SECTION 3: AIR RESOURCES

Introduction

This section describes the ambient (surrounding) air quality of the TVA region, discusses TVA emission contributions to ambient air quality, and identifies air quality impacts to human health and welfare. Volume 2, Technical Document 2, Environmental Consequences, describes how changes in TVA emissions could affect regional air quality, human health, environmental resources, and materials.

The primary region of the affected environment is broadly defined as the state of Tennessee, as well as southwestern Kentucky, southwestern Virginia, western North Carolina, and northern Georgia, Alabama, and Mississippi. This area represents the watershed of the Tennessee River and the 201 counties of the greater TVA service area, as shown in *Figure T1-2*. Emissions from outside the Tennessee Valley region contribute to air quality in the Valley. Also, TVA emissions are transported outside the Valley and have some impact on air quality beyond the primary study area. Although the study area experiences a number of air quality problems, overall air quality is good.

Weather and Climate Patterns

Weather and climate patterns of the Tennessee Valley affect several aspects of TVA's energy strategy. Strategy considerations include:

- Ability to meet permitted thermal limits for cooling water discharges and nuclear safety intakes
- Available energy supply from hydroelectric power generation (a function of reservoir water levels)
- Energy demand for heating and air conditioning
- Dispersion of air emissions from TVA facilities and their impact on regional air quality

Much of the year the western extension of the Azores-Bermuda high pressure ridge dominates the TVA region. This circulation results in extended periods of fair weather and, at times, atmospheric stagnation. Its greatest influence is in the summer and fall. Warm, humid air masses dominate in the summer with occasional tropical disturbances from the Gulf or cold fronts from the northwest, north, or northeast. Light winds and considerable sunshine typify summer weather, often with afternoon cumulus clouds and scattered thunderstorms. The Bermuda high is much weaker in winter and spring. Stronger westerly flows dominate the weather pattern, bringing alternately low and high pressure systems. Storms come primarily from the Southwest and the Gulf Coast or from the Plains and the Midwest.

FIGURE T1-8. **Climatic Averages of Eight First-Order National Weather Service Stations in the TVA Region[1]**

	MEAN TEMPERATURE [2]		MEAN DEWPOINT [3]		PRECIPITATION [2]		Percent of	WIND SPEED [3]	
	Celsius	Fahrenheit	Celsius	Fahrenheit	Millimeters	Inches	Possible Sunshine [4]	Meters Per Second	Miles Per Hour
Annual	14.9	58.9	8.9	48.0	1,270	50.01	59	3.3	7.3
Winter	4.5	40.1	-0.8	30.5	334	13.13	47	3.8	8.4
Spring	14.9	58.8	7.9	46.2	360	14.19	61	3.7	8.3
Summer	24.7	76.5	18.8	65.9	301	11.87	64	2.6	5.8
Fall	15.7	60.3	9.6	49.3	275	10.82	61	2.9	6.5
Maximums and Month of Occurrence									
Month	JULY		JULY		MARCH		JUNE	MARCH	
Maximum	25.5	77.9	19.7	67.4	135	5.32	66	4.2	9.3
Minimums and Month of Occurrence									
Month	JANUARY		JANUARY		OCTOBER		JANUARY	AUGUST	
Minimum	3.0	37.4	-1.6	29.1	76	2.99	44	2.5	5.5

1 Cities include Asheville, North Carolina; Tri-Cities Airport, Knoxville Airport, Chattanooga, Nashville and Memphis, Tennessee; Birmingham and Huntsville, Alabama.

2 1961 – 1990 normals.

3 1951-1980 hourly data bases.

4 Excluding Tri-Cities Airport and Huntsville; data periods for the other six varying, but generally including 1951-1980.

FIGURE T1-9. **Annual Average Temperatures and Precipitation Averaged for 1961-1990 Across the TVA Region**

	TEMPERATURE		PRECIPITATION	
	Celsius	Fahrenheit	Millimeters	Inches
Southwest Virginia, Western North Carolina	12.0	53.6	1,268	49.9
Eastern Tennessee	13.7	56.7	1,271	50.0
Central Tennessee & Kentucky	13.7	56.7	1,358	53.5
Western Tennessee & Kentucky	14.5	58.0	1,302	51.3
North Georgia & Northeast Alabama	15.5	59.8	1,431	56.3
Northwest Alabama & North Mississippi	16.3	61.3	1,435	56.5

Two charts paint a picture of climate conditions in the TVA region. *Figure T1-8* gives 30-year average temperatures for the Tennessee Valley. Average summer temperatures are 24.7^{o} C (76.5^{o} F) and winter temperatures, 4.5^{o} C (40.1^{o} F). Heat waves with daily maximum temperatures above 35° C (95° F) occur in some summers, and cold waves with temperatures falling below -15° C (5° F), in some winters. The southern and western parts of the region are warmer than the northern and eastern parts *(Figure T1-9)*. *Figure T1-10* contrasts summer temperatures during 1988 and 1989. These are examples of temperatures for unusually dry and wet years. Summer 1988 was warmer than normal; summer 1989, cooler than normal.

Figure T1-8 indicates that precipitation is abundant and normally well distributed throughout the year, although winter and spring are somewhat wetter than summer and fall. Averages in this table are representative of lower elevations in the Tennessee Valley. Patterns of precipitation across the TVA region are indicated in *Figure T1-9*. *Figure T1-11* indicates regional patterns during the abnormally dry summer of 1988 and wet summer of 1989. The last in a series of five drier than normal years was 1988. The period from 1985 to 1988 marked the four driest consecutive years during the last 100 years in the Tennessee River Basin. This pattern is important in interpreting regional air quality impacts during the decade of the 1980s.

Wind speed and direction significantly determine weather patterns and dispersion of emissions. *Figure T1-8* shows that surface wind speeds are relatively light, with higher winds in winter and spring and lower winds in summer and fall. Wind speeds at higher elevations are generally stronger than averages shown in the table. The most frequent surface wind directions are from the south or southeast and from the north or northeast sectors. *Figure T1-12* gives the surface wind roses (direction patterns) for airports in the TVA region. At higher levels in the atmosphere, winds generally blow from the southwest, west, or northwest, as shown on the same map by the Nashville winds-aloft wind rose for an altitude of 1,500 meters above ground level. A windrose is a diagram with spokes representing the sixteen cardinal directions (i.e., N, NNE, NE, etc.). The frequency with which the measured wind blows from a given direction is illustrated by the distance between the point where a heavy line, or edge of the rose, crosses a spoke and the center of the diagram. In *Figure T1-12*, the wind direction frequencies in all windroses have been normalized (i.e., divided by a common factor) using the frequency of the most frequent wind direction. Thus, the heavy line in each windrose crosses the outer end of the spoke representing the most frequent wind direction (a normalized frequency of one). A direction only half as frequent as the most frequent direction has a normalized frequency of 0.5, and the heavy line crosses the midpoint of the spoke.

Figure T1-8 indicates that solar radiation (shown as percent of possible sunshine) and dewpoint are higher in the summer than other seasons.

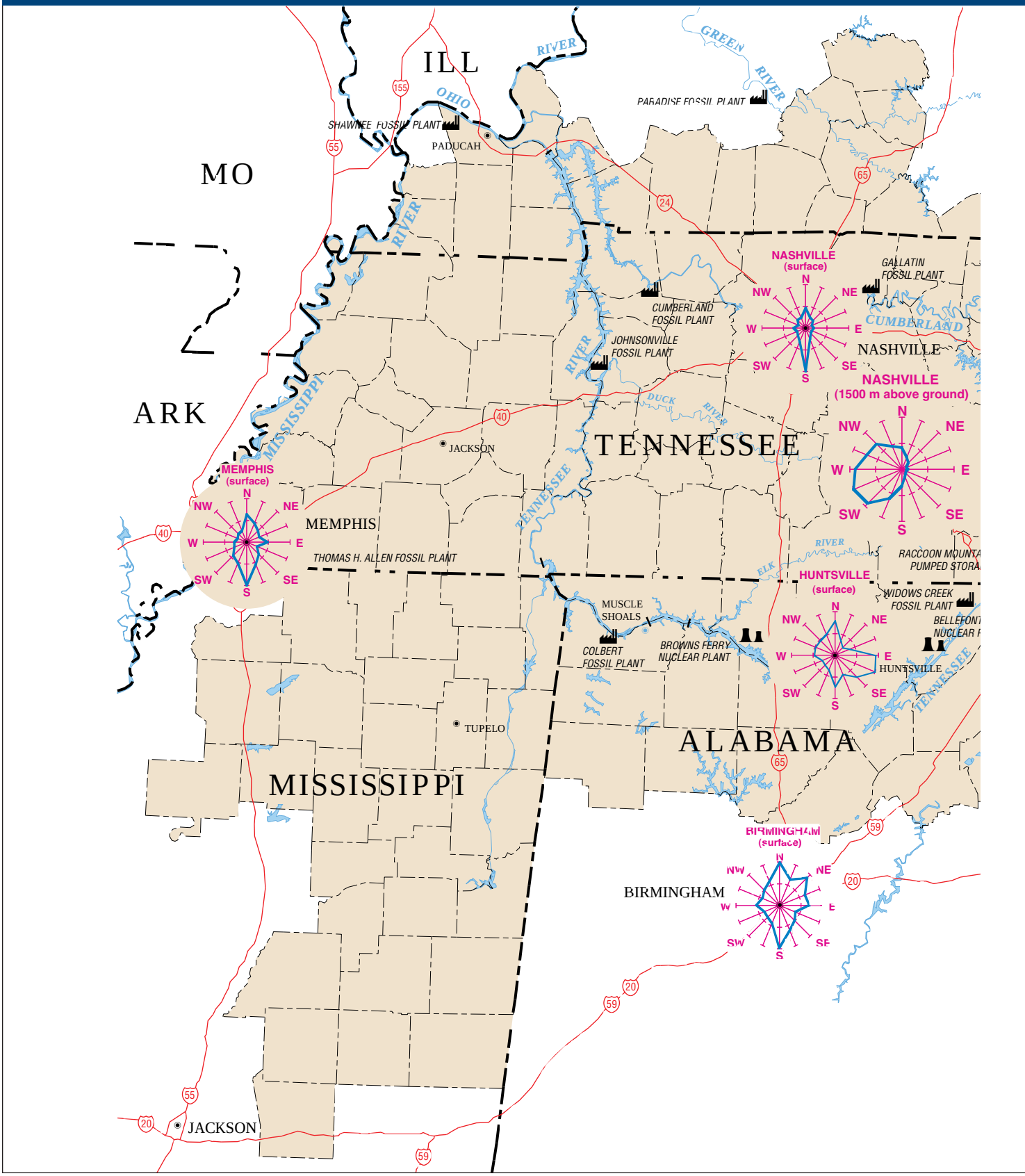
FIGURE T1-10. **Summer Temperature Across the TVA Region for 1988 and 1989**

