ADDENDUM TO THE ASSESSMENT OF AIR QUALITY FOR THE STAR LAKE - BISTI REGIONAL COAL ENVIRONMENTAL STATEMENT

RADIAN
CORPORATION

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Presented to:

Bureau of Land Management
Albuquerque District Office
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1.0 INTRODUCTION

This volume presents an addendum to the Regional Assessment of Air Quality, Volume 2 (Radian, 1977) performed for the Star Lake - Bisti Regional Environmental Statement (ES). Information presented in this addendum differs from the original report in several key areas:

1. A different set of coal development cases are examined.

2. Regional impacts are assessed for a new time frame (1980, 1985, and 1990).

3. The impacts of the 1977 Clean Air Act Amendments (Federal Register, Vol. 43, June 17, 1978) are addressed. The new definition of fugitive dust and the examination of its impacts are discussed.

4. Recently developed factors for calculating particulate emissions from mines are incorporated in the analyses.

Although this report is not organized in the format specified in Section 1792 of the BLM Manual, it contains sufficient information to produce a complete air quality regional environmental statement component. The description of the existing climate and air quality found in the Regional Assessment of Air Quality, Volume 2 (Radian, 1977) has not changed and is, therefore, not included in this addendum report.

2.0 PLANNING AND ENVIRONMENTAL CONTROLS

The following rules and regulations would partially mitigate impacts on air quality resulting from proposed mines, railroads, and power plant units in the Star Lake-Bisti study region. Mitigating effects of specific rules and regulations are summarized in the following sections.

2.1 Mines

Emissions of fugitive dust from mines are controlled by rules and regulations limiting the quantity of their emissions and limiting their impact on ambient air quality. These regulations are listed in Table 2-1.

Air Quality Standards

The proposed mines must not cause the National Ambient Air Quality Standards (Federal Register, Vol. 36, November 23, 1971), New Mexico Ambient Air Quality Standards and Regulations) or the Regulations for Prevention of Significant Deterioration (Federal Register, Vol. 43, June 19, 1978) to be violated. The federal and state air quality standards and the PSD increments are presented and discussed in Chapter 2 of the Regional Assessment of Air Quality, Volume 2 (Radian, 1977).

Air Quality Operating and Emissions Restrictions

The proposed actions would be required to obtain permits from the U. S. EPA based on PSD regulations (Federal Register, Vol. 43, No. 118, June 19, 1978). Under the PSD regulations, the proposed coal-related actions would be subject to a two-tiered analysis to determine the impact of TSP emissions on air quality. First, the proposed actions would be required to employ best available control technology (BACT) and best management practices for the mitigation of TSP emissions. Under the recently promulgated PSD regulations, certain fugitive dust emissions controlled at the BACT level would be excluded from the more detailed second-tier analysis. These exempt

Table 2-1

SUMMARY OF IMPORTANT AIR QUALITY RULES AND REGULATIONS

RELATED TO MINING OPERATIONS

	Rules and Regulations	Authority	Applicability
1.	New Mexico Air Quality Standards and Regulations (201, Ambient Air Quality Standards and Regulations as Amended 4/19/74)	New Mexico Air Quality Control Act, CHP 277, Laws of 1967	Federal, State anf fee coal
2.	New Mexico Air Quality Standards and Regulations (672, Coal Mining and Preparation Plants - Particulate Matter)	New Mexico Air Quality Control Act, CHP 277, Laws of 1967	Federal, State and fee coal
3.	40 CFR 52 (Federal Register, Vol. 43, No. 118, June 19, 1978)	1977 Clean Air Act Amendments to Prevent Significant Deterioration	Federal, State and fee coal
4.	30 CFR 700 (Federal Register, Vol. 42, No. 239, December 13, 1977)	Surface Mining Reclamation and Enforcement Act, Public Law 95-87	Federal, State and fee coal
5.	30 CFR 211 (Federal Register, Vol. 41, May 17, 1976)	Federal Coal Mine Health and Safety Act of 1969 (83 Stat 742; 30 USC 801)	Federal
6.	40 CFR 50 (Federal Register, Vol. 36, November 23, 1971)	Clean Air Act of 1970 (Public Law 91-604, 84	Federal, State and fee coal

fugitive dust emissions would be those generated by handling and transport of soils uncontaminated by industrial activity. Such sources would include top-soil and overburden removal, transport, dumping, loading, and storage. In addition, road dust generated by haul road traffic would be exempt from the second tier air quality impact analysis. Fugutive dust generated by mining, handling, and transportation of coal would, however, be included in the analysis.

Applicants for each of the proposed actions would be subject to the second-tier air quality impact analysis (including increments, air quality standards, soils, vegetation, visibility, and monitoring) only if controlled or allowable particulate emissions exceed 50 tons per year.

Although EPA Region VI does not identify specific BACT and best management practices to mitigate fugitive dust from coal mines, a list of possible practices and controls is given in Table 2-2. When obtaining a PSD permit from EPA, the applicant must select practices and controls which are most suitable for the mining operation and which are also acceptable to EPA.

Applicants for the proposed actions would also be required to obtain permits to operate from the New Mexico Environmental Improvement Agency (New Mexico Air Quality Act, 12-4-67). Prior to issuance of a permit, the applicant must submit plans, specifications and other relevant information the EIA deems necessary.

Section 672 (Coal Mining and Preparation Plants - Particulate Matter) of the New Mexico Air Quality Standards and Regulations states necessary abatement and preventative measures for particulate matter. Section 672 requires 1) all crushers, conveyors, screens, cleaners, hoppers, and chutes, designed for continuous preparation or transportation of coal, must be equipped with hoods, sprays, or shields where reasonably necessary to prevent particulate matter from becoming airborne, and 2) all haul roads must be sprayed where reasonably necessary to prevent particulate matter from becoming airborne.

Table 2-2

POSSIBLE CONTROLS AND MANAGEMENT PRACTICES FOR MITIGATING FUGITIVE DUST FROM COAL MINES

Activity	Control or Practices
Overburden removal	. Minimize distance of fall from bucket
Blasting/drilling	. Minimize blast area
	. Use sequential blasting
	. Drill with fluid media
	. Vent drill into collection device
Truck loading	. Minimize fall distance
Truck hauling	. Apply paving, water, chemical sealant or some other form of dust suppression to road surface
	. Wash, wet down, treat, or cover haul trucks
	. Restrict vehicle speeds and haul distances
	. Restrict vehicles to designated roads
	. Maintain roads and remove loose debris
	. Construct "curb-type" structures on roads
Truck dumping	. Maintain negative pressure on bottom dump trucks
	. Minimize fall distance
	. Dump on downwind site of open storage
Storage piles	. Employ closed or covered storage
Overburden disposal and exposed areas	. Minimize soil pile area
	. Cover exposed areas with mulch during revegetation
	. Furrow spoil piles
	. Establish windbreaks
	. Minimize topsoil disturbance
	. Employ rapid revegetation
Crushing, screening, conveying, and transfer points	. Cover or enclose activities
	. Install fabric filters
	. Water spray activities

The Surface Mining Reclamation and Enforcement Act (Federal Register, Vol. 42, December 13, 1977) and the Federal Coal Mine Health and Safety Act of 1959 (Federal Register, Vol. 41, May 17, 1976) stipulate general measures to be taken to mitigate air impacts of fugitive dust. Both acts specify that soil erosion must be minimized to control air pollution. In addition, the Federal Coal Mine Health and Safety Air Requires that (1) the lessee must insure compliance with air pollution control measures required by the terms and conditions of other applicable leases, permits, licenses, and approved plans, and (2) the lessee must design coal storage piles to minimize fire hazards and, therefore, air pollution resulting from fires.

2.2 Railroads

The specific regulations pertaining to the control of smoke from diesel-powered locomotives are limited to the permissible operating levels cited under Regulation 401 by the New Mexico Environmental Improvement Agency (New Mexico Air Quality Control Act; Ambient Air Quality Standards and Regulations as amended June 26, 1971).

These regulations state that no person shall permit, cause, suffer or allow the emission into the open air of any smoke having a density of shade greater than #1 on the Ringelmann scale for any period greater than ten seconds from any diesel-powered locomotive operating below 8,000 feet (mean sea level). In addition, the regulations stipulate that no person shall permit, cause, suffer or allow the emission into the open air of any smoke having a density of shade greater than #2 on the Ringelmann scale for any period greater than ten seconds from any diesel-powered locomotive that is 1) operating above 8,000 feet (mean sea level) or 2) involved in switching and railroad yard use. This regulation does not apply to emissions from diesel-powered locomotives if the emissions are a direct result of a cold engine start-up.

The emissions for particulates, sulfur dioxide, and nitrogen dioxide are limited for oil combustion sources with heat inputs greater than 10^{12} Btu per year by New Mexico regulations number 501, 605, and 606. Regulation 501 states that no person owning or operating oil burning equipment having a heat input of greater than 1,000,000 million (10^{12}) British Thermal Units per year per unit shall permit, cause, suffer or allow particulate matter emissions to the atmosphere in excess of .005 pounds per million British Thermal Units of heat input.

Regulation 605 stiuplates that no person owning or operating oil burning equipment having a heat input of greater than 1,000,000 million (10^{12}) British Thermal Units per year per unit shall permit, cause, suffer or allow nitrogen dioxide emissions to the atmosphere in excess of .3 pounds per million British Thermal Units of heat input.

Fugitive dust emissions from construction of railways are required to be controlled in the short-term by washing, wetting down or otherwise treating or covering vehicles, roads, and cargo as necessary to minimize the amount of fugitive dust emitted in transit and in loading.

2.3 Power Plants

The primary pollutants associated with generation and distribution of electricity are fugitive dust due to construction operations and coal storage, and fly ash, sulfur dioxide, and oxides of nitrogen from coal burning. Fugitive dust emissions from construction must be controlled by washing, wetting down or otherwise treating or covering vehicles, roads, and cargo as necessary to minimize the amount of dust emitted in transit and in loading. Long-term fugitive dust must be minimized by revegetation, surface compaction or sealing, or other effective alternatives for land reclamation.

Pollutant emissions from the proposed coal-fired power plant units would be limited by federal new source performance standards (Federal Register, December 23, 1971) and by New Mexico Air Quality Standards and Regulations (Regulation 504). The New Mexico regulations are considerably more stringent than federal new source performance standards.

The state regulations would limit particulate emissions to 0.05 lb/million Btu with no more than 0.02 lb/million Btu for fine particles less than 2 microns aerodynamic diameter; and 0.34 lb/million Btu for sulfur dioxide; and 0.45 lb/million Btu for nitrogen dioxide.

Fly ash is generally minimized by the installation and operation of electrostatic precipitators. Much of trace elements released from the combustion of the coal will appear in the fly ash and bottom ash and the scrubber waste of the power plant.

SO_2 emissions resulting from coal-fired power plants may be minimized by using the best available scrubber technology. Careful attention to standards possibly coupled with a monitoring program help minimize violations. Power plants can minimize non-methane hydrocarbons emissions by an intensive operational and maintenance program on boilers.

3.0 AIR QUALITY IMPACTS

3.1 Introduction

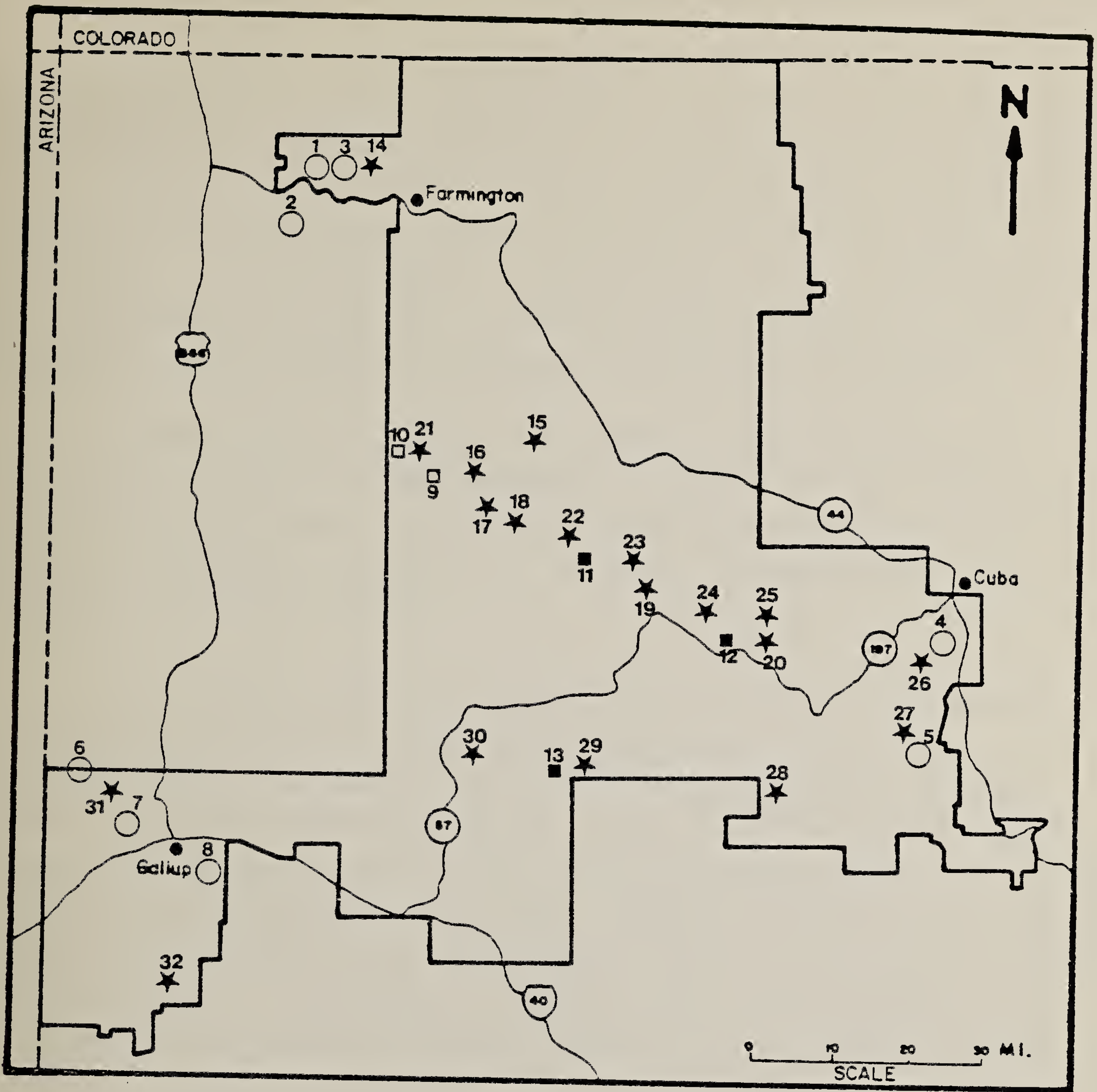
Air quality impacts caused by coal developments and related activities in the Star Lake-Bisti ES region are addressed assuming a normal (or average) level of control. These controls include a normal precipitation pattern over the study region as well as no new coal fires. Some existing fires may contribute to ambient concentrations of total suspended particulates (TSP), but they are already accounted for in the baseline TSP concentrations.

The impacts on the ambient TSP, SO_2, and NO_2 concentrations are examined for the four levels of coal development for the study years 1980, 1985, and 1990. The predicted pollutant concentrations are compared to the national and New Mexico ambient air quality standards and to the increments for prevention of significant deterioration of air quality (PSD). These four levels are Case 1, no action level of development; Case 2, proposed action level of development; Case 3, partial action level of development; and Case 4, full level of development.

3.2 Emissions

Air quality modeling requires as inputs the pollutant emissions for each source modeled. These emissions are the quantity of each pollutant emitted to the atmosphere by a source. Emissions were estimated for surface mines, underground mines, power plants, and towns.

Coal mines are the major contributors of particulate emissions in the study region. The location of the mines modeled in this chapter are shown in Map 3-1. Fugitive emissions are emitted from a number of activities within the mines, including blasting, coal and overburden loading and dumping, haul road and access road traffic, and wind erosion of exposed areas.



MAP 3-1

LOCATION OF MINES IN ES REGION

Case I ○

1) San Juan Power Plant
2) Four Corners Power Plant
3) Western-San Juan
4) Ideal Basic
5) Arroyo
6) McKinley
7) Carbon
8) AMCOAL

Case II □

9) NMGS
10) Western-Bisti

Case III ■

11) Alamito
12) Chaco-Star Lake
13) South Hospah

Case IV ★

14) Western-San Juan Extension
15) Salt River Project
16) Eastern
17) Arch Mineral
18) Peabody-Gallo Wash
19) Chaco-Gallo Wash
20) Freeman United
21-32) Potential Coal Mining Development

For these operations, emission factors from the documents prepared by PEDCo Environmental, Inc. (1978), and Cowherd, et al (1974) were used to relate the level of activity of an operation to fugitive dust emissions. Operation information was extracted from information on file with the COAR at BLM Albuquerque. The annual emissions of particulates from the various regional coal developments for 1980, 1985, and 1990 are shown in Table 3-1. The Appendix contains a detailed description of the emission calculations.

Small amounts of hydrocarbons, carbon monoxide, and oxides of nitrogen are released from vehicles, steam generators, and other combustion sources within coal mines. Because of the small quantities emitted, the effects on surrounding air quality are expected to be insignificant (U. S. Department of Interior, 1976).

The region's three power plants, Four Corners, San Juan, and New Mexico Generating Station, all would emit particulates, SO_x, and NO_x. Emission parameters for the Four Corners station were taken from the New Mexico Environmental Improvement Agency's file. The Public Service Company of New Mexico, owners of the New Mexico Generating Station (NMGS), provided emission and stack parameters for their plant. Emission parameters for the San Juan station were extracted from its environmental report on file at the BLM office in Albuquerque (U. S. Department of Interior, 1977). The emissions for the three generating stations are listed in Table 3-2 for the three study years.

