3, section 2.3)) is used to calculate design-bases accident doses for the PSAR. Reference 1 suggests that dispersion values a factor of 10 lower than those in the Regulatory Guide No. 1.4 be used to assess the environmental effect of accidents. As a result of the meteorological investigations at the site, TVA has concluded that use of the Regulatory Guide No. 1.4 dispersion conditions reduced by a factor of 2.5 is an appropriate basis for estimating environmental effects and is consistent with the approach used by the Atomic Energy Commission and others. Figure G-1 gives the dispersion

values used as a function of distance for the time periods used in the analyses. Section 1.2 gives the wind direction frequencies used in the analysis. The minimum site exclusion distance is 585 meters.

11. Population densities - The population exposures from each postulated event have been estimated using projected population information for the year 2010. The population distribution used is given in section 1.2. Population doses are based on doses to persons residing within 50 miles of the plant site.

1.2 Evaluation of environmental impact of postulated accidents - The principal effect of accidents on the environment is the increased exposure to man which might result from the release of radioactive material. This potential for exposure is summarized in Table G-1 for the principal accidents analyzed. The analysis of this information shows that no accident or class of accidents is environmentally significa

Table G-1

SUMMARY OF RADIOLOGICAL CONSEQUENCES OF POSTULATED ACCIDENTS

| Class | Event | Individual Doses at the Site Boundary (rem) | | | | Fraction of Limit[b] | Dose Commitment to Population[a] (man-rem) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Gamma Radiation | Beta Radiation | Gamma Plus Beta | Iodine Inhalation | | Gamma Radiation | Beta Radiation | Iodine Inhalation | Total |
| 1.0 | Trivial incidents | * | * | * | * | * | * | * | * | * |
| 2.0 | Small releases outside containment | * | * | * | * | * | * | * | * | * |
| 3.0 | Radwaste system failures | | | | | | | | | |
| 3.1 | Equipment leakage or malfunction | 1.8(-2) | 4.7(-2) | 6.5(-2) | NIL | 1.3(-1) | 2.3(+0) | 6.2(+0) | NIL | 8.5(+0) |
| 3.2 | Release of waste gas storage tank contents | 7.0(-2) | 1.9(-1) | 2.6(-1) | NIL | 5.2(-1) | 9.2(+0) | 2.5(+1) | NIL | 3.4(+1) |
| 3.3 | Release of liquid waste storage tank contents | - | - | - | - | 2.6(-4) | - | - | - | 3.3(+1) |
| 4.0 | Fission products to primary system (BWR) | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 5.0 | Fission products to primary and secondary systems (PWR) | | | | | | | | | |
| 5.1 | Fuel cladding defects and steam generator leaks | * | * | * | * | * | * | * | * | * |
| 5.2 | Offdesign transient that induce fuel failure above the expected and steam generator leak | 5.2(-4) | 1.0(-3) | 1.5(-3) | 1.3(-3) | 4.0(-3) | 6.8(-2) | 1.4(-1) | 1.7(-1) | 3.7(-1) |
| 5.3 | Steam generator tube rupture | 4.1(-2) | 5.8(-2) | 1.0(-1) | 1.7(-2) | 2.1(-1) | 5.4(+0) | 7.7(+0) | 2.2(+0) | 1.5(+1) |
| 6.0 | Refueling accidents | | | | | | | | | |
| 6.1 | Fuel bundle drop | 9.3(-4) | 2.1(-3) | 3.0(-3) | 4.5(-4) | 6.4(-3) | 1.2(-1) | 2.8(-1) | 5.9(-2) | 4.6(-1) |
| 6.2 | Heavy object drop onto fuel in core | 2.0(-2) | 4.6(-2) | 6.6(-2) | 8.9(-3) | 1.4(-1) | 2.7(+0) | 6.0(+0) | 1.2(+0) | 9.9(+0) |

Table G-1 (continued)

SUMMARY OF RADIOLOGICAL CONSEQUENCES OF POSTULATED ACCIDENTS

| Class | Event | Individual Doses at the Site Boundary (rem) | | | | | Dose Commitment to Population[a] (man-rem) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Gamma Radiation | Beta Radiation | Gamma Plus Beta | Iodine Inhalation | Fraction of Limit[b] | Gamma Radiation | Beta Radiation | Iodine Inhalation | Total |
| 7.0 | Spent fuel handling accident | | | | | | | | | |
| 7.1 | Fuel assembly drop in fuel storage pool | 9.3(-4) | 2.1(-3) | 3.0(-3) | 4.5(-4) | 6.4(-3) | 1.2(-1) | 2.8(-1) | 6.0(-2) | 4.6(-1) |
| 7.2 | Heavy object drop onto fuel rack | 6.9(-4) | 2.5(-3) | 3.2(-3) | 9.3(-4) | 7.1(-3) | 9.1(-2) | 3.4(-1) | 1.2(-1) | 5.5(-1) |
| 7.3 | Fuel cask drop[d] | NIL | 1.0(-3) | 1.0(-3) | 2.0(-4) | 2.1(-3) | 1.2(-3) | 1.3(-1) | 2.6(-2) | 1.6(-1) |
| 8.0 | Accident initiation events considered in design basis evaluation in safety analysis report | | | | | | | | | |
| 8.1 | Small loss-of-coolant | 0.9(-4) | 2.3(-4) | 3.2(-4) | 1.0(-4) | 8.4(-4) | 1.9(-2) | 5.0(-2) | 1.4(-2) | 8.3(-2) |
| 8.1 | Large loss-of-coolant | 5.6(-2) | 6.9(-2) | 1.3(-1) | 5.2(-2) | 2.9(-1) | 9.8(+0) | 1.4(+1) | 9.3(+0) | 3.3(+1) |
| 8.1(a) | Instrument line break | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 8.2(a) | Rod ejection accident | 2.0(-3) | 2.9(-3) | 4.9(-3) | 5.1(-2) | 4.4(-2) | 3.6(-1) | 5.8(-1) | 7.2(+0) | 8.1(+0) |
| 8.3(a) | Small MSLR | NIL | NIL | NIL | 3.5(-3) | 2.4(-3) | 2.8(-3) | 3.5(-3) | 4.6(-1) | 4.6(-1) |
| 8.3(a) | Large MSLR[c] | NIL | NIL | NIL | 3.5(-3) | 2.4(-3) | 2.8(-3) | 3.5(-3) | 4.6(-1) | 4.6(-1) |

*Evaluated as routine releases in Section 2.4, Radioactive Discharges
**Iodine ingestion
NA Not applicable
NIL Results in doses less than $10^{-4}$ rem and population doses less than $10^{-3}$ man-rem
a. Based on estimated population within 50 miles of plant
b. Estimated fraction of 10 CFR Part 20 limit at site boundary
c. Main steamline rupture
d. Represents the release from a single fuel element, since the number of elements in a cask varies with shipping method

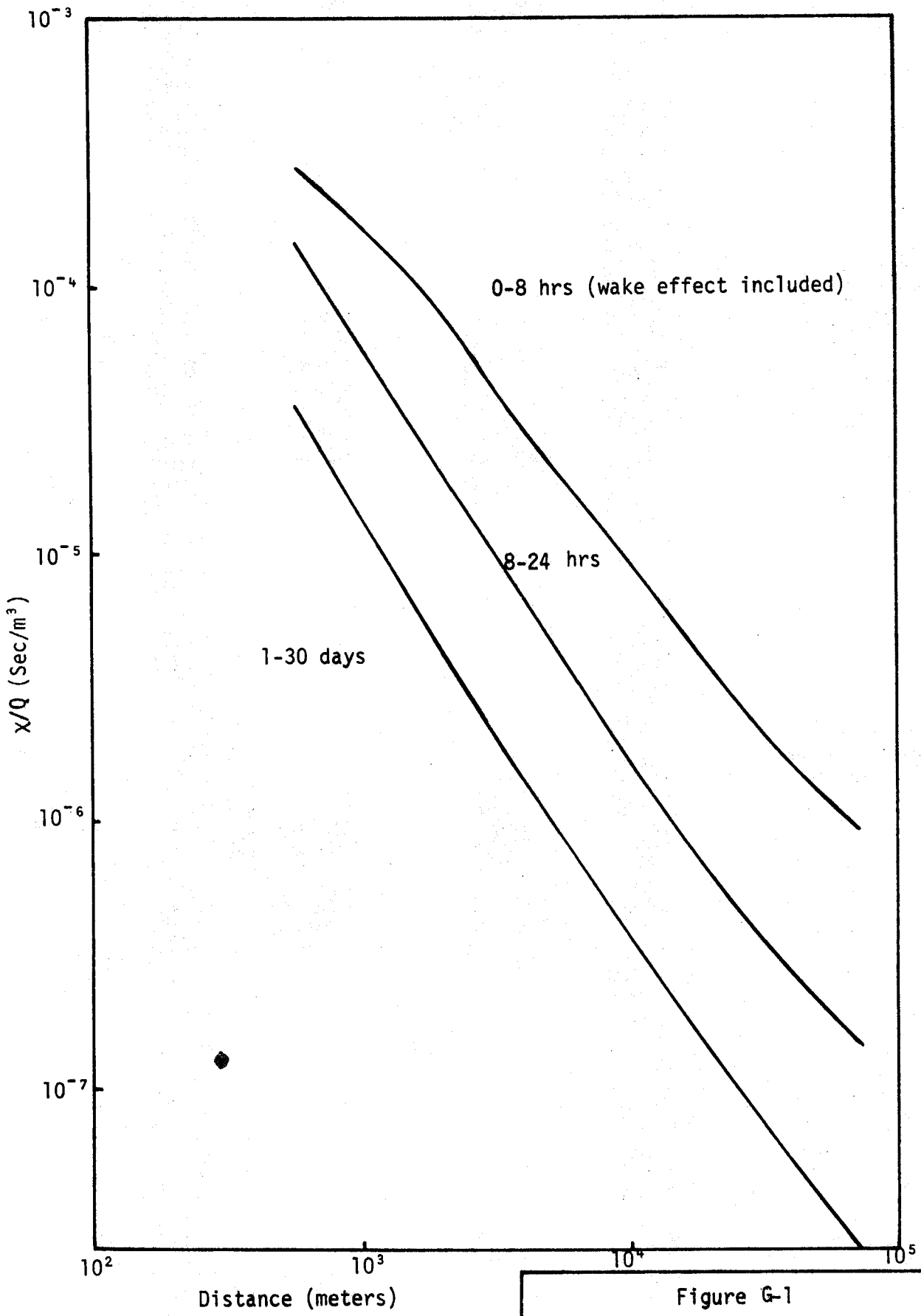


Figure G-1

SEQUOYAH NUCLEAR PLANT
χ/Q VERSUS DISTANCE
FOR ACCIDENT ANALYSIS

# Appendix H

## RADIOLOGICAL IMPACT OF LIQUID EFFLUENTS

The calculation of radiation doses to organisms that are exposed in their normal environment is a difficult task. Because of the complexity of biological functions and the interrelationship between organisms and their environments, it is necessary to develop simplified dose models that can predict doses resulting from the more significant exposure pathways. While these models cannot predict the detailed variances of a system and while the results of an analysis cannot be applied equally to all members of a population, assumptions are chosen so that the radiation doses are conservative, i.e., overestimated. Only the basic assumptions are given in this appendix along with a brief outline of the models and methods of calculation. Doses listed in Table H-2 are calculated for the radionuclides which are expected to be released during normal operation of the Sequoyah Nuclear Plant.

Tritium doses are considered separately and are based on a normalized release of 1 Ci per year. The tritium dose can be computed by multiplying this normalized value by the annual tritium release in curies (See Table 2.4-2).

Calculations of doses to humans include doses to bone, G.I. tract, thyroid, skin tissues, and the total body. Total body doses are calculated for organisms other than man. Population doses are estimated for the year 2010 based on the current populations multiplied by 1.70. The factor 1.70 is the increase projected for a 125-county area in the Tennessee River Basin.

1. Doses to man from the ingestion of water - Data listed in Table H-1 for public and industrial water systems is used to calculate dose commitments from the consumption of Tennessee River water. Prior to initial operation of the Sequoyah Nuclear Plant the intake for the Savannah Utility District water supply will be relocated (section 2.9.2) where it is not expected to be affected by effluents from the nuclear plant. It is assumed that the plant effluent is mixed with one-half of the riverflow in the 12-mile reach between the nuclear plant site and the first water supply intake. Although natural water turbulence will continue to increase the dispersion downstream, it is assumed that half-dilution is maintained as far as Chickamauga Dam past which full-dilution is assumed.

Dilution is calculated using average-annual flow data for the Tennessee River as measured during 1899-1968. The average flow ranges from approximately 35,000 $ft^3/s$ at the nuclear plant site to 65,000 $ft^3/s$ at the mouth of the river near Paducah, Kentucky.

Radioactive decay and the buildup of daughter activity are based on estimates of the transport time using data for water velocities which vary between 0.1 and 3.5 ft/s. No radioactive decay is considered between the time of intake in a water system and the time of consumption. It is assumed that each individual consumes 2,200 ml of water per day (the average daily adult ingestion from all sources including drinking water, food, bottled drinks, etc.).

Due to a lack of definitive data, no credit is taken for removal of activity from the water through adsorption on solids and sedimentation, by deposition in the biomass, or by processing within water treatment systems.

Internal doses, $D_{ij}$, for the $j^{th}$ organ from the $i^{th}$ radionuclides are calculated using the relation

$$D_{ij} = (DCF)_{ij} \times I_i, \tag{1}$$

where $(DCF)_{ij}$ = the dose commitment factor for the $j^{th}$ organ from the $i^{th}$ radionuclides for an average adult assuming that the dose can be accumulated over a 50-year interval, (mrem/uCi),

$I_i$ = the activity of the $i^{th}$ radionuclide taken into the body annually via ingestion, (uCi).

The dose commitment factors are derived from data given in the references listed[1,2,3,4] and are identified in units of (mrem/uCi) by the equation

$$(DCF)_{ij} = \frac{51.2 \times 10^3 \; f_{wij} \varepsilon_{ij} \left(1-\exp(-\lambda_{ij} T)\right)}{m_j \; \lambda_{ij}}, \tag{2}$$

where $51.2 \times 10^3 = \left(1.60 \times 10^{-8} \; \frac{\text{g-rad}}{\text{MeV}}\right) \left(3.20 \times 10^9 \; \frac{\text{dis}}{\text{uCi-day}}\right)\left(10^3 \; \frac{\text{mrem}}{\text{rem}}\right)$

$f_{wij}$ = fraction of the $i^{th}$ radionuclide taken into the body by ingestion that is retained in the $j^{th}$ organ, (dimensionless),

$\varepsilon_{ij}$ = effective energy absorbed in the $j^{th}$ organ per disintegration of the $i^{th}$ radionuclide including daughter products, (MeV-rem/dis-rad),

$\lambda_{ij}$ = the effective decay constant of the $i^{th}$ radionuclide in the $j^{th}$ organ, ($day^{-1}$),

T = integration time, (1,825 days),

$m_j$ = mass of the $j^{th}$ organ, (g).

In the absence of detailed knowledge regarding solubility characteristics of the radionuclides, the dose for the G.I. tract is overestimated using the assumption that none of the radionuclides is removed from the G.I. tract by absorption. Estimates of the doses to bone, thyroid, and total body are based on fractional uptakes given by the International Commission on Radiological Protection.[2] A detailed breakdown of the dose commitments at each of the public water supply intakes is shown in Tables H-2 and H-3.

For comparison, dose commitments are also calculated for a hypothetical individual whose entire yearly water supply is obtained from the plant discharge conduit prior to dilution in the Tennessee River. These estimates are upper limits based on discharge flow rates corresponding to the different modes of plant operation. Average annual concentrations of radionuclides in the liquid effluent can be estimated by dividing the releases by the annual discharge flow.

Dose commitments for the annual intake of ground water are derived from the estimates of the doses at Tennessee River water supplies. It is assumed that the radioactivity concentration in ground water within 0.5 mile of the Tennessee River is 100 percent of that present in the river. A conservative estimate of the human population drinking ground water within 0.5 mile of the river is 24,000 persons between the Sequoyah Nuclear Plant site and Paducah, Kentucky. The maximum population dose commitment (thyroid) for an annual release of 2.0 Ci in the liquid effluent is 0.30 man-rem. This dose commitment $DC_P$ is obtained as follows:

$$DC_P = \sum_{i=1}^{26} \frac{P_i}{A_i} \times A_i^* \times DC_i$$

where $P_i$ = population of county i,

$A_i$ = county area, (mile$^2$),

$A_i^*$ = county area within 0.5 mile of the Tennessee River, (mile$^2$),

$DC_i$ = individual thyroid dose commitment calculated for a public water supply in or near county i, (rem).

Doses to humans from ingestion of Tennessee River water affected by slug releases can be estimated using the data in Section A of Tables H-2 and H-3 provided: (1) the distribution of activity is essentially the same as that given in Table K-1 of Appendix K, (2) the total activity of the slug release is known, and (3) the river velocities and dilution factors are not grossly different from the average values on which the routine dose estimates are based. A conservative estimate of the doses to humans from a slug of radioactivity released during low-flow conditions can be obtained by multiplying the doses in Table H-2 by: (1) the ratio of activity released to 2.0 Ci, and (2) by the ratio of the average flow rate to the actual flow rate. For example, a slug of 1.0 Ci activity released during a 5 percent* flow condition could result in doses that are higher than those in Table H-2 by the factor

$$F = \frac{1.0 \text{ Ci}}{2.0 \text{ Ci}} \times \frac{(\text{Average Flow Rate})}{0.37 \times (\text{Average Flow Rate})} = 1.4$$

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*A 5 precent flow rate is that which is equaled or exceeded 95 percent of the time. This flow rate is approximately 37 percent of the annual-average flow rate based on daily discharge data during 1960-70 for Watts Bar, Chickamauga, Nickajack, Guntersville, Wheeler, Pickwick Landing, and Kentucky Dams.