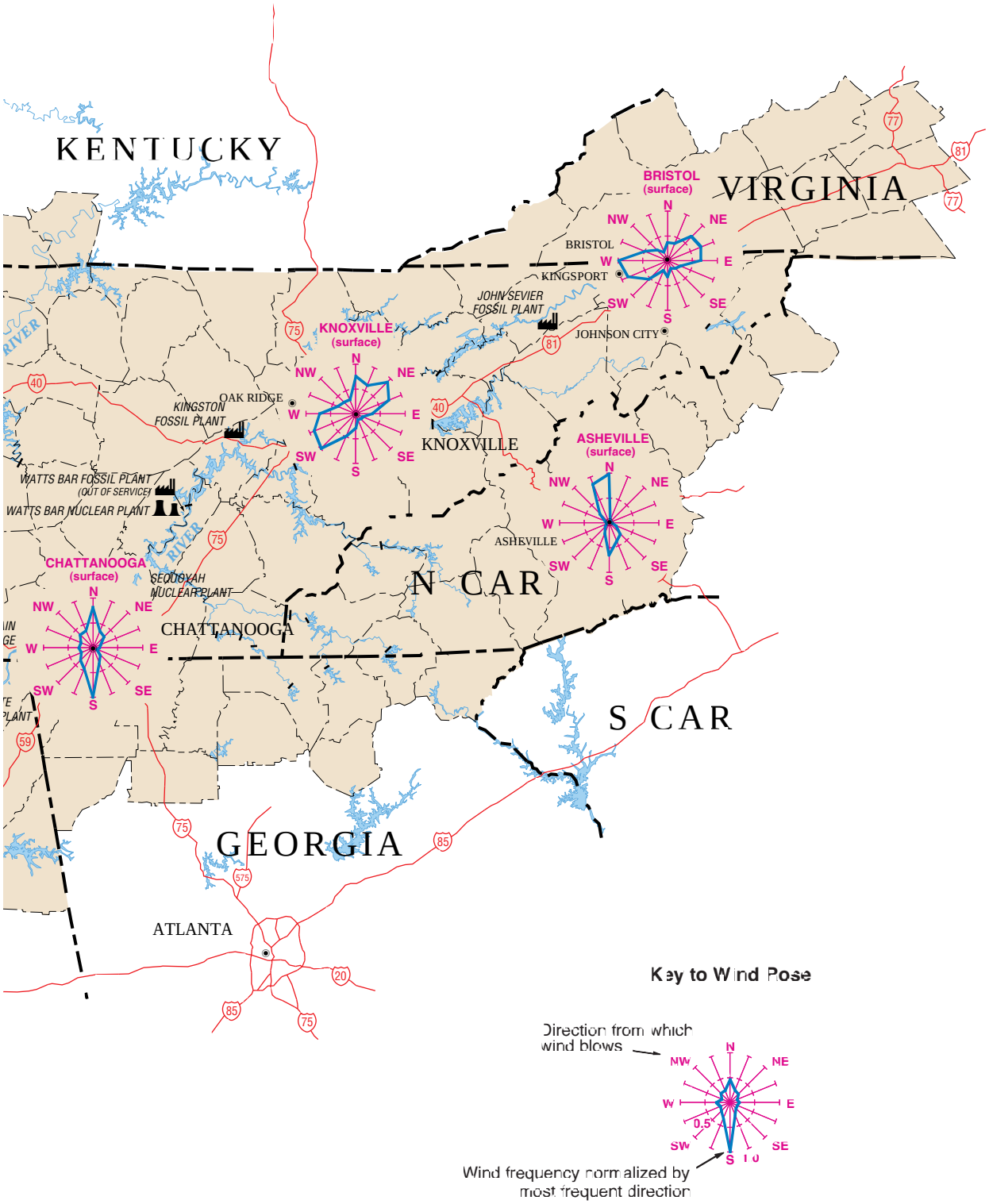
	Summer 1988 Fahrenheit	Summer 1989 Fahrenheit
Southwest Virginia, Western North Carolina	71.1	70.3
Eastern Tennessee	74.8	73.6
Central Tennessee & Kentucky	76.8	74.2
Western Tennessee & Kentucky	78.5	76.3
North Georgia & Northeast Alabama	77.5	75.8
Northwest Alabama & North Mississippi	79.3	77.5

FIGURE T1-11. **Summer Precipitation Across the TVA Region for 1988 and 1989**

	Summer 1988 Inches	Summer 1989 Inches
Southwest Virginia, Western North Carolina	10.5	20.5
Eastern Tennessee	10.0	17.9
Central Tennessee & Kentucky	10.1	18.3
Western Tennessee & Kentucky	9.3	15.9
North Georgia & Northeast Alabama	9.5	21.2
Northwest Alabama & North Mississippi	7.8	21.2

FIGURE T1-12. **Prevailing Wind Direction for Surface Winds at 8 Regional Airports and Winds Aloft at Nashville**





MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

Weather Patterns and Air Pollution

Weather and climate affect pollutant levels within the troposphere, or lowest layer of the atmosphere. Wind, temperature, humidity, atmospheric turbulence, clouds, and precipitation influence air pollution locally and regionally. These different scales interact with various meteorological factors to control air pollution through the transport, transformation, dilution, and removal of air pollutants.

WIND

The atmosphere is composed primarily of oxygen and nitrogen. Their relative abundance remains constant throughout the troposphere in a homogeneous mix. Pollutant concentrations are highly non-homogeneous, as are water vapor and clouds. Consequently, the relative mix of atmospheric constituents varies geographically and from one day to the next. However, the atmosphere does exhibit some persistent trends when examined over a period of a year or longer. Perhaps the most significant trend is a general tendency for westerly air flow across the United States. Individual weather systems, such as large-scale (horizontal dimensions greater than 1,000 kilometers) extra-tropical cyclones (low pressure areas) and anti-cyclones (high pressure areas), may move in varying directions. In addition, local (near surface) winds may tend to blow more frequently with a southerly or northerly component. However, when averaged over all areas for an entire year, the general direction of air flow is from west to east.

Wind direction holds implications for air pollution transport. Pollutant sources tend to have their greatest environmental impact east of their location. Local geography may modify this tendency somewhat, especially for pollutant emissions close to the ground. However, emissions from elevated stacks such as power plants are transported primarily toward the east. This does not mean that, on an individual episode basis, such sources cannot impact areas in other directions. Indeed, instances of episodic exposure are most likely to deviate from the standard west-to-east rule-of-thumb for the source of pollution to the receptor of pollution. Examples of these short-term exposures would involve high hourly ozone concentrations and high acidic deposition rates associated with individual precipitation events.

TEMPERATURE AND WATER VAPOR

Air temperature and water vapor levels are generally greater in summer than in winter, and are generally higher in the southern United States than in the North. This has important implications for some secondary pollutant formation. Chemical reactions in the atmosphere generally depend on the temperature: the higher the temperature, the faster the reaction rate. Some chemical reactions, especially those associated with ozone formation, also depend on water vapor. Higher humidity levels produce faster reactions. In addition, biogenic or natural sources (plants and soils) emit chemical byproducts most strongly when air temperatures are high. Thus, natural nitrogen oxide and isoprene (volatile organic compounds emitted by vegetation) emissions are most likely to be high when atmospheric conditions are also most conducive to photochemical production of ozone.

Atmospheric humidity also strongly influences the size of fine aerosols or particles suspended in the air. As humidity rises, more particles are able to attract greater amounts of water vapor. These particles then scatter light. When this happens, a haze forms that reduces incoming sunlight and obscures visibility. Thus, regional visibility impairment is strongly coupled not only with the proximity of pollution sources producing fine suspended particles, but also with air masses characterized by high moisture content.