The towns of Gallup, Crownpoint, Farmington, Aztec, and Bloomfield are anticipated to have an impact on regional air quality for TSP, SO_2, and NO_2. Current emissions for these pollutants were obtained from the National Emissions Data System (NEDS) Inventory for 1977 (U. S. Environmental Protection Agency, 1977a). The total pollutant emissions of McKinley and San Juan Counties were apportioned to the five towns based on the percentage of the county population in each town. The 1980, 1985, and 1990 emissions from the towns were forecasted to increase in direct proportion to projected growth of their populations between 1978 and the study year for each level of coal development. The population projections for the five towns are listed in

TABLE 3-1

PARTICULATE EMISSION (TONS/YR) FROM MINING ACTIVITIES FOR THREE DEVELOPMENT LEVELS

Mine	Overburden Removal	Coal Removal	Truck Dumping	Haul Roads	Access Roads	Storage Piles/Exposed Area	Misc.	Total
1980								
Case I								
AMCOAL	130	30	2	268	13	167	22	632
Arroyo	47	–	3	154	7	99	6	316
Carbon Coal	346	97	24	111	40	456	66	1,140
McKinley	992	300	18	218	100	958	184	2,770
Western-San Juan	400	120	7	119	71	281	69	1,067
Ideal Basic	N/A	24	5	131	32	182	2	376
Case II								
Western-Bisti	32	1	1	34	57	792	42	959
Case III								
Chaco-Star Lake	105	7	7	119	66	410	75	789
South Hospah	95	2	2	12	16	509	39	675
1985								
Case I								
AMCOAL	130	30	2	268	13	167	22	632
Arroyo	56	1	4	190	7	119	11	388
Carbon Coal	375	97	26	183	40	317	60	1,098
McKinley	992	300	18	148	100	958	184	2,700
Wester-San Juan	400	120	7	119	145	281	69	1,141
Ideal Basic	N/A	100	20	544	86	182	10	942
Case II								
Western-Bisti	32	8	8	346	56	394	95	1,489
Case III								
Chaco-Star Lake	403	21	21	346	69	624	197	1,681
South Hospah	612	12	2	46	33	509	122	1,336
Alamito	938	21	21	346	114	868	208	2,516
1990								
Case I								
McKinley	992	300	18	360	100	958	184	2,912
Western-San Juan	353	108	6	108	145	248	62	1,030
Ideal Basic	N/A	100	20	544	86	182	10	942
Case II								
Western-Bisti	811	18	18	729	83	1,122	195	2,976
Case III								
Chaco-Star Lake	716	24	24	403	69	1,010	243	2,489
South Hospah	612	12	2	46	33	509	122	1,345
Alamito	938	21	21	346	137	868	208	2,539

TABLE 3-2

POWER PLANT EMISSIONS

	TSP (tons/yr)	SO_2 (tons/yr)	NO_x (tons/yr)
1980			
San Juan	500	15,330	27,300
Four Corners	34,340	137,770	88,660
1985			
San Juan	830	23,215	37,730
Four Corners	4,760	49,350	66,685
NMGS	956	5,741	8,600
1990			
San Juan	830	23,215	37,730
Four Corners	4,760	49,350	66,685
NMGS	2,868	17,223	25,800

Table 3-3. The resultant TSP, SO_2, and NO_x emissions from the towns are listed in Table 3-4 for each year and level of development or case. The Appendix documents the assumptions used in calculating town emission rates for dispersion modeling.

The air quality impact of vehicle emissions from major roads in the region would be highly variable, intermittent, and generally confined to the immediate vicinity of the roads. Hence, the vehicular emissions were not included in the dispersion modeling.

Other developments in the region include construction of three transmission and two railroad lines. Most of the pollutant emissions associated with the proposed 230 KV transmission lines would occur during the construction phase. Emissions would not impact the regional air quality because emissions would be temporary, intermittent, and confined to a small area.

The construction and use of access roads and staging areas would result in increased emissions of fugitive dust in the region. Occasionally, blasting and drilling of holes for placing poles and anchors for the towers would generate some fugitive dust. During cleanup activities following construction of the transmission lines, small amounts of fugitive dust would be generated during the grading, harrowing, and seeding of the soil surface for reclamation. In addition, a small amount of gaseous emissions wouuld be generated by combustion sources such as passenger and construction vehicles, generators, and compressors.

Negligible emissions of pollutants would be expected after the transmission lines begin operation. The lines would be patrolled by helicopter and pollutant emissions would be small and intermittent. The movement of equipment into the area to perform occasional maintenance would generate small amounts of fugitive dust.

TABLE 3-3

POPULATIONS FOR MAJOR TOWNS

	1980			1985			1990		
Town	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
Aztec	5800	6000	6100	6650	6900	7000	8150	8500	8650
Bloomfield	2650	2750	2850	2950	3100	3200	3500	3700	3800
Crown Point	4800	5150	5400	5200	5600	5900	5850	6500	6800
Farmington	32850	33450	33900	35650	36450	36950	39050	40250	40800
Gallup	20150	20550	20850	22100	22600	22900	24550	25350	25750

TABLE 3-4

EMISSIONS FROM MAJOR TOWNS

City	1980 TSP tons/yr	1980 SO_2 tons/yr	1980 NO_x tons/yr	1985 TSP tons/yr	1985 SO_2 tons/yr	1985 NO_x tons/yr	1990 TSP tons/yr	1990 SO_2 tons/yr	1990 NO_x tons/yr
				Case 1					
Crown Point	40	21	368	44	23	399	49	25	449
Gallup	170	88	1545	186	96	1695	205	108	1884
Grants	113	59	1035	130	68	1176	148	80	1350
Aztec	65	37	448	74	41	510	91	51	629
Bloomfield	30	16	205	32	19	227	39	22	270
Farmington	367	204	2532	398	220	2748	435	244	3010
				Case 2					
Crown Point	44	23	395	47	25	430	55	29	498
Gallup	173	89	1577	191	100	1734	213	110	1943
Grants	114	60	1044	131	68	1190	151	79	1368
Aztec	67	37	462	76	43	532	94	53	655
Bloomfield	31	18	212	35	19	239	41	23	285
Farmington	372	207	2580	405	228	2811	449	250	3103
				Case 3					
Crown Point	46	23	415	50	25	453	58	30	522
Gallup	177	92	1600	193	100	1757	218	112	1976
Grants	116	60	1051	131	69	1199	152	79	1378
Aztec	68	37	470	79	43	540	96	53	667
Bloomfield	32	18	220	36	20	247	42	23	293
Farmington	380	212	2613	413	230	2850	454	253	3144

Emissions from the operation of unit trains can be divided into those resulting from the railway construction and those from the operation of the unit trains, i.e., diesel combustion. The Con Paso Railroad, first analyzed in the Case 1 level of development, would be constructed from 1977 to 1981, and begin operation in 1982. The Star Lake Railroad, first analyzed for the Case 3 level, would be constructed from 1978 to 1980, and begin operation in 1980.

Gaseous emissions from combustion sources such as gasoline and diesel powered vehicles and equipment, and intermittent fugitive dust emissions would result from site preparation activities such as blasting, grading, and earth moving.

Emissions from operation of the Star Lake Railroad were presented in the Site Specific Analysis of the Star Lake Railroad for the three study years. These emissions are primarily combustion emissions from the diesel engines. Emissions from the Con Paso Railroad were scaled from Star Lake's emissions by comparing travel distances for unit trains. Table 3-5 contains the emissions for the two railroads for the three study years.

The railroad emissions would be intermittent and confined to narrow corridors following the lines. Exact schedules of train operations were not available, making predictions using dispersion models impossible. However, train operations would contribute less than 1% of the total particulate emission from the mines located near the tracks. Gaseous pollutant emissions would be less than 15% of those for all the towns and other coal-related activities. The locomotive emisssions would be spread out over all railroad lines; thus, railroad associated emissions are expected to have little effect on regional air quality. Once constructed, the fugitive emissions from the railroad right-of-way would have a negligible impact on the regional TSP air concentrations. Therefore, they were not modeled for the air quality impact analysis.

Table 3-5

TSP, SO_2 AND NO_2 EMISSIONS (TONS/YEAR) FROM OPERATION OF RAILROADS

	TSP	SO_2	NO_2	TSP	SO_2	NO_2	TSP	SO_2	NO_2
Star Lake Railroad	7	17	111	46	106	686	49	113	730
Con Paso Railroad									

3.3 Modeling Procedures

The annual average SO_2, NO_2, and TSP concentrations were predicted with a model based on the study-state Gaussian dispersion equation presented in the Workbook of Atmospheric Diffusion Estimates (Turner, 1972). Statistical meteorological data constructed from observations taken at the National Weather Service offices in Farmington, New Mexico, for 1959-1967 and Gallup, New Mexico, for 1973-1975 were input to the annual dispersion model. The pollutant concentrations were computed for grid points (receptors) overlying the affected areas of the region. The modeling procedure for predicting annual pollutant concentrations from the mines, towns and power plants is described in the Appendix.

The maximum 7-day, 30-day, 24-hour, and 3-hour pollutant concentrations near the towns and the mines were estimated from predicted annual concentrations using Larsen statistics (Larsen, 1971). All emissions of sulfur oxides were assumed to be sulfur dioxide (SO_x). All nitrogen oxides (NO_x) emitted to the atmosphere were assumed to be converted to nitrogen dioxide (NO_2).

The short-term concentrations for the three power plants were predicted using EPA's single source CRSTER model. CRSTER is described in the Interim Guideline on Air Quality Models (EPA, 1977) as a "steady-state Gaussian plume technique applicable to both rural and urban areas in uneven terrain. The purpose of the technique is: (1) to determine the maximum concentrations, for certain averaging times between 1-hour and 24-hours, over a one year period due to a single point source of up to 19 stacks, (2) to determine the meteorological conditions which cause the maximum concentrations, and (3) to store concentration information useful in calculating frequency distributions for various averaging times. The concentration for each hour of the year is calculated and midnight-to-midnight averages are determined for each 24-hour period." The Appendix contains more explicit details on CRSTER.

3.4 Resultant Regional Air Quality

The impact of the no action level of development on ambient TSP, SO_2, and NO_2 concentrations is first assessed for the study years 1980, 1985, and 1990. Then the impact of the proposed action level of development is assessed for those years. Thirdly, the impact of the regional partial action level is predicted for the same three years. Finally, the impact of the regional full development level is qualitatively discussed, since mining plans and procedures for this level are not final at this time. The predicted pollutant concentrations for the first three cases are compared to the National Ambient Air Quality Standards (NAAQS) and New Mexico Ambient Air Quality Standards and impacts on visibility are addressed.

Under the new PSD regulations, fugitive dust from transporting and handling soil at surface mines is omitted or exempt from ambient impact reviews. Particulate emissions from "non-exempt" sources such as coal extraction and handling and from industrial process units are typically less than 15% of the total emission from a mine. Annual ambient TSP concentrations predicted as a result of modeling all particulate emissions seldom exceed 5 $\mu g/m^3$ above baseline concentrations at distances greater than 3 miles from mining activities. Therefore, particulate levels from the "non-exempt sources would be less than 1 $\mu g/m^3$ at these distances with no impact on PSD Class II increments.

Maximum 24-hour concentrations at greater than 2-3 miles from most mining activities would be less than 20 $\mu g/m^3$ above baseline concentrations. Hence, none of the mines would be expected to exceed the Class II increments under the new review procedure since 85% of the TSP concentration would be due to fugitive dust. Mesa Verde National Park and Bandalier and San Pedro Parks Wilderness Areas are the nearest Class I areas. The latter is 10 miles from the nearest mining activity. Again, increases in TSP concentrations this far from a mining source would not be expected to exceed Class I increments.

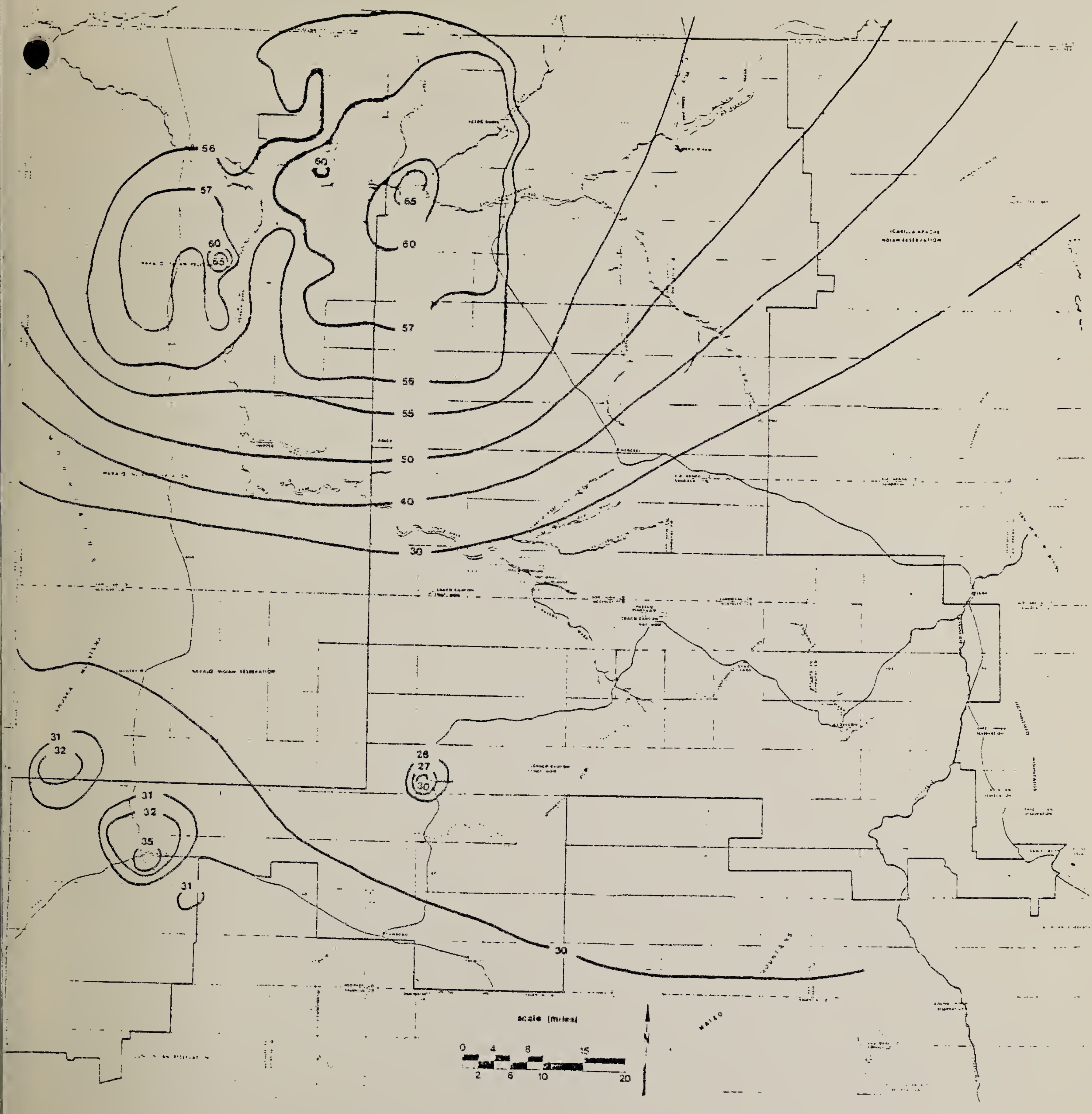
3.4.1 Case 1 - No Action Level

Air quality impacts analyzed in this section reflect future air quality without the proposed actions. Facilities modeled include the San Juan and Four Corners Generating Stations and the AMCOAL, Arroyo #1, Carbon Coal-Gamerco, Pittsburgh and Midway-McKinley, Western Coal-San Juan, and Ideal Basic coal mines. The Ideal Basic mine is underground; the others are surface mines.

The area affected by the particulate emissions from the mines would be limited to a few square miles around the individual mines. Since most of the fugitive dust generated by mining operations consists of relatively large diameter particles, considerable particulate deposition would occur before the particles are transported far. The increase of annual TSP concentrations are predicted to be less than 1 $\mu g/m^3$ beyond a five-mile radius from the mines and their haul roads for the three study years (Maps 3-2, 3-3, and 3-4.)

The New Mexico annual ambient air quality standards for TSP may be exceeded very near specific mining operations within or very near the mine boundaries. However, TSP concentrations would drop below standard levels at very short distances from the individual sources.

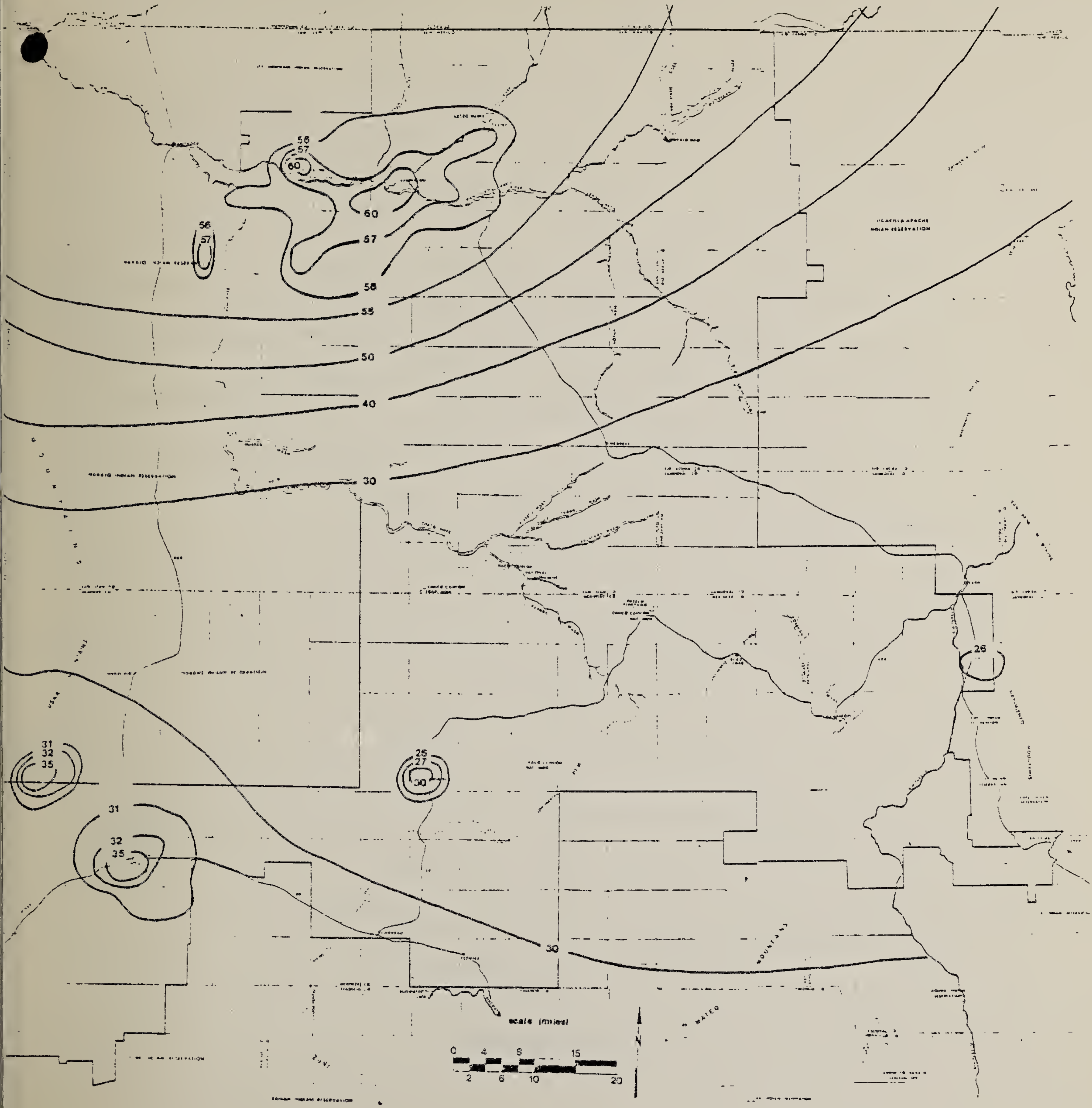
In 1980 and 1985 emissions from Carbon Coal's mine would interact with emissions from Gallup. In 1985 production at AMCOAL would increase and its emissions will also interact with those from Gallup. These interactions would raise the TSP concentrations 5 $\mu g/m^3$ above the background level of 30 $\mu g/m^3$ over an area 1½ miles in radius centered at Gallup. In 1990, when neither mine is operating, Gallup would still show an annual TSP concentration of 35 $\mu g/m^3$ although this concentration would cover a smaller area. During the study years Gallup would show a maximum 24-hour concentration of 119 $\mu g/m^3$. These annual and 24-hour concentrations are below New Mexico's annual standard of 60 $\mu g/m^3$ and 24-hour standard of 150 $\mu g/m^3$.