2. Doses to man from the consumption of fish - Current estimates of Tennessee River annual fish harvests are 15.2 lb/acre sport fish[5] and 13.7 lb/acre edible commercial fish.[6] It is assumed that these rates will increase with the population expansion, so that the dose calculations are based on harvests of 26 lb/acre sport fish and 23 lb/acre commercial fish in the year 2010. The Tennessee River is segmented into 15 reaches in order to facilitate the calculations of fish harvests and radioactivity concentrations. For convenience the limits defining the reaches correspond to the locations of the mainstream dams and the Bellefonte and Browns Ferry Nuclear Plant sites. Additional points were selected to subdivide Nickajack, Guntersville, and Kentucky Reservoirs into shorter reaches. The radioactivity levels in the fish from each reach are estimated by the product of an average activity concentration in the reach and a concentration factor for each radionuclide. Concentration factors derived from references 7 and 8 are listed in Table H-4. It is assumed that the maximum annual consumption of fish by an individual is 45 lbs. The population dose is calculated using the assumption that all of the edible fish harvested are consumed by humans. Radioactive decay is not considered between the time the fish is removed from the water and the time of consumption, and the entire mass of the fish is assumed to be eaten.

Dose commitments are calculated with equations 1 and 2 which are discussed for water ingestion in the previous section, and the results are shown in Tables H-2 and H-3.

Calculations indicate that there would be no significant radiological impact from human utilization of shellfish. Shellfish

are not now being harvested commercially in the Tennessee River, and consumption of shellfish by humans is assumed to be negligible.

3. Doses to man due to water sports - Estimates of the doses from immersion in the Tennessee River are calculated for each radionuclide using the following relations. For the dose rate to the skin,

$$R_i = 51.2 \times 10^3 \, C_{wi} \left(\overline{E}_\beta/2 + E_\gamma\right)_i \; \frac{\text{mrem}}{\text{day}} \tag{3}$$

For the dose rate to the total body,

$$R_i = 51.2 \times 10^3 \, C_{wi} \, E_{\gamma i} \quad \frac{\text{mrem}}{\text{day}} \tag{4}$$

where $51.2 \times 10^3$ = (see Equation 1),

$C_{wi}$ = water concentration for the $i^{th}$ radionuclide, (uCi/g),

$E_{\gamma i}$ or $(\overline{E}_\beta/2 + E_\gamma)_i$ = average effective energy emitted by the $i^{th}$ radionuclide per disintegration, (MeV-rem/dis-rad).

Dose rates for above-water activities such as boating are assumed to be given by Equations 3 and 4 divided by 2. In order to estimate the doses from shoreline activities the simplifying assumption is made that all persons along the shoreline receive the same dose rate as a person boating or skiing. Water concentrations are calculated for 15 reaches between the nuclear plant site and Kentucky Dam (TRM 22.4). Doses to the population are calculated using estimates for above-water visits, inwater visits, and shoreline visits for the respective reaches based on current information given in reference 9 multiplied by the predicted population growth factor of 1.70.

The maximum individual doses for above-water use of the river are estimated for a commercial fisherman who is not a water sport enthusiast but who might be exposed for 300 days per year at 5 hours per day. The maximum individual doses for inwater activities are estimated for a person who swims 918 hours per year (6 hours per day for the 5 warm months) at a location just below the Sequoyah site. In order to estimate the maximum tritium dose to a swimmer, continuous immersion for 5 months in the Tennessee River just below the Sequoyah site is assumed.

4. Doses to organisms other than man - A comprehensive analysis of the radiation doses to species other than humans would require many man-years of effort that could be justified only if a significant radiological impact on a particular species were anticipated. After consultation with professionals in the health physics and radioecology fields, a decision was made by TVA to restrict the analyses to those organisms living on or near the Sequoyah site that would most likely receive the greatest doses. These include terrestrial vertebrates, aquatic plants, aquatic invertebrates, and fish.

(1) Terrestrial vertebrates - Radioactivity contained in nuclear plant liquid effluents is concentrated in fish, invertebrates, and plants by factors that range from less than 1 to greater than $10^5$ depending on interrelated physical, chemical, and biological factors. Terrestrial vertebrates will receive a radiation dose from liquid effluents if their food chain includes aquatic organisms that have concentrated radionuclides. In general, aquatic plants such as green algae concentrate trace elements to a greater extent than do

fish and invertebrates.[7] Therefore, internal dose estimates have been made for ducks and muskrats with the conservative assumption that their diet consists entirely of green algae from algal masses growing near the Sequoyah discharge. Equations 1 and 2 from section 1 are used for estimating the annual internal total body dose. It is assumed that the duck or muskrat has a mass m of 1,000 g, an effective radius of 10 cm, and consumes 333 g of green algae per day. Long-lived radionuclides such as Sr-90 can deliver significant portions of the total dose commitment long after the time of ingestion. Therefore, a period of 5 years was chosen for the integration interval T. In the absence of data specifically applicable to ducks or muskrats, ICRP data[2] are used for the fractional uptake in the total body and for the biological half-life of parent radionuclides. The use of human data for the biological half-lives is considered to be conservative because, in general, warm-blooded vertebrates that are smaller than man exhibit more rapid elimination rates.[8] Equation 5 is a combination of the above assumptions with Equations 1 and 2.

$$D_i = 51.2 \times 10^3 \, I_i \, f_{wi} \, \epsilon_i \, (1-\exp(-\lambda_i T))/\lambda_i m \quad \text{mrad} \qquad (5)$$

where

$I_i = 333 \frac{g}{d} \times C_{wi} \, F_{pi} \times 365 \frac{d}{y}$, (uCi/yr),

$C_{wi}$ = water concentration, (uCi/g),

$F_{pi}$ = concentration factor[7,8] for aquatic plants, (dimensionless).

T = 1,825 days

m = 1,000 g

External doses are estimated with Equation 4 using the conservative assumption that the duck and muskrat are exposed continuously by full immersion in the water.

Estimates of the doses to ducks and muskrats living near the Sequoyah Nuclear Plant are shown in Table H-5. The dose to a person from eating a duck or a muskrat that has been living near the nuclear plant site for 5 years is calculated to be 3.0 mrem.

(2) Aquatic plants, invertebrates, and fish - Radionuclide activity internally deposited in these organisms is estimated from the concentration in the water in the Tennessee River just below the liquid effluent discharge, assuming mixing with one-half the average riverflow, multiplied by the applicable concentration factors.[7,8] Doses are estimated for organisms having effective radii of 3 cm and 30 cm. Although estimates for both geometries are reported, an effective radius of 30 cm could represent organisms weighing up to 250 pounds. This geometry probably results in overestimates of the doses. In the absence of a detailed knowledge of the dynamic behavior of daughter products that are produced from internally deposited parents, the conservative assumption is made that all daughter products are permanently bound in the organisms and every daughter in a decay chain contributes energy at an equilibrium disintegration rate for each disintegration of the parent. The annual doses from the $i^{th}$ radionuclide are calculated using the relation:

$$D_i = 51.2 \times 10^3 \, C_{fi} \, \varepsilon_i \times 365 \text{ mrad} \qquad (6)$$

where

$C_{fi}$ = radioactivity concentration in the organism

$= C_{wi} \times F_i$, (uCi/g),

$C_{wi}$ = water concentration, (μCi/g),

$F_i$ = concentration factor, (dimensionless)

External doses for organisms surrounded by water are calculated using Equation 4. Benthic organisms such as mussels, worms, and fish eggs may receive higher external doses if significant radioactivity is associated with bottom sediments. Accurate prediction of the accumulation of activity in sediment requires a detailed knowledge of a number of physicochemical factors including mineralogy, particle size, exchangeable calcium in the sediment, channel geometry, waterflow patterns, and the chemical forms of the radiocompounds. Many of these factors must be obtained from extensive field experiments. In the absence of detailed knowledge, the doses are calculated using the following assumptions:

1. Two-tenths of the activity in the liquid effluent is deposited uniformly in a sediment bed having dimensions of 10 cm x 100 m x 10 km.
2. The radioactivity concentration in the sediment is calculated assuming a buildup over the plant life of 35 years at a constant rate of deposition.
3. Beta doses are based on a 4-π geometry and gamma doses assume a 2-π geometry.

The doses calculated using these assumptions are probably overestimated. Periodic surveillance of the sediment downstream from the nuclear plant will detect a buildup of radionuclides in the sediment, should it occur. If a gradual buildup of radionuclides in the sediment does occur, corrective action will be taken prior to its becoming a significant environmental hazard.

Estimates of the doses to aquatic plants, invertebrates, and fish living near the Sequoyah Nuclear Plant are shown in Table H-6.

## REFERENCES FOR APPENDIX H


1. Lederer, C. M., et al., Table of Isotopes, New York, John Wiley & Sons, 1968.

2. ICRP Publication 2, New York, Pergammon Press, 1959.

3. Cowser, K. E., et al, "Dose-Estimation Studies Related to Proposed Construction of an Atlantic-Pacific Interoceanic Canal with Nuclear Explosives: Phase I," Oak Ridge National Laboratory Report, ORNL-4101, 1967.

4. Eve, I.S., "A Review of the Physiology of the Gastrointestinal Tract in Relation to Radiation Doses from Radioactive Materials," Health Physics 12, p. 131 (1966).

5. Tennessee Game and Fish Commission, Tennessee Valley Authority, and Kentucky Department of Fish and Wildlife Resources, "Kentucky Lake Fishing."

6. U.S. Department of the Interior, "Estimated Commerical Fish Narvest, Tennessee Valley, 1969," Bureau of Commercial Fisheries.

7. Chapman, W. H., et al, "Concentration Factors of Chemical Elements in Edible Aquatic Organisms," Lawrence Radiation Laboratory Report, UCRL-50564, 1968.

8. Reichle, D. E., et al, "Turnover and Concentration of Radionuclides in Food Chains," Nuclear Safety, 11, No. 1 (January-February 1970).

9. Tennessee Department of Conservation, "Statistical Summary--State Demand, Supply, and Comparisons," Tennessee Statewide Comprehensive Outdoor Recreation Plan - 1969, Final Report, Appendix IV, Table 27, 1969, p. 31.

Table H-1

## TENNESSEE RIVER DRINKING WATER SUPPLY INTAKE

## DOWNSTREAM FROM THE SEQUOYAH NUCLEAR PLANT

| | Location (TRM) | Distance (miles) | Populations Served 1970 | 2010 |
|---|---|---|---|---|
| Sequoyah Nuclear Plant | 484.5 | 0.0 | 0 | 0 |
| Atlas Chemical Industries | 473.0 | 11.5 | 2,000 | 3,400 |
| Farmers Chemical Corp. | 473.0 | 11.5 | 230 | 400 |
| E. I. DuPont | 470.5 | 14.0 | 3,000 | 5,100 |
| Chattanooga | 465.3 | 19.2 | 290,000 | 490,000 |
| South Pittsburg | 418.0 | 66.5 | 5,600 | 9,500 |
| Bridgeport | 413.6 | 70.9 | 3,100 | 5,300 |
| Widows Creek Steam Plant | 407.6 | 76.9 | 460 | 800 |
| Scottsboro | 385.8 | 98.7 | 11,000 | 19,000 |
| Sand Mountain Water Authority | 382.1 | 102.4 | 8,200 | 14,000 |
| Christian Youth Camp | 368.2 | 116.3 | 130 | 200 |
| Guntersville | 358.0 | 126.5 | 6,600 | 11,000 |
| N. E. Morgan Co., Water and Fire | 334.4 | 150.1 | 3,600 | 6,100 |
| Huntsville | 334.2 | 150.3 | 150,000 | 250,000 |
| Decatur | 306.0 | 178.5 | 41,000 | 70,000 |
| U. S. Plywood - Champion Papers | 283.0 | 201.5 | 500 | 900 |
| Wheeler Dam | 274.9 | 209.6 | 50 | 100 |
| Reynolds Metals | 260.0 | 224.5 | 5,000 | 8,500 |
| Muscle Shoals | 259.6 | 224.9 | 7,500 | 13,000 |
| Wilson Dam | 259.5 | 225.0 | 2,500 | 4,300 |
| Sheffield | 254.3 | 230.2 | 14,000 | 24,000 |
| Colbert Steam Plant | 245.0 | 239.5 | 350 | 600 |
| Cherokee | 239.3 | 245.2 | 2,700 | 4,600 |
| Tri-County Utility District | 193.5 | 291.0 | 1,700 | 2,800 |
| Clifton | 158.0 | 326.5 | 1,000 | 1,700 |
| New Johnsonville | 100.5 | 384.0 | 950 | 1,600 |
| Camden | 100.4 | 384.1 | 3,100 | 5,200 |
| Foote Mineral | 100.0 | 384.5 | 170 | 300 |
| Johnsonville Steam Plant | 100.0 | 384.5 | 380 | 600 |
| Bass Bay Resort | 79.5 | 405.0 | 120 | 200 |
| Paris Landing State Park | 66.3 | 418.2 | 100 | 200 |
| Grand Rivers | 24.0 | 460.5 | 640 | 1,100 |
| Paducah | 0.1 | 484.4 | 63,000 | 110,000 |

Table H-2

DOSES[a] TO HUMANS FROM WATER CONTAINING A MIXTURE[b] OF RADIONUCLIDES

A. Ingestion of Tennessee River Water[c]

| Location | Bone | G.I. Tract | Thyroid | Total Body |
|---|---|---|---|---|
| Sequoyah Nuclear Plant (for comparison) | 3.0 (-3)[d] | 4.5 (-3) | 7.5 (-2) | 1.7 (-3) mrem |
| Atlas Chemical Corp. | 2.9 (-3) | 3.7 (-3) | 6.4 (-2) | 1.7 (-3) mrem |
| | 9.9 (-3) | 1.3 (-2) | 2.2 (-1) | 5.6 (-3) man-rem |
| Farmers Chemical Corp. | 2.9 (-3) | 3.7 (-3) | 6.4 (-2) | 1.7 (-3) mrem |
| | 1.1 (-3) | 1.4 (-3) | 2.4 (-2) | 6.3 (-4) man-rem |
| E. I. DuPont | 1.5 (-3) | 1.8 (-3) | 3.1 (-2) | 8.2 (-4) mrem |
| | 7.4 (-3) | 9.1 (-3) | 1.6 (-1) | 4.2 (-3) man-rem |
| Chattanooga | 1.4 (-3) | 1.7 (-3) | 3.0 (-2) | 8.0 (-4) mrem |
| | 7.0 (-1) | 8.5 (-1) | 1.5 (+1) | 4.0 (-1) man-rem |
| South Pittsburg | 1.3 (-3) | 1.3 (-3) | 2.2 (-2) | 7.4 (-4) mrem |
| | 1.3 (-2) | 1.2 (-2) | 2.1 (-1) | 7.1 (-3) man-rem |
| Bridgeport | 1.3 (-3) | 1.2 (-3) | 2.1 (-2) | 7.4 (-4) mrem |
| | 7.0 (-3) | 6.6 (-3) | 1.1 (-1) | 3.9 (-3) man-rem |
| Widows Creek Steam Plant | 1.3 (-3) | 1.2 (-3) | 2.1 (-2) | 7.4 (-4) mrem |
| | 1.0 (-3) | 9.5 (-4) | 1.6 (-2) | 5.8 (-4) man-rem |
| Scottsboro | 1.3 (-3) | 1.1 (-3) | 1.8 (-2) | 7.2 (-4) mrem |
| | 2.4 (-2) | 2.1 (-2) | 3.4 (-1) | 1.3 (-2) man-rem |
| Sand Mountain Water Authority | 1.3 (-3) | 1.1 (-3) | 1.8 (-2) | 7.2 (-4) mrem |
| | 1.8 (-2) | 1.5 (-2) | 2.5 (-1) | 1.0 (-2) man-rem |
| Christian Youth Camp | 1.3 (-3) | 1.0 (-3) | 1.6 (-2) | 7.0 (-4) mrem |
| | 2.7 (-4) | 2.1 (-4) | 3.3 (-3) | 1.5 (-4) man-rem |
| Guntersville | 1.2 (-3) | 9.5 (-4) | 1.4 (-2) | 6.9 (-4) mrem |
| | 1.4 (-2) | 1.1 (-2) | 1.6 (-1) | 7.7 (-3) man-rem |
| N. E. Morgan Co. Water and Fire | 1.2 (-3) | 8.6 (-4) | 1.2 (-2) | 6.4 (-4) mrem |
| | 7.1 (-3) | 5.2 (-3) | 7.4 (-2) | 3.9 (-3) man-rem |
| Huntsville | 1.2 (-3) | 8.6 (-4) | 1.2 (-2) | 6.4 (-4) mrem |
| | 2.9 (-1) | 2.1 (-1) | 3.0 | 1.6 (-1) man-rem |
| Decatur | 1.1 (-3) | 8.0 (-4) | 1.1 (-2) | 6.2 (-4) mrem |
| | 7.8 (-2) | 5.6 (-2) | 7.5 (-1) | 4.3 (-2) man-rem |
| U. S. Plywood - Champion Papers | 1.0 (-3) | 6.9 (-4) | 8.1 (-3) | 5.6 (-4) mrem |
| | 8.6 (-4) | 5.8 (-4) | 6.9 (-3) | 4.8 (-4) man-rem |
| Wheeler Dam | 9.9 (-4) | 6.5 (-4) | 6.6 (-3) | 5.5 (-4) mrem |
| | 8.5 (-5) | 5.5 (-5) | 5.6 (-4) | 4.7 (-5) man-rem |
| Reynolds Metals | 9.6 (-4) | 6.0 (-4) | 4.8 (-3) | 5.3 (-4) mrem |
| | 8.2 (-3) | 5.1 (-3) | 4.1 (-2) | 4.5 (-3) man-rem |

a. Estimates for parts A, B, and C are internal dose commitments for each annual intake of radioactivity. Estimates for part D are external doses for each annual exposure.
b. Excluding tritium.
c. Based on the estimated population in the year 2010.
d. $3.0 \times 10^{-3}$