ATMOSPHERIC INSTABILITY

Wind speed has a dilution effect on air pollutants, with stronger winds resulting in lower concentrations of pollutants. Atmospheric turbulence, defined as air motion over spatial scales of a few hundreds of meters down to a few centimeters, is even more important in determining how rapidly pollutant emissions are diluted upon entering the atmosphere. Turbulence is produced primarily by wind shear (wind speed and/or direction changes over small distances) and convective instability. The latter is especially important on sunny afternoons when solar heating of the ground produces local "thermals" or masses of heated air which rise and eventually mix with their surroundings. This process leads to a fairly rapid vertical exchange of mass (moisture and pollution), heat energy, and momentum. Thus, the vertical structure of the lower atmosphere, or boundary layer, is controlled by convective processes much of the time. Air pollutants emitted near the ground are immediately (i.e., within a few minutes) diluted vertically whenever strong vertical turbulence occurs. Pollutants from elevated points are often not diluted as rapidly, and may actually avoid much vertical dilution altogether if emitted from a sufficiently tall stack. Thus, pollutants emitted at night, when convective turbulence is uncommon, undergo only slow dilution, enabling plumes of pollutants from some sources to travel long distances intact.

CLOUDS AND PRECIPITATION

Few natural components of the atmosphere are more variable than clouds. They can be associated with the large-scale cyclones, medium-(or meso-) scale thunderstorm complexes, or small-scale afternoon thermals. Clouds form over elevated terrain, when warm and moist air passes over cold water or land,

and whenever conditions are conducive to fog. Except in the case of fog, clouds are produced when moist air rises and cools. This cooling can result in the air temperature falling below the dewpoint, or temperature at which the relative humidity is 100 percent. At this point air becomes slightly oversaturated, and water vapor condenses onto the available surfaces of fine suspended particles. These very small droplets (generally less than 100 micrometers) form clouds.

Clouds are important in air pollution formation for several reasons:

- Clouds scatter solar radiation, sending some of it back into space. This can reduce the amount reaching the lower troposphere, thereby minimizing photochemistry.
- Clouds can reduce the air temperature near the ground, which can also lead to reduced photochemistry.
- Clouds formed as the result of convective instability can puncture the stable layer that usually caps the surface-based mixing layer of the atmosphere. This can lead to the vertical exchange of pollutants between the mixing layer and the "free troposphere" above.

Clouds are especially important in promoting aqueous-phase chemical reactions that produce secondary pollutants, such as sulfate aerosols, from the sulfur dioxide emitted by human-produced sources. After a cloud evaporates, it leaves behind fine acidic particles. These particles eventually fall out of the atmosphere or are scavenged by precipitation. Precipitation cannot exist without clouds. Consequently, precipitating clouds have the following roles:

- Serve as efficient scavengers of some air pollutants
- Can deliver large amounts of acidic pollutants to the ground
- Play an important role in cleansing the atmosphere
- Over elevated terrain, surface vegetation can intercept clouds and scavenge droplets, thereby depositing pollutants directly to the surface as cloud or "occult" deposition.

Precipitation acts in a manner similar to clouds in scavenging airborne particles and gases. Rain can deliver large amounts of acidic materials in a relatively short period of time. Water from rainfall can cover leaf surfaces by depositing pollutants directly on vegetation, runoff into surface waters, or percolate into soils. Percolated water deposits pollutants in the soils or, in some cases, delivers pollutants into groundwater storage. Snowfall can enable pollutants to build up in accumulated snowpack, especially in mountainous terrain, and deliver large pulses of pollutants to surface waters during spring melt.

Air Regulations

CRITERIA AIR POLLUTANTS

The TVA region generally has good air quality. This conclusion is based primarily on widespread attainment of the National Ambient Air Quality Standards. These standards have been established by the U.S. Environmental Protection Agency (EPA) for pollution concentrations in the outdoor air. The Environmental Protection Agency has established standards for six "criteria" pollutants: sulfur dioxide, nitrogen dioxide, carbon monoxide, lead, particulate matter, and ozone. Two levels for air quality were established. Primary standards are set at levels to protect public health; secondary standards are set to protect public welfare (e.g., visibility, aquatic ecosystems, crops and forests, soils, materials). Current National Ambient Air Quality Standards are shown in the table in *Figure T1-13*.

The terms "primary pollutants" and "secondary pollutants" are distinctly different from the terms " primary standards" and "secondary standards." Primary pollutants are emitted directly from the source into the atmosphere; secondary pollutants are formed in the atmosphere from primary emissions. Examples of

FIGURE T1-13. **The National Ambient Air Quality Standards Set Limits for Six Pollutants to Protect Human Health and the Environment**

Pollutant	Averaging Time	STANDARD Primary	STANDARD Secondary
Carbon Monoxide	8-hour	9.0	none
	1-hour	35.0	none
Lead	Quarter Year	1.5	1.5
Nitrogen Dioxide	Annual	0.053	0.053
Ozone	1-hour	0.12	0.12
Particulate Matter Less Than 10 Microns in Size (PM10)	24-hour	150 μg/m^3	150 μg/m^3
	Annual	50 μg/m^3	50 μg/m^3
Sulfur Dioxide	3-hour	none	0.50
	24-hour	0.14	none
	Annual	0.03	none

National standards, other than annual standards, are not to be exceeded more than once per year (except where noted in the figure). Units are parts per million by volume of air except for particulate matter with diameters less than or equal to 10 microns, which is expressed in micrograms per cubic meter. The ozone standard is attained when the expected number of days per calendar year in which the maximum hourly average concentration is above the standard is equal to or less than one day.

primary pollutants are sulfur dioxide, nitrogen dioxide, and particulate matter. Examples of secondary pollutants are ozone, acidic deposition, and fine-particulate matter.

Locales where pollutant concentrations do not exceed the level of the standards are in compliance with the National Ambient Air Quality Standards. They are designated "attainment areas." Where standards are not achieved, they are designated "nonattainment." Where insufficient information exists for designation, areas are unclassified. The maps in *Figures T1-14* through *T1-17* show areas of attainment and nonattainment in the TVA region for sulfur dioxide, ozone, total suspended particulates, and lead. The maps indicate that the National Ambient Air Quality Standards have been attained in most locations in the region.

Specific discussions of criteria pollutants, their sources, ambient trends, and future regulations follow the discussion of air quality concerns related to the Clean Air Act Amendments.

CLEAN AIR ACT AMENDMENTS OF 1977

The Clean Air Act Amendments of 1977 established timetables for periodically reviewing existing standards and adopting new standards if necessary at approximately five-year intervals. Standards are under review by the Environmental Protection Agency in 1995 for sulfur dioxide, particulate matter smaller than 10 microns, and ozone. The Environmental Protection Agency's 1994 review of the nitrogen dioxide standard recommended no changes. No action on the carbon monoxide or lead standards is being considered.

Prevention of Significant Deterioration

The Prevention of Significant Deterioration section of the 1977 Clean Air Act Amendments provides special protection for air quality and air quality-related values in national parks and wilderness areas, designated as Class I areas. Class I areas within the Energy Vision 2020 Study Area include the Great Smoky Mountains National Park, Mammoth Cave National Park, and the Joyce Kilmer/Slickrock, Shining Rock, Linville Gorge, Cohutta, Sipsey, and Mingo National Wilderness Areas. The map in *Figure T1-18* depicts these areas.

Federal land managers (including the National Park Service and U.S. Forest Service) have authority to review state permit requests for new or expanding sources whose air emissions might impact air quality and air quality-related values in a Class I area. Air quality-related values include visibility, flora, fauna, surface waters, ecosystems, and geological, cultural, and historical resources. A specific national goal was defined for visibility to prevent impairment by human-induced air pollutants. Action is required to mitigate any existing visibility impairment in a Class I area and to forestall any future impairment. Legislation requires reasonable progress toward this national goal (U.S. Code of Federal Regulations 1977). If federal land managers determine that emissions from the requesting source could cause an adverse impact to air quality-related values, they can recommend that the states deny or otherwise modify a permit application to restrict emissions or to offset impacts. The burden of proof to demonstrate source-specific impacts falls on the federal land manager.

Since 1990 the National Park Service and the U.S. Forest Service have cited adverse impacts from acid deposition, ozone, and visibility impairment in Class I areas in southern Appalachia. These agencies have recommended emission offsets as a permit condition for several new applicants in Virginia, Tennessee, and North Carolina. In the February 1992 Federal Register (U.S. Code of Federal Regulations 1992), the National Park Service announced a preliminary finding of adverse air quality impacts in the Great Smoky Mountains National Park and recommended that the states disallow any net increase in emissions in a 200-kilometer exclusion zone surrounding the Park. In a 1994 publication "Clearing the Air at Great Smoky Mountains National Park," the National Park Service discusses adverse impacts documented in the Great Smoky Mountains National Park and their actions to protect the park's natural resources (Shaver et al. 1994).

Air quality in southern Appalachia meets all current federal standards. Voluntary and cooperative action is required to effectively mitigate present and prevent future adverse impacts. Contributions from existing industries and communities, as well as new or expanding sources, must be considered. The Southern Appalachian Mountain Initiative, a regional air quality assessment program, includes the eight states surrounding the southern Appalachians, the Environmental Protection Agency, the National Park Service, the U.S. Forest Service, TVA, industries, the community, environmental groups, academia, and the general public. The Southern Appalachian Mountain Initiative intends to evaluate and recommend options to remedy existing and prevent future adverse air quality impacts. The Southern Appalachian Mountain Initiative and other research and assessment programs in which TVA is cooperating are described later in this section.