Map 3-2

ANNUAL AVERAGE TSP CONCENTRATIONS ($\mu g/m^3$) FOR 1980

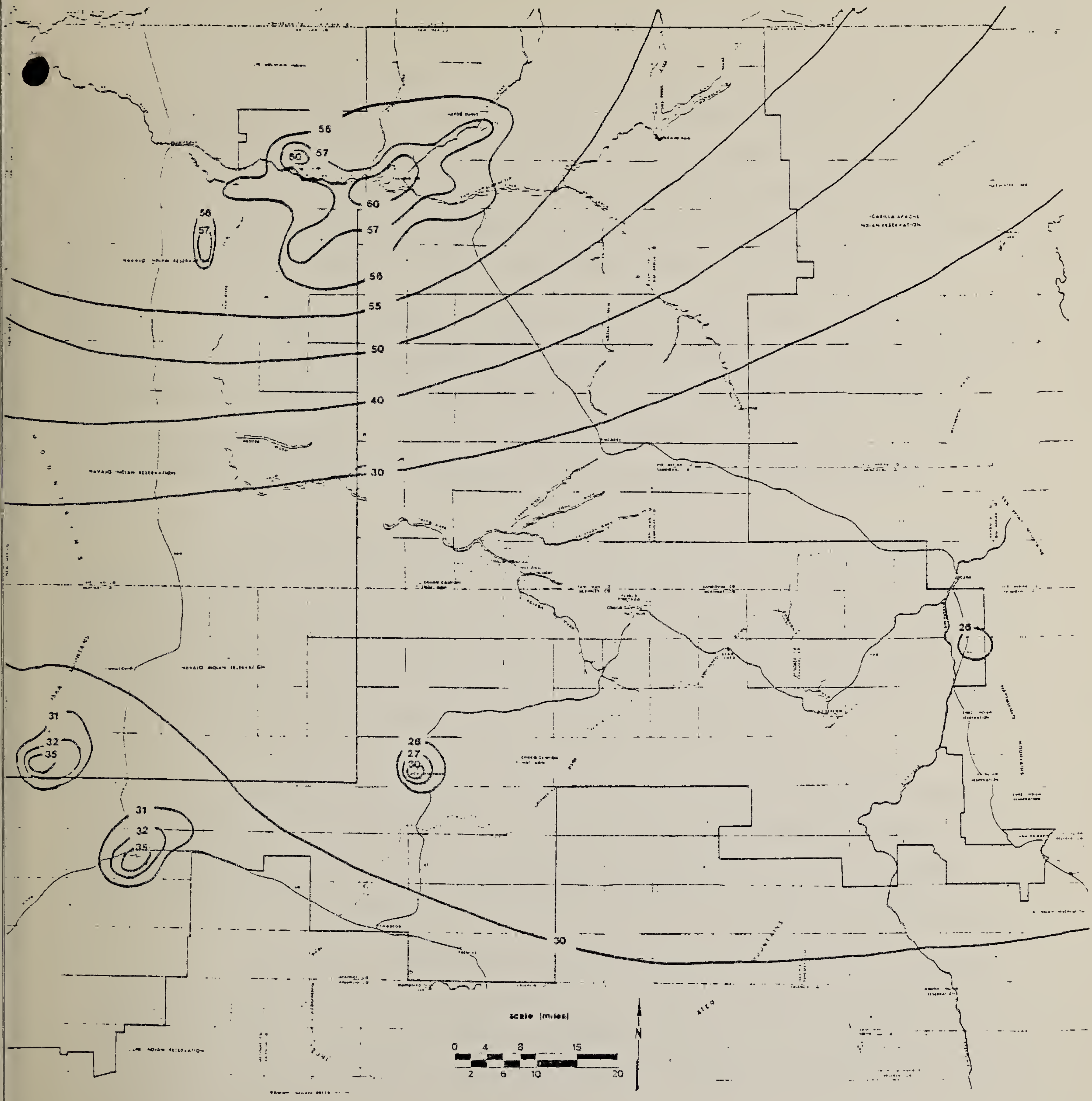
FOR DEVELOPMENT CASES 1 & 2



Map 3-3

ANNUAL AVERAGE TSP CONCENTRATIONS ($\mu g/m^3$) FOR 1985

FOR DEVELOPMENT CASE 1



Map 3-4

ANNUAL AVERAGE TSP CONCENTRATIONS ($\mu g/m^3$) FOR 1990
FOR DEVELOPMENT CASE 1

Predicted concentrations reflect average concentrations over an area around the towns, but actual concentrations monitoried in the town may be near sources and thus show much higher concentrations. New Mexico's annual and 24-hour TSP standards were violated in Gallup and Farmington in 1974, 1975, and 1976. These violations occurred without the increases in the Case 1 populations projected for the three study years.

In 1980, interaction between emissions from the San Juan Generating Station, the Four Corners Generating Station, the Western San Juan mine and Farmington would cause TSP concentrations to violate New Mexico's annual and 24-hour standards. Table 3-6 contains the short-term TSP, SO_2, and NO_2 concentrations resulting from emissions from the generating stations.

A maximum annual TSP concentration of 65 $\mu g/m^3$ and a maximum 24-hour concentration of 221 $\mu g/m^3$ would occur over about a 3 by 5 mile area around Farmington. These concentrations represent an increase of 10 $\mu g/m^3$ over the annual background (55 $\mu g/m^3$) and a 34 $\mu g/m^3$ increase over the 24-hour baseline concentration (187 $\mu g/m^3$). Class II PSD increments are 19 and 37 $\mu g/m^3$, respectively, thus the PSD increment would not be used.

A maximum annual TSP concentration of 65 $\mu g/m^3$ will also occur over a 1 mile square area southwest of the Four Corners Generating Station. A maximum 24-hour concentration of 264 $\mu g/m^3$ is predicted near the station. Both predicted levels exceed the New Mexico ambient air quality standards.

A small area, two miles in diameter, around the Western San Juan mine would show an annual TSP concentration of 60 $\mu g/m^3$ and a 24-hour maximum of 204 $\mu g/m^3$. Since New Mexico standards are not to be equaled, or exceeded, the annual standard of 60 $\mu g/m^3$ and the 24-hour standard of 150 $\mu g/m^3$ would be violated.

By 1985 controls installed at the Four Corners plant would reduce TSP concentrations in the northwest corner of the ES region. Near the Four Corners Station in 1985 and 1990 the maximum annual concentration would be

TABLE 3-6

MAXIMUM SHORT-TERM CONCENTRATIONS* ($\mu g/m^3$) PREDICTED AROUND GENERATING STATIONS

COMPARED TO NATIONAL AND NEW MEXICO AMBIENT AIR STANDARDS

Power Plant	Pollutant	Averaging Period	1980	1985	1990	National Standards Primary	National Standards Secondary	New Mexico Standards
Four Corners	SO_2	24-hour	416	137	137	365	–	216
		3-hour	1768	610	610	–	1300	–
	TSP	24-hour	264	200	200	260	150	150
		1-hour	899	474	474	–	–	–
	NO_2	24-hour	293	186	186	–	–	200
San Juan	SO_2	24-hour	37	53	53	365	–	216
		3-hour	181	270	270	–	1300	–
	TSP	24-hour	188	189	189	260	150	150
		1-hour	407	413	413	–	–	–
	NO_2	24-hour	135	152	152	–	–	200
New Mexico Generating Station	SO_2	24-hour	–	16	50	365	–	216
		3-hour	–	86	257	–	1300	–
	TSP	24-hour	–	87	92	260	150	150
		1-hour	–	201	244	–	–	–
	NO_2	24-hour	–	22	65	–	–	200

*Including background

[illegible]

57 μg/m^3. A maximum 24-hour concentration of 200 μg/m^3 would occur within 2 miles of the station exceeding the federal secondary and New Mexico standards.

Modeling results show that emissions from the San Juan plant alone would have a small impact on regional air quality. The plant would violate the New Mexico 24-hour standard in 1980 with a concentration of 188 μg/m^3 and 189 μg/m^3 in 1985 and 1990. These levels, however, are only 1 μg/m^3 over the 24-hour background concentration for 1980 and 2 μg/m^3 for the other two years. In both 1985 and 1990 the region's maximum annual TSP concentration, 60 μg/m^3, would occur over about a 9 by 4 mile area around Farmington and in a small area near the Western San Juan mine. These areas would show maximum 24-hour concentrations of 204 μg/m^3. Both would violate New Mexico's annual and 24-hour standards.

Maximum 7- and 30-day TSP concentrations are predicted to occur in the same areas where the maximum annual concentration occurs. In the area around Farmington and the area in the mountains 10 miles southwest of the Four Corners Generating Station, the maximum 7- and 30-day TSP concentration in 1980 would be 140 μg/m^3 and 101 μg/m^3, respectively. These concentrations violate the New Mexico standards of 90 μg/m^3 for the 30-day average and 110 μg/m^3 for the 7-day average. Although more stringent control methods on the Four Corners Generating Station would reduce TSP concentration in 1985 and 1990 in the northwest portion of the ES region, the highest 7- and 30-day TSP concentrations would still occur in the area surrounding Farmington. During these two study years the worst-case 7-day concentration would reach 120 μg/m^3 and the 30-day would be 93 μg/m^3. Similar concentrations would be found in a three square mile area surrounding the Western-San Juan mine and the San Juan Generating Station. These concentrations would also violate the New Mexico standards. The area surrounding any of the other mines or towns would not reach concentrations this high for any of the study years.

In 1980 the national and New Mexico annual standards for SO_2 and NO_2 will not be violated. However, in the area southwest of the Four Corners Generating Station, the New Mexico 24-hour standard for both SO_2 and NO_2 as

well as the national 24-hour SO_2 standard would be exceeded. Maps 3-5 and 3-7 illustrate annual SO_2 and NO_2 concentrations predicted for 1980.

The impact on regional SO_2 concentrations by emissions from towns would be small. In 1980, the annual SO_2 concentration for an area about 20 miles by 12 miles around Farmington would be 13 $\mu g/m^3$ and the maximum 24-hour concentrations would reach 44 $\mu g/m^3$. An annual SO_2 concentration of 2 $\mu g/m^3$ for the area around Gallup is predicted for the three study years. Maximum 24-hour SO_2 concentrations would be 7 $\mu g/m^3$. Crownpoint SO_2 concentrations would be 1 $\mu g/m^3$ for the annual and 4 $\mu g/m^3$ for the 24-hour averaging periods. The NO_2 concentrations for the area surrounding Gallup would exhibit an annual maximum of 10 $\mu g/m^3$ and a 24-hour maximum of 34 $\mu g/m^3$ for each of the three study years. Maximum annual NO_2 concentrations would reach 7 $\mu g/m^3$ and maximum 24-hour levels would reach 24 $\mu g/m^3$ in the area around Crownpoint during the three study years.

The interaction of emissions from the two generating stations will raise SO_2 levels in the northwest section of the ES region. In 1980 in a small area in the mountains southwest of the Four Corners Station and in an area south of Farmington, annual concentrations would reach 20 $\mu g/m^3$. The total maximum 24-hour concentration within 2 miles of the Four Corners Station would be 416 $\mu g/m^3$. This level would exceed the state 24-hour standard of 216 $\mu g/m^3$ and the national standard of 365 $\mu g/m^3$.

In 1980 maximum annual NO_2 concentrations would reach 20 $\mu g/m^3$ over about a 13-mile by 17-mile area around Farmington and a small area southwest of the Four Corners Station. Maximum 24-hour concentrations would reach 68 $\mu g/m^3$ near Farmington. Within 2 miles of the Four Corners Station, a 24-hour maximum of 293 $\mu g/m^3$ would occur violating the New Mexico standard of 156 $\mu g/m^3$.

In 1985 and 1990 no ambient air quality standards for gaseous pollutants would be violated except the New Mexico NO_2 standard. Maps 3-6 and 3-8 illustrate annual SO_2 and NO_2 concentrations predicted for the three years. Controls

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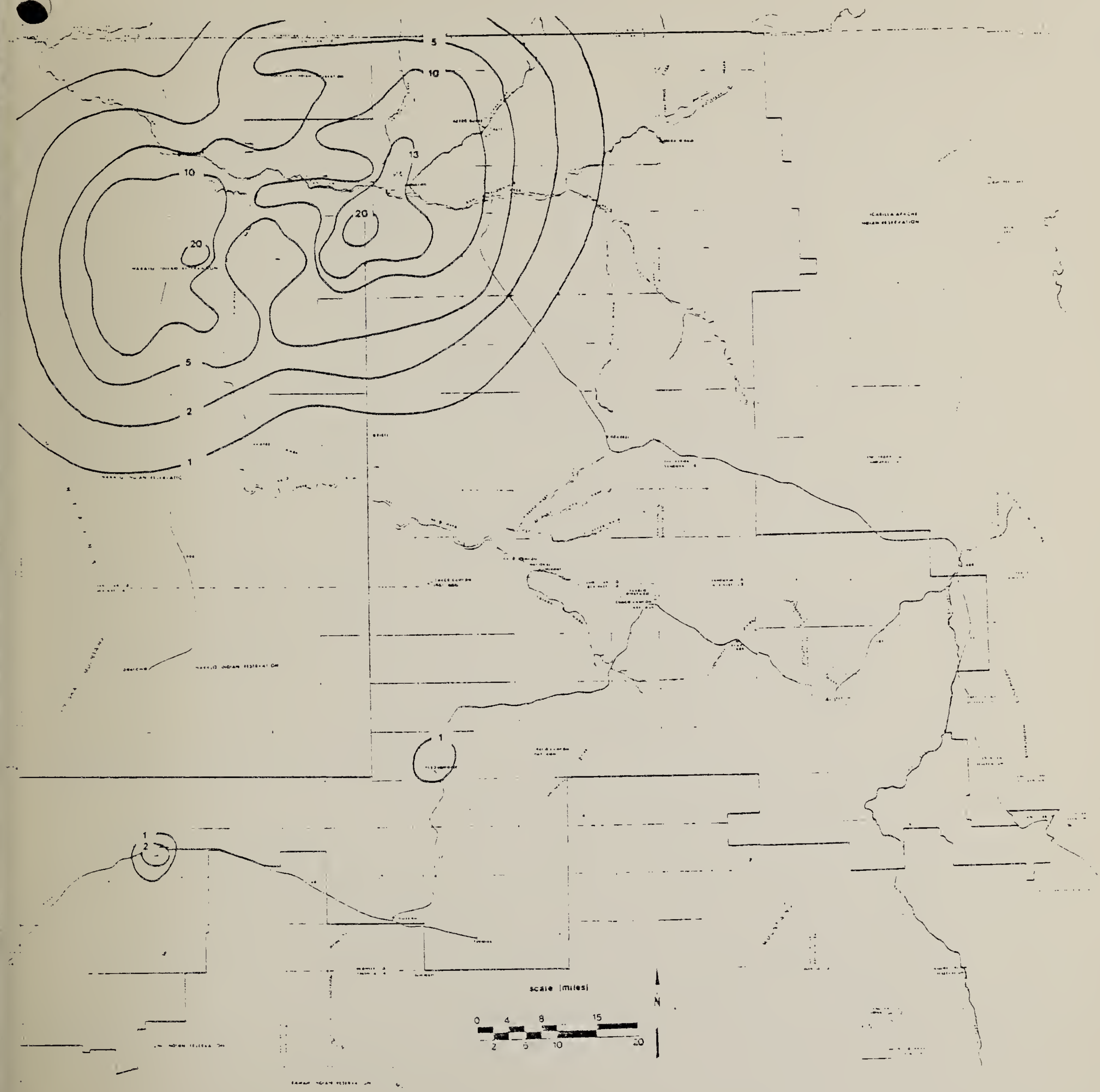
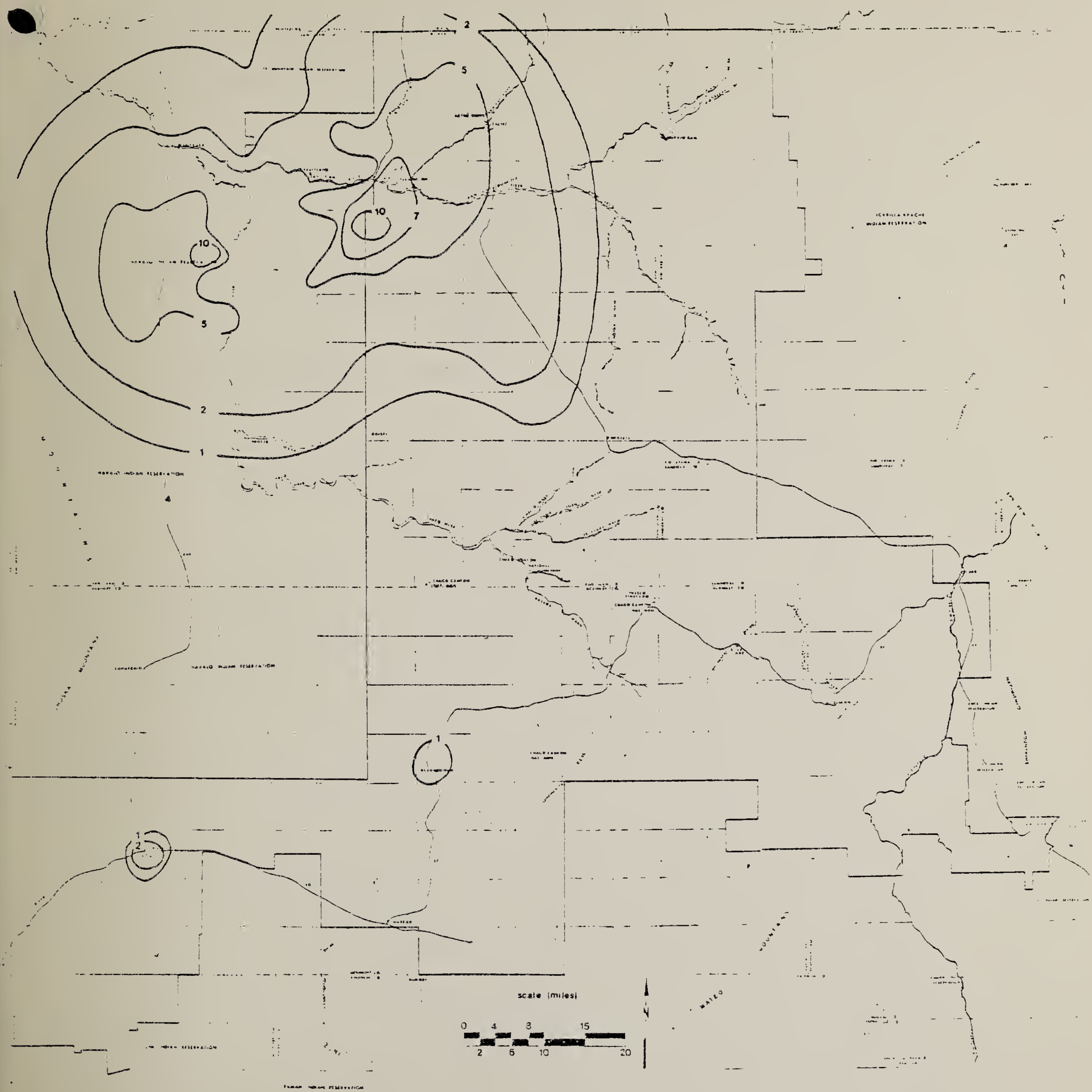