Table H-2 (Continued)

| Location | Bone | G.I. Tract | Thyroid | Total Body |
|---|---|---|---|---|
| Muscle Shoals | 9.6 (-4) | 6.0 (-4) | 4.8 (-3) | 5.3 (-4) mrem |
| | 1.2 (-2) | 7.6 (-3) | 6.1 (-2) | 6.8 (-3) man-rem |
| Wilson Dam | 9.6 (-4) | 6.0 (-4) | 4.8 (-3) | 5.3 (-4) mrem |
| | 4.1 (-3) | 2.5 (-3) | 2.0 (-2) | 2.3 (-3) man-rem |
| Sheffield | 9.6 (-4) | 6.0 (-4) | 4.7 (-3) | 5.3 (-4) mrem |
| | 2.3 (-2) | 1.4 (-2) | 1.1 (-1) | 1.3 (-2) man-rem |
| Colbert Steam Plant | 9.5 (-4) | 5.9 (-4) | 4.5 (-3) | 5.2 (-4) mrem |
| | 5.7 (-4) | 3.5 (-4) | 2.7 (-3) | 3.1 (-4) man-rem |
| Cherokee | 9.5 (-4) | 5.9 (-4) | 4.4 (-3) | 5.2 (-4) mrem |
| | 4.4 (-3) | 2.7 (-3) | 2.0 (-2) | 2.4 (-3) man-rem |
| Tri-County Utility District | 9.1 (-4) | 5.4 (-4) | 3.3 (-3) | 5.0 (-4) mrem |
| | 2.6 (-3) | 1.5 (-3) | 9.2 (-3) | 1.4 (-3) man-rem |
| Clifton | 8.9 (-4) | 5.3 (-4) | 3.0 (-3) | 4.9 (-4) mrem |
| | 1.5 (-3) | 9.0 (-4) | 5.1 (-3) | 8.3 (-4) man-rem |
| New Johnsonville | 7.9 (-4) | 4.7 (-4) | 2.3 (-3) | 4.3 (-4) mrem |
| | 1.3 (-3) | 7.5 (-4) | 3.7 (-3) | 7.0 (-4) man-rem |
| Camden | 7.9 (-4) | 4.7 (-4) | 2.3 (-3) | 4.3 (-4) mrem |
| | 4.1 (-3) | 2.4 (-3) | 1.2 (-2) | 2.2 (-3) man-rem |
| Foote Mineral | 7.9 (-4) | 4.7 (-4) | 2.3 (-3) | 4.3 (-4) mrem |
| | 2.2 (-4) | 1.3 (-4) | 6.4 (-4) | 1.2 (-4) man-rem |
| Johnsonville Steam Plant | 7.9 (-4) | 4.7 (-4) | 2.3 (-3) | 4.3 (-4) mrem |
| | 5.0 (-4) | 3.0 (-4) | 1.5 (-3) | 2.8 (-4) man-rem |
| Bass Bay Resort | 7.8 (-4) | 4.6 (-4) | 2.0 (-3) | 4.3 (-4) mrem |
| | 1.6 (-4) | 9.3 (-5) | 4.2 (-4) | 8.8 (-5) man-rem |
| Paris Landing State Park | 7.7 (-4) | 4.5 (-4) | 1.8 (-3) | 4.2 (-4) mrem |
| | 1.3 (-4) | 7.6 (-5) | 3.1 (-4) | 7.2 (-5) man-rem |
| Grand Rivers | 7.6 (-4) | 4.3 (-4) | 1.1 (-3) | 4.2 (-4) mrem |
| | 8.3 (-4) | 4.7 (-4) | 1.2 (-3) | 4.5 (-4) man-rem |
| Paducah | 7.5 (-4) | 4.3 (-4) | 1.1 (-3) | 4.1 (-4) mrem |
| | 8.1 (-2) | 4.6 (-2) | 1.1 (-1) | 4.4 (-2) man-rem |
| Total Population Dose Commitments | 1.3 | 1.3 | 2.0 (+1) | 7.4 (-1) man-rem |
| **B. Ingestion of Nuclear Plant Effluent Prior to Dilution in the Tennessee River** | | | | |
| Individual Dose Commitments | 2.0 (-2) | 3.0 (-2) | 4.9 (-1) | 1.1 (-2) mrem[e] |
| | 2.9 (-2) | 4.4 (-2) | 7.2 (-1) | 1.6 (-2) mrem[f] |
| **C. Eating Fish Taken from the Tennessee River** | | | | |
| Maximum Individual Dose Commitment | 3.4 (-2) | 2.3 (-2) | 5.6 (-2) | 2.0 (-2) mrem |
| Population Dose Commitment | 1.0 (+1) | 6.1 | 9.7 | 5.8 man-rems |

e. Assuming a discharge of 1,100,000 GPM (cooling towers in open or helper mode). Since plant is operational 96 percent of the year in this mode a 0.96 multiplication factor was used.

f. Assuming a discharge of 32,000 GPM (cooling towers in closed mode). Since plant is operational 4 percent of the year in this mode a 0.04 multiplication factor was used.

Table H-2 (Continued)

D. Use of the Tennessee River for Water Sports

| | Above Water[g] | | In Water[h] | | Shoreline[i] | | |
|---|---|---|---|---|---|---|---|
| | Skin | Total Body | Skin | Total Body | Skin | Total Body | |
| Maximum Individual Dose | 6.5 (-5) | 5.3 (-5) | 1.8 (-4) | 1.5 (-4) | 6.5 (-5) | 5.3 (-5) | mrem |
| Population Dose | 2.2 (-3) | 1.8 (-3) | 8.2 (-4) | 7.0 (-4) | 1.9 (-3) | 1.6 (-3) | man-rem |

[g]Boating and fishing, for example.
[h]Swimming and water skiing, for example.
[i]Picnicking and bank fishing, for example.

Table H-3

## DOSES[a] TO HUMANS FROM WATER CONTAINING TRITIUM[b]

### A. Ingestion of Tennessee River Water[c]

| | Individual (mrem) | Population (man-rem) |
|---|---|---|
| Sequoyah Nuclear Plant (for comparison) | 8.6 (-6)[d] | - |
| Atlas Chemical Industries | 8.5 (-6) | 2.9 (-5) |
| Farmers Chemical Corp. | 8.5 (-6) | 3.3 (-6) |
| E. I. DuPont | 4.3 (-6) | 2.2 (-5) |
| Chattanooga | 4.2 (-6) | 2.1 (-3) |
| South Pittsburg | 4.0 (-6) | 3.8 (-5) |
| Bridgeport | 3.9 (-6) | 2.1 (-5) |
| Widows Creek Steam Plant | 3.9 (-6) | 3.1 (-6) |
| Scottsboro | 3.8 (-6) | 7.2 (-5) |
| Sand Mountain Water Authority | 3.8 (-6) | 5.3 (-5) |
| Christian Youth Camp | 3.8 (-6) | 8.0 (-7) |
| Guntersville | 3.7 (-6) | 4.1 (-5) |
| N. E. Morgan Co. Water and Fire | 3.5 (-6) | 2.1 (-5) |
| Huntsville | 3.5 (-6) | 8.7 (-4) |
| Decatur | 3.4 (-6) | 2.4 (-4) |
| U. S. Plywood - Champion Papers | 3.0 (-6) | 2.6 (-6) |
| Wheeler Dam | 3.0 (-6) | 2.6 (-7) |
| Reynolds Metals | 2.9 (-6) | 2.5 (-5) |
| Muscle Shoals | 2.9 (-6) | 3.7 (-5) |
| Wilson Dam | 2.9 (-6) | 1.2 (-5) |
| Sheffield | 2.9 (-6) | 6.9 (-5) |
| Colbert Steam Plant | 2.9 (-6) | 1.7 (-6) |
| Cherokee | 2.9 (-6) | 1.3 (-5) |
| Tri-County Utility District | 2.8 (-6) | 7.7 (-6) |
| Clifton | 2.7 (-6) | 4.6 (-6) |
| New Johnsonville | 2.4 (-6) | 3.9 (-6) |
| Camden | 2.4 (-6) | 1.2 (-5) |
| Foote Mineral | 2.4 (-6) | 6.7 (-7) |
| Johnsonville Steam Plant | 2.4 (-6) | 1.5 (-6) |
| Bass Bay Resort | 2.4 (-6) | 4.9 (-7) |
| Paris Landing State Park | 2.4 (-6) | 4.0 (-7) |
| Grand Rivers | 2.3 (-6) | 2.5 (-6) |
| Paducah | 2.3 (-6) | 2.5 (-4) |
| Population Total | | 3.9 (-3) man-rems |

a. Estimates are internal dose commitments for each annual intake of tritium
b. Normalized to 1.0 Ci total annual release
c. Based on the estimated population in the year 2010
d. $8.6 \times 10^{-6}$

Table H-3 (Continued)

| | |
|---|---|
| **B. Ingestion of Nuclear Plant Effluent Prior to Dilution in the Tennessee River** | |
| Individual Dose Commitment | 5.8 (-5)[e] mrem |
| | 8.4 (-5)[f] mrem |
| **C. Eating Fish Taken from the Tennessee River** | |
| Maximum Individual Dose Commitment | 1.1 (-7) mrem |
| Population Dose Commitment | 3.3 (-5) man-rem |
| **D. Use of the Tennessee River for Water Sports** | |
| Maximum Individual Dose[g] | 5.4 (-6) mrem |
| Population Dose | 7.4 (-4) man-rem |

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Assuming a discharge of 1,100,000 GPM (cooling towers in open or helper mode).
Since plant is operational 96 percent of the year in this mode a 0.96 multiplication factor was used.
Assuming a discharge of 32,000 GPM (cooling towers in closed mode). Since plant is operationa 4 percent of the year in this mode a 0.04 multiplication factor was used.
Assuming continuous immersion for 5 months.

Table H-4

## CONCENTRATION FACTORS FOR AQUATIC ORGANISMS

| Nuclide | Half-Life (d) | Concentration Factors: Fish | Concentration Factors: Invertebrates | Concentration Factors: Plants |
|---|---|---|---|---|
| H-3 | 4.5 (+3) | 1.0 [a] | 1.0 [a] | 1.0 [a] |
| Cr-51 | 2.8 (+1) | 2.0 (+2) [a] | 2.0 (+3) [a] | 4.0 (+3) [a] |
| Mn-54 | 3.0 (+2) | 2.5 (+1) [a] | 1.4 (+5) [b] | 3.5 (+4) [b] |
| Mn-56 | 1.1 (-1) | 2.5 (+1) [a] | 1.4 (+5) [b] | 3.5 (+4) [b] |
| Fe-59 | 4.6 (+1) | 3.0 (+2) [a] | 3.2 (+3) [a] | 5.0 (+3) [a] |
| Co-58 | 7.1 (+1) | 2.1 (+1) [b] | 1.3 (+3) [a] | 6.2 (+3) [b] |
| Co-60 | 1.9 (+3) | 4.8 (+1) [b] | 1.5 (+3) [a] | 6.2 (+3) [b] |
| Br-84 | 2.2 (-2) | 1.3 (+2) [a] | 1.0 (+2) [a] | 7.5 (+2) [a] |
| Rb-88 | 1.2 (-2) | 2.0 (+3) [a] | 2.0 (+3) [a] | 1.0 (+3) [a] |
| Rb-89 | 1.1 (-2) | 2.0 (+3) [a] | 2.0 (+3) [a] | 1.0 (+3) [a] |
| Sr-89 | 5.3 (+1) | 3.5 [c] | 4.0 (+3) [b] | 3.0 (+3) [b] |
| Sr-90 | 1.0 (+4) | 9.9 [c] | 4.0 (+3) [b] | 3.0 (+3) [b] |
| Sr-91 | 4.0 (-1) | 4.0 (-2) [c] | 3.2 (+3) [b] | 3.0 (+3) [b] |
| Sr-92 | 1.1 (-1) | 1.1 (-2) [c] | 2.1 (+3) [b] | 3.0 (+3) [b] |
| Y-90 | 2.7 | 1.0 (+2) [a] | 1.0 (+3) [a] | 1.0 (+4) [a] |
| Y-91 | 5.9 (+1) | 1.0 (+2) [a] | 1.0 (+3) [a] | 1.0 (+4) [a] |
| Y-92 | 1.5 (-1) | 1.0 (+2) [a] | 1.0 (+3) [a] | 1.0 (+4) [a] |
| Zr-95 | 6.6 (+1) | 1.0 (+2) [a] | 1.0 (+3) [a] | 1.0 (+4) [a] |
| Nb-95 | 3.5 (+1) | 3.0 (+4) [a] | 1.0 (+2) [a] | 1.0 (+3) [a] |
| Mo-99 | 2.8 | 1.0 (+2) [a] | 1.0 (+2) [a] | 1.0 (+2) [a] |
| Te-132 | 3.2 | 4.0 (+2) [d] | 1.0 (+3) [d] | 1.0 (+3) [d] |
| Te-134 | 2.9 (-2) | 4.0 (+2) [d] | 1.0 (+3) [d] | 1.0 (+3) [d] |
| I-131 | 8.1 | 4.5 (+1) [b] | 1.0 (+3) [b] | 2.0 (+2) [b] |
| I-132 | 9.4 (-2) | 4.3 [b] | 1.0 (+3) [b] | 2.0 (+2) [b] |
| I-133 | 8.5 (-1) | 2.3 (+1) [b] | 1.0 (+3) [b] | 2.0 (+2) [b] |
| I-134 | 3.6 (-2) | 1.7 [b] | 1.0 (+3) [b] | 2.0 (+2) [b] |
| I-135 | 2.8 (-1) | 1.1 (+1) [b] | 1.0 (+3) [b] | 2.0 (+2) [b] |
| Cs-134 | 7.5 (+2) | 1.0 (+3) [a] | 9.9 (+3) [b] | 2.5 (+4) [b] |
| Cs-136 | 1.4 (+1) | 9.3 (+2) [a] | 5.8 (+3) [b] | 2.5 (+4) [b] |
| Cs-137 | 1.1 (+4) | 1.0 (+3) [a] | 1.0 (+4) [b] | 2.5 (+4) [b] |
| Cs-138 | 2.2 (-2) | 2.2 (+1) [a] | 2.2 (+1) [b] | 2.5 (+4) [b] |
| Ba-140 | 1.3 (+1) | 1.0 (+1) [a] | 2.0 (+2) [a] | 5.0 (+2) [a] |
| La-140 | 1.7 | 1.0 (+2) [a] | 1.0 (+3) [a] | 1.0 (+4) [a] |
| Ce-144 | 2.8 (+2) | 1.0 (+2) [a] | 1.0 (+3) [a] | 1.0 (+4) [a] |
| Pr-144 | 1.2 (-2) | 1.0 (+2) [a] | 1.0 (+3) [a] | 1.0 (+4) [a] |

a. W. H. Chapman, L. H. Fisher, and M. W. Pratt, "Concentration Factors of Chemical Elements in Edible Aquatic Organisms," Lawrence Livermore Laboratory Report, UCRL-50564 (1968).

b. D. E. Reichle, P. B. Dunaway, and D. J. Nelson, "Turnover and Concentration of Radionuclides in Food Chains," Nuclear Safety, 11, (1) (January-February, 1970).

c. Personal Communication D. J. Nelson, Oak Ridge National Laboratory, to W. H. Wilkie 1972.

d. Personal Communication S. V. Kaye, Oak Ridge National Laboratory, to W. H. Wilkie, 1972.

Table H-5

DOSES[a] TO DUCKS AND MUSKRATS LIVING NEAR THE SEQUOYAH NUCLEAR PLANT

| | 2.0 Ci Mixture | 1.0 Ci Tritium |
|---|---|---|
| Internal | 2.7 (+2) mrad | 6.1 (-5)[b] mrad |
| External | 8.7 (-4) mrad | 0 |
| Total | 2.7 (+2) mrad | 6.1 (-5) mrad |

a. Internal dose commitments for each annual intake and external doses from each annual exposure.
b. $6.1 \times 10^{-5}$

Table H-6

DOSES TO AQUATIC ORGANISMS LIVING IN THE TENNESSEE RIVER

NEAR THE SEQUOYAH NUCLEAR PLANT

A. Doses from an Annual Release of a 2.0 Ci Radionuclide Mixture[a]

| | Internal (mrad) | | External (mrad) |
|---|---|---|---|
| | 3-cm | 30-cm | |
| Plants | 6.2 | 15 | 1.7 (-3)[b] |
| Invertebrates | 2.9 | 6.6 | 1.7 (-3) suspended<br>200 benthic |
| Fish | 0.3 | 0.7 | 1.7 (-3) |

B. Doses from an Annual Release of 1.0 Ci Tritium

| | |
|---|---|
| Plants, invertebrates, and fish | 1.3 (-5) mrad (internal) |

a. Excluding tritium
b. $1.7 \times 10^{-3}$

# Appendix I

## RADIOLOGICAL IMPACT OF GASEOUS EFFLUENTS

Estimation of doses due to gaseous effluents from the Sequoyah Nuclear Plant is an important consideration in assessing the environmental impact of the plant. The methods of calculation and the results presented in this appendix should provide a realistic estimate of the impact from radionuclides released in gaseous effluents during normal operation. Where assumptions are necessary in developing these methods of calculation, they are chosen to yield conservative results. The following doses to humans are calculated for the routine releases of radionuclides listed in Table 2.4-2.

1. External beta doses
2. External gamma doses
3. Thyroid doses due to inhalation of radioactive iodine
4. Thyroid doses due to concentration of radioactive iodine in milk

The doses and radioiodine concentrations which appear in Tables I-2, I-3, and I-4 are calculated assuming operation of two units for 1 year at full power with 0.25 percent failed fuel. Doses are calculated for routine releases with a waste treatment system with 60-day holdup and for alternate systems with 45-day holdup, recombiners, cryogenic removal, and absorbtion by solvent.