AIR QUALITY CONCERNS SINCE THE 1977 CLEAN AIR ACT AMENDMENTS

Several air quality concerns have emerged in the past two decades. Acid deposition, regional visibility impairment, hazardous air pollutants, and greenhouse gases are now either regulated or are being considered for regulation. The 1990 Clean Air Act Amendments:

- Strengthened regulatory authority to address areas that were not in attainment with the National Ambient Air Quality Standards
- Legislated emission reductions to reduce acid deposition

- Required reductions of hazardous air pollutants from known industrial sources
- Provided for studies to characterize the extent of utility emissions of hazardous air pollutants
- Set up additional monitoring and reporting requirements for major sources of pollutants

Discussions of acid deposition, visibility impairment, hazardous air pollutants, and greenhouse gases follow discussions of criteria pollutants below.

Air Pollutants

SULFUR DIOXIDE

Health and Welfare Concerns

Depending on the concentration, sulfur dioxide can impact human health. As a respiratory irritant, it was one of the first air pollutants to be regulated because of its association with industrial pollution episodes in the 1940s and 1950s that resulted in a number of deaths in England. *Figure T1-19* shows that ambient exposures of sulfur dioxide in the Tennessee Valley have been reduced by more than 40 percent since 1979. Current ambient levels of sulfur dioxide are now well below the national standards and the thresholds for damage to vegetation and materials. Despite success in reducing ambient concentrations, the Environmental Protection Agency is evaluating whether short-term exposures to elevated sulfur dioxide concentrations may pose a health risk to a small population of exercising, nonmedicated asthmatics. The Agency is considering a new short-term standard that could require further sulfur dioxide emission reductions. Sulfur dioxide is also a precursor for sulfate, a secondary pollutant that contributes to acidic deposition and fine-particulate matter that can impact human health and impair visibility.

Sources of Contribution

At ambient outdoor levels, sulfur dioxide is an odorless, colorless gas. Biological decay, volcanic activity, and other natural sources contribute about half the total global emissions of atmospheric sulfur. In industrialized countries human-produced sources far exceed natural sources. Fossil-fuel power plants, industrial boilers, ore processing facilities, and petroleum refineries are sources of major human-produced emissions. The Environmental Protection Agency's 1990 Interim Emissions Inventory was used to project total sulfur dioxide emissions from point, area, and mobile sources in the general source area for the Tennessee Valley. This is shown on the map in *Figure T1-20*.

FIGURE T1-19. **Concentrations of Sulfur Dioxide in the Energy Vision 2020 Study Area Are 40 Percent Below 1979 Levels**

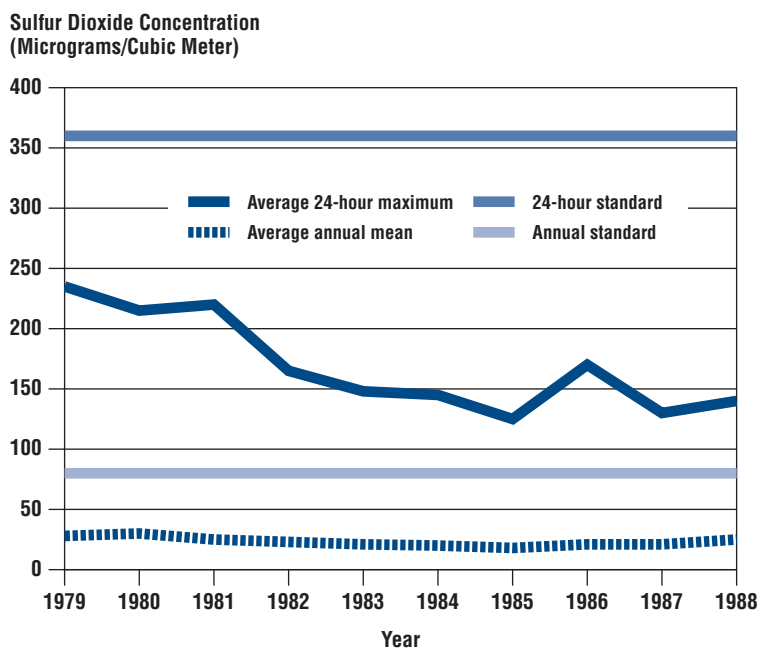
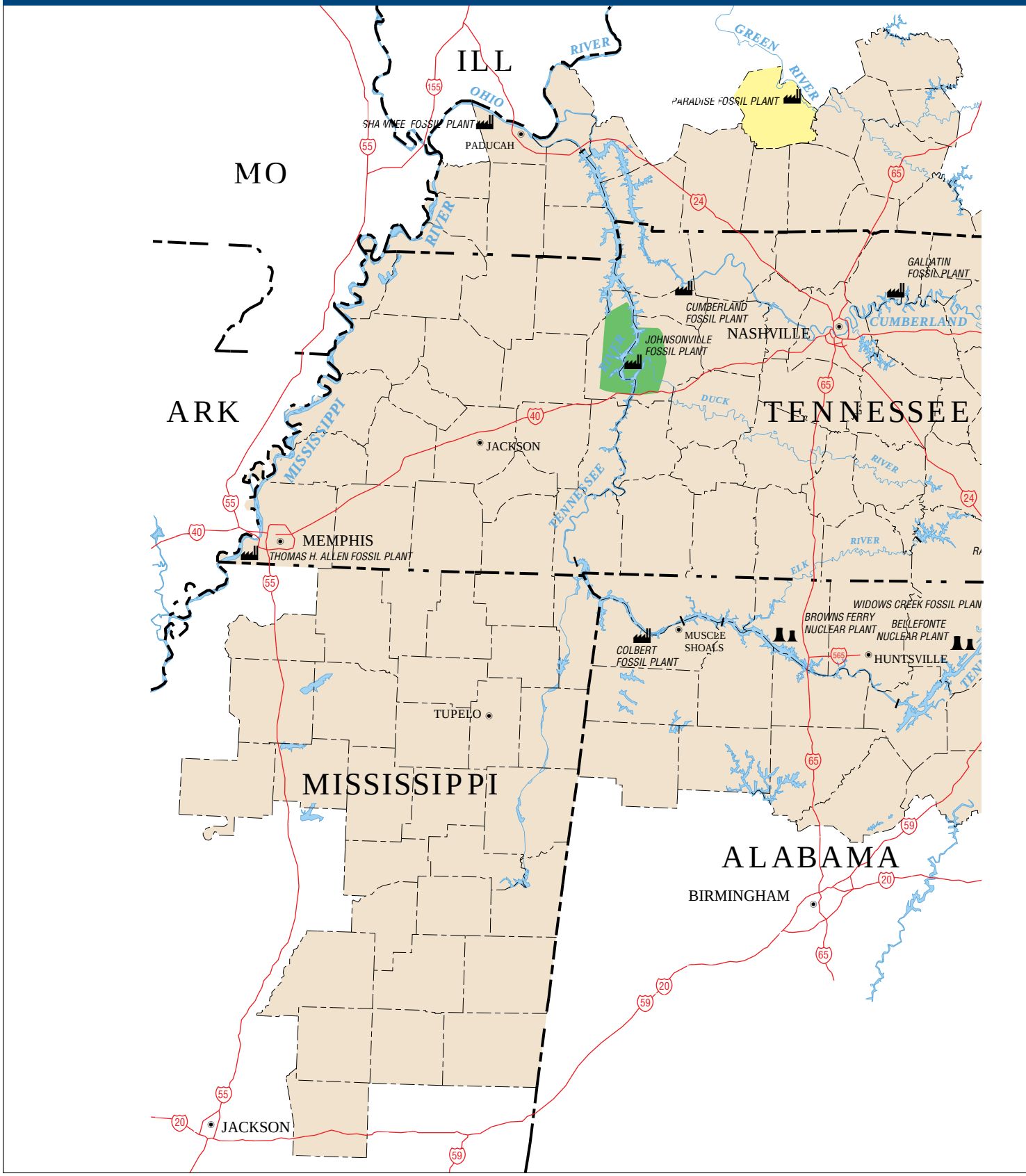


FIGURE T1-14. **Areas in Nonattainment for Sulfur Dioxide Under the National Ambient Air Quality Standards**