Map 3-5

ANNUAL AVERAGE SO_2 CONCENTRATIONS ($\mu g/m^3$) FOR 1980

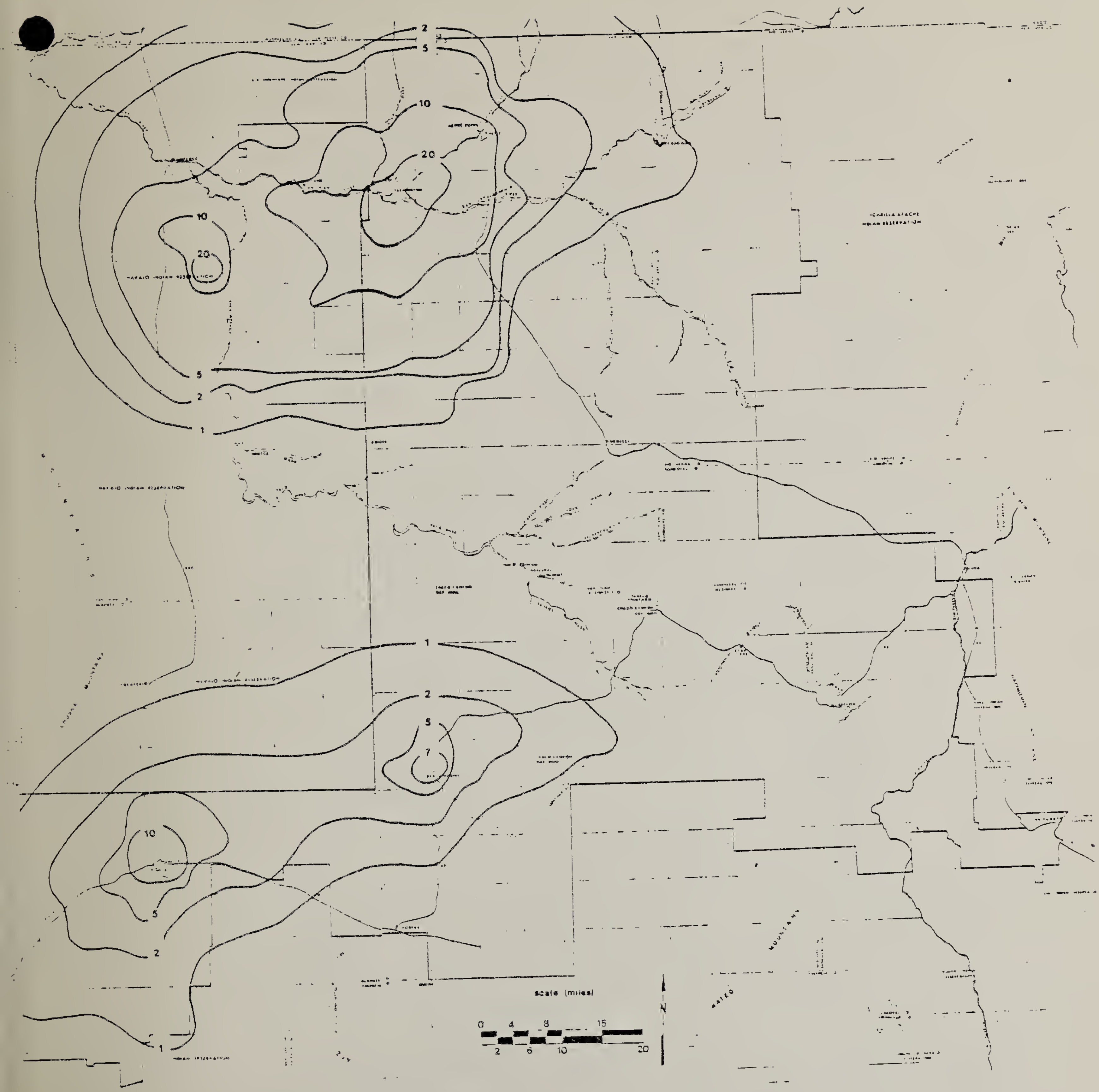
FOR DEVELOPMENT CASES 1, 2, AND 3



Map 3-6

ANNUAL AVERAGE SO_2 CONCENTRATIONS (ug/m^3) FOR 1985 AND 1990

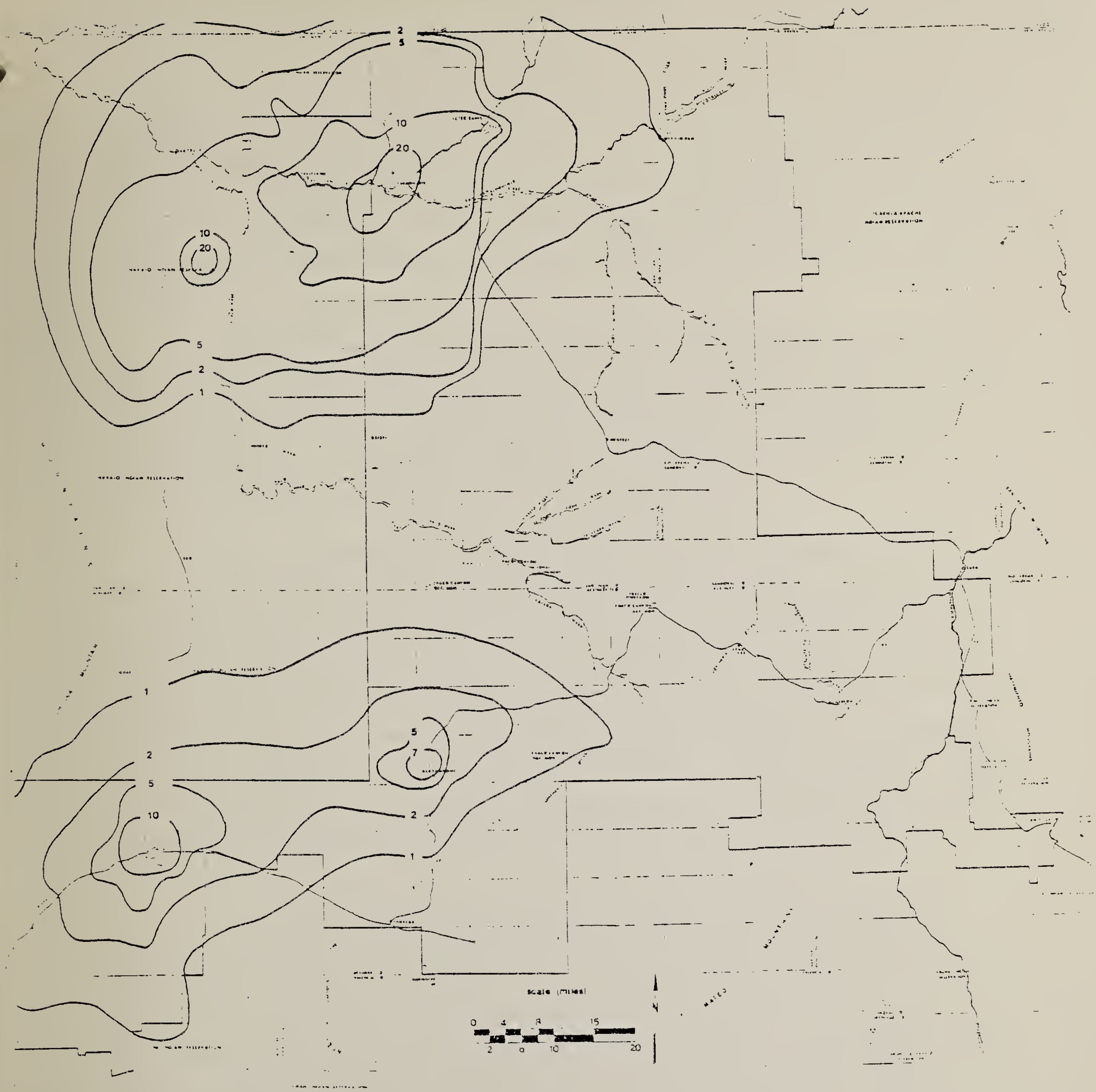
FOR DEVELOPMENT CASE 1



Map 3-7

ANNUAL AVERAGE NO_2 CONCENTRATIONS ($\mu g/m^3$) FOR 1980

FOR DEVELOPMENT CASES 1, 2, AND 3



Map 3-8

ANNUAL AVERAGE NO_2 CONCENTRATIONS ($\mu g/m^3$) FOR 1985 AND 1990
FOR DEVELOPMENT CASE 1

implemented in 1982 on the Four Corners would cause annual SO_2 concentrations around Farmington to decrease to 7 $\mu g/m^3$. Also, annual SO_2 levels would increase to 10 $\mu g/m^3$ southwest of the Four Corners Station and the area south of Farmington. Farmington's 24-hour maximum would reach 24 $\mu g/m^3$ for 1985 and 1990. Near the Four Corners Station the maximum 24-hour SO_2 concentration would be 137 $\mu g/m^3$.

Maximum annual NO_2 concentrations for 1985 and 1990 in the northwest corner of the ES region should remain near 1980 maximum levels; however, the affected areas would be approximately 20% smaller. A maximum 24-hour NO_2 concentration of 186 $\mu g/m^3$, exceeding the New Mexico standard of 156 $\mu g/m^3$, would occur within 2 miles of the Four Corners Station.

Mesa Verde National Park would be the nearest mandatory Class I PSD area affected by the new units of the San Juan Generating Station. None of the increments will be used due to emissions from the generating station. The predicted TSP and SO_2 concentrations are compared to Class I increments in Table 3-7. It should be noted that the distance between the San Juan Generating Station and the Mesa Verde National Park, 42 kilometers, is near the limit for accurately predicting concentrations via dispersion models. Changes in wind fields and uneven terrain encountered along this distance would tend to reduce the concentration below that which the model would predict.

In the southern section of the ES region away from towns and mines, the average annual horizontal visibility related to atmospheric particulates is expected to remain near the baseline of 53 miles. Within 2 miles of Gallup average annual visibility will decrease to 44 miles for the three study years. In 1985 and 1990 within 3 miles of the McKinley mine annual average visibilities would also be 44 miles. Worst-case 24-hour visibilities for these two areas would be about 17 miles.

Annual baseline visibility in the northern part of the ES region away from the influence of the towns and power plants would be 32 miles, and the worst-case 24-hour, about 12 miles. In [illegible], the annual visibility in [illegible]

TABLE 3-7

SO_2 AND TSP CONCENTRATIONS ($\mu g/m^3$) AT MESA VERDE NATIONAL PARK DUE TO EMISSIONS FROM THE NEW UNITS OF OF THE SAN JUAN GENERATING STATIONS

Pollutant		Concentration 1980	Concentration 1985	Concentration 1990	Class I Increments
SO_2	Annual	<1.	<1.	<1.	2
	24-hour	1.5	3.	3.	8
	3-hour	9.	18.	18.	25
TSP	Annual	<1.	<1.	<1.	5
	24-hour	<1.	<1.	<1.	10

area around Farmington will reduce to 28 miles, with a worst-case 24-hour visibility of 10 miles.

Visibilities in the area southwest of the Four Corners Station would not differ significantly from those around Farmington. A worst-case 24-hour visibility of 8 miles would occur within 2 miles of the Four Corners Station. In 1985 and 1990 the annual visibility around Farmington would improve slightly to 30 miles and the worst-case 24-hour level would reach 11 miles. Annual visibility in the area affected most strongly by the Four Corners Station would increase to 31 miles. The worst-case 24-hour visibility would be about 11 miles. In 1985 and 1990 the worst-case 24-hour visibility within 2 miles of the Four Corners Station would increase to 11 miles from 8 miles in 1980.

Emissions of particulates and SO_2 from the San Juan Power Plant would have almost no effect on visibilities in the area of the Mesa Verde National Park. The average worst-case 1-hour TSP concentration in the park due to emissions from all 4 units of the generating station would be 2.2 $\mu g/m^3$. The station would also contribute approximately 3.2 $\mu g/m^3$ of sulfates due to conversion of its SO_2 emissions. A 1 percent conversion rate of SO_2 to sulfates was assumed. The particulates and sulfate levels caused by the San Juan Station emissions would reduce visibility due to atmospheric particulates less than half a mile assuming an annual rural TSP concentration of 25 $\mu g/m^3$.

3.4.2 Case 2 - Partial Action Level

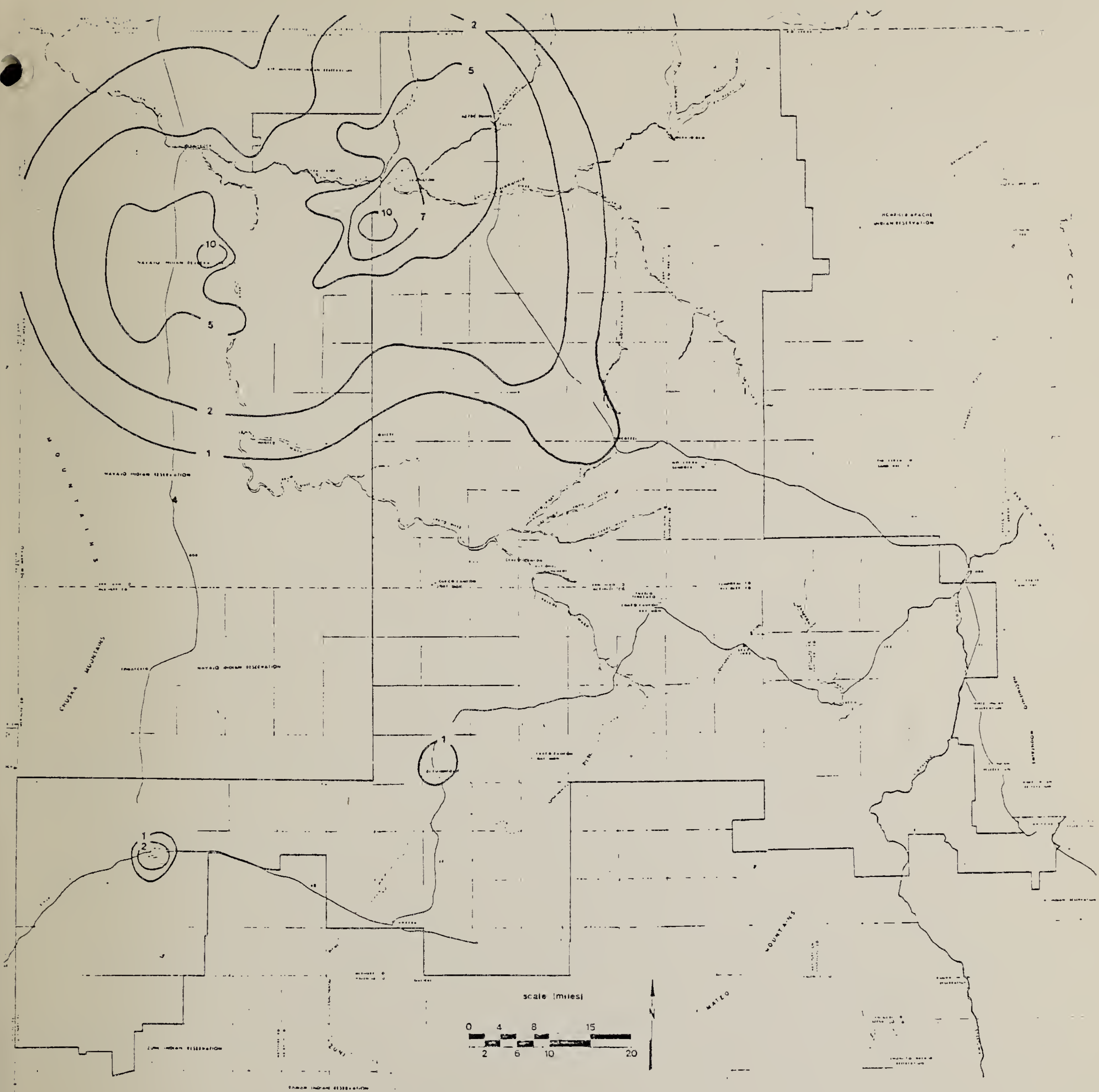
Sources of pollutants in addition to those in the no-action case include the New Mexico Generating Station (NMGS) and its associated coal mine, the Western-Bisti. Also included is Phase I of the 230 KV Fruitland Coal Load Transmission mine. Map 3-1 shows the locations of these sources.

The only emissions of pollutants from transmission line construction would be gaseous emissions and road dust created by vehicular traffic and construction equipment. These emissions would be small, intermittent, and localized and would have no noticeable impact on the local or regional air quality.

In 1980 air quality impacts on the region would be very nearly the same as for the no-action case. The New Mexico Generating Station would not be operating and the Western-Bisti strip mine would just be starting operation. Maps 3-2, 3-5, and 3-7 illustrate annual TSP, SO_2, and NO_2 concentrations predicted for 1980.

The New Mexico Generating Station would be in operation by 1985. Its emissions would be smaller than the Four Corners or San Juan Stations (Table 3-2). However, emissions from NMGS would interact with those from the other two stations to raise SO_2 and NO_2 concentrations in an area 19 miles east-north-east of the NMGS. The stations' plumes impact on a 15 by 20 mile area of high terrain in this section of the ES region. In 1985 and 1990 annual SO_2 concentrations in this area would reach 1 to 2 $\mu g/m^3$, while the worst-case 24-hour concentration would range from 3 to 7 $\mu g/m^3$. In 1990 the area affected by this interaction would increase approximately 4 times in size although the concentrations remain the same. Map 3-9 illustrates SO_2 concentrations for the Case 2 development in 1985 and Map 3-10 illustrates those for 1990.