Radionuclides will be released from the Sequoyah Nuclear Plant through vents located near the top of various plant buildings. To calculate downwind, ground-level air concentrations of these radionuclides,

a ground-level, sector-average, volume-source dispersion equation as described by Davidson[1,2] is used (equation 1).

$$\chi_{kmn} = \sum_{i} \sum_{j} \frac{\sqrt{2}\, Q_n f_{ijk}}{\sqrt{\pi}\, \Sigma_{zim}\, u_j \theta x_m} \exp\left(\frac{-\lambda_n x_m}{u_j}\right) \qquad (1)$$

and

$$\Sigma_{zim} = (\sigma_{zim}{}^2 + \frac{cA}{\pi})\ 1/2$$

where

$\chi_{kmn}$ = average-annual, ground-level concentration of radionuclide n in sector k at distance $x_m$, ($Ci/m^3$),

$Q_n$ = release rate of radionuclide n, (Ci/s),

$f_{ijk}$ = fraction of the release period during which the wind blows in direction k, with speed j, and atmospheric stability condition i,

$\sigma_{zim}$ = vertical standard deviation of the plume for stability condition i at distance $x_m$, (m),

$\Sigma_{zim}$ = vertical standard deviation of the plume (modified for the effect of building wake dilution) for stability condition i at distance $x_m$, (m),

c = a parameter which relates the cross-sectional area of the building to the size of a turbulent wake caused by the building,

A = cross-sectional area of the reactor building, ($m^2$),

$x_m$ = downwind distance at which the radionuclide concentration is calculated, (m),

$u_j$ = wind speed j, (m/s),

$\theta$ = sector width, (radians),

$\lambda_n$ = radioactive decay constant for radionuclide n, ($sec^{-1}$).

It is necessary to use a sector-average, volume-source dispersion equation to account for vertical perturbation of the plume due to the building turbulent wake. The vertical plume perturbation is not accounted for in a sector-average, point-source dispersion equation.

In equation 1 the sector width, $\theta$, is assumed to be 22.5°, c is assumed to be 0.5, and A is assumed to be 1,800 $m^2$ which is the minimum cross-sectional area of the reactor building. Pasquill vertical plume standard deviations[1] are used. Values for the annual joint meteorological frequency, $f_{ijk}$, in equation 1 are determined by methods discussed in Appendix A. In this section, the annual joint meteorological frequencies for the seven Pasquill stability conditions A through G are presented as a function of wind direction and wind speed in Appendix A. The data are grouped for five wind speed ranges (0-0.5, 0.6-3.4, 3.5-7.4, 7.5-12.4, >12.5 mi/h) and for 16 standard wind directions (N, NNE, NE, ---, NW, NNW).

Application of average-annual meteorology in these calculations yields realistic dose estimates for continuous releases from the plant. For intermittent releases during periods of favorable meteorological dispersion conditions, application of average-annual meteorology will yield conservative dose estimates.

1. <u>External beta doses</u> - Beta doses to an individual are computed using an immersion dose model described by the equation:

$$D_\beta = \sum_n 4.64 \times 10^9 \, \overline{E}_{\beta n} \chi_{kmn}, \qquad (2)$$

where

$D_\beta$ = external beta dose due to immersion in a cloud, (mrem/yr),

$4.64 \times 10^9$ = conversion constant for external beta dose calculations, $\left(\frac{\text{mrem/yr}}{\text{Ci-MeV/dis-m}^3}\right)$

$\overline{E}_{\beta n}$ = average beta energy of nuclide n, (MeV/dis),

$\chi_{kmn}$ = (defined following equation 1)

In this equation, a correction factor of 0.64 is included to account for cloud geometry and a correction factor of 0.5 is included to account for self-shielding by the human body. The average beta energies for the nuclides are calculated from information contained in reference 3 and are listed in Table I-1.

In computing the beta dose to the population within 50 miles of the Sequoyah Nuclear Plant, the area is divided into 16 directional sectors and 10 concentric rings, i.e., 160 area elements. A beta dose computed at the center of each element is multiplied by the number of people residing in that element. A summation of these products over all elements gives the total population dose within 50 miles of the plant. The projected population for the year 2010, as listed in section 1.2, is used in calculating population dose.

The individual and population external beta doses for gaseous effluents are reported in Table I-2.

2. External gamma doses - Gamma doses to individuals are computed using an immersion dose model described by the equation:

$$D_\gamma = \sum_n 7.21 \times 10^9 \, \overline{E}_{\gamma n} \, \chi_{kmn} \tag{3}$$

where

$D_\gamma$ = external gamma dose due to immersion in a cloud, (mrem/yr),

$7.21 \times 10^9$ = conversion constant for external gamma dose calculations, $\left(\frac{\text{mrem/yr}}{\text{Ci-MeV/dis-m}^3}\right)$

$\overline{E}_{\gamma n}$ = average gamma energy of nuclide n, (MeV/dis),

$\chi_{kmn}$ = (defined following equation 1)

Equation 2 includes a correction factor of 0.5 to account for cloud geometry. The average gamma energies used in calculating external gamma doses are computed from data contained in reference 3 and are listed in Table I-1.

The total population gamma dose within 50 miles of the Sequoyah Nuclear Plant is calculated using the method described for the population beta dose. The annual individual and population external gamma doses for gaseous effluents are reported in Table I-2.

3. <u>Thyroid doses due to iodine inhalation</u> - The equation used in calculating inhalation doses for routine releases of radioiodine from the Sequoyah Nuclear Plant is:

$$D = \sum_n 8.76 \times 10^3 \; \chi_{kmn} \, (BR) \, (DCF_n), \tag{4}$$

where

D = thyroid dose committed (mrem/yr)

$8.76 \times 10^3$ = hours per year,

$\chi_{kmn}$ = (defined following equation 1)

BR = breathing rate, ($m^3/h$),

$DCF_n$ = dose commitment factor for inhalation of iodine isotope n, (mrem/Ci inhaled).

Maximum individual thyroid doses due to intake of radioiodine are calculated for a 1-year-old child in accordance with the recommendations of the Federal Radiation Council.[4] Population doses are calculated using adult parameters and the same method described for calculating population beta doses.

The breathing rate assumed for a 1-year-old child is 0.29 $m^3/h$[5] and for an adult is 0.83 $m^3/h$.[6] The iodine inhalation dose commitment factors for the 1-year-old child and for the adult are obtained from reference 7.

The calculated annual individual and population iodine inhalation doses for gaseous effluents are reported in Table I-3.

4. Thyroid doses due to iodine ingestion - The equation used in calculating the thyroid doses due to iodine ingestion through the milk food chain is:

$$D = \sum_n 3.15 \times 10^7 \, (\chi_{kmn}) \, (v_g) \, (M_n) \, (CR) \, (DCF_n) \qquad (4)$$

where

D = thyroid dose committed, (mrem/yr),

$3.15 \times 10^7$ = seconds per year,

$\chi_{kmn}$ = (defined following equation 1)

$v_g$ = radioiodine deposition velocity, (m/s),

$M_n$ = empirically determined value for concentration of iodine isotope n in milk per unit deposition rate, $\left(\frac{Ci/liter}{Ci/m^2\text{-day}}\right)$,

CR - milk consumption rate, (liter/day),

$DCF_n$ = dose commitment factor for ingestion of iodine isotope n, (mrem/Ci ingested).

Only Iodine-131 and 133 are considered in calculating milk ingestion doses due to routine releases of radioiodine. Iodine-132, 134, and 135 have short half-lives (< 7 hours) and will have essentially disappeared due to decay before significant concentration in milk occurs.

The 1-year-old child is assumed to be the critical receptor in calculating the maximum dose to an individual drinking milk produced at the nearest dairy farm (2.8 miles NNE of the plant). Population doses to persons within 50 miles of the plant are calculated using adult parameters. The assumption is made that all milk produced within 50 miles of the Sequoyah Nuclear Plant is consumed within this area, and cows are assumed to graze the pastures during the entire year. County milk production data[8,9,10,11] are used in computing milk ingestion population doses. The population dose for the year 2010 is estimated assuming that the population dose increases in direct proportion to the increase in the population.

The numerical values used for the parameters, $v_g$, M, CR, and DCF, are determined using references 7, 12, 13, 14, and 15.

The individual and population milk ingestion doses are reported in Table I-3.

## REFERENCES FOR APPENDIX I


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3. C. M. Lederer, et at., Table of Isotopes, Sixth Edition, John Wiley and Sons, New York, 1968.

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5. Neil Gaeta, "An Evaluation of the Offsite Radiological Health Aspects from the Nuclear Facility of the Yankee Atomic Electric Company," U.S. Department of Health, Education, and Welfare, Public Health Service, Nuclear Facilities Environmental Analysis Section.

6. "Recommendations of the International Commission on Radiological Protection, Report of Committee II on Permissible Dose for Internal Radiation," ICRP Publication 2, Pergamon Press, New York, New York, 1959.

7. K.E. Cowser, et al., "Dose Estimation Studies Related to Proposed Construction of an Atlantic-Pacific Interoceanic Canal with Nuclear Explosives: Phase I," Oak Ridge National Laboratory Report, ORNL-4101, March 1967.

8. Census of Agriculture, County Data Reports for Alabama, Georgia, and Tennessee, U.S. Bureau of Census, 1969.

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12. T. J. Burnett, "Aderivation of the 'Factor of 700' for $^{131}I$," Health Physics, Vol. 18, pp. 73-75, 1970.

13. H. J. Dunster, "District Surveys Following the Windscale Incident, October 1957," Proceedings of the Second U.N. International Conference on the Peaceful Uses of Atomic Energy, Vol. 18, p/316, p. 306, 1958.

14. "Background Material for the Development of Radiation Protection Standards," Federal Radiation Council Report No. 5, July 1964.

15. A. R. Tamplin, "I-131, I-133, and Cow Milk," University of California, Lawrence Radiation Laboratory, Livermore, California, UCRL-14146, April 1965.

Table I-1

AVERAGE GAMMA AND BETA ENERGIES USED TO ESTIMATE EXTERNAL DOSES FROM NUCLIDES RELEASED IN GASEOUS EFFLUENTS

| Isotope | Average Gamma Energy (MeV/dis) | Average Beta Energy (MeV/dis) |
|---|---|---|
| I-131 | 3.8 (-1) | 2.0 (-1) |
| I-132 | 2.5 | 5.0 (-1) |
| I-133 | 6.7 (-1) | 4.4 (-1) |
| I-134 | 2.4 | 5.2 (-1) |
| I-135 | 1.7 | 3.3 (-1) |
| Kr-83m | 9.0 (-3) | 0 |
| Kr-85m | 1.5 (-1) | 2.5 (-1) |
| Kr-85 | 2.0 (-3) | 2.4 (-1) |
| Kr-87 | 1.5 | 1.3 |
| Kr-88 | 1.7 | 3.9 (-1) |
| Kr-89 | 3.9 | 1.7 |
| Xe-131m | 2.5 (-2) | 1.2 (-1) |
| Xe-133m | 5.3 (-2) | 1.6 (-1) |
| Xe-133 | 4.9 (-2) | 1.2 (-1) |
| Xe-135m | 4.3 (-1) | 9.9 (-2) |
| Xe-135 | 2.3 (-1) | 3.3 (-1) |
| Xe-137 | 3.2 (-1) | 1.7 |
| Xe-138 | 2.9 | 9.4 (-1) |

Table I-2

ESTIMATED ANNUAL EXTERNAL GAMMA AND BETA DOSES FROM NUCLIDES RELEASED IN GASEOUS EFFLUENTS[a]

| | Total Routine Releases | | | |
|---|---|---|---|---|
| | Including 60-day Holdup | Including 45-day Holdup | Including Recombiners | Including Cryogenic or Gas Absorption Removal System |
| Maximum Individual Gamma Dose at Site Boundary (mrem) | 1.8 | 2.2 | 1.8 | 1.7 |
| Maximum Individual Beta Dose at Site Boundary (mrem) | 3.7 | 4.3 | 3.6 | 1.9 |
| Total Population Gamma Dose Within 50 miles (man-rem) | 5.1 | 6.8 | 4.8 | 4.7 |
| Total Population Beta Dose Within 50 miles (man-rem) | 1.5 (+1)[b] | 1.8 (+1) | 1.4 (+1) | 7.1 |

a. For operation of two units at full power with 0.25 percent failed fuel.
b. $1.5 \times 10^1$.

Table I-3

ESTIMATED ANNUAL THYROID DOSE COMMITMENTS FROM RADIOIODINE RELEASED IN GASEOUS EFFLUENTS[a]

| | Total Routine Releases | | | |
|---|---|---|---|---|
| | Including 60-day Holdup | Including 45-day Holdup | Including Recombiners | Including Cryogenic or Gas Absorption Removal System |
| **Iodine Inhalation** | | | | |
| Maximum Individual Thyroid Dose at Site Boundary (mrem) | 1.0 (-1)[b] | 1.0 (-1) | 1.0 (-1) | 1.0 (-1) |
| Total Population Thyroid Dose Within 50 miles (man-rem) | 2.1 (-1) | 2.1 (-1) | 2.1 (-1) | 2.1 (-1) |
| **Iodine Ingestion via Milk** | | | | |
| Maximum Individual[c] Thyroid Dose at Nearest Dairy Farm (mrem) | 7.5 (-1) | 7.6 (-1) | 7.5 (-1) | 7.5 (-1) |
| Total Population Thyroid Dose Within 50 miles (man-rem) | 2.3 | 2.3 | 2.3 | 2.3 |

a. For operation of two units at full power with 0.25 percent failed fuel.
b. $1.0 \times 10^{-1}$.
c. See Appendix I1 for iodine ingestion dose calculated by methods specified in Regulatory Guide 1.42.

# Appendix I1

## CHILD THYROID DOSE RATE FROM INGESTION OF RADIOIODINE CALCULATED USING METHODS SPECIFIED IN REGULATORY GUIDE 1.42

USAEC Regulatory Guide 1.42 was distributed in June 1973 shortly before issuance of the Sequoyah Nuclear Plant Final Environmental Statement and the Final Safety Analysis Report but subsequent to the completion of all radiological impact assessments by the Tennessee Valley Authority. This appendix describes the results of an analysis of the thyroid dose to a one-year-old child from ingestion of milk containing I-131. The calculations are performed according to the guidelines specified in Regulatory Guide 1.42.

The TVA procedure for calculating the I-131 milk-ingestion dose rate is the same as specified in Regulatory Guide 1.42 for internal radiation dosimetry and meteorological dispersion. However, the source term (i.e., I-131 released), is calculated to be 0.1 Ci/yr of I-131 using the procedure given in the guide. Information concerning the cow locations within the area surrounding the Sequoyah Nuclear Plant is supplied by TVA's Agricultural Resource Development Branch and dose rates from ingestion of I-131 are determined for each location. The cow location which resulted in the highest calculated dose rate is 2.8 miles (4,506 meters) NNE of the Sequoyah Nuclear Plant. The child thyroid dose rate due to ingestion of I-131 in milk is estimated to be 12 mrem/year which is less than the 15 mrem/yr design objective dose rate specified in Regulatory Guide 1.42.

It is estimated that the dose calculated by the methods specified in Regulatory Guide 1.42 from releases of I-133 and I-135 would be less than 10 percent of the dose calculated for releases of I-131.

# Appendix J

## ESTIMATION OF POTENTIAL INTERNAL DOSE FROM RADIOACTIVE PARTICULATES

A conservative estimate of the internal dose due to airborne radioactive particulates originating from the Sequoyah Nuclear Plant gaseous effluents is presented in this appendix. The estimated doses due to releases of radioactive iodines, kryptons, and xenons are specifically addressed in Appendix I and are not considered in this analysis.

The maximum inventory within a 50-mile radius of the plant is estimated for each particulate. In calculating these particulate inventories, direct releases from the plant and particulate ingrowth due to radioactive decay are considered. These particulate inventories are multiplied by the maximum average-annual atmospheric dispersion factor ($\chi/Q$) within a 50-mile radius of the plant to obtain an estimate of the maximum particulate air concentrations. In calculating these air concentrations, depletion of the plume due to deposition on the ground is neglected.

For radioactive particulates with half-lives of less than 3 hours it is assumed that an air concentration of MPC*,1 x $10^{-2}$ will limit the internal dose to the whole body or to any organ to 15 mrem per year. For particulates with half-lives equal to or greater than 3 hours it is assumed that an air concentration of MPC x $10^{-5}$ will limit the internal dose to the whole body or to any organ to 15 mrem per year. Inherent in this philosophy is the assumption that inhalation

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*Maximum permissible concentration as given in Appendix B, Table II, Column 2 of 10 CFR Part 20.

is the major internal dose pathway for particulates with half-lives less than 3 hours. For particulates with half-lives equal to or greater than 3 hours it is assumed that reconcentration through the food chains is the major internal dose pathway. It is also assumed that the internal dose due to particulate reconcentration through food chains is 1,000 times greater than the internal dose due to inhalation. In the proposed Appendix I[2] to 10 CFR Part 50 it is stated that the factor of 1,000 used to predict the dose due to reconcentration through food chains is "highly conservative" for particulates with half-lives greater than 8 days. Application of this reconcentration factor to particulates with half-lives between 3 hours and 8 days adds additional conservatism to the analysis.

To estimate the maximum internal dose due to particulates, the following equation is used:

$$D_p = 15\left\{ \sum_i \frac{X_i}{(MPC)_i(10^{-2})} + \sum_j \frac{X_j}{(MPC)_j(10^{-5})} \right\} \qquad (1)$$

where

$D_p$ = estimated internal dose due to airborne particulates (mrem/yr)

$X_i$ = calculated maximum air concentration of the $i^{th}$ particulate with half-life of less than 3 hours (uCi/cc)

$(MPC)_i$ = maximum permissible air concentration for $i^{th}$ particulate as given in 10 CFR Part 20 (uCi/cc)

$X_j$ = calculated maximum air concentration of the $j^{th}$ particulate with half-life equal to or greater than 3 hours (uCi/cc)

$(MPC)_j$ = maximum permissible air concentration for $j^{th}$ particulate as given in 10 CFR Part 20 (uCi/cc)

For a particulate not listed in 10 CFR Part 20 the lowest value for the isotopes of the element which are listed is used except for Rb-88 and Cs-138. For Rb-88 and Cs-138 an MPC is calculated using the procedures and data given in ICRP Publication 2.[3] Dose limits which are a factor of 10 below those given in ICRP Publication 2 are used. The data required for use with Equation 1 to estimate the internal dose due to particulate are listed in Table I-1.