LEGEND

Does not meet Secondary Standard
Does not meet Primary or Secondary Standard

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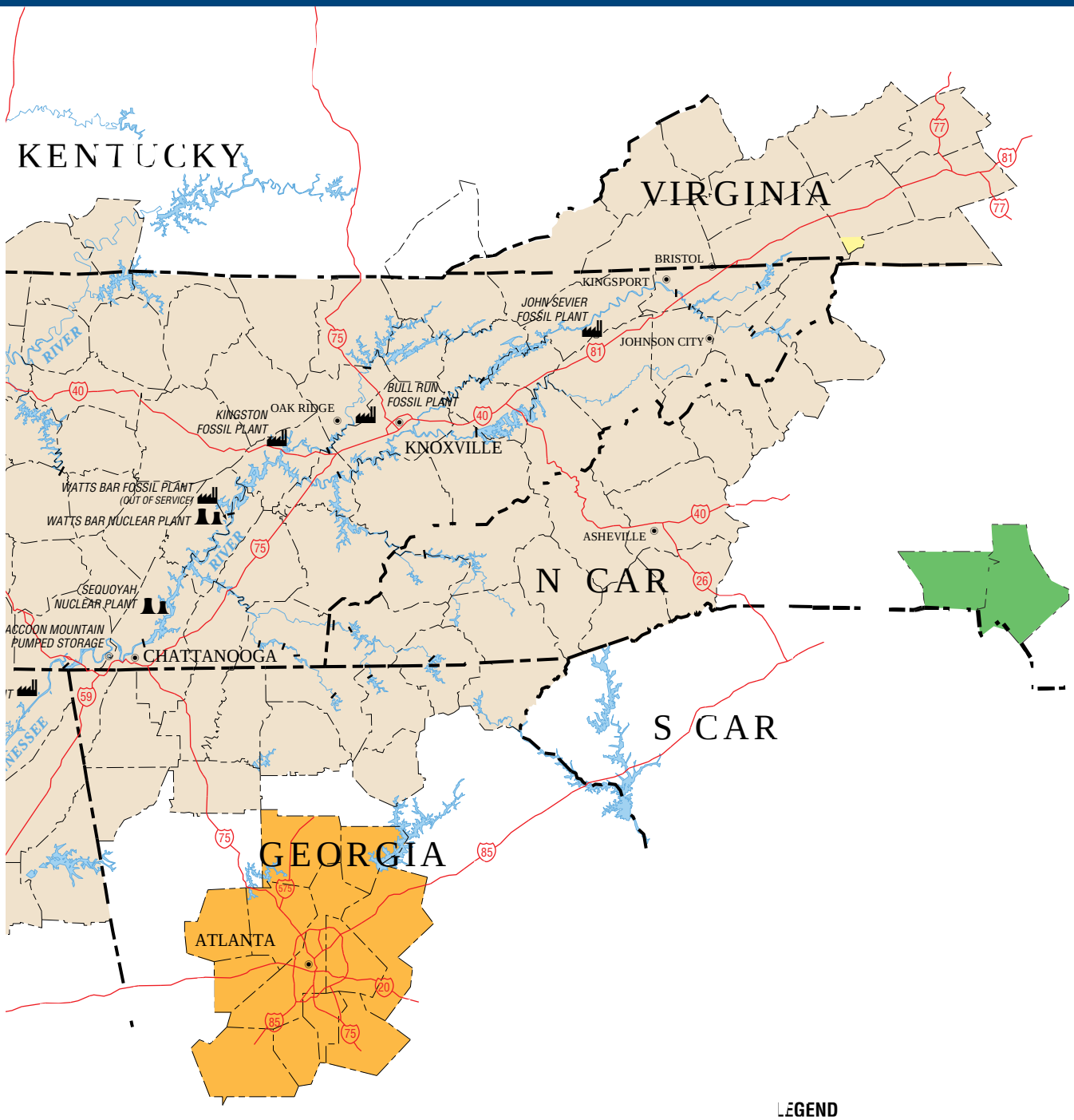
FIGURE T1-15. **Areas in Nonattainment for Ozone Under the National Ambient Air Quality Standards**

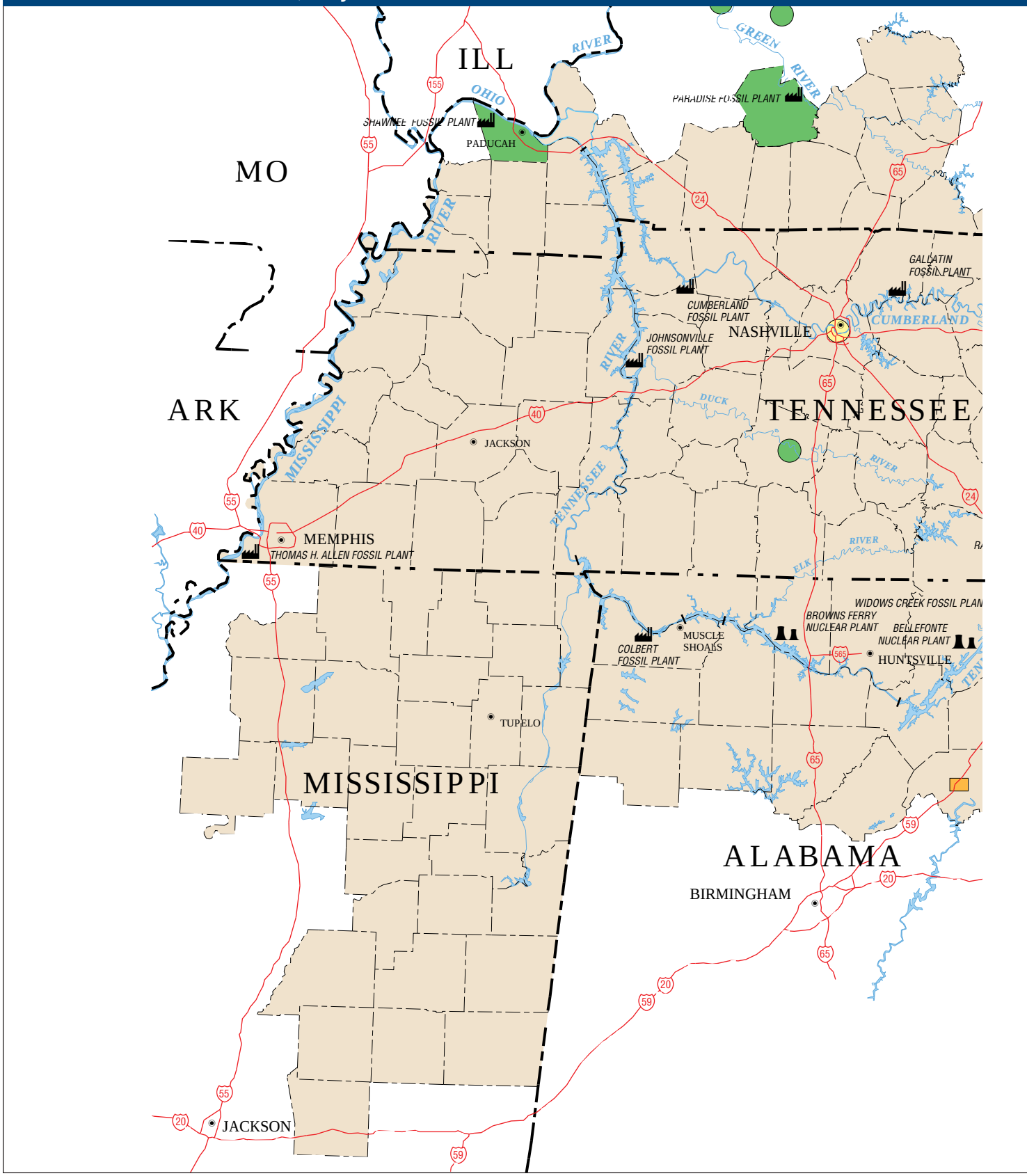


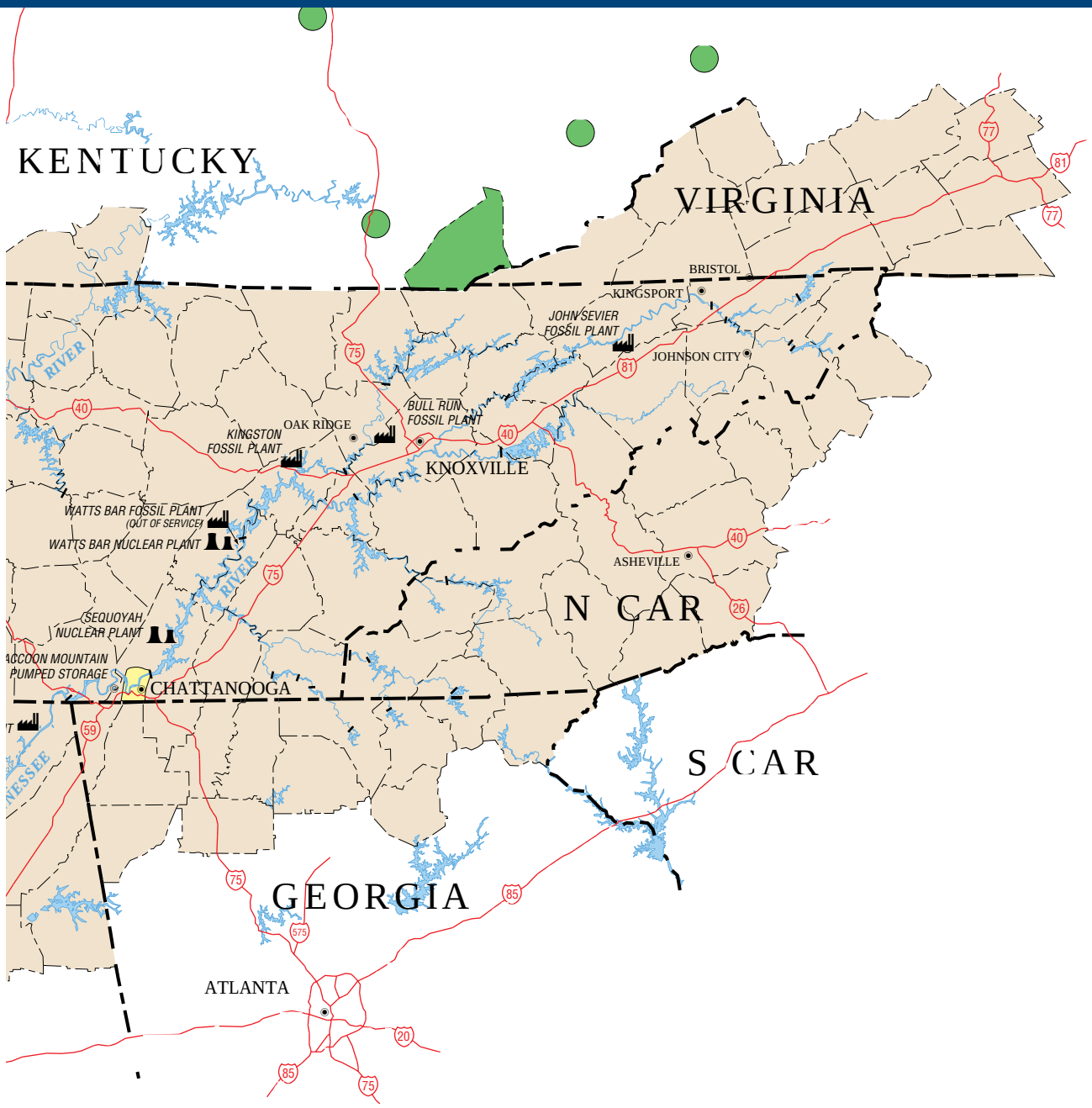
LEGEND

Does not meet Primary Standard (SERIOUS).
Does not meet Primary Standard (MODERATE).
Does not meet Primary Standard (MARGINAL)

MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE T1-16. **Areas in Nonattainment for Total Suspended Particulate Matter Under the National Ambient Air Quality Standards**





LEGEND

Does not meet Primary Standard
Does not meet Secondary Standard
Cannot be Classified

MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE T1-17. **Areas in Nonattainment for Lead Under the National Ambient Air Quality Standards**

LEGEND

Does not meet Primary Standard

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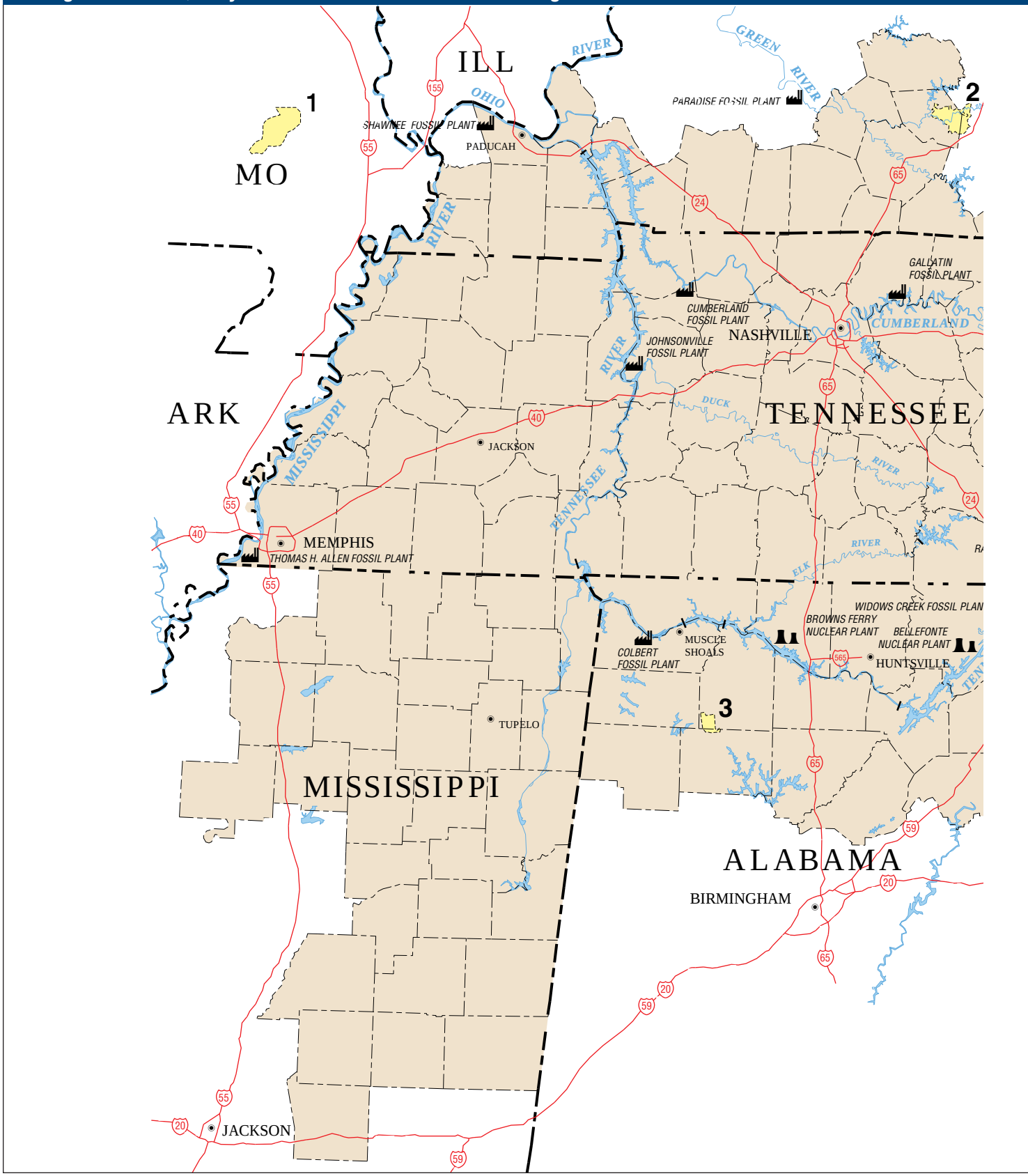
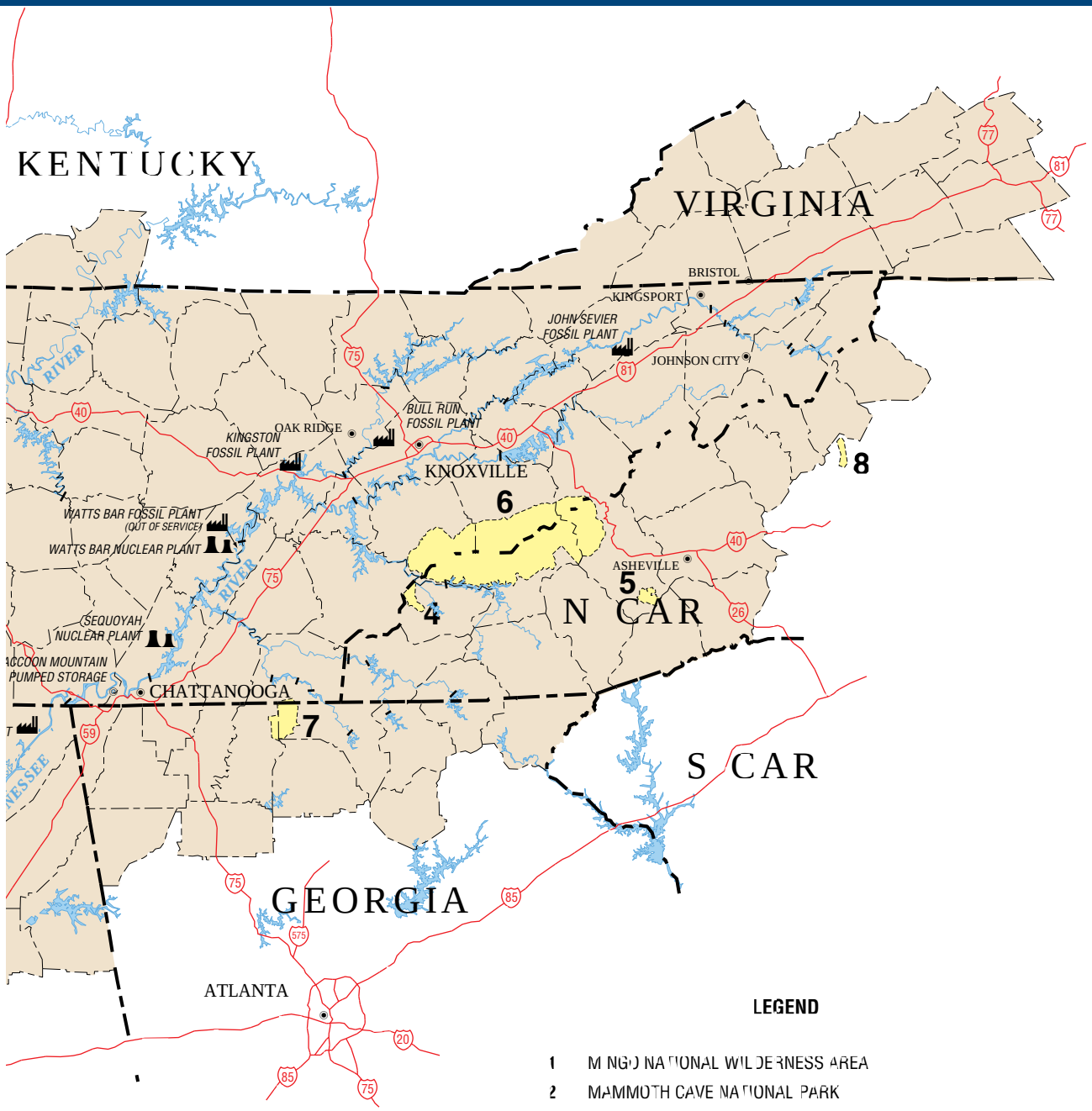
FIGURE T1-18. **National Park and National Wilderness Areas in the Energy Vision 2020 Study Area Designated as Air Quality Class I Areas for the Prevention of Significant Deterioration**