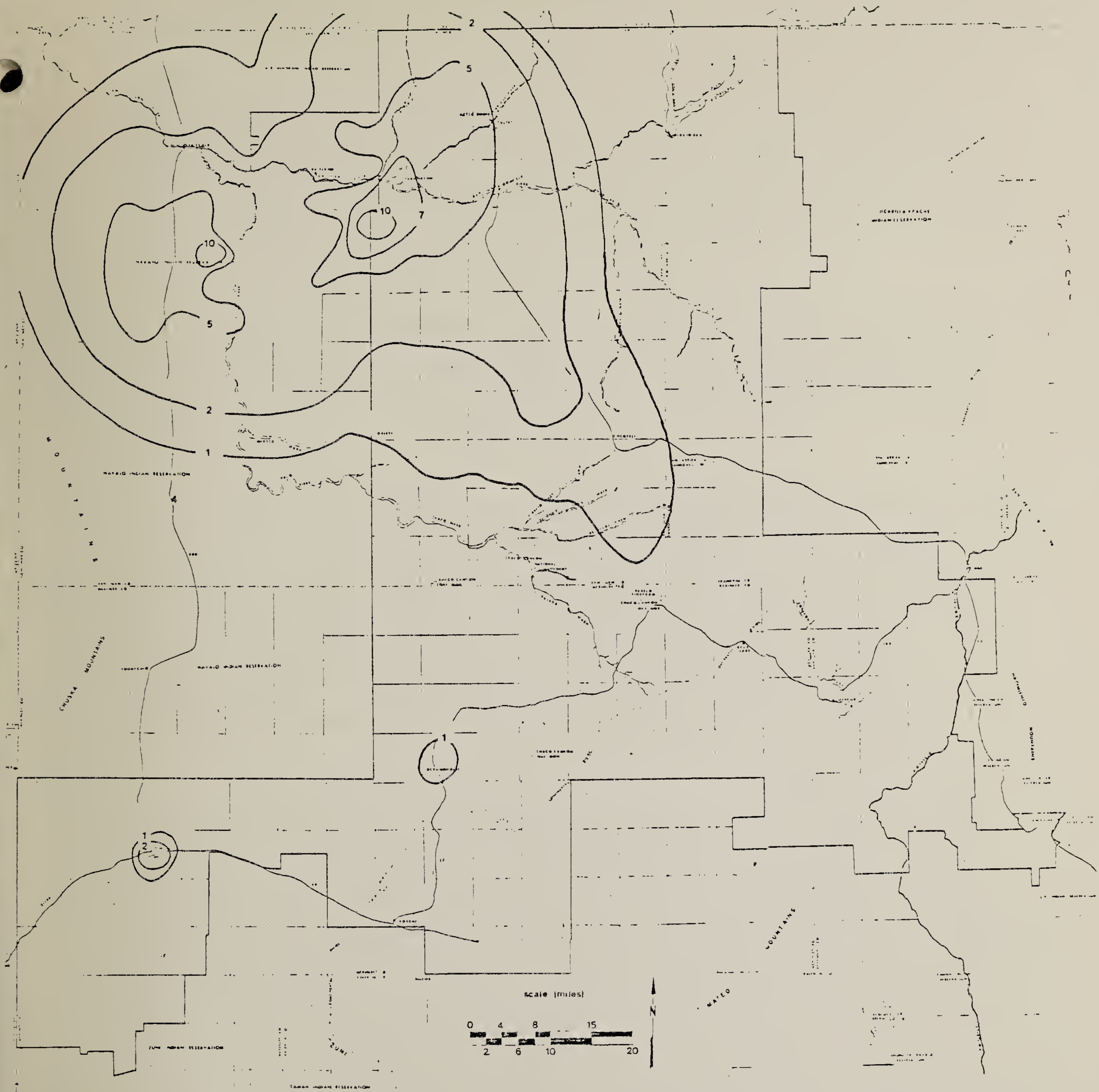
Interactions of the generating stations' emissions would cause a similar pattern for NO_2 concentrations in 1985 and 1990. Annual NO_2 concentrations for 1985 in the area east-north-east of the NMGS would be 1 $\mu g/m^3$,



Map 3-10

ANNUAL AVERAGE SO_2 CONCENTRATION ($\mu g/m^3$)

FOR ~~1990~~ 1985 FOR DEVELOPMENT CASES 2 AND 3



Map 3-9

ANNUAL AVERAGE SO_2 CONCENTRATIONS ($\mu g/m^3$)

FOR ~~1985~~ 1990 FOR DEVELOPMENT CASES 2 AND 3

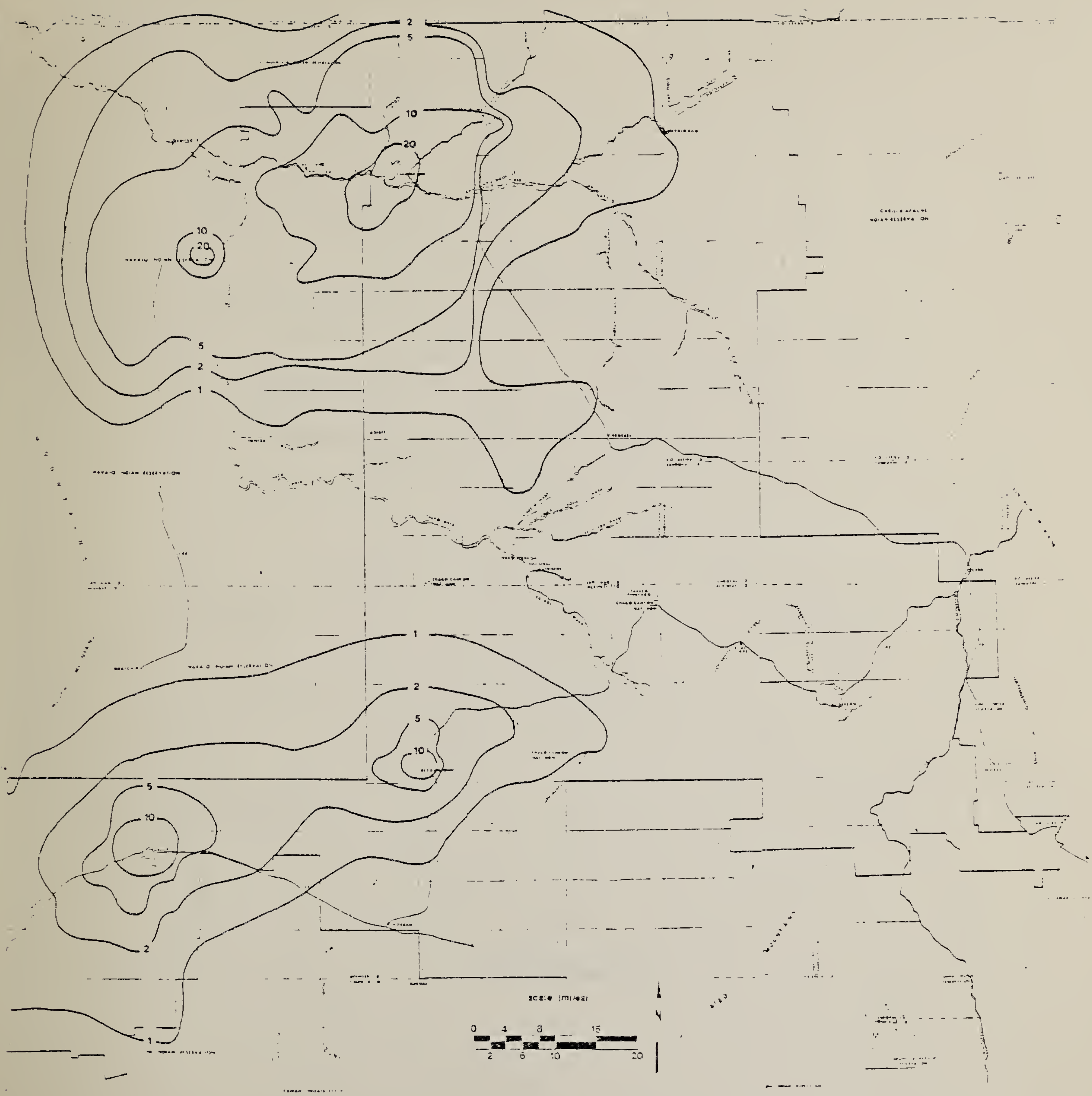
with a worst-case 24-hour concentration of 3 $\mu g/m^3$. In 1990, the area affected by the interacting plumes would increase 4 times. The annual NO_2 concentration would increase to 2 $\mu g/m^3$ and the worst-case 24-hour concentration would be 7 $\mu g/m^3$. Maps 3-11 and 3-12 illustrate NO_2 concentrations for the Case 2 development in 1985 and 1990.

Maximum short-term concentrations due to the NMGS for 1985 and 1990 are shown in Table 3-6. These concentrations occur within 3 miles of the generating station. Neither the national nor the New Mexico standards are violated.

Chaco Canyon National Monument may be designated a Class I PSD area. If so, its PSD increments would be impacted by emissions from the NMGS. Table 3-8 compares predicted maximum SO_2 and TSP concentrations in the monument due to the generating station with the Class I increments. The annual and 24-hour TSP increments would not be consumed either year. In 1985, none of the SO_2 increments would be exceeded. But in 1990, when two more units would have to be added, the 3-hour SO_2 increment would be consumed.

The population growth associated with the proposed actions will not significantly effect regional gaseous concentrations. Concentrations of SO_2 and NO_2 would increase in the cities but not noticeably in the area surrounding them. Due to the proposed actions, populations would increase only 2% to 3% in Farmington and Gallup over the non-action levels. Crownpoint would experience an 11% population increase in 1990 over the no-action level; however, the increase in pollutant emissions would be small because of the small existing population of the town.

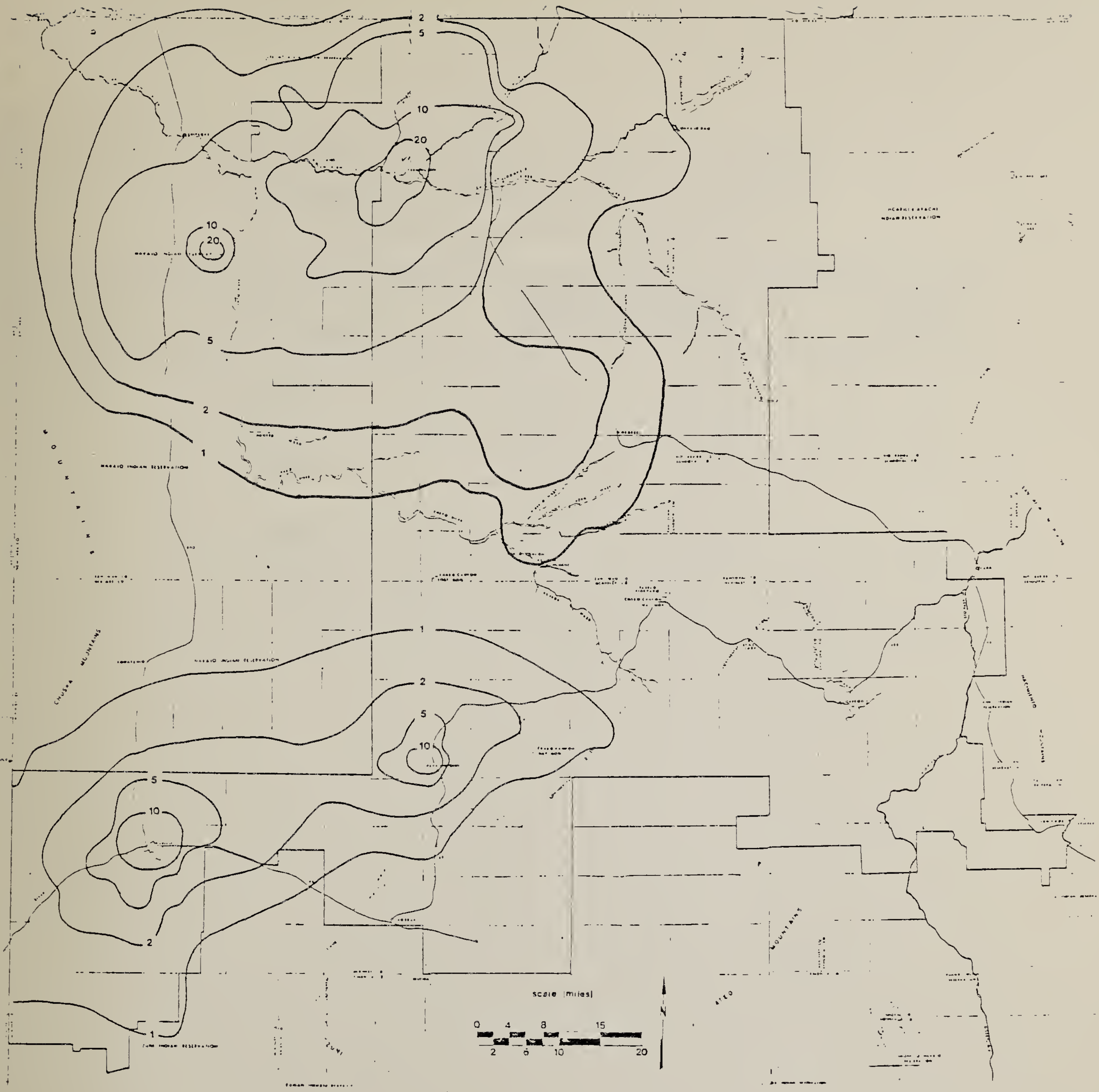
In 1985 and 1990 regional TSP concentrations would increase in the area of the Western-Bisti mine. The effect of emissions from this mine on TSP concentrations would drop to less than 1 $\mu g/m^3$ beyond 6 miles from the mining activities. Two miles from the mine, TSP concentrations would be 35 $\mu g/m^3$ or 5 $\mu g/m^3$ above background. The maximum 24-hour TSP concentration at the edge of this area would be 119 $\mu g/m^3$. In 1990 the only change over



Map 3-11

ANNUAL AVERAGE NO_2 CONCENTRATIONS ($\mu g/m^3$)

FOR 1985 FOR DEVELOPMENT CASES 2 AND 3



Map 3-12

ANNUAL AVERAGE NO_2 CONCENTRATIONS ($\mu g/m^3$)

FOR 1990 FOR DEVELOPMENT CASES 2 AND 3

Table 3-8

SO_2 AND TSP CONCENTRATIONS ($\mu g/m^3$) AT THE CHACO CANYON NATIONAL MONUMENT DUE TO EMISSIONS FROM THE NEW MEXICO GENERATING STATION

Pollutant	Average Time	Concentrations 1985	Concentrations 1990	Class I Increments
SO_2	Annual	<1	<1	2
	24-Hour	2	6	8
	3-Hour	10	31	25
TSP	Annual	<1	<1	5
	24-Hour	<1	<1	10

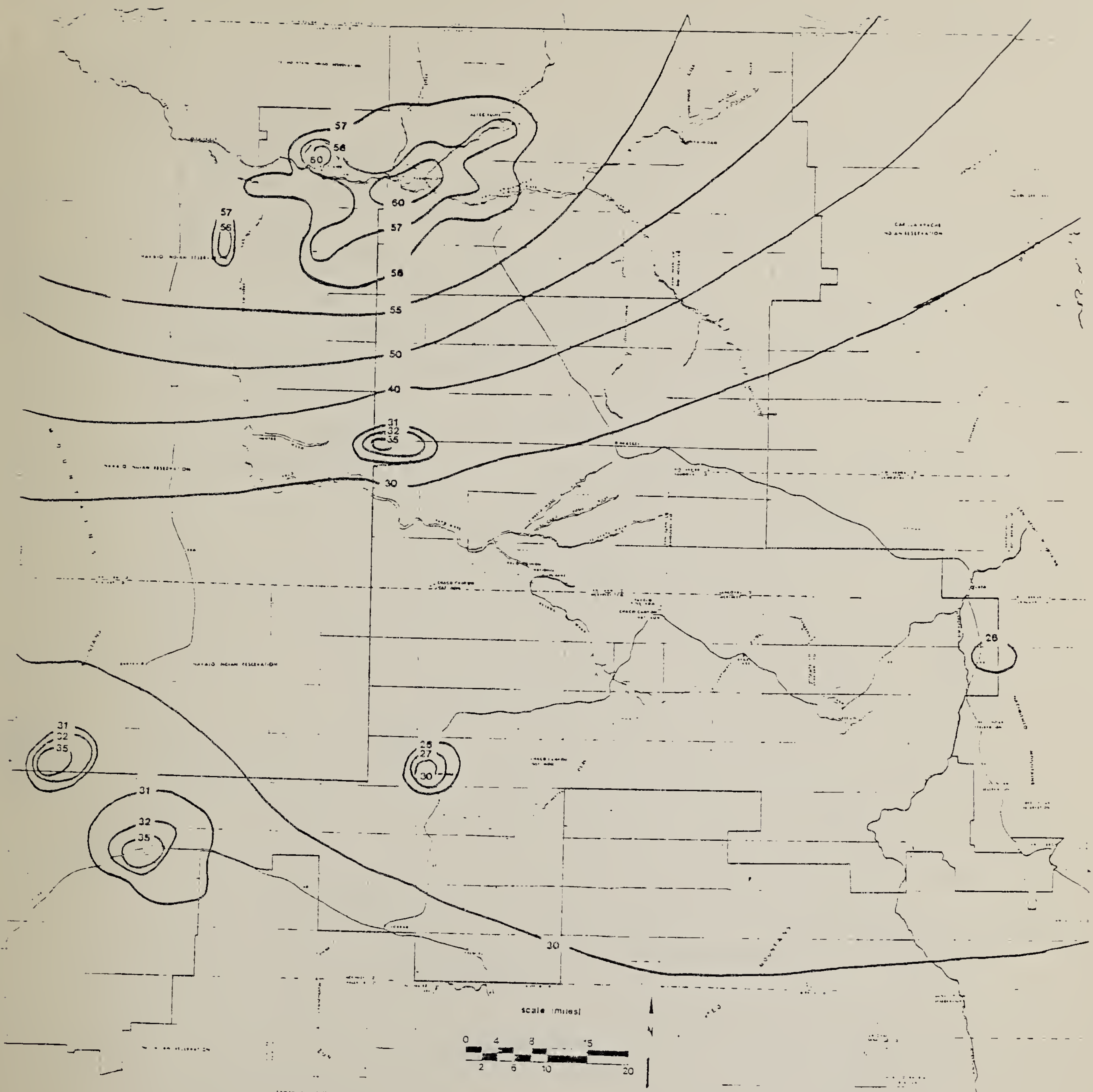
1985 TSP concentration would occur near Gallup due to the termination of the Carbon and AMCOAL mines. Maps 3-13 and 3-14 illustrate annual TSP concentrations predicted for 1985 and 1990.

Maximum 7- and 30-day TSP concentrations in the area surrounding new activities of this development would not violate New Mexico standards or reach levels as high as those described in the Case 1 discussion.

The Class II PSD increments for TSP would not be consumed by the Western-Bisti mine or the NMGS which both begin operating in this level of development.

Regional visibilities would not differ significantly from those discussed in the no-action level except within 2 miles of the Western-Bisti mine. By 1985, the annual visibility in this area would be reduced from 48 to 43 miles; the worst-case 24-hour visibility would be reduced to 17 miles.