The maximum individual internal dose due to particulates is estimated to be 0.5 mrem per year. This dose is calculated using very conservative methods and assumptions. Therefore, it should not be compared directly with the doses due to liquid and gaseous releases presented in Appendices H and I which are calculated using more realistic methods and assumptions. However, since a maximum individual internal dose of only 0.5 mrem per year is estimated by this very conservative analysis, it is concluded that airborne particulates are not a major contributor to internal dose for the projected releases from the Sequoyah Nuclear Plant.

## REFERENCES FOR APPENDIX J

1. "Standards for Protection Against Radiation," Rules and Regulations, Title 10, Code of Federal Regulations, Part 20, U.S. Atomic Energy Commission, December 1970.

2. "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criteria 'as Low as Practicable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," Proposed Appendix I to Title 10, Code of Federal Regulations, Part 50, U.S. Atomic Energy Commission, Federal Register, Vol. 36, No. 111, June 9, 1971.

3. "Recommendations of the International Commission on Radiological Protection, Report of Committee II on Permissible Dose for Internal Radiation," ICRP Publication 2, Pergamon Press, New York, New York, 1959.

Table J-1

DATA USED TO ESTIMATE INTERNAL DOSES FROM PARTICULATES

| Isotope | Maximum Particulate Inventory (Ci/sec) | Calculated Maximum Concentration, χ, (μCi/cc) | MPC 10 CFR 20 (μCi/cc) | $\frac{\chi}{MPC \times 10^{-5}}$ | $\frac{\chi}{MPC \times 10^{-2}}$ |
|---|---|---|---|---|---|
| Cr-51 | 1.1 (-14) | 1.7 (-19) | 8 (-8) | 2.1 (-7) | |
| Mn-54 | 1.0 (-14) | 1.6 (-19) | 1 (-9) | 1.6 (-5) | |
| Mn-56 | 1.4 (-14) | 2.2 (-19) | 2 (-8) | | 1.1 (-9) |
| Fe-59 | 1.2 (-14) | 2.0 (-19) | 2 (-9) | 9.8 (-6) | |
| Co-58 | 3.1 (-13) | 4.9 (-19) | 2 (-o) | 2.4 (-5) | |
| Co-60 | 9.8 (-15) | 1.6 (-19) | 3 (-10) | 5.2 (-5) | |
| Br-84 | 2.5 (-13) | 3.8 (-18) | 6 (-9)[a] | | 6.3 (-8) |
| Rb-87 | 1.8 (-21) | 2.9 (-26) | 2 (-9) | 1.4 (-12) | |
| Rb-88 | 1.5 (-6) | 2.3 (-11) | 2 (-7)[b] | | 1.4 (-2) |
| Rb-89 | 1.6 (-14) | 2.4 (-19) | 2 (-9)[a] | | 1.2 (-8) |
| Sr-89 | 1.3 (-14) | 2.1 (-19) | 3 (-10) | 6.8 (-5) | |
| Sr-90 | 4.6 (-16) | 7.3 (-21) | 3 (-11) | 2.4 (-5) | |
| Sr-91 | 6.6 (-16) | 1.0 (-20) | 9 (-9) | 1.2 (-7) | |
| Y-90 | 6.1 (-16) | 9.6 (-21) | 3 (-9) | 3.7 (-7) | |
| Y-91m | 3.1 (-16) | 4.9 (-21) | 6 (-7) | | 8.1 (-13) |
| Y-91 | 2.2 (-14) | 3.4 (-19) | 1 (-9) | 3.4 (-5) | |
| Y-92 | 1.3 (-16) | 2.1 (-21) | 1 (-8) | 2.1 (-8) | |
| Zr-95 | 2.8 (-15) | 4.5 (-20) | 1 (-9) | 4.5 (-6) | |
| Nb-95m | 4.2 (-17) | 6.7 (-22) | 3 (-9)[a] | 2.2 (-8) | |
| Nb-95 | 2.8 (-15) | 4.5 (-20) | 3 (-9) | 1.5 (-6) | |
| Mo-99 | 6.9 (-12) | 1.1 (-16) | 7 (-9) | 1.5 (-3) | |
| Tc-99m | 4.7 (-12) | 7.4 (-17) | 5 (-7) | 1.5 (-5) | |
| Tc-99 | 2.1 (-19) | 3.3 (-24) | 2 (-9) | 1.7 (-10) | |
| Te-132 | 4.0 (-13) | 6.4 (-18) | 4 (-9) | 1.6 (-4) | |
| Te-134 | 2.0 (-15) | 3.1 (-20) | 4 (-9)[a] | | 7.8 (-10) |

Table J-1 (Continued)

DATA USED TO ESTIMATE INTERNAL DOSES FROM PARTICULATES

| Isotope | Maximum Particulate Inventory (Ci/sec) | Calculated Maximum Concentration, χ, (μCi/cc) | MPC 10 CFR 20 (μCi/cc) | $\frac{\chi}{MPC \times 10^{-5}}$ | $\frac{\chi}{MPC \times 10^{-2}}$ |
|---|---|---|---|---|---|
| Cs-134 | 8.9 (-13) | 1.4 (-17) | 4 (-10) | 3.5 (-3) | |
| Cs-135 | 5.4 (-12) | 8.6 (-17) | 3 (-9) | 2.9 (-3) | |
| Cs-136 | 3.7 (-13) | 5.8 (-18) | 6 (-9) | 9.6 (-5) | |
| Cs-137 | 4.4 (-12) | 7.0 (-17) | 5 (-10) | 1.4 (-2) | |
| Cs-138 | 5.5 (-8) | 8.7 (-13) | 3 (-7)[b] | | 3.5 (-4) |
| Ba-137m | 4.2 (-12) | 6.6 (-17) | 1 (-9) | | 6.6 (-5) |
| Ba-140 | 1.2 (-14) | 1.8 (-19) | 1 (-9) | 1.8 (-4) | |
| La-140 | 1.0 (-14) | 1.5 (-19) | 4 (-9) | 3.9 (-6) | |
| Ce-144 | 1.1 (-15) | 1.8 (-20) | 2 (-10) | 9.0 (-6) | |
| Pr-144 | 1.1 (-15) | 1.8 (-20) | 5 (-9)[a] | | 3.6 (-10) |
| | | | | 2.0 (-2) | 1.4 (-2) |

a. An MPC is not listed for this isotope in 10 CFR 20. The lowest MPC given in 10 CFR 20 for the element is used.

b. Calculated using the procedures and data given in ICRP Publication 2 and dose limits a factor of 10 below those given in ICRP Publication 2.

# Appendix K

## RADIOLOGICAL IMPACT OF EXTERNAL DOSE FROM REFUELING WATER, PRIMARY WATER, AND CONDENSATE STORAGE TANKS

The direct gamma radiation dose rate at the site boundary from two refueling water storage tanks, two primary water storage tanks, and two condensate storage tanks has been calculated. The assumptions used in performing these analyses are given below:

1. The dose rate model considers the tanks to be cylindrical, "self-absorbing" volume sources surrounded by a thin steel slab.
2. The physical dimensions and volumes of the tanks are: Refueling water storage tank: 43'6" dia. x 32'0" high, 350,000 gallons per tank; primary water storage tank: 32'6" dia. x 30'9" high, 187,000 gallons per tank; and condensate storage tank: 46'0" dia. x 35'0" high, 397,000 gallons per tank.
3. The refueling and primary water storage tanks are considered filled to the volumes shown in 2 above. The condensate storage tank is filled to 190,000 gallons per tank and all tank liquid is assumed to have a density of 1.0 $g/cm^3$.
4. The isotopic distribution of the radioactivity in each tank is shown in Table K-1. The specific activity in the refueling water storage tank is 0.0012 uCi/ml, the primary water storage tank specific activity is 0.0012 uCi/ml, and the condensate storage tank specific activity is 0.0036 uCi/ml.

The total activity, exclusive of tritium, in each refueling water storage tank is 1.51 Ci, 0.81 Ci in primary water storage tank, and in each condensate storage tank the total activity is 2.56 Ci.

5. The isotopic mixture is considered uniformly distributed in the tank.
6. Decay of the isotopes is not considered in the calculation.
7. Only those gamma rays of significant energy (MeV) and intensity (number per disintegration) are included in the calculations.
8. The average gamma energy for the mixture of isotopes given in Table K-1 is calculated to be 0.60 MeV per photon for the refueling water and primary water storage tanks and 0.65 MeV per photon for the condensate storage tank.
9. The individual contribution from each nuclide to the total photon and energy emission rate is weighted according to its fraction of the total activity.
10. The distance from the tanks to the nearest point on the site boundary is used for these calculations (540 meters for the refueling water storage tanks, 525 meters for the primary water storage tanks, and 579 meters for the condensate storage tanks.)
11. Attenuation and buildup for air and for the 1/4" steel tank wall are considered in the calculations. Self-absorption and buildup due to the water in the tanks is also considered.
12. No credit for the air-earth interface absorption and scattering effect is taken in the calculations.

Using these assumptions, the direct gamma dose rate at the site boundary from activity contained in each refueling water storage tank is calculated to be 0.006 mrem/yr and 0.005 mrem/yr for each primary water storage tank. For each condensate water storage tank, the direct gamma dose rate is 0.007 mrem/yr. The total direct gamma dose rate at the restricted area boundary from the two refueling water storage tanks, the two primary water storage tanks, and the two condensate storage tanks is calculated to be 0.036 mrem/yr.

Table K-1

ISOTOPIC DISTRIBUTION OF ACTIVITY IN REFUELING WATER, PRIMARY WATER, AND CONDENSATE STORAGE TANKS[a]

| Isotope | Refueling Water Storage Tank (curie/tank) | Primary Water Storage Tank (curie/tank) | Condensate Storage Tank (curie/tank) |
|---|---|---|---|
| Cr-51 | | | 1.556 (-3) |
| Mn-54 | 4.98 (-4) | 2.66 (-4) | 2.303 (-3) |
| Fe-59 | 5.49 (-4) | 2.93 (-4) | 2.194 (-3) |
| Co-58 | 1.42 (-2) | 7.59 (-3) | 6.092 (-2) |
| Co-60 | 4.89 (-4) | 2.61 (-4) | 2.335 (-3) |
| Sr-89 | 2.17 (-3) | 1.16 (-3) | 2.372 (-3) |
| Sr-90 | 8.70 (-5) | 4.65 (-5) | 1.117 (-4) |
| Y-90 | | | 1.119 (-4) |
| Y-91 | | | 4.089 (-3) |
| Zr-95 | 4.74 (-4) | 2.53 (-4) | 5.429 (-4) |
| Nb-95 | 3.89 (-4) | 2.08 (-4) | 6.522 (-4) |
| Nb-95m | | | 1.125 (-5) |
| Mo-99 | 5.91 (-2) | 3.16 (-2) | 1.064 (-2) |
| Te-99m | | | 1.018 (-2) |
| Te-132 | | | 1.317 (-3) |
| I-131 | 4.44 (-1) | 2.37 (-1) | 2.437 (-1) |
| I-132 | | | 1.357 (-3) |
| I-133 | | | 6.028 (-8) |
| Xe-131m | | | 3.026 (-3) |
| Xe-133m | | | 1.828 (-5) |
| Xe-133 | | | 7.553 (-3) |
| Cs-134 | 1.58 (-1) | 8.44 (-2) | 2.017 (-1) |
| Cs-136 | 3.88 (-2) | 2.07 (-2) | 2.875 (-2) |
| Cs-137 | 8.00 (-1) | 4.27 (-1) | 1.029 |
| Ba-137m | | | 9.472 (-1) |
| Ba-140 | 3.88 (-4) | 2.07 (-4) | 9.287 (-4) |
| La-140 | | | 1.068 (-3) |
| Ce-144 | 2.08 (-4) | 1.11 (-4) | 2.584 (-4) |
| Pr-144 | | | 2.584 (-4) |
| Total | 1.51 | 0.81 | 2.56 |

a. Exclusive of tritium.

# Appendix L

## CUMULATIVE RADIOLOGICAL IMPACT ON THE TENNESSEE RIVER FROM THE OPERATION OF TVA NUCLEAR PLANTS

TVA has calculated the expected radiation doses to man and to species other than man resulting from radionuclides in liquid effluents released to the Tennessee River from the operation of the Watts Bar, Sequoyah, Bellefonte, and Browns Ferry Nuclear Plants in the year 2010. A summary of these doses is given in Table H-1. Data were generated for reaches and drinking water supplies between Watts Bar Dam and Paducah, Kentucky, and the Tennessee Valley population doses are summations of all the appropriate populations within this region. Population figures are derived from 1960 and 1970 census values for a 125-county Tennessee Valley region using linear interpolation of recent data for public water supplies, commercial[1] and sport[2] fish harvests, and the use of the Tennessee River for water sports.[3] Doses are calculated using the models and assumptions described in Appendix H. Estimated doses are listed for Chickamauga Lake and for the individual drinking water supplies within approximately 50 miles downstream from the Sequoyah Nuclear Plant site. Doses are estimated to be smaller at water supplies farther downstream.

The maximum dose* to an individual from eating fish and drinking water near the Sequoyah site from the cumulative releases of radionuclides in the liquid effluents from TVA nuclear plants is calculated to be less

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*Tritium doses are not included in the values listed in Table 1. Doses from tritium released from TVA nuclear plants in liquid effluents are estimated to be less than 10 percent of the doses from the mixture of radionuclides excluding tritium.

than 0.2 mrem per year, which is less than 0.2 percent of the total dose that an individual receives from natural background radiation. The Tennessee Valley population dose*,** from the cumulative releases of radionuclides in liquid effluents from TVA nuclear plants is calculated to be 54 man-rem, which is less than 0.04 percent of the dose from naturally occurring background radiation.

It is concluded that the combined doses resulting from the normal operation of the Watts Bar, Sequoyah, Bellefonte, and Browns Ferry Nuclear Plants will present no significant risk to the health and safety of the public.

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*Tritium doses are not included in the values listed in Table 1. Doses from tritium released from TVA nuclear plants in liquid effluents are estimated to be less than 10 percent of the doses from the mixture of radionuclides excluding tritium.

**Based on a projection for the year 2010 of 1,100,000 people served by the water supplies listed in Table L-1 of Appendix with the conservative assumption that all edible fish harvested from the Tennessee River are consumed by this population.

## REFERENCES FOR APPENDIX L

1. U.S. Department of the Interior, "Estimated Commercial Fish Harvest, Tennessee Valley, 1969, "Bureau of Commercial Fisheries.

2. Tennessee Game and Fish Commission, Tennessee Valley Authority, and Kentucky Department of Fish and Wildlife Resources, "Kentucky Lake Fishing."

3. Tennessee Department of Conservation, "Statistical Summary--State Demand, Supply, and Comparisons," Tennessee Statewide Comprehensive Outdoor Recreation Plan - 1969, Final Report, Appendix IV, Table 27, 1969.

Table L-1

RADIOLOGICAL IMPACT OF TVA'S NUCLEAR PLANTS ON THE TENNESSEE RIVER IN 2010[a]

| | Tennessee Valley Authority Nuclear Plants | | | | | |
|---|---|---|---|---|---|---|
| | Watts Bar | Sequoyah | Bellefonte | Browns Ferry | Total | |
| Average Annual Radioactivity Released[b] | 0.92 | 2.0 | 0.93 | 0.43 | 4.0 | Ci/yr |
| I. Average Annual Doses to Humans | | | | | | |
| A. Ingestion of Tennessee River Water | | | | | | |
| 1. Water supplies | | | | | | |
| Atlas Chemical Industries | | | | | | |
| a. individual | 1.3 (-2) | 6.4 (-2) | - | - | 7.7 (-2) | mrem[c] |
| b. population | 3.8 (-2) | 2.2 (-1) | - | - | 2.6 (-1) | man-rem[c] |
| Farmers Chemical Corp. | 4.3 (-3) | 2.4 (-2) | - | - | 2.8 (-2) | man-rem[c] |
| E.I. Dupont | 5.7 (-2) | 1.6 (-1) | - | - | 2.2 (-1) | man-rem[c] |
| Chattanooga | 5.3 | 1.5 (+1) | - | - | 20 | man-rem[c] |
| South Pittsburg | 7.6 (-2) | 2.1 (-1) | - | - | 2.9 (-1) | man-rem[c] |
| 2. Tennessee Valley[d] population dose | 7.7[c] | 2.0 (+1)[c] | 2.2[c] | 1.2 (-2)[e] | 30 | man-rem |
| B. Eating Fish Taken from the Tennessee River | | | | | | |
| 1. Chickamauga Lake downstream from the Sequoyah Nuclear Plant | | | | | | |
| a. maximum individual | 2.6 (-2) | 5.6 (-2) | - | - | 8.2 (-2) | mrem[c] |
| b. population | 4.0 (-1) | 8.7 (-1) | - | - | 1.3 | man-rem[c] |
| 2. Tennessee Valley population dose | 7.5[e] | 1.0 (+1)[e] | 5.3[e] | 7.5 (-1)[f] | 24 | man-rem |

Table L-1 (Continued)

| | Tennessee Valley Authority Nuclear Plants | | | | |
|---|---|---|---|---|---|
| | Watts Bar | Sequoyah | Bellefonte | Browns Ferry | Total |
| C. Use of the Tennessee River for Water Sports | | | | | |
| 1. Chickamauga Lake below the Sequoyah Nuclear Plant site | | | | | |
| a. above-water | 1.8 (-4) | 4.1 (-4) | - | - | 5.9 (-4) man-rem[g] |
| b. in-water | 6.7 (-5) | 1.6 (-4) | - | - | 2.3 (-4) man-rem[g] |
| 2. Tennessee Valley population dose | | | | | |
| a. above-water | 1.3 (-3) | 2.2 (-3) | 1.3 (-3) | 8.9 (-5) | 4.9 (-3) man-rem[g] |
| b. in-water | 5.2 (-4) | 8.2 (-4) | 4.7 (-4) | 4.0 (-5) | 1.9 (-3) man-rem[g] |
| II. Doses to Organisms Living near the Sequoyah Nuclear Plant site | | | | | |
| A. Terrestrial Vertebrates | 8.8 (+1) | 2.7 (+2) | - | - | 3.6 (+2) mrad[h] |
| B. Aquatic Organisms | | | | | |
| 1. Plants | 4.7 | 1.5 (+1) | - | - | 2.0 (+1) mrad[h] |
| 2. Invertebrates | 1.9 | 6.6 | - | - | 8.5 mrad[h] |
| 3. Fish | 1.9 (-1) | 6.8 (-1) | - | - | 8.7 (-1) mrad[h] |

a. Assuming normal operation full time
b. Excluding tritium
c. Doses to thyroid tissue
d. Between Watts Bar Dam and Paducah, Kentucky
e. Doses to bone tissue
f. Doses to G.I. tract tissue
g. Doses to skin tissue
h. Doses to the total organism

# Appendix M

## RESERVOIR THERMOHYDRODYNAMICS AND THE DIFFUSER SYSTEM

This appendix describes the prediction and control of water temperatures in Chickamauga Reservoir during operation of the Sequoyah Nuclear Plant in the open mode.