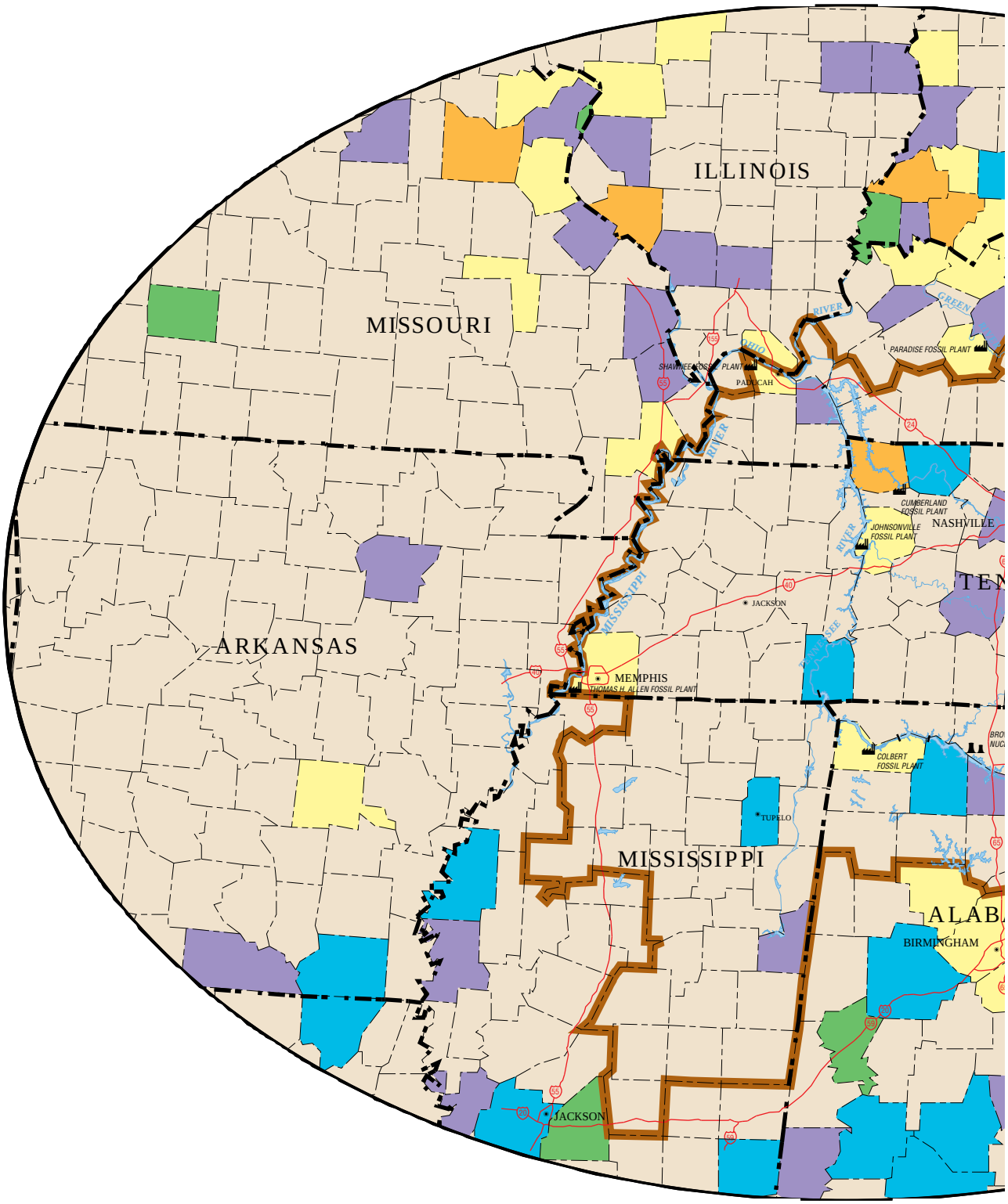


LEGEND

1 MINGO NATIONAL WILDERNESS AREA
2 MAMMOTH CAVE NATIONAL PARK
3 SIPSEY NATIONAL WILDERNESS AREA
4 JOYCE KILMER/SLICKROCK NATIONAL WILDERNESS AREA
5 SHINING ROCK NATIONAL WILDERNESS AREA
6 GREAT SMOKY MOUNTAINS NATIONAL PARK
7 COHUTTA NATIONAL WILDERNESS AREA
8 LINVILLE GORGE NATIONAL WILDERNESS AREA

MAPS PREPARED BY TVA GEOGRAPHIC INFORMATION AND ENGINEERING

FIGURE T1-20. **Total Sulfur Dioxide Emissions from Point, Area, and Mobile Sources in the Greater Source Area for Energy Vision 2020**



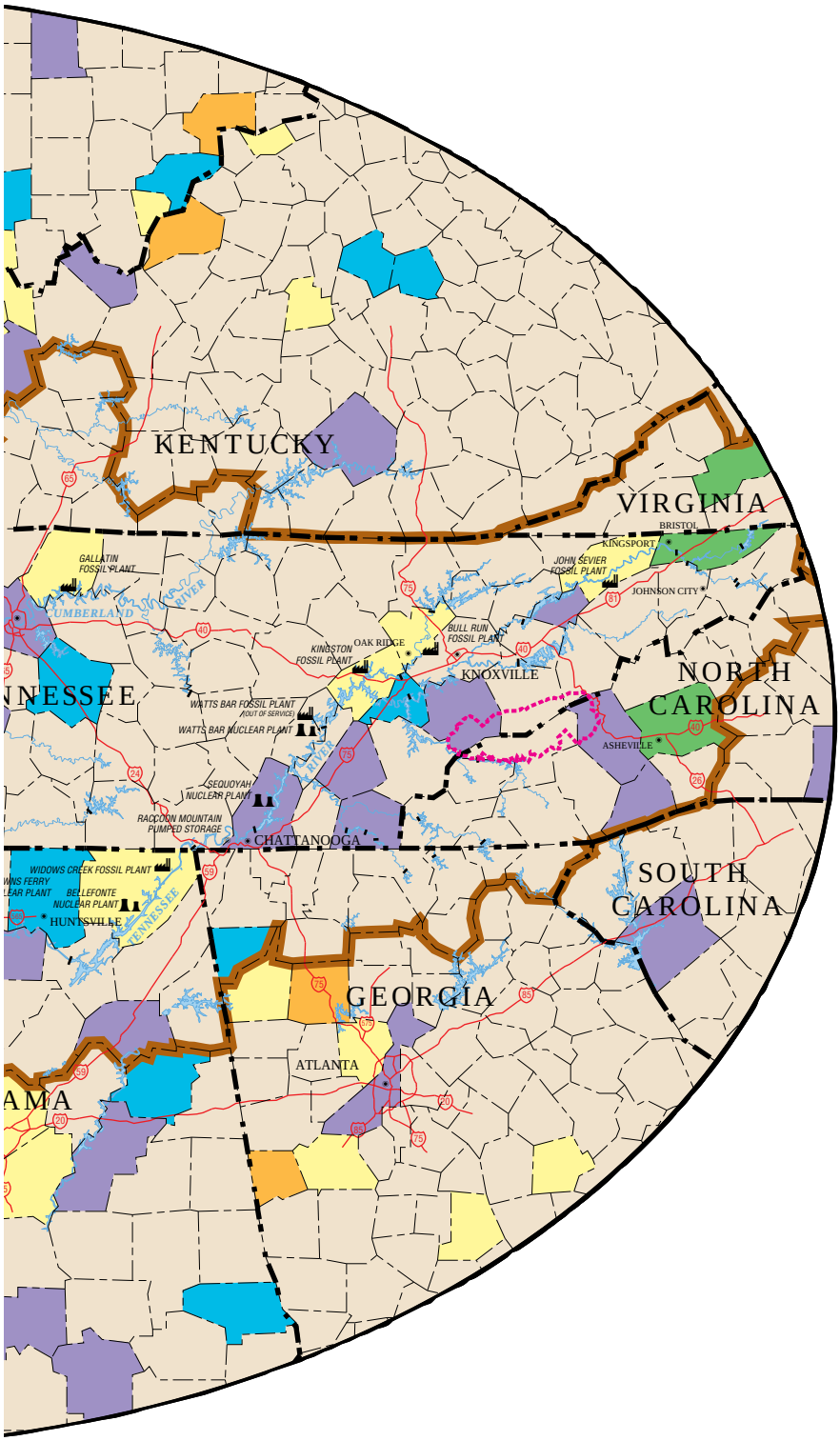
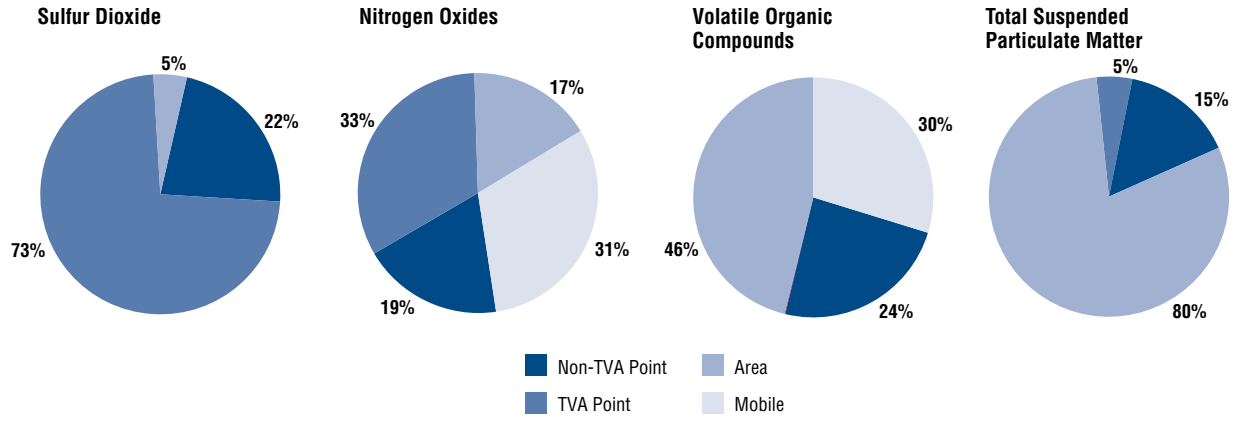