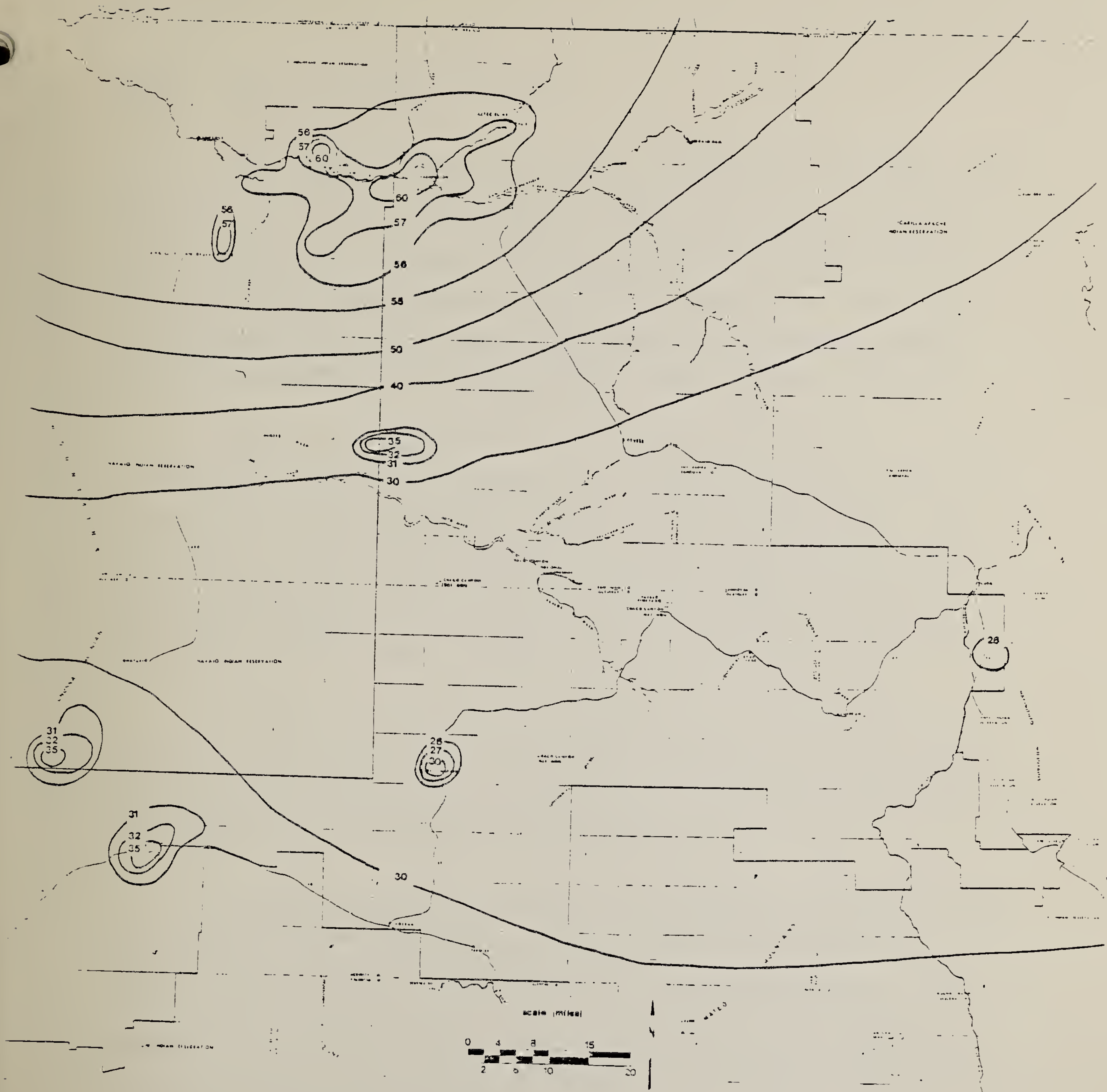
Particulate and SO_2 emissions from the NMGS would have a slight effect on visibilities in the Chaco Canyon National Monument. The worst-case 1-hour TSP concentration in the monument due to the generating station would be 2.7 $\mu g/m^3$ in 1985 and 8.1 $\mu g/m^3$ in 1990. Also, the station would contribute 2.3 $\mu g/m^3$ to the worst-case 1-hour sulphate concentration in 1985 and 7 $\mu g/m^3$ in 1990. A 1 percent conversion rate of SO_2 to sulphate was assumed. Since the monument has an annual background TSP concentration of 25 $\mu g/m^3$, the generating station's particulate and SO_2 emissions would reduce the worst-case 1-hour visibility less than a ½ mile in 1985 and slightly less than a mile in 1990.



Map 3-13

ANNUAL AVERAGE TSP CONCENTRATIONS ($\mu g/m^3$) FOR 1985

FOR DEVELOPMENT CASE 2



Map 3-14

ANNUAL AVERAGE TSP CONCENTRATIONS ($\mu g/m^3$) FOR 1990

FOR DEVELOPMENT CASE 2

3.4.3 Case 3 - Proposed Action Level

This level of development includes, in addition to the Case 1 and 2 activities, the Alamito, Chaco-Star Lake, and Cherokee and Pittsburgh-South Hospah surface mines. Other projects for this case are the Star Lake Railroad, continuation of the Fruitland Transmission Line, and the Rio Puerco Transmission Line from the NMGS. Air quality impacts of the railroad and transmission lines would be insignificant and were not modeled. Map 3-1 shows the locations of the sources included in the partial action level.

There are no additional sources of gaseous emissions for this level of development. Population increases in Farmington and Gallup would range from 3 to 4.8% over the no-action level for the three study years. These increases would not significantly raise pollutant concentrations in the ES region. Thus, SO_2 and NO_2 concentrations would not change from those described for Cases 1 and 2, although the area affected by the emissions from cities would increase in proportion to their population growth.

In 1980 the South Hospah and Chaco-Star Lake mines would begin operation. Annual TSP concentrations around both mines will drop to less than 26 $\mu g/m^3$ three miles from mining activities. Worst-case 24-hour concentrations at this distance would be 88 $\mu g/m^3$.

In 1985 Chaco and South Hospah, with emissions increased over the 1980 levels, would have an annual TSP concentration of 27 $\mu g/m^3$ and maximum 24-hour average of 92 $\mu g/m^3$ 3 miles from mining activities. Five miles from the mining the annual concentration would be 26 $\mu g/m^3$ with a maximum 24-hour average of 88 $\mu g/m^3$. The Alamito mine, which would begin operation in 1982, would have an influence on TSP concentrations equal to those of the Chaco and South Hospah mines.

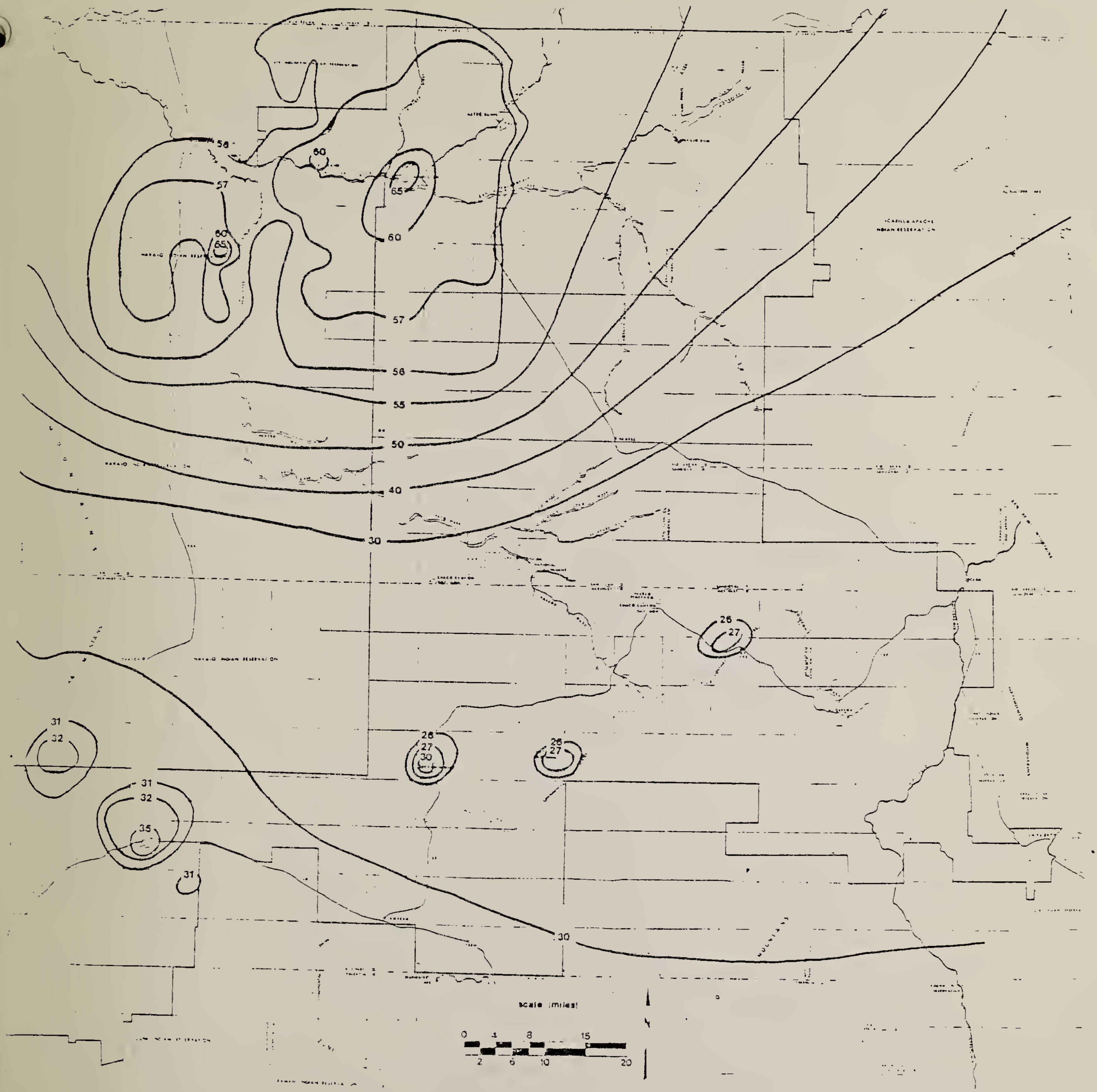
By 1990, there would be two mining areas in the Chaco mine. Two miles from both mining areas, annual TSP concentrations would decrease to

30 μg/m³; and maximum 24-hour concentrations in these areas would be 102 μg/m³. Annual TSP concentrations would be 26 μg/m³ or less over an area about 5-6 miles in radius around the mine. The Alamito and South Hospah mines would have concentration patterns very similar to those predicted for 1985. Maps 3-15, 3-16, and 3-17 illustrate the impact of the partial-action development on annual TSP levels.

Maximum 7- and 30-day TSP concentrations in the area surrounding new activities of this development would not violate New Mexico standards or reach levels as high as those described in the Case 1 discussion.

The Class II PSD increment for TSP would not be consumed in the three study years by the mines which begin operation in this level of development. In addition, emissions from the mines would not use any of the PSD increments in Chaco Canyon National Monument should it be designated a Class I area.

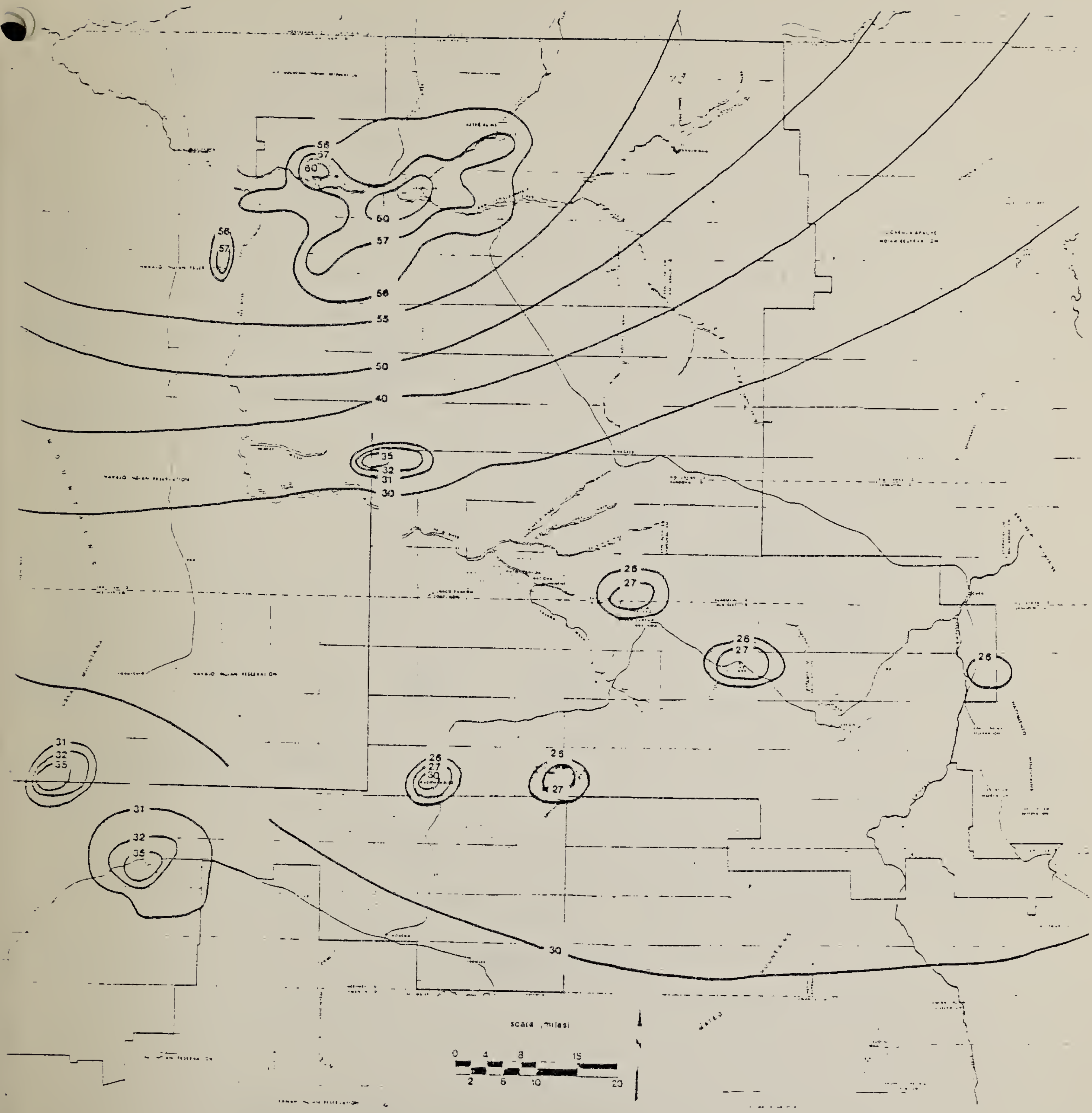
Visibilities in the ES region would not change significantly from those for Case 2 except in areas influenced by the three additional mines of the partial-action development. In 1980, the average annual visibility 3 miles from either mine would be 52 miles, very nearly the annual baseline visibility. The worst-case 24-hour visibility would be 22 miles. During 1985, annual and the worst-case 24-hour visibilities would decrease by 1 mile each within 3 miles of the three mines. In 1990, visibilities around Alamito and South Hospah would not differ from 1985 visibilities. Three miles from the Chaco mining activities the annual visibility would be reduced to 48 miles with a worst-case 24-hour visibility of 20 miles. There would be no reduction in the worst-case, 1-hour visibility in the Chaco Canyon National Monument.



Map 3-15

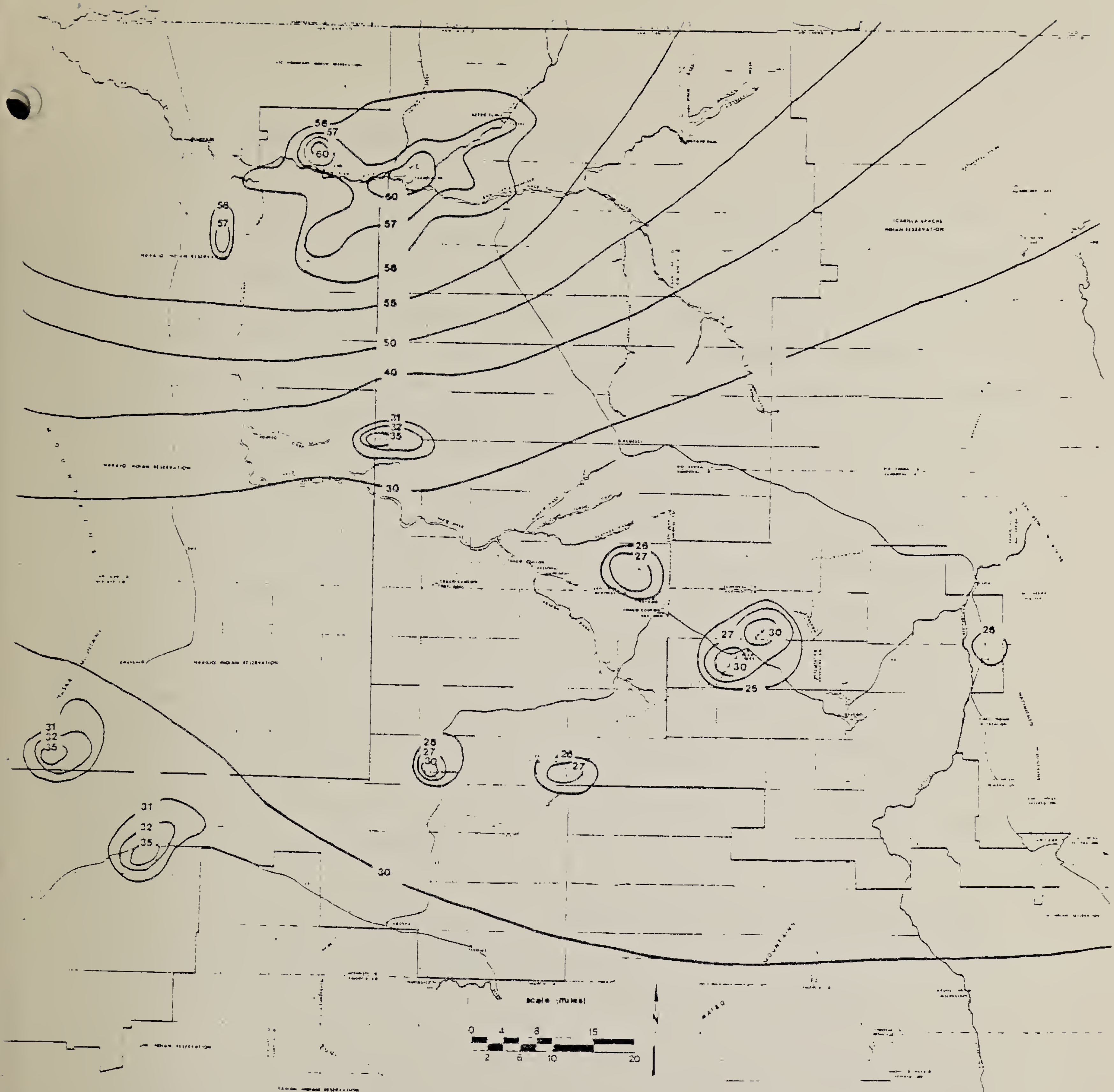
ANNUAL AVERAGE TSP CONCENTRATIONS ($\mu g/m^3$) FOR 1980

FOR DEVELOPMENT CASE 3



Map 3-16

ANNUAL AVERAGE TSP CONCENTRATIONS ($\mu g/m^3$) FOR 1985
FOR DEVELOPMENT CASE 3



Map 3-17

ANNUAL AVERAGE TSP CONCENTRATIONS ($\mu g/m^3$) FOR 1990

FOR DEVELOPMENT CASE 3

3.4.4 Case 4 - High-Level Development

An additional 15 identified mines and 17 potential mining areas would be included in the high-level development. The identified mines would increase coal production from 47% in 1980 to 416% in 1990 over the Case 3 production. Except for the extension of the Western-San Juan mine, all the identified mines lie near one another along the Fruitland coal load. Map 3-1 shows the locations of these additional mines. Particulate emissions from these mines would interact with the proposed Western-Bisti mine and the partial-development Alamito and Chaco Star Lake mines. This would increase TSP concentrations in the center of the ES region. Interaction between adjacent mines would increase annual TSP concentration 5 to 10 $\mu g/m^3$ above the baseline concentrations in the area between mining operations; maximum 24-hour concentrations would increase by 35 $\mu g/m^3$. These increases would occur over the area of mining activity bounded by the Western-Bisti mine on the northwest corner and the Peabody-Star Lake mine on the southeast corner. This area is 60 miles long and 4 to 10 miles wide. Although annual TSP concentrations would increase significantly, they would remain below the New Mexico standards. Annual and 24-hour TSP concentrations in this area of increased mining would be lower than concentrations in the Farmington area with the no-action developments.