The construction of cooling towers will make possible the operation of the condenser cooling system in a helper mode where a portion of the heat will be removed from the condenser water by the towers before it is discharged into the river. Although the details of the design are not final, it will involve the same condenser waterflow (1,250 $ft^3/s$) for each unit, the same condenser rise (29.5$^oF$), but a lower temperature rise in the discharged water than in an open-mode operation. This difference from open-mode operation will result in a different relationship between the reservoir flow magnitude and the temperature rises in the reservoir. The temperature rises in the reservoir will be lower, but operations in general should result in similar flow and temperature patterns as described below for the open mode of operation.

The thermal regime in Chickamauga Reservoir during the operation of Sequoyah Nuclear Plant will depend upon the effects of the heated water discharged on the natural temperature distribution. The diffusers will mix the heated condenser water with some portion of the reservoir flows in a jet mixing region. The mixed flow leaving the jet mixing region may spread upstream as a wedge and/or laterally into

the shallow areas of the reservoir during low streamflows. The submerged dam is designed to decrease the upstream movement of heated water and to allow only cooler water from upstream to be drawn under the skimmer wall even if a warm-water wedge exists. In the region downstream from the plant, the mixed flow may (1) form a surface layer and lose heat to the atmosphere, (2) be essentially at normal surface temperature and therefore produce no change in surface temperatures, or (3) be confined beneath a warmer natural surface layer.

The qualitative descriptions of the thermal regime at Sequoyah were deduced from the Browns Ferry model studies on the basis of similarit of the diffuser design. The dimensions of the initial jet mixing region are believed to be a sufficiently local phenomena that the estimates of the approximate extent of the mixing region will not be affected by the upstream dam or any other geometrical features which differ from Browns Ferry. However, an accurate quantitative description of the percent of the river flow which mixes with the diffuser discharge and a precise knowledge of the lateral and upstream distribution of heated water would require a physical model study of the Sequoyah site.

The following discussion centers first on 2-unit operation and then on the differences expected when only one unit is operating. For convenience the discussion has been separated into three sections: (1) the initial jet mixing in the immediate vicinity of the diffusers, (2) an intermediate region covering a 4- to 6-mile reach upstream and downstream from the plant, and (3) the far field or extended downstream reach including the releases from Chickamauga Dam.

1. Two-unit operation -

(1) Initial jet mixing - When both units are operating at full load, the diffusers will have a total discharge, $Q_c$, of about 2,500 $ft^3/s$ at a temperature rise, $\Delta T_c$, of $29.5^oF$. This flow will be discharged through thousands of 2-inch diameter ports at a velocity of about 10 ft/s. Initial mixing of the jets with that portion of the reservoir flow passing over the diffusers will occur rapidly. Based upon model tests conducted for the Browns Ferry diffusers, it is estimated that complete mixing should occur within about 50 feet from the diffusers. Figure M-1 shows the temperature distribution obtained from the Browns Ferry model tests in the immediate vicinity of the diffusers for a steady total reservoir flow of 30,000 $ft^3/s$. Within a few feet, the temperature rise had dropped from $29^oF$ to $13^oF$. For a similar dilution ratio for Sequoyah, a similar rapid mixing will occur. The Browns Ferry tests also showed that the maximum temperature rise at the bottom will be about $7^o$ to $8^oF$ for a distance of about 30 feet downstream from the diffuser. Since the Sequoyah diffusers will be situated on a low fill, the temperature rise at the reservoir bottom should be similar but over a shorter length.

The steady-state mixed temperature, $T_m$, resulting from mixing with a portion of the total reservoir flow, $Q_R$, is:

$$T_M = [QcTc + (PQ_R - Qc)T_R] / (PQ_R) \qquad (1)$$

where P is the portion of the reservoir flow that mixes with the diffuser flow in the near field, Qc is the flow through the diffusers, and Tc is the temperature of the diffuser discharge. Equation (1) can also be expressed in terms of temperature rises:

$$\Delta T_R = T_M - T_R = Qc\,\Delta\,Tc/PQ_R \qquad (2)$$

where $\Delta Tc = Tc - T_R = 29.5^{o}F$.

Field tests have indicated that P without the proposed structures is about 0.6.

Four factors will tend to modify this factor in the immediate vicinity of the proposed diffuser pipes. These are: (1) the proposed underwater dam, (2) lateral (or end) entrainment into the diffuser jets, (3) the discharge pond dikes, and (4) the location of the diffuser pipes such that they will occupy part of the present flow area in the right overbank area and in the main channel.

Equation (2) is plotted as shown in figure M-2 for P = 0.6. The minimum total flow required to meet an allowable temperature rise of $5.4^{o}F$ will be about 22,000 $ft^3/s$ when the condenser flow is 2,500 $ft^3/s$.

When the reservoir exhibits stratification, the mixed temperature can be estimated by using:

$$T_M = [QcTc + P_s Q_{RS} T_{RS} + (P_B Q_{RB} - Qc)T_{RB}] \,/\, (P_s Qs + P_B Q_B) \qquad (3)$$

where $Q_{RS}$, $Q_{RB}$ : reservoir flows in the surface and bottom layers, respectively

$P_s$, $P_B$ : the percentages of $Q_{RS}$, $Q_{RB}$, respectively, mixed with the diffuser flow.

If the surface layer is originally warmer than the bottom layer ($T_{RS} > T_{RB}$), it is possible that $T_M$ could be greater than, equal to, or less than $T_{RS}$.

Equations (1) to (3) predict steady-state temperatures that are approached asymptotically after any change in flow

conditions. At flows above approximately 10,000 $ft^3/s$, the steady-state mixed temperature is approached rapidly. At very low reservoir flows, an upstream moving underflow is induced along the bottom by the diffuser jet action. This underflow is significant because it prolongs the time required to reach steady-state conditions.

(2) Intermediate region - In the intermediate region, which may extend several miles upstream and downstream from the diffusers, the temperature distribution is considerably affected by the fact that $T_M$ is always greater than the upstream natural reservoir temperature and thus stratification may occur.

As the mixed flow (at temperature $T_M$) leaves the jet mixing region, it immediately flows adjacent to that portion of the reservoir flow which did not pass through the jet mixing zone. For 2-unit operation, the unaffected reservoir flow is primarily the 200-foot width of flow on the left side of the main channel. There also will be some unaffected flow on the right overbank area. Generally, the density difference between the mixed and natural flows will promote the formation of stratification. The cooler water will flow under the warmer mixed flow of temperature $T_M$ in the main river channel downstream from the diffusers, while the mixed flow will move downstream, laterally over the shallow area and, under certain conditions, upstream against the reservoir flow. The larger the flow in the reservoir, the weaker the stratification will be; for sufficiently large streamflows no upstream wedge will form and additional mixing may occur by natural turbulent processes, resulting in a downstream mixed temperature less than the initial mixed temperature $T_M$.

It is possible to calculate theoretically the riverflows which will prevent the upstream movement of heated water in the intermediate region. For an assumed value of P = 0.6, in the case of flow less than 30,000 $ft^3/s$, a warm water wedge of temperature equal to or less than $T_M$ will extend upstream. The stablized length of the upstream wedge will depend upon the reservoir flow. For flows greater than 30,000 $ft^3/s$, there will be no heated water upstream from the submerged dam, although a wedge may extend from the diffusers to the dam. For flows greater than 50,000 $ft^3/s$, there will be no heated water upstream from the diffusers.

The possible thermal regimes in the intermediate region are qualitatively illustrated in figures M-3 through M-6. First, figure M-3 shows the case of a reservoir flow of less than 30,000 $ft^3/s$. In this case, a warm water wedge extends upstream past the submerged dam and the reservoir flow between 30,000 $ft^3/s$ and 50,000 $ft^3/s$ such that the warm water wedge is confined below the submerged dam. In figure M-5 a flow of more than 50,000 $ft^3/s$ has prevented the formation of any upstream wedge. Figure M-6 illustrates the case in which a large reservoir flow has provided sufficient turbulence to destroy the downstream stratification. It should be noted that portions of the shallow overbank downstream from the discharge pond will always experience some induced temperature rise either by the formation of a stratified system or by lateral turbulent mixing.

(3) <u>Downstream region</u> - Initially, just below the diffusers, the downstream-moving heated flow will be limited to the deep river channel but within 2 miles it will be spread over the

full width of the reservoir. The vertical temperature distribution in the region downstream from this point will be dependent upon the interaction of the mixed flow with the natural stratification in Chickamauga Reservoir.

When there is little or no natural stratification in the reservoir, the mixed temperature will always be greater than the ambient surface temperature. In this case, the mixed flow will form a surface layer which will flow downstream. However, since the mixed temperature will be only slightly above the equilibrium temperature, the amount of heat lost between the plant and Chickamauga Dam will be small. During the summer when periods of natural stratification occur, little change will be noted in the surface water temperature in the recreational area of Chickamauga Dam. In most instances, the temperature of the mixed layer will be essentially the same as the present surface temperature. In some instances the natural surface temperature may be greater than the mixed flow temperature and the mixed flow will spread across the reservoir beneath the naturally heated surface water. In either case, little or no heat will be lost from the mixed layer as it flows downstream since it is either near equilibrium temperature or not exposed to the atmosphere. In all cases there may be a cooler, lower layer composed of riverflow which did not pass through the diffuser mixing region and which was not mixed during passage through the intermediate zone. The turbines at Chickamauga at present withdraw from the entire depth of the reservoir. It is expected that they will continue to withdraw over the entire depth after the Sequoyah plant goes into operation even though the reservoir may at times be stratified to a deeper depth.

In calculating downstream temperature, the following assumptions have been made:

1. During the summer months (June-August) the discharge from the Sequoyah diffusers is insulated from losing heat to the atmosphere by an overlying natural surface layer in Chickamauga Reservoir which is at a temperature greater than the mixed heated discharge issuing from the mixing zone of the diffusers. During the remaining months of the year, the heated discharge becomes a surface layer in Chickamauga Reservoir and begins to lose heat immediately as it flows downstream.
2. Complete mixing of the diffuser discharge and the entire riverflow occurs as the flows pass through Chickamauga Dam.

Figures M-7 and M-8 show calculations of the downstream decay of the temperature rise induced by 2-unit operation of the Sequoyah plant for winter and summer conditions. In all cases an initial temperature rise of 5.4°F (3°C) is assumed. The calculations are based on a 1-dimensional temperature equation:

$$\frac{d\ \Delta T}{dx} = - \frac{Kb\ \Delta T}{Q}$$

where T = temperature rise

K = heat loss coefficient

b = surface width of the river

Q = riverflow

x = distance downstream from the plant

2. <u>One-unit operation</u> -

(1) <u>Initial jet mixing</u> - When there is only one unit in operation at full load, the total diffuser discharge, $Q_c$,

will be 1,250 $ft^3/s$ and will occur at a 5 ft/s velocity through all diffuser ports if two diffusers are in use (the anticipated normal operating procedure). The diffuser discharge temperature, $T_c$, will again be 29.5°F above the reservoir temperature, $T_R$.

The steady-state mixed temperature, $T_M$, can be obtained by equation (1), and the mixed temperature rise, $\Delta T_R$, can be obtained by equation (2). Since the discharge is expected to be through two diffusers, the assumed value of P will remain at 0.6. The $\Delta T_R$ values are plotted as a function of $Q_R$ as shown in figure M-2. The minimum reservoir flow rate required is 11,000 $ft^3/s$ for the 5.4°F rise.

(2) Intermediate region - As discussed above, for any given reservoir flow 1-unit operation will result in a lower mixed temperature, $T_M$, than for two units. Thus, the temperature of the mixed layer in the intermediate region will be less for one unit. The reservoir flow necessary to prevent a heated wedge upstream from the submerged dam will be 22,000 $ft^3/s$; 40,000 $ft^3/s$ will prevent any movement of heated water upstream from the diffusers. Otherwise, it is expected that the general thermal regime for 1-unit operation will be similar to that described for two units (see figure M-3 through M-6).

(3) Downstream region - The downstream temperature regime for 1-unit operation is expected to be similar to that described for two units except that any temperature rise induced downstream will be smaller for one unit than for two. When surface heat loss occurs, the temperature decrease downstream will be more rapid for one unit because of the smaller heat addition by the plant. The calculated

downstream decay of the temperature rise induced by 1-unit operation of the Sequoyah plant for winter and summer conditions is shown by figures M-9 and M-10.