KENTUCKY
VIRGINIA
BRISTOL
KINGSPORT
JOHN SEVIER FOSSIL PLANT
JOHNSON CITY
GALLATIN FOSSIL PLANT
CUMBERLAND RIVER
BULL RUN FOSSIL PLANT
KINGSTON FOSSIL PLANT
OAK RIDGE
KNOXVILLE
NORTH CAROLINA
NNESSEE
WATTS BAR FOSSIL PLANT (OUT OF SERVICE)
WATTS BAR NUCLEAR PLANT
ASHEVILLE
SEQUOYAH NUCLEAR PLANT
RACCOON MOUNTAIN PUMPED STORAGE
CHATTANOOGA
WIDOWS CREEK FOSSIL PLANT
BELLEFONTE NUCLEAR PLANT
HUNTSVILLE
TENNESSEE RIVER
SOUTH CAROLINA
GEORGIA
ATLANTA
AMA

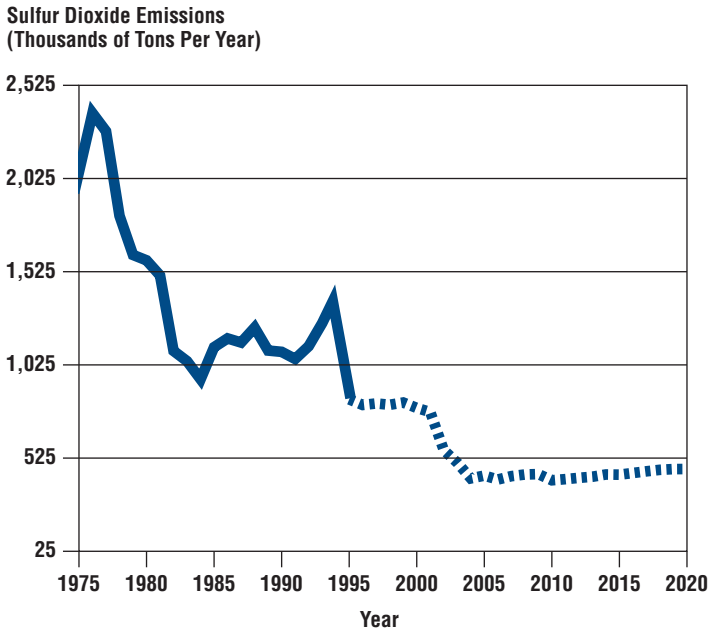
FIGURE T1-21. **Total Emissions of Human-Produced Sulfur Dioxide, Nitrogen Oxides, Volatile Organic Compounds, and Total Suspended Particulate Matter from the 201-County TVA Service Area**



Total emissions of sulfur dioxide, nitrogen oxides, and volatile organic compounds emissions from point, area, and mobile sources from the 201-county TVA service area are derived from Environmental Protection Agency 1990 Interim Inventory. Total suspended particulate matter emissions are derived from the 1985 Interim Inventory.

In the 201 counties of the TVA service area, TVA accounts for three-fourths of the total human-produced sulfur dioxide emissions as shown in *Figure T1-21*. In the greater source area that contributes to sulfur dioxide loadings in the Tennessee Valley, TVA's emissions are roughly one-fourth of total human-produced emissions. TVA sulfur dioxide emissions peaked in 1976 at 2,376,000 tons and have been reduced by two-thirds over the past two decades through installation of emission controls, coal washing, or switching to coals with lower sulfur content, as shown in the graph in *Figure T1-22*. Following full implementation of the 1990 Clean Air Act Amendments, TVA sulfur dioxide emissions are estimated to remain below 500,000 tons per year.

FIGURE T1-22. **Historic and Projected TVA Emissions of Sulfur Dioxide**



TVA emissions of sulfur dioxide have been reduced 60% since the1970s and will be further reduced in compliance with the 1990 Clean Air Act Amendments.

Ambient Trends

Figure T1-23 depicts emissions for each TVA coal-fired plant during fiscal year 1993. In 1995 scrubbers were placed into operation at the Cumberland Plant. This reduced sulfur dioxide emissions by 95 percent. Of the seven Valley counties with sulfur dioxide nonattainment areas in 1979, five have been reclassified as attainment areas, and two are pending reclassification. *(See Figure T1-14.)*

Future Regulations

The current national standard designates 3-hour, 24-hour, and annual average limits for ambient sulfur dioxide exposures. On November 15, 1994, the Environmental Protection Agency proposed to confirm the existing standards as adequate. They also proposed three alterna-

tive standards to address the possible health risk associated with short-term (five-minute) exposures by exercising asthmatic individuals. All three alternatives are likely to rely on increased monitoring in the vicinity of industrial sources to demonstrate compliance and could result in additional sulfur dioxide reductions.

Briefly, the three alternatives are:

- Revise National Ambient Air Quality Standard to include a 5-minute standard of 0.60 parts per million. This concentration could not be exceeded more than once per year.
- Establish a new regulatory program under section 303 (Emergency Powers) of the Clean Air Act. A five-minute standard of 0.60 parts per million would be used and action could be required after the first time concentrations are exceeded.
- Augment enforcement of existing standards through enhanced monitoring and by targeting sources that are most likely to produce high five-minute peak concentrations.

Sulfur dioxide monitoring in the vicinity of TVA coal-fired power plants is routinely collected as hourly rather than 5-minute averages. Extrapolating from this data, five-minute levels might exceed 0.60 parts per million at some TVA coal-fired plants. Implementation of a five-minute standard as described could result in additional sulfur dioxide control requirements at these plants.

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Health and Welfare Concerns

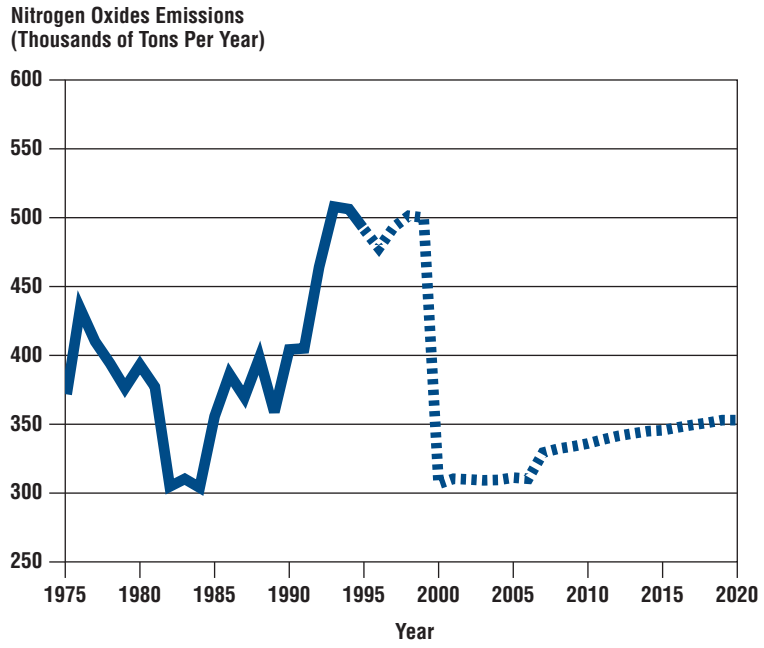
Depending on concentration, nitrogen dioxide can be a respiratory irritant. At current ambient levels in the TVA region, nitrogen dioxide health-related impacts are negligible. Nitrogen dioxide levels in the Tennessee Valley are well below the annual standard. There are no nitrogen dioxide nonattainment areas in the TVA region. Nitrogen oxides emissions do, however, contribute to regional acidic deposition and ozone formation. These are discussed in later sections. A very small amount (less than 5 percent) of the total nitrogen oxides emitted from a coal-fired power plant is nitrogen dioxide. Nitric oxide is the primary nitrogen species emitted and reacts rapidly with ozone in the atmosphere to form nitrogen dioxide.

Sources of Contribution

Natural sources of nitrogen oxides include microbial activity, lightning, and forest fires. Major human-produced sources include motor vehicles, fossil fuel power plants, industrial boilers, nitrogen fertilizers, and agricultural burning. The map in *Figure T1-24* displays total nitrogen oxides emissions from human sources, point (utility and industry), area (urban and small point source), and mobile (vehicle) sources in the greater source area likely to contribute to ozone levels in the Tennessee Valley, based on the Environmental Protection Agency's Interim 1990 emissions inventory. Within the 201 counties of TVA's service area, TVA emissions accounted for 33 percent of total human-produced nitrogen oxides, while mobile sources accounted for 31 percent. The map in *Figure T1-25* shows biogenic or natural emissions of nitrogen oxides estimated for the greater TVA source region. The Environmental Protection Agency's Biogenic Emissions Inventory, System II Model was used. Emissions of nitrogen oxides from fertilized soils on a hot, sunny summer afternoon can contribute up to 20 percent of daily nitrogen oxides emissions from all sources.

The graph in *Figure T1-26* illustrates TVA emissions of nitrogen oxides since 1975. The decline and rise of emissions between 1975 and 1990 is tied to coal use which varies with power system sales and the level of power production by nuclear

FIGURE T1-26. **Historic and Projected TVA Emissions of Nitrogen Oxides**



TVA nitrogen oxides emissions increased during the 1990s as coal-fired generation increased. Emissions will decrease as TVA complies with the 1990 Clean Air Act Amendments.