Maximum 7- and 30-day TSP concentrations in the area surrounding new activities of this development would not violate New Mexico standards or reach levels as high as those described in the Case 1 discussion.

The Class II PSD increment for TSP would not be consumed by the mines which begin operation in this level of development. If Chaco Canyon National Monument was to be designated a Class I PSD area, only mines very near the monument's border would consume the TSP increment. No impacts on the PSD Class I increments for SO_2 would occur as a result of development of new mines.

Impacts on the Class I increment would occur only for small areas along the monument's northern border. The impact on PSD increments for TSP

in Chaco Canyon would be very small since "exempt" fugitive dusts, which make up 85% of the emissions from surface mines, are not considered in determining the amount of the PSD increment consumed. Also, most of the dust coming from the mines consists of large particles which settle before they are transported far.

The increased population due to the high-level development would increase TSP, SO_2, and NO_2 emissions from towns. Annual and 24-hour concentrations around Gallup and Farmington could increase by 5% over the partial-action level. But, the largest percentage increase in concentrations would likely occur around Crownpoint. Crownpoint would experience a relatively large population growth, 17% over the 1990 partial-action level. As a result, pollutant concentrations could increase 17% due to the proximity of Crownpoint to the additional mines of the high-level development. Concentration increases would result in the continued violation of ambient air quality standards in the area surrounding Farmington. In addition, the size of the area influenced by the emissions from the town would certainly increase not only due to increased emissions but to increased dimensions of the town.

Both average annual and worst-case 24-hour visibilities around Gallup and Farmington would decrease by at least 1 mile. The largest change in visibilities would occur in the 60 mile long area along the Fruitland coal load where the majority of the high-level mines would be located. Annual visibilities in this area would drop from the present 53 miles to 43 miles while the worst-case 24-hour visibility would be reduced from 23 miles to 17 miles.

One-hour worst-case visibilities in the Chaco Canyon National Monument could be reduced from their present value of 12 miles to 9 miles. This reduction would occur along the northern border of the monument if surface mines are operating within 3 to 5 miles from the monument boundary. It appears that no coal leases assigned to any of the four development cases will be located any closer than 3-5 miles from the monument.

4.0 ANY ADVERSE IMPACTS WHICH CANNOT BE AVOIDED SHOULD THE PROPOSED ACTIONS BE IMPLEMENTED

The increase of emissions of particulates, SO_2, and NO_2 would be unavoidable although their increases would be controlled. Although stringent fugitive dust control measures would be applied to the mines, federal and state ambient standards would be violated very near specific dust sources in the mines.

Best available control technology would be applied to control SO_2, NO_x, and particulate emissions from the power plants to mitigate impacts on ambient air quality standards and PSD increments. Even though ambient pollutant levels resulting from emissions from new power plant units would be relatively low, atmospheric pollutant levels would increase.

A loss of visibility would be anticipated because of the increase in particulate emissions and the aerosol formed in the atmosphere from sulfur dioxide, nitrogen oxides, and hydrocarbons. However, the decrease in visibility in the ES region as a whole would not be significant.

The degradation of air quality caused by emissions related to growth of towns would cause an unavoidable increase in pollutant levels around the towns. The attendant urban development would be created from the need to supply services to the labor force and their families.

5.0 THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF THE LONG-TERM PRODUCTIVITY

While operating, coal mines could possibly exceed the New Mexico and National Ambient air quality standards very near the mines. Since the fugitive dust emissions from the mines are excluded from contributing to the PSD increments, a very small portion of the TSP increments would be consumed.

In the long-term, the increased urbanization from population growth associated with the coal mining would cause a rise in TSP, SO_2, and NO_2 concentrations in the towns of the ES region. If the labor force remains after the coal mining has ceased, the projected urban air pollutant concentrations would persist. Moreover, if they are re-employed, new sources of industrial pollution may arise.

6.0 ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES WHICH WOULD BE INVOLVED IN THE PROPOSED ACTIONS SHOULD THEY BE IMPLEMENTED

The loss of clean, clear air during mining operations would be irretrievable. The TSP concentrations greater than the New Mexico and national ambient air quality standards around proposed mines and proposed activities would be irretrievable. Any fugitive dust emissions at the mines would reduce visibilities around the mines. However, these impacts would not be irreversible.

Increased urbanization of the ES region caused by surface mining would irretrievably increase ambient pollutant concentrations. The air quality impact caused by urbanization would be reversible to the extent that most of the population associated with surface mining would move out of the region after the mining ceases.

7.0 REFERENCES

Brier, G. W., 1973: "Validity of the Air Quality Display Model Calibration Procedure." Publication No. EPA-R4-73-017, Environmental Protection Agency, Research Triangle Park, North Carolina.

Briggs, G. A., 1971: Some Recent Analyses of Plume Rise Observation, in Proceedings of the Second International Clean Air Congress, England, H.M. W. T. Baery (ed.).

Briggs, G. A., 1972: "Discussion on Chimney Plumes in Neutral and Stable Surroundings," Atmospheric Environment 6, 507-510.

Busse, Adrian D. and John R. Zimmerman, 1973: Users Guide for the Climatological Dispersion Model, EPA-R4-73-024.

Cowherd, Chatten, Kenneth Axetell, Jr., Christine Guenther, George Jutze, 1974: Development of Emission Factors for Fugitive Dust Sources, Publication No. EPA-450/3-74-037, U. S. Environmental Protection Agency, Office of Air and Waste Management, Research Triangle Park, North Carolina.

Ettinger, Harry J. and George W. Royer, 1972: "Visibility and Mass Concentration in a Nonurban Environment," Journal of the Air Pollution Control Association, Los Alamos Scientific Laboratory, University of California, Los Alamos, New Mexico.

Holzworth, G., 1972: Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States, Environmental Protection Agency, Office of Air Program, Research Triangle Park, North Carolina.

Larsen, Ralph I., 1971: A Mathematical Model for Relating Air Quality Measurements to Air Quality Standards, Environmental Protection Agency, Research Triangle Park, North Carolina.

Makecki, E. J., personal communications, 1978: Department of Geography and Science and Public Policy Program, University of Oklahoma, Norman, Oklahoma.

Mills, M. T. and F. A. Record, 1975: Comprehensive Analysis of Time-Concentration Relationships and Validation of a Single-Source Dispersion Model, Publication No. EPA-450/3-75-083 (NTIS PB 250814/AS), Environmental Protection Agency, Research Triangle Park, North Carolina.

Pasquill, F., 1974: Atmospheric Diffusion, 2nd ed., John Wiley and Sons, New York.

PEDCo-Environmental, Inc., 1977: "Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions," EPA-450/3-77-010, U. S. Environmental Protection Agency, Contract No. 68-02-1375, Task No. 33, Cincinnati, Ohio.

PEDCo-Environmental, Inc., 1978: "Survey of Fugitive Dust from Coal Mines," Contract No. 68-01-4489, Project No. 3311, Cincinnati, Ohio.

Radian Corporation, 1976: Final Report: Arkansas Air Quality Maintenance Plan Development, U. S. Environmental Protection Agency, Region IV, Dallas, Texas.

Radian Corporation, 1977: Regional Assessment of Air Quality, Volume 2, Bureau of Land Management, Albuquerque, New Mexico, August 5, 1977.

Slade, David H., 1968: Meteorology and Atomic Energy, U. S. Atomic Energy Commission, Division of Technical Information.

Turner, D. B., 1972: Workbook of Atmospheric Dispersion Estimates, U. S. Environmental Protection Agency, Office of Air Programs, Publication No. AP-26.

U. S. Department of the Interior, 1976: Final Environmental Statement, Northwest Colorado Coal, Bureau of Land Management.

U. S. Department of the Interior, 1977: Proposed Expansion of the San Juan Power Plant, New Mexico: Final Environmental Statement, FES-77-29, Bureau of Reclamation.

U. S. Environmental Protection Agency, 1975: Supplement 5 for Compilation of Air Pollution Emission Factors, Research Triangle Park, North Carolina.

U. S. Environmental Protection Agency, May 1976, Wyoming Air Quality Maintenance Area Analysis, EPA-908/1-76-008, Air and Hazardous Materials Division, Denver, Colorado.

U. S. Environmental Protection Agency, 1977a, National Emission Data Systems Inventory for McKinley and San Juan Counties, New Mexico, Dallas, Texas.

U. S. Environmental Protection Agency, 1977, Interim Guideline on Air Quality Models, OAQPS No. 1.2-080, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

APPENDIX

MODELING AND ANALYSIS METHODS

APPENDIX

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Emission Calculations

Mines

Emissions calculations were made for 1980, 1985, and 1990. Only fugitive dust emissions were calculated for the coal mining operations because particulates are the only pollutant generated in sufficient quantity to have a significant effect on air quality. Major sources within a surface mine which contribute to fugitive dust emissions include draglines, blasting, exposed areas, topsoil removal, loading of coal and overburden, and haul road traffic. Fugitive dust sources for both surface and underground mines include coal crushing, coal storage piles, and access road traffic.

The emissions of fugitive dust associated with construction activities would be very small in comparison to the emissions from the actual mining operations. Construction-related emissions would also occur intermittently and would not have a significant impact on air quality.

The ten coal mines modeled and their associated total particulate emissions are listed for each of the study years in Table 3-1, Section 3.0.

The emission factors used to calculate fugitive dust emissions from surface coal mines are listed in Table A-1. The factors are based on PEDCo's (1978) study. Emission factors for mines having soil similar to the soil in the ES were used. Information on file at the BLM office in Albuquerque, New Mexico was used to determine mining activities and soil characteristics in the ES region. Fugitive dust control factors were applied to emission rates where appropriate.

The overburden at the different sites was removed by one of two methods--dragline or shovel/truck loading. An emission factor of .053 lb/yd^3 for dragline removal of overburden was arrived at using available information. The emission factor from northern Wyoming (PEDCo, 1978) for shovel loading

Table A-1

UNCONTROLLED EMISSION FACTORS
FOR SURFACE COAL MINES

Operation	Units	Factor
Dragline	lb/yd^3	.053
Haul Roads	lb/veh-mi	13.6
Blasting		
Coal	lb/ton	.036
Exposed Areas	tons/acre-yr	1.1
Shovel/Truck Loading		
Coal	lb/ton	.007
Overburden	lb/ton	.037
Truck Dumping		
Coal	lb/ton	.007
Overburden	lb/ton	.002
Coal Storage Pile	lb/ton	.076
Topsoil Removal	lb/yd^3	.38
Front-end Loader	lb/ton	.12
Haul Road Construction & Repair	lb/hr	32.
Coal Crushing	lb/ton	2.
Access Road Traffic	lb/veh-mi	3.3

of overburden was used because it was the only one available. An overburden density of 1.75 tons per cubic yard was used to convert overburden volumes to tonnages based on the available information.

Coal removal at various sites was performed in one of two ways--shovel/truck loading or front-end loader. Using available information, an emission factor of .007 lb/ton was arrived at for removing coal by shovel/truck loading. Where available information indicated a front-end loader would be used to load coal the emission factor for Central North Dakota was used because it was the only one available.

Use of bottom dump trucks for coal dumping was assumed for the mines based on available information. An emission factor of .007 lb/ton was arrived at for coal dumping. The emission factor for overburden dumping in northern Wyoming was used because it was the only one available. Overburden dumping was a factor only at sites which remove overburden by shovel/truck loading as opposed to the use of draglines.

In determining the number of haul truck cycles required to transport coal or overburden, each truck was assumed to carry 120 tons unless a different capacity was indicated in the available information.

Unless otherwise indicated, a haul road length of one mile, one-way, was assumed to determine the vehicle miles traveled per year. Based on available information a haul road emission factor of 13.6 lb/veh. mi. was arrived at and used with a control factor of 50% for watering to determine the final emission values for haul road traffic.

The emission factor for haul road construction and repair was taken from the Wyoming Air Quality Maintenance Area Analysis (Environmental Protection

Agency, 1976). Based on regular haul road watering, a control efficiency of 50% was applied to calculating particulate emissions (PEDCo, 1978). Haul road construction and repair were assumed to occur eight hours per day, 83 days per year at each mine. For all the mines, a maximum access road length of one mile was used to calculate vehicle mileage. This assumption was made because access road emissions greater than one mile from the mine have little impact at the mine itself. The number of vehicles was calculated based on 1.5 employees per vehicle. Average employment figures for each mine were used. A particulate emission factor of 3.3 lb/veh.-mi. was arrived at for access road traffic (Colorado Air Pollution Control Division, 1978).

Emissions from coal and overburden storage were calculated by adding together emissions from wind erosion from storage piles, emissions from maintenance, and emissions from loading of coal out of the piles. Wind erosion emissions from coal storage piles were calculated using an emission factor of .018 lb/ton (Colorado Air Pollution Control Division, 1978). A storage pile of 125,000 tons was assumed for sites which mined in excess of 500,000 tons in a given year, the size of the storage pile was assumed to be 25% of the coal mined. the size of the storage pile was assumed to be 25% of the coal mined.

Particulate emissions due to load-out of coal from storage piles were calculated using a factor of 0.05 lb/ton stored and the particulate emissions from coal pile maintenance were calculated using a factor of 0.03 lb/ton (Colorado Air Pollution Control Division, 1978).

The complete equation used to determine wind erosion of exposed areas is:

$E_s = AIKCL'V'$, (Cowherd, et al, 1974)

where E_s = suspended particulate fraction of wind erosion losses, tons/acre-year

A = portion of total wind erosion losses that would be measured as suspended particulates, estimated to be 0.025

I = soil erodibility

K = surface roughness factor

C = climatic factor

L' = unsheltered field width factor

V' = vegetative cover factor

The soil erodibility of 42 tons/acre-year used was based on soils maps for the ES study region. Because an unridged surface was assumed, a surface roughness of 1.0 was used. The reported climatic factor of 1.2 was used (Cowherd, et al, 1974). An unsheltered field width factor of 0.9 was selected (Cowherd, et al, 1974), assuming an unsheltered distance along the prevailing wind direction, L, of 2000 feet. A vegetative cover factor of 1.0 was used, assuming no cover on the exposed areas. Emissions from exposed areas were calculated with the assumption that three times the annual disturbed area due to mining would contribute atmospheric particulates from wind erosion.

Emissions due to coal crushing and screening, topsoil removal and blasting comprise the values of the miscellaneous category. The emission factor for coal crushing was taken from emission factors developed by the U. S. Environmental Protection Agency for stone quarrying and processing (U. S. Environmental Protection Agency, 1975). A fabric filter system with a 99% collection efficiency was assumed to be installed on all coal crushers. All

coal mines were assumed to have both primary and secondary coal crushing operations as indicated from available information.

For topsoil removal, volumes were determined by using 780 yd^3 per acre, based on an average topsoil depth of 6 inches over the mining area. This depth was the topsoil thickness that would be replaced during reclamation. The emission factor in Table A-1 accounts for both scraping and dumping.

Coal and overburden blasting procedures were not specified for all the mines in the ES region. An average emission factor based on the amount of coal mined per year was developed using blasting information that was available.

The emission factors used to calculate fugitive dust emissions from the one underground mine in the ES region are listed in Table A-2. The factors are based on PEDCo's (1978) study. Since overburden is not a concern when dealing with underground mines, emissions can be based solely on a tons-of-coal-mined basis. The emissions fro underground mines due to crushing and screening, exposed areas and haul and access road traffic were computed in the same manner as for surface mines.

In computing wind erosion values for underground mines, emissions due to exposed areas were the only values considered. This was due to the fact that emissions related to storage piles were included in the coal removal and truck dumping values as shown in Table A-1.

The values of the miscellaneous category for underground mines consist solely of the emissions due to coal crushing and screening. This is due to the fact that blasting and topsoil removal are not included among underground mining activities.

Table A-2

UNCONTROLLED EMISSION FACTORS FOR
UNDERGROUND COAL MINES*

Operation	Units	Factor
Portal Conveying	lb/ton	.05
Load from Portal Conveyor onto Storage Pile	lb/ton	.04
Wind Erosion and Maintenance	lb/ton	.004
Load Out from Storage Pile	lb/ton	.05
Conveying to Processing Plants	lb/ton	.05
Load Out into Trucks	lb/ton	.05

* PEDCo (1978)

Emission sources for coal removal for underground mines consist of the portal conveyors, wind erosion and maintenance, loading out from storage piles, conveying to processing plant, and loading out into trucks.

The emissions for truck dumping for underground mines consist of the emissions due to loading from portan conveyors onto storage piles.

Towns

Emissions from towns with populations greater than 1000 were calculated based on population growth. Current emissions of total suspended particulates (TSP), sulfur oxides (SO_2), and nitrogen oxides (NO_x) for McKinley and San Juan Counties were determined from the National Emissions Data System (NEDS) Inventory for 1977 (U. S. Environmental Protection Agency, 1977). Emissions were apportioned by comparing estimated city populations for the three years for each case to the estimated 1977 county populations. This information was obtained from information at BLM's Albuquerque office. By using these population estimates and projections, the emissions of each pollutant for urban areas for 1977 were determined as the ratio of the urban area population to the county-wide population multiplied by the total area source emissions of each pollutant for the county. Emissions for 1980, 1985, and 1990 for each pollutant and each urban area were then calculated by multiplying the 1977 urban area emissions by the ratio of the projected urban population for the study years to the 1977 population.

Dispersion Modeling Techniques

Basic Models

The models used in this study predict annual average and short-term ambient pollutant concentrations. The annual average model uses statistical meteorological data constructed from observations made at National Weather

Service Offices. The computation of concentrations for a grid of receptors is based on the joint frequency of wind speed, wind direction and stability classes. The model is based upon the steady-state Gaussian dispersion equation, modified to account for deposition of particulate matter.