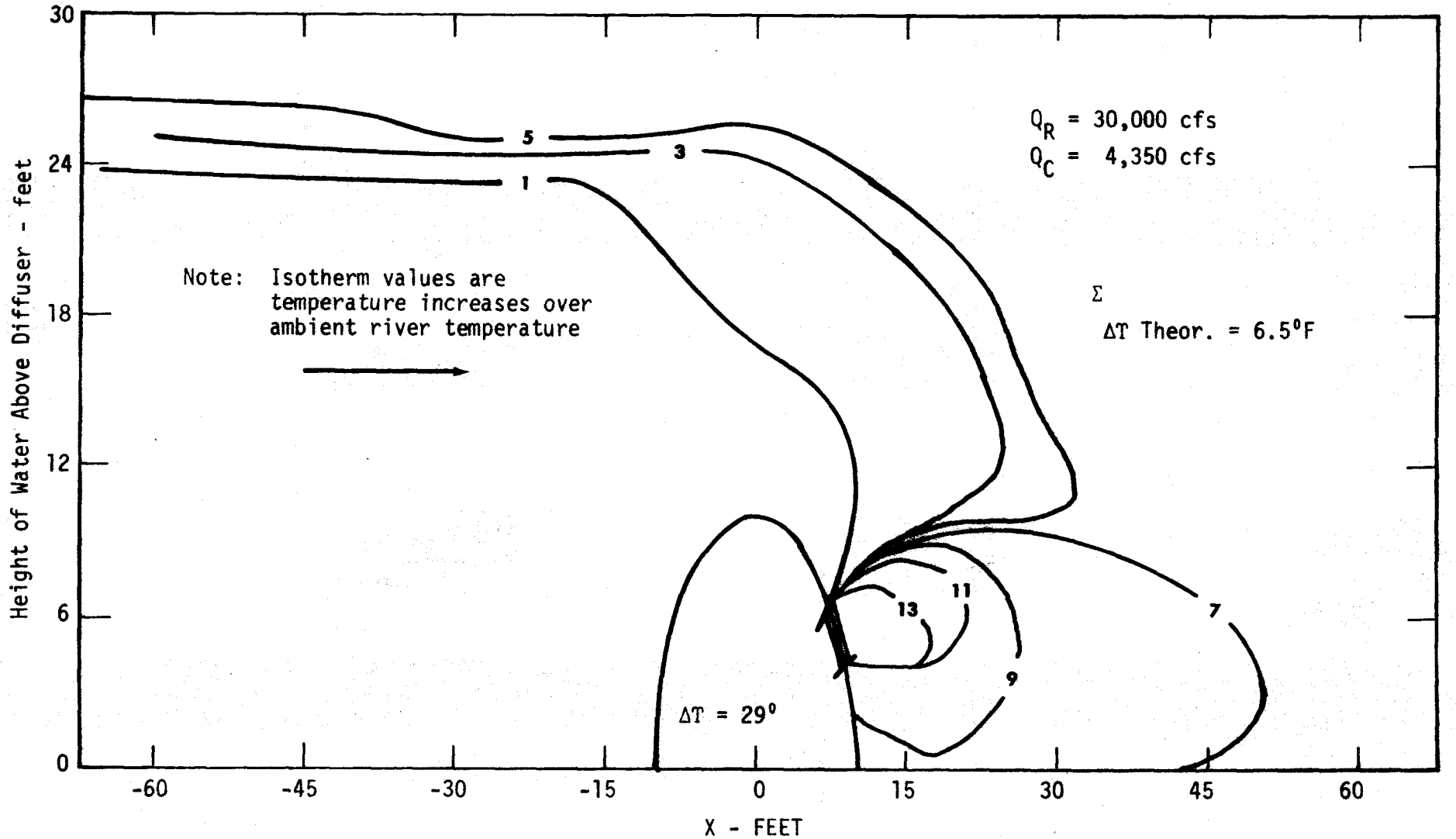



Figure M-1

TEMPERATURE SURVEY IN VICINITY OF JET PORTS

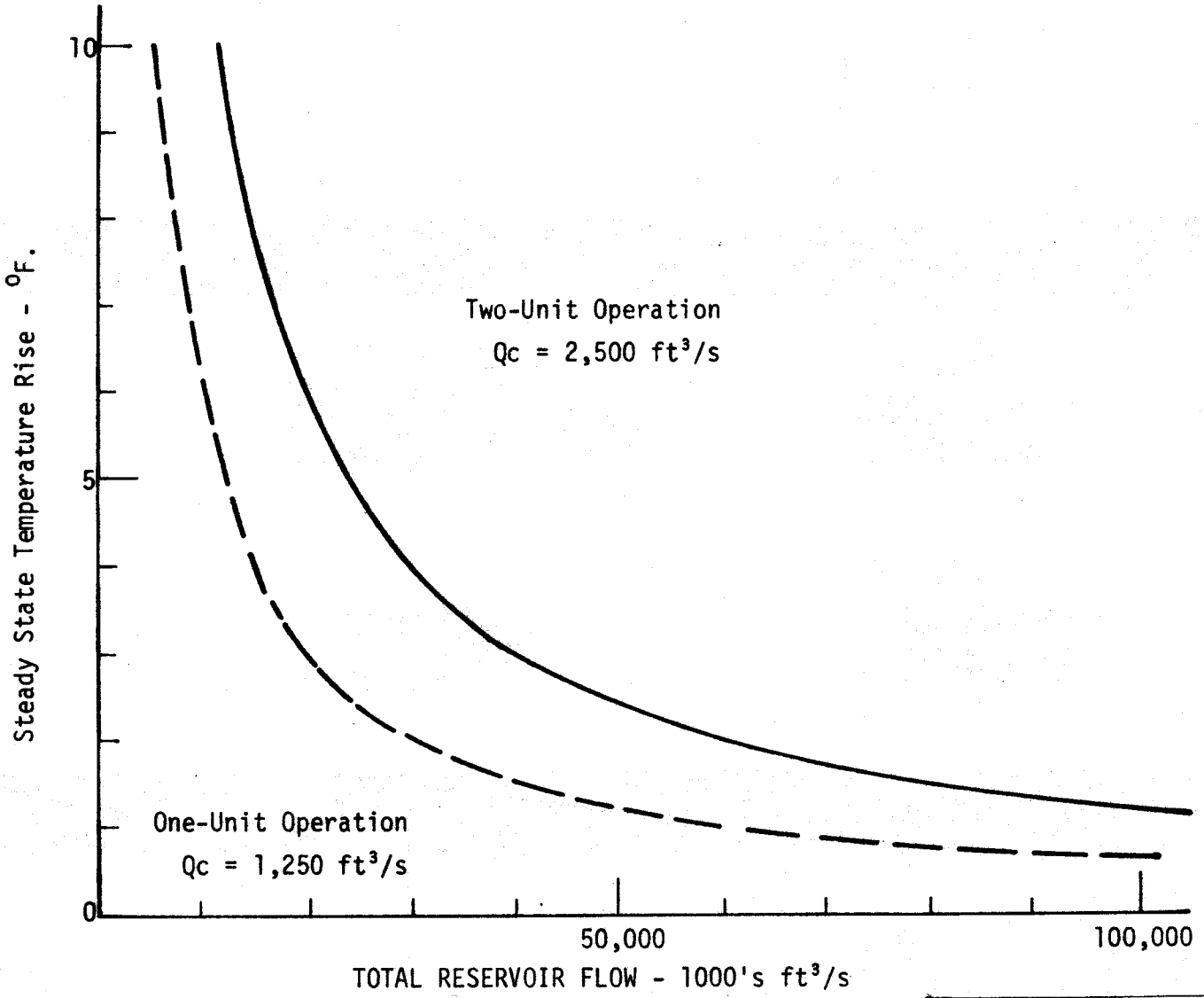



Figure M-2
SEQUOYAH NUCLEAR PLANT
TEMPERATURE-FLOW RELATIONSHIP
ONE- AND TWO-UNIT OPERATION
AT FULL LOAD

Note: These curves are based on the assumption that the discharge mixes with 60 percent of the riverflow.

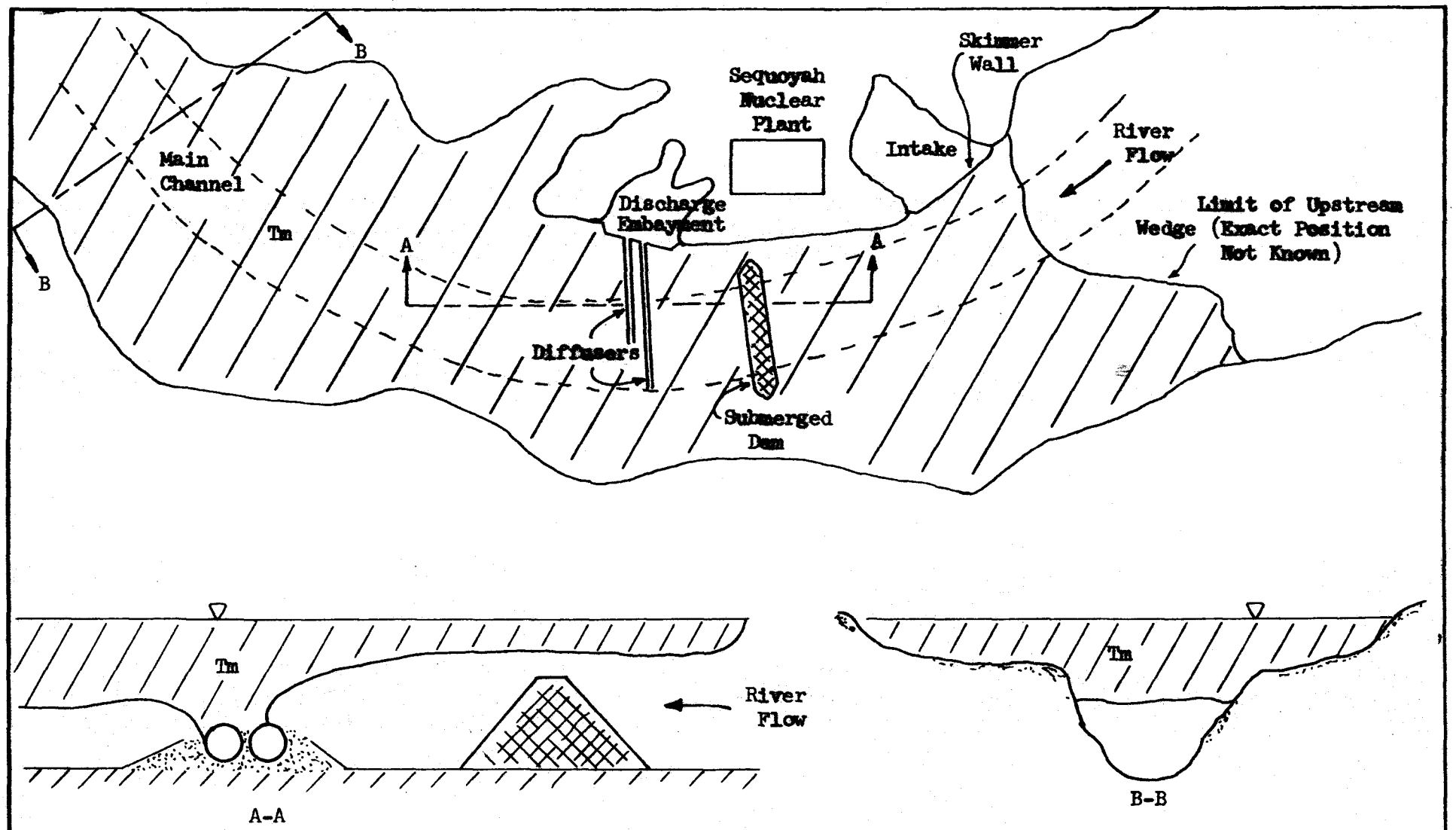



Figure M-3
Temperature Regime For
$Q_r < 30{,}000\ ft^3/s$

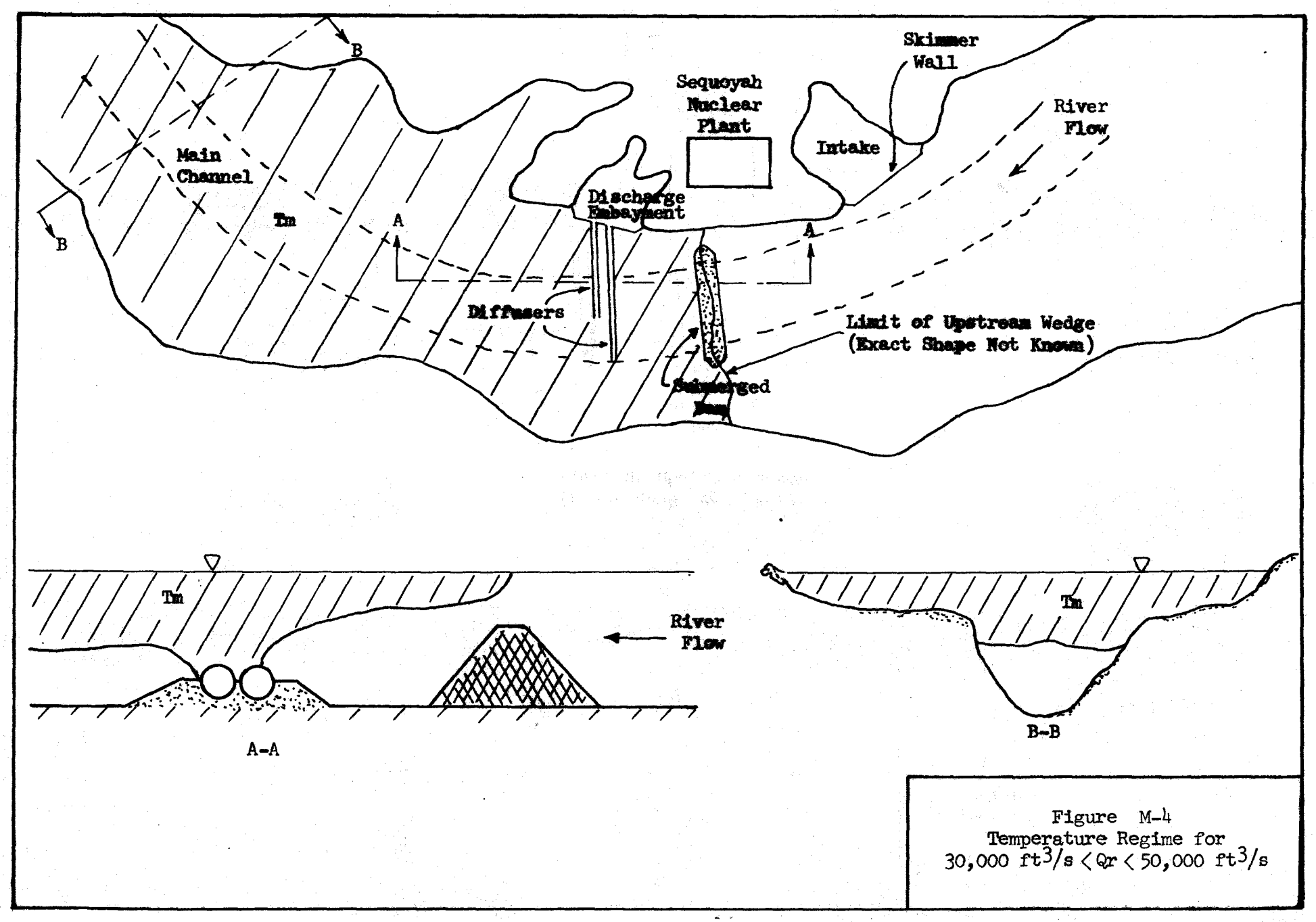



Figure M-4
Temperature Regime for
30,000 $ft^3/s < Qr < 50,000\ ft^3/s$

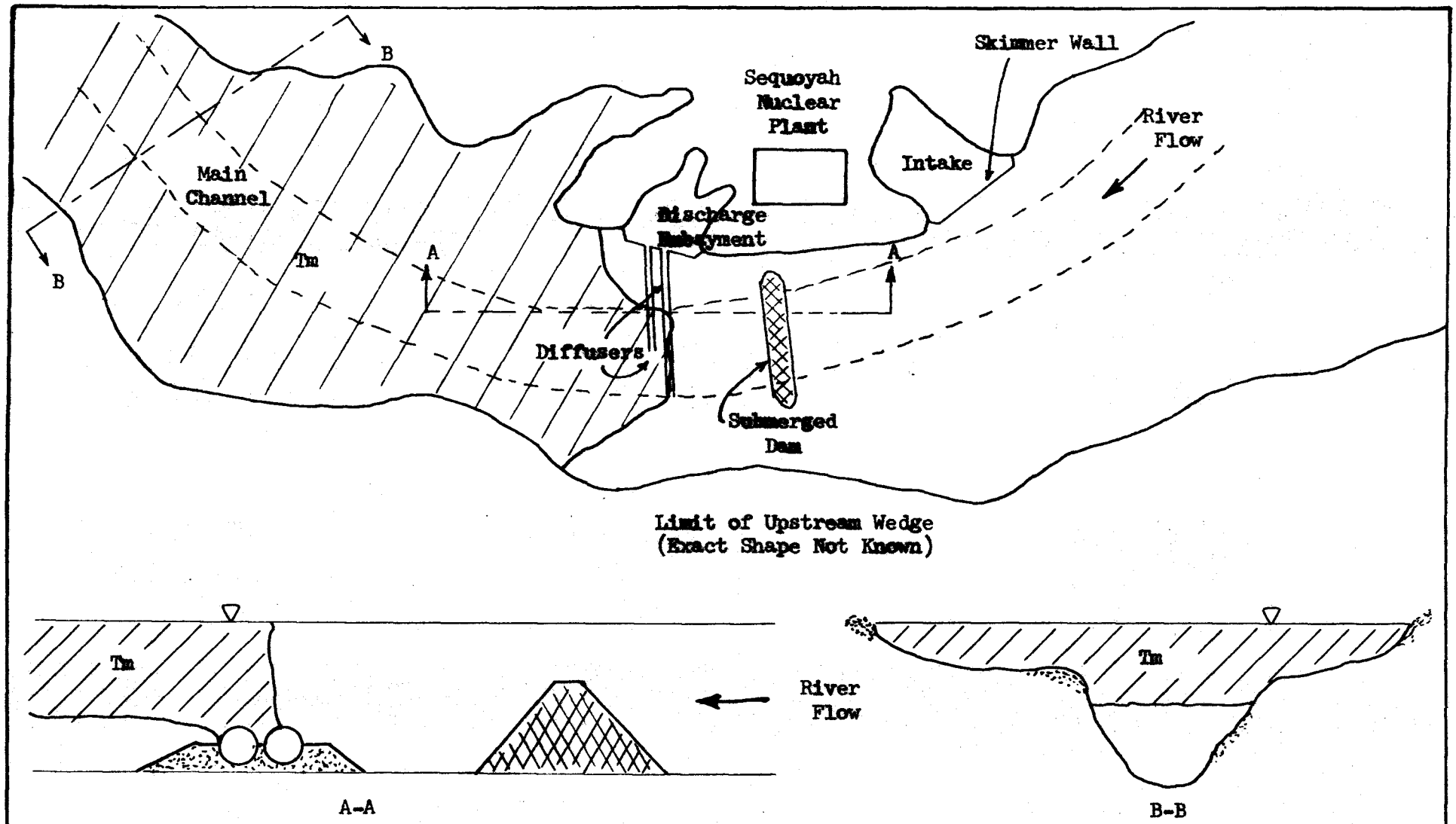



Figure M-5
Temperature Regime for
Qr > 50,000 $ft^3/s$
With Stratification

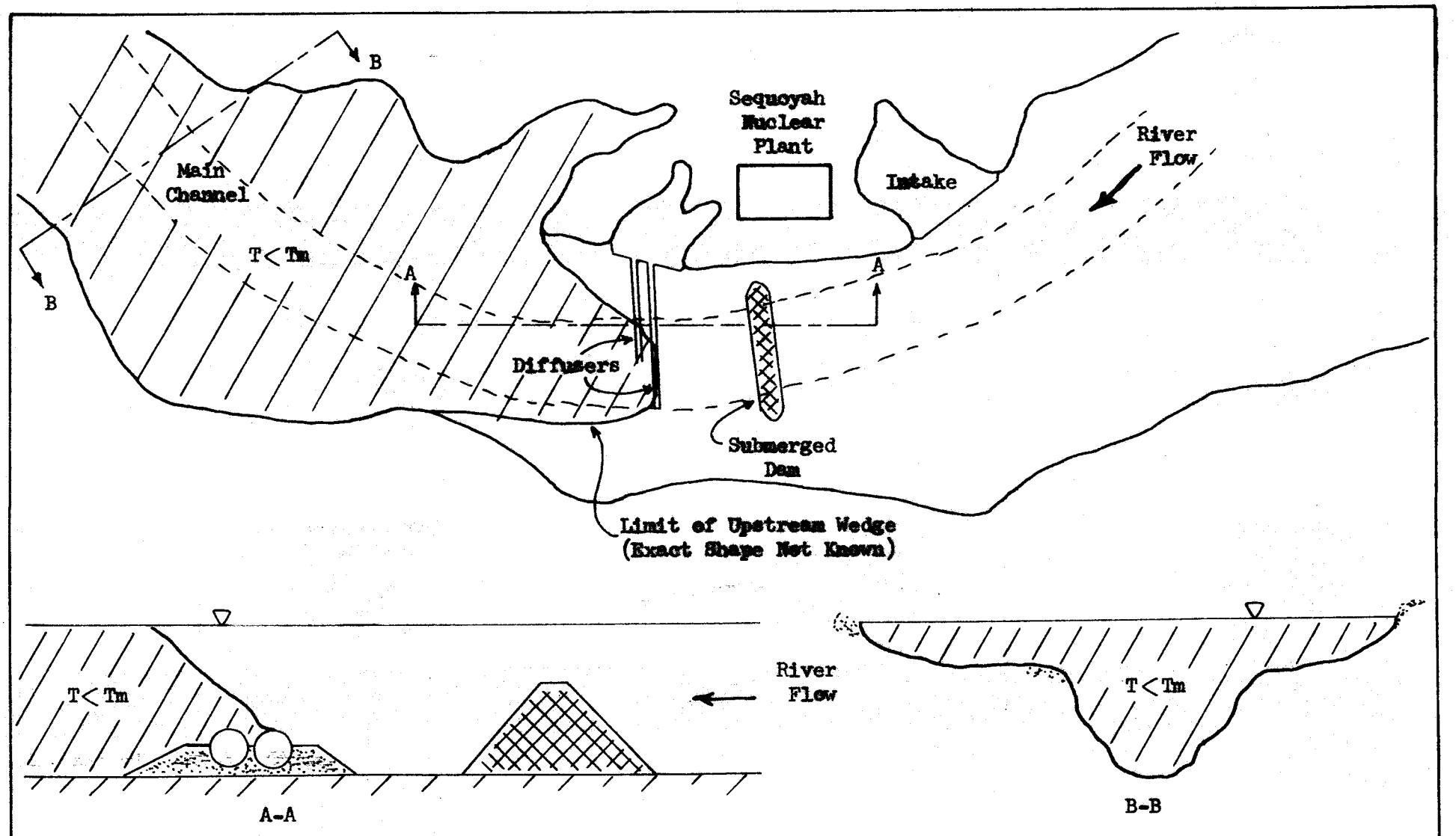
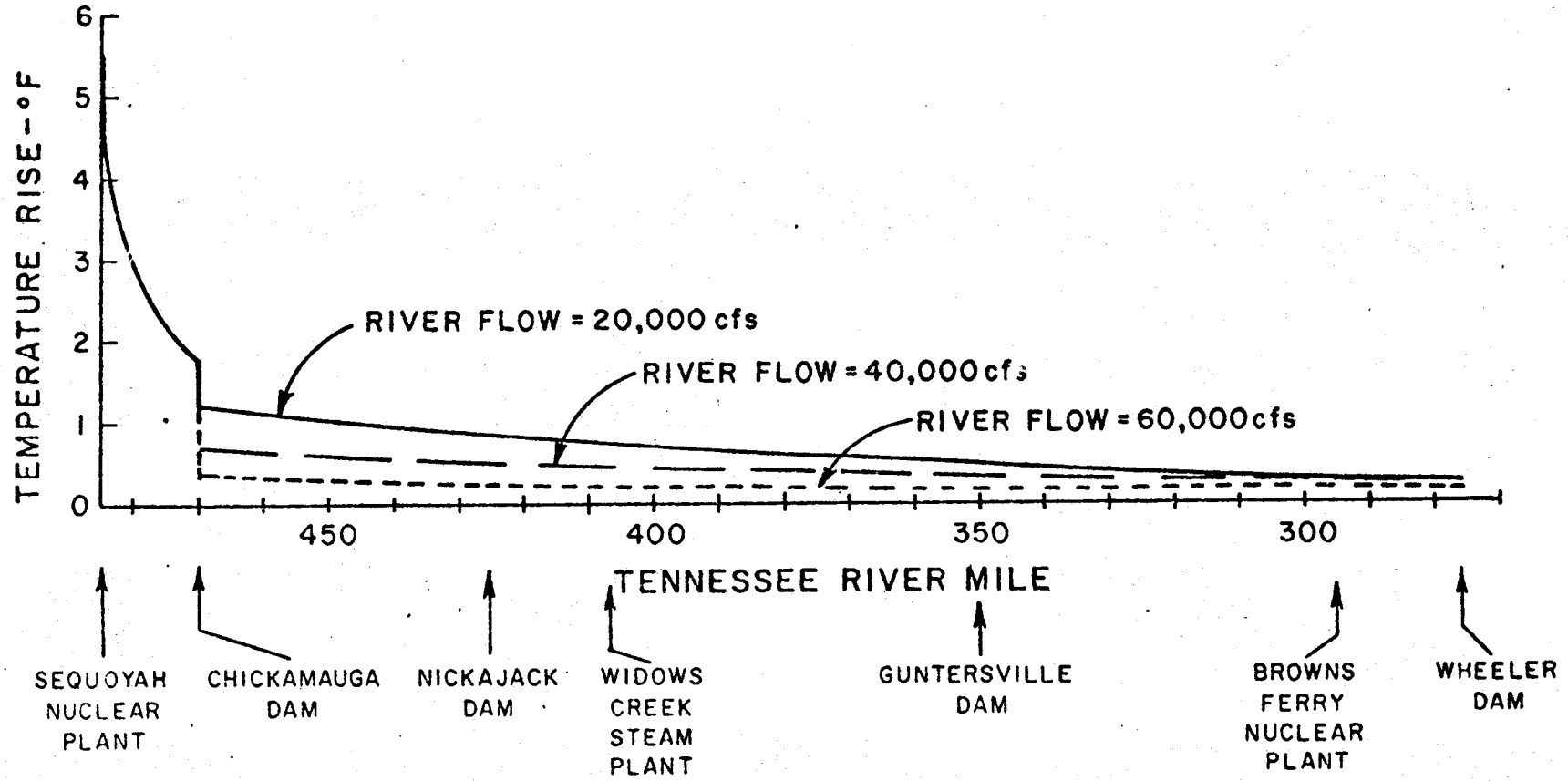


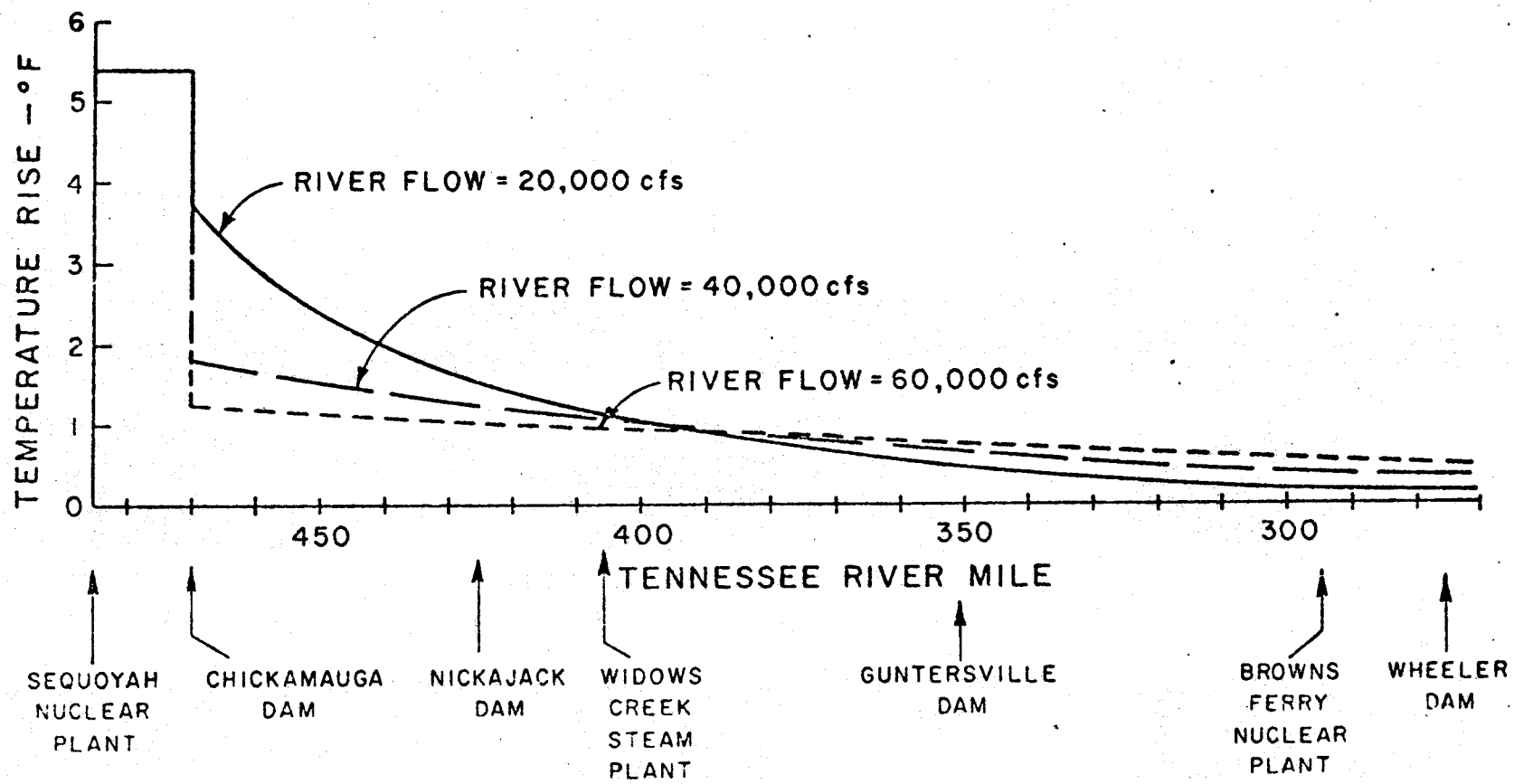

Figure M-6
Temperature Regime For
Qr > 50,000 $ft^3/s$
Without Stratification




NOTE: 1. TEMPERATURE RISE AFTER INITIAL JET MIXING ASSUMED TO BE 5.4°F (3°C)

2. HEAT LOSS COEFFICIENT ASSUMED TO BE 90 BTU/FT$^2$/DAY/°F

Figure M-7
TWO UNITS WINTER CONDITIONS
SEQUOYAH NUCLEAR PLANT




NOTE: 1. TEMPERATURE RISE AFTER INITIAL JET MIXING ASSUMED TO BE 5.4°F (3°C)

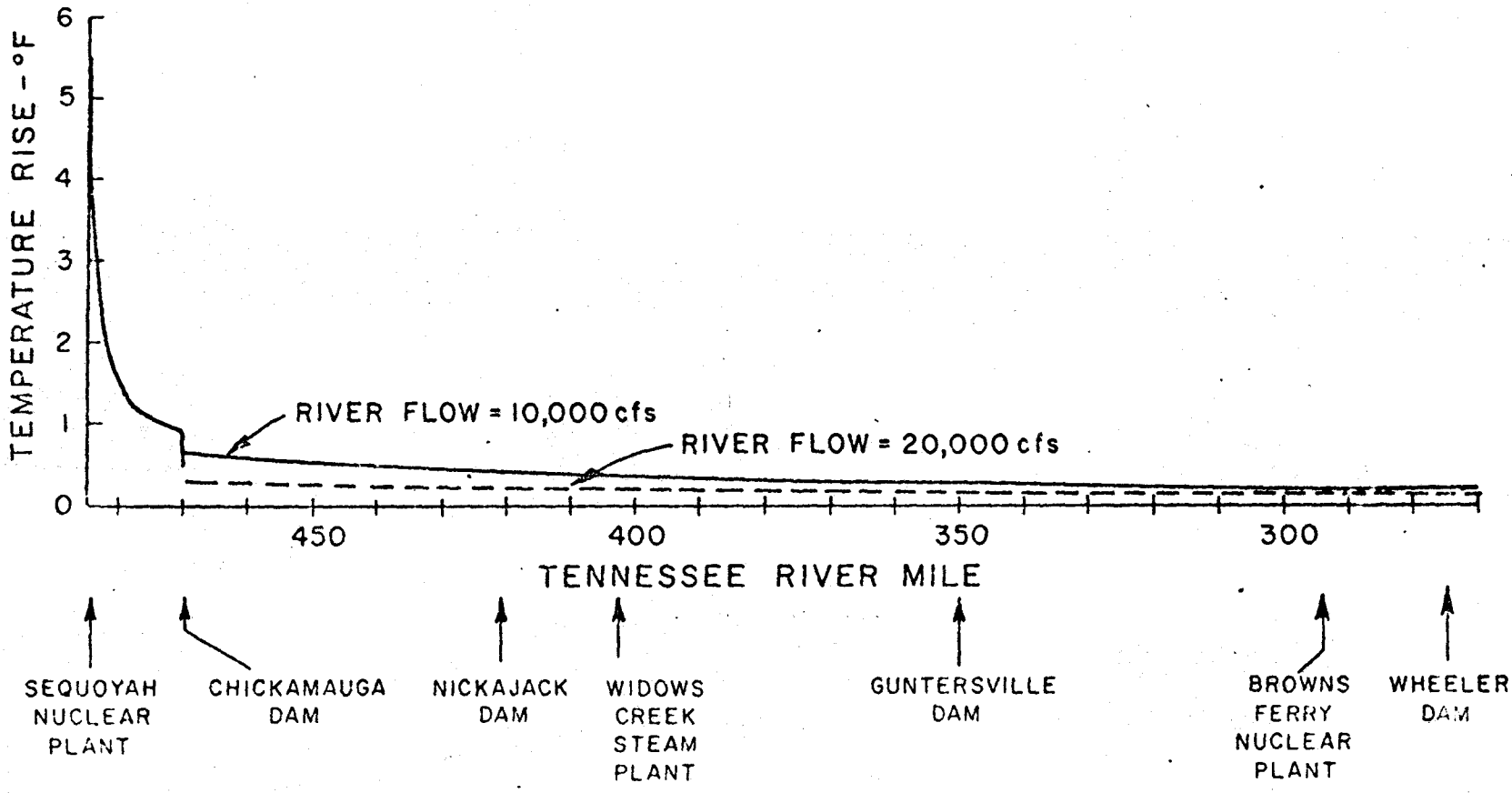
2. HEAT LOSS ASSUMED ZERO BETWEEN SEQUOYAH SITE AND CHICKAMAUGA DAM

3. HEAT LOSS COEFFICIENT ASSUMED EQUAL TO 135 BTU/FT$^2$/DAY/°F

Figure M-8

TWO UNITS SUMMER CONDITIONS

SEQUOYAH NUCLEAR PLANT



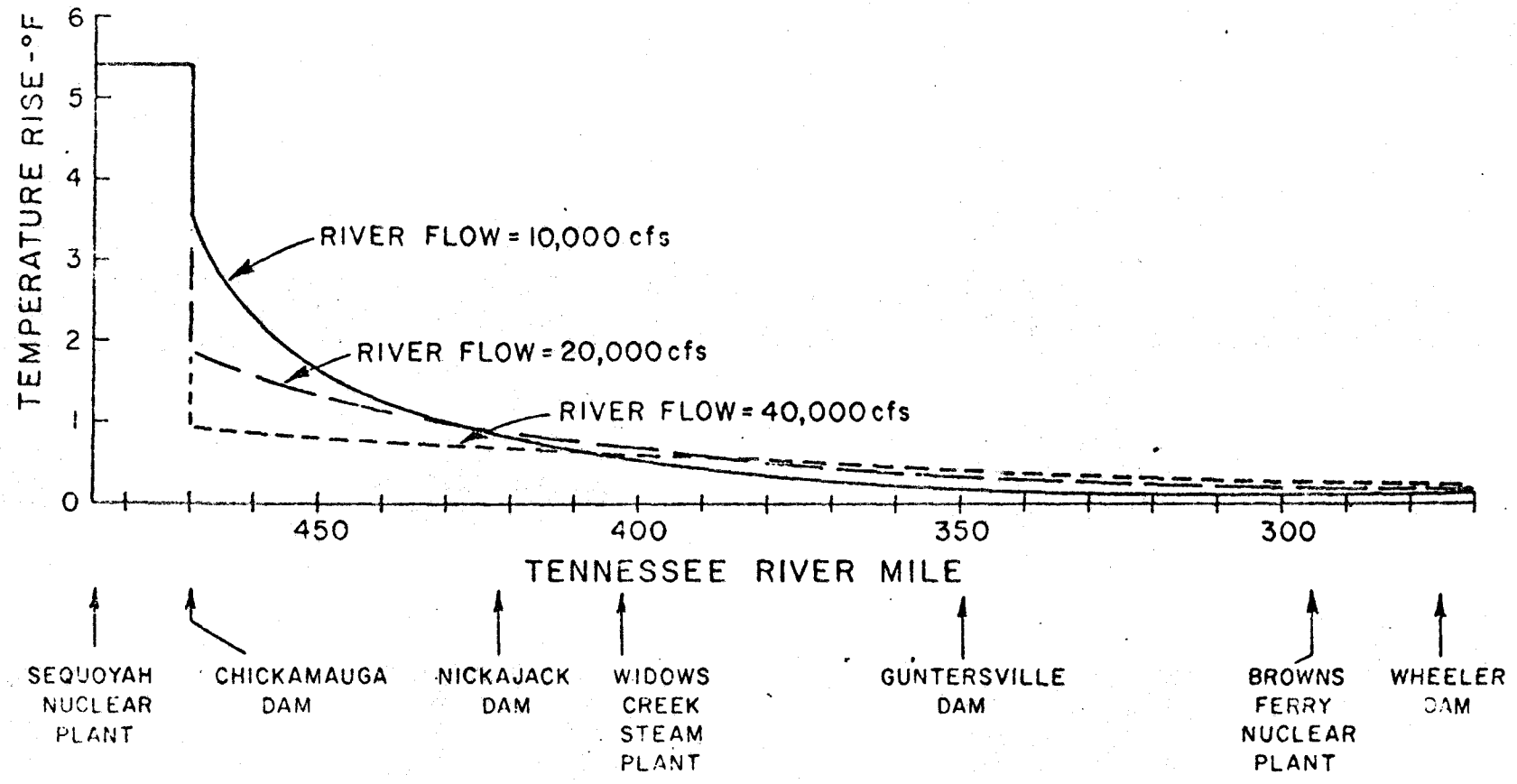

NOTE: 1. TEMPERATURE RISE AFTER INITIAL JET MIXING ASSUMED TO BE 5.4 °F (3° C)

2. HEAT LOSS COEFFICIENT ASSUMED TO BE 90 BTU/FT$^2$/DAY/°F

Figure M-9

ONE UNIT WINTER CONDITIONS

SEQUOYAH NUCLEAR PLANT




NOTE: 1. TEMPERATURE RISE AFTER INITIAL JET MIXING ASSUMED TO BE 5.4 °F (3°C)

2. HEAT LOSS ASSUMED ZERO BETWEEN SEQUOYAH SITE AND CHICKAMAUGA DAM

3. HEAT LOSS COEFFICIENT ASSUMED TO BE 135 BTU/FT$^2$/DAY/°F

Figure M-10

ONE UNIT SUMMER CONDITIONS

SEQUOYAH NUCLEAR PLANT