Two short-term modeling methods were used to predict maximum pollutant concentrations for averaging periods of 24-hour or less. Predicted annual average pollutant concentrations were scaled using statistical techniques developed by Larsen (1971) to determine maximum short-term pollutant concentrations in the vicinity of towns and mines. Maximum 24-hour TSP concentrations in the vicinity of generating stations were determined using an EPA-developed 24-hour steady-state Gaussian dispersion model (CRSTER).

All models implemented in this study are derived from the basic diffusion equation which describes the mass flow-rate from a region of high concentration to one of lower concentration (Pasquill, 1974):

$$\frac{\partial c}{\partial t} = \nabla uc + \nabla^2 kc + Q - D$$

where

c = pollutant concentration

u = wind vector

k = diffusivity or dispersion coefficients

Q = emission rate of pollutant

D = deposition rate

$\nabla = \frac{\partial}{\partial x} + \frac{\partial}{\partial y} + \frac{\partial}{\partial z}$

$-\nabla uc$ = transportation term (wind)

$\nabla^2 kc$ = diffusion term

The equation is difficult to use in this form. Certain assumptions must be made in order to develop a more usable algorithm for the dispersion model. The assumptions are:

1. The rate of change of pollutant concentration is zero, i.e., $\frac{\partial c}{\partial t} = 0$, for the averaging time.

2. There is no vertical component to the wind.

3. Diffusion only occurs in the vertical and horizontal directions, i.e., no downwind diffusion.

4. The maximum concentration is at the plume centerline anywhere downwind. The distribution of the concentration in the vertical and horizontal is normal or Gaussian.

5. Wind speed and direction are constant for the time increment for when predictions are made.

6. Except for the deposition of larger size particulates, none of the pollutants are lost from the plume. When the plume impacts the ground all its matter is reflected back.

Using these assumptions a new form, the steady-state Gaussian formulation, is developed which is much easier to use but restricted in applications (Turner, 1972). The standard form for relating point source emissions to air pollutant concentrations can be written:

$$c = \{\text{source emissions}\}\{\text{horizontal dispersion}\}\{\text{vertical dispersion}\}\{\text{deposition}\}$$

$$\frac{Q}{2\pi\mu\sigma_y\sigma_z} \exp\left[-\frac{1}{2}\left(\frac{Y}{\sigma_y}\right)^2\right] \left\{\exp\left[-\frac{1}{2}\left(\frac{z-H}{\sigma_z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{z+H}{z}\right)^2\right]\right\} \exp\left[\frac{-vd}{\mu}\left(a^x\right)^{-g}\right]$$

where

c = pollutant concentration at point x, y, z

Q = mass emission rate (g/sec)

u = wind speed (m/sec)

x = downwind distance to receptor(m)

y = crosswind distance to receptor (m)

z = height of receptor above ground (m)

H = height of plume centerline above ground (m)

σ_y = horizontal crosswind dispersion coefficient (m)

σ_z = vertical crosswind dispersion coefficient (m)

v_d = deposition velocity (m/s)

a,b = constants dependent upon atmospheric stability

In use, the equation is generalized to represent the pollutant concentration at any number of downwind receptors due to multiple point sources averaged over a number of meteorological conditions.

Annual Model

The steady-state Gaussian dispersion formulation can be modified to predict annual average pollutant concentrations. This model, almost identical to the Climatological Dispersion Model (CDM) developed by the U. S. Environmental Protection Agency (Busse and Zimmerman, 1973), requires the input of a meteorological data base consisting of joint frequencies of wind speed, wind

direction and stability class. This dispersion equation is exercised to predict pollutant concentrations for a rectangular receptor grid for each of 576 combinations of wind speed, wind direction and stability class.

The predicted annual average concentration is, then, a weighted average of each of the 576 predictions for each receptor. The weighting factor is the frequency of occurrence of each of the 576 sets of meteorological conditions.

For N point sources the equation used in the annual model for calculating the average concentration $\overline{Cp}$ is:

$$\overline{Cp} = \frac{16}{2\pi} \sum_{n=1}^{N} \sum_{\ell=1}^{6} \sum_{m=1}^{6} \frac{\Phi\left(k_n, \ell_m\right) G_n S\left(r_n u_\ell P_m\right)}{r_n}$$

where

ℓ = index identifying the wind speed class

m = index identifying stability class

n = index identifying source

r_n = distance from receptor to n^{th} source

Gn = emission rate from n^{th} source

k_n = wind sector appropriate to the n^{th} source

u_ℓ = representative wind speed

Pm = stability class

$\Phi\ (k_n, \ell_m)$ = annual joint frequency distribution

$S\ (r_n, u_\ell, P_m)$ = dispersion function $= \frac{2}{\sqrt{2\pi}\ u_\ell \sigma_z (r_n)} \exp - \frac{1}{2} \left(\frac{h}{\sigma_z (r)}\right)$

If $\sigma_z(r)$ is less than or equal to 80% of the afternoon mixing height,

$$S(r_n, u_\ell, P_m) = \frac{1}{U_\ell L}.$$

The horizontal dispersion coefficient, σ_y, is not used in this form of the annual model. Crosswind or horizontal dispersion is considered uniform throughout the $22\frac{1}{2}^o$ wind sector, k_n.

A spatially integrated form of Gaussian plume equation is used to allow simulation of area sources. The numerical integration techniques of Gaussian quadrature and sector averaging are used for the two dimensional integration needed to calculate an area source's impact on air quality. Emissions are assumed homogeneous over the entire area source. The average annual concentration $\overline{C}_A$ due to area sources at a particular receptor is

$$\overline{C}_A = \frac{16}{2\pi} \int_o^\infty \left[\sum_{k=1}^{16} q_k(r) \sum_{\ell=1} \sum_{m=1} \Phi(k_n, \ell_n,) S(r_n, u_\ell, Pm) \right] dr$$

All variables are the same as in the point source formulation except:

$q_k(r) = Q(r,\phi)d\phi$,

$Q(r,\phi)$ = emission rate of the area source per unit area and unit time, and

ϕ = angle relative to polar coordinates centered on the receptor.

Short-Term Models

For calculating maximum 24-hour pollutant concentration in the vicinity of towns and mines, statistical methods developed by Larsen (1971) were used. Analyses of air pollution data collected in towns indicate the following: pollutant concentrations are log-normally distributed for all

averaging times, median concentrations are proportional to averaging times raised to an exponent, and maximum concentrations are inversely proportional to averaging time raised to an exponent (Larsen, 1971). These characteristics were used to develop equations for the standard geometric deviation, geometric mean, and maximum concentration for several different cities in the U. S. Correlations between the standard geometric deviation and the maximum concentration for different averaging times were also developed. These correlations are used to estimate concentrations for different averaging times based on a concentration at a known averaging time.

Larsen's statistics may be used to predict maximum short-term pollutant concentrations near towns or in the vicinity of a group of geographically distributed low-level area sources such as mines. However, a short-term Gaussian dispersion model is preferable to Larsen statistics for predicting maximum pollutant concentrations in the vicinity of single tall-stack point sources. Therefore, maximum 1-, 3-, and 24-hour average pollutant levels in the vicinity of power plants in the ES study region were predicted using a short-term Gaussian model (CRSTER).

The short-term model (CRSTER) is used to predict pollutant concentrations for averaging periods ranging up to 24 hours. The desired averaging period is divided into an integral number of time intervals. The specified plant emissions and meteorological conditions are assumed constant within a time interval, but can change from one interval to another. For a given interval, the short-term model is used to compute the concentrations at particular receptors, and the final concentration for the desired averaging time is computed as a weighted average of the contributions from the

individual time increments. The CRSTER model is based upon a modified version of the Gaussian plume equation.

The meteorological input data for CRSTER consists of a year's supply of hourly values for wind speed, direction, mixing height and other meteorological variables required for the determination of stability class and plume rise.

Plume Rise

Both the annual and 24-hour models require a calculation of plume rise. As a plume leaves its source, its buoyancy or momentum causes it to rise until it reaches equilibrium with the atmosphere. Briggs (1971, 1972) formulated two cases for plume rise. The first is for neutral and unstable atmospheric conditions and the second for stable atmospheric conditions. His research concluded that the final rise occurs at a downwind distance that is a function of buoyancy.

The formulation for unstable and neutral conditions is:

$$\Delta h = \frac{1.6F^{1/3}}{u} (3.5\ X^*)^{2/3}$$

where

$F = gv' (T_o - T_a)/T_a$, the bouyancy (m^4/sec^3)

g = gravitational acceleration (m/sec^2)

v = exhaust volume flux (m^3/sec)

T_o = stack gas temperature (^oK)

T_a = ambient temperature (^oK)

u = wind speed at top of stack (m/sec)

X^* = downwind distance at plume height equilibrium (m)

$X^* = 14F^{5/8}$ for $F \leq 55$

$= 34F^{2/5}$ for $F > 55$

Under stable conditions Briggs derived the following:

$$\Delta h = 2.9 \left(\frac{F}{us}\right)^{1/3}$$

where

s = the stability parameter

$$= g/\theta_a \frac{\partial \theta_a}{\partial z} \quad (\sec^{-2})$$

θ_a = ambient potential temperature

Z = height (m)

The potential temperature is that temperature a parcel of air would have if brought from its original temperature and pressure to a standard pressure of 1000 mb. Thus:

$$\frac{\partial \Theta_a}{\partial Z} \simeq \frac{\Delta T}{\Delta Z} + 10^{o}C/Km \text{ rise}$$

In the stable case $\frac{\partial \theta_a}{\partial Z}$ is always positive.

Atmospheric Stability and Dispersion Coefficients

The dispersion coefficients (σ_y and σ_z) used in the annual and short-term Gaussian models are empirically determined functions related to atmospheric turbulence, distance from the source and the length of the concentration averaging time.

These coefficients describe the shape or spread of the plume in the vertical and horizontal crosswind directions. The atmospheric turbulence is defined by the stability classes. These classes are determined for the annual model by the wind speed and solar radiation during the day or wind speed and

cloud cover during the night. The relationship between stability classes and surface meteorological conditions is presented in Table A-3 (Turner, 1972). The most unstable class is A with F the most stable. The neutral class, D, should be assumed for overcast conditions during day or night.

The dispersion coefficients or standard deviations of pollution concentration are largest in unstable conditions and smallest in stable conditions. This means that the plume disperses more rapidly in the vertical and horizontal directions during unstable conditions than during stable conditions. The annual model uses the Pasquill-Gifford dispersion coefficients.

Wind Speed Extrapolation

Wind speed normally increases with height. The data for wind speed are normally collected on an anemometer 10 meters above ground. To account for any increase in speed when the pollutants are emitted from sources higher than 10 m, the following function was derived (Busse and Zimmerman, 1973):

$$u_z = u_{10} \left(\frac{Z}{10}\right)^p$$

where

u_{10} = wind speed at 10 meters

Z = height of pollutant emission

p = empirically determined constant (a function of stability)

Table A-3

RELATIONSHIP BETWEEN STABILITY CATEGORIES

AND SURFACE METEOROLOGICAL CONDITIONS

Surface Wind Speed (at 10 m), m sec^{-1}	Day Incoming Solar Radiation			Night	
	Strong	Moderate	Slight	Thinly Overcast or ≥4/8 Low Cloud	≤3/8 Cloud
< 2	A	A–B	G		
2–3	A–B	B	C	E	F
3–5	B	B–C	C	D	E
5–6	C	C–D	D	D	D
> 6	C	D	D	D	D

Stability Class	p
A	.1
B	.15
C	.2
D	.25
E & F	.3

Meteorological Inputs

Necessary meteorological inputs to the annual model are the mixing height, the ambient temperature and joint frequencies of occurrence of wind speed, wind direction, and stability class. Mixing height is the height above the ground through which vertical mixing of the air occurs. The mixing layer is established as the sun heats the ground and causes the air immediately above it to warm. This warm air is unstable and begins to rise, then cool and fall, only to be warmed again. As the day proceeds, more and more air is warmed and the mixing height increases. Pollutants are rapidly diluted in the unstable air within the mixing layer but cannot rise above the mixing layer into the stable layer. Thus, only the mixing layer, not the entire atmosphere, can dilute the concentration of the emitted pollutants.

For surface-generated dust, the height of this layer is not very important. The majority of the dust will settle out even at relatively low mixing heights before complete mixing can occur. It is much more important to consider mixing height in the dilution of gaseous pollutants from elevated smokestacks. Not only are emissions released from these sources at higher levels, but they are also usually buoyant and rise higher than the physical stack height.

The short-term Gaussian model (CRSTER) requires the input of average wind speed, wind direction, stability class, and temperature for each time increment modeled for every day of the year. Data must be obtained from surface meteorological data tapes available from the National Climatic Center.

Source Inputs

The location of each source, its dimensions and its emissions parameters must be input to the annual and short-term models. Multiple sources and pollutants can be modeled. Table A-4 describes the necessary source parameters for different types of sources.

Deposition

In addition to diffusion and transport, fallout or deposition of pollutants has been added to the model. This feature takes into account the settling of large dust particles.

The rate of fallout or deposition of particulate matter as it diffuses downwind from its source is a function fo ground level concentration and settling velocity. The settling velocity results from a balance between the aerodynamic drag (particle bouyancy) and the earth's gravitational force. Thus particle size and density have an influence on settling velocities. The average settling velocity for an average particle (diameter of 22 microns and density of 2 g/cm^3) would be 3 cm/sec (PEDCo, 1977). The actual deposition velocity may be greater than this because deposition mechanisms include, in addition to gravity; surface impaction, electrostatic attraction, adsorption, and chemical interaction. Therefore, 5 cm/sec was used as the deposition velocity in the modeling (PEDCo, 1977).

Table A-4

SOURCE PARAMETERS REQUIRED FOR MODELING

Point	Area	Line
Location An arbitrary coordinate system is used to describe source location in relationship to receptors and other sources. Stack Height Stack Flow Rate Volumetric flow rate of gases leaving the stack Stack Temperature Stack Emissions Mass flow of pollutants per unit time	Location Height Height of source above receptor plane Dimensions Lengths of sides of area Orientation The number of degrees from north the area is rotated Emissions Density Mass rate of generation of pollutants (mass per unit time) divided by the total area over which emissions occur	Location Height Height of source above receptor plane Dimensions Length Orientation The number of degrees from north the line is rotated Emissions Density Mass rate of generation of pollutants (mass per unit time) divided by the total distance over which emissions occur

For downwind distances considered in modeling, the vertical dispersion may be limited for a major portion of the day by the prevailing mixing layer. This layer typically begins at ground level at sunrise and rises to a maximum in the afternoon.

The height of the mixing layer goes through annual as well as diurnal variations. Therefore, mean annual mixing heights for each stability class are calculated (Busse and Zimmerman, 1973).

Stability Class	Mixing Height
A	1.5 x HT
B	HT
C	HT
D Day	HT
D Night	(HT + HMIN) / 2
E + F	HMIN

HT is the mean annual afternoon mixing height for the geographical region for which the modeling is performed and HMIN is the mean annual morning mixing height as defined in Holzworth (1972).

A joint frequency distribution of wind speed, wind direction, and stability class in input to the model. The distribution includes six stability classes, sixteen wind directions and six wind speeds. The percent occurrence of each combination (576 total is calculated from hourly weather observations by the National Weather Service from observations taken during a private monitoring program. The percent occurrence can be postulated for areas lacking meteorological data.

Dispersion Model Outputs

The annual average model computes the concentration of each pollutant emitted for a rectangular grid of receptor points. The grid must be large enough to overlay the area of interest; its size is dependent upon the resolution required for accurate analysis of the concentrations. From this grid, isopleths of ambient pollutant concentrations can be generated for the area of interest. Maximum short-term pollutant concentrations predicted by applying Larsen's statistics (Larsen, 1971) to annual average modeling results are displayed in the same manner as the annual average concentration predictions.

The output from CRSTER consists of the highest and second highest concentrations for the year at each receptor for 1-, 3-, and 24-hours. The annual arithmetic average at each receptor and the highest 1- and 24-hour concentrations over the receptor field for each day are also included in the output. The concentrations of concern in this study were the 24-hour concentration for NO_x, the 3- and 24-hour concentrations for SO_2 and the 3- and 24-hour concentrations for TSP.

Pollutant concentrations estimated by the dispersion models represent increases in concentrations caused by the modeled sources. In order to assess more accurately the effective impact and to compare predicted concentrations to state and federal standards, it is necessary to determine the contributions to ambient pollutant levels by pollutant sources already existing when the proposed actions take place. These baseline concentrations are then added to the source-contributed concentrations to determine the ambient air quality which will occur as a result of proposed actions.

Baseline concentrations represent pollutant concentrations (natural and man-made) from sources other than the modeled sources. Because the dispersion model is used to account for major man-made sources of pollution, the baseline concentrations for each pollutant are assumed to represent the contributions from non-anthropogenic sources and minor man-made sources. For a discussion on how baseline concentrations for this study were obtained see Chapter 2.1.2 of the Regional Assessment of Air Quality, Vol. II (Radian, 1977).

Model Validation and Confidence Limits

Since at best the models are approximations of actual physical processes, their results must be compared to actual field measurements to determine model accuracy. Theoretically this procedure would entail determining the cause of any observed descrepancies and either improving the data base or modifying the model. But the complexity of the parameters involved precludes the easy identification of error sources. Emissions data, source locations, plant parameters, and meteorological conditions are all functions, whose accuracies cannot be controlled by the model. The measured field concentrations used in model validation are also subject to measurement error and may not truly represent existing conditions throughout the study area.

As a result, a validation study may involve more time and scientific expertise than is readily available. In this situation it is necessary to calibrate the model. Statistical techniques can identify systematic errors and generate a correction factor. Studies including calibrations show that model estimates are generally accurate within a factor of two (Brier,

1973; Mills and Record, 1975) and that model concentrations are both overpredicted and underpredicted. Studies performed by Radian Corporation (1976), in which annual average particulate concentrations from groundlevel area sources were predicted, show that the model was accurate within a factor of 1.8.

Application of Dispersion Models

This section describes the specific application of the annual average and short-term models to the prediction of pollutant concentrations resulting from the emissions of sources in the ES region. Included is a discussion of source treatments, assumptions applied in using the Gaussian models and in applying Larsen statistics, meteorological conditions input to the models, and the application of estimated baseline pollutant concentrations for the region.

Source Treatments

Sources of particulate, SO_x, and NO_x emissions from major sources within the study region were input to the dispersion models.

Towns and mines in the Star-Lake Bisti study region were modeled as area sources. Although each mine or town contains many pollutant sources, emissions were assumed to have a uniform density throughout the area. For the mines an average emission height of five meters was used. This height was derived after considering the size of storage piles and the heights of trucks and loading devices, crushing and sorting machinery, road repair equipment, etc.

Areas of towns were determined from an equation developed by Malecki (1978) for small towns in the western United States. The equation relates

the area of towns to the population. This equation takes the form:

$$A = 2.245 + 0.21P$$

where

A = town area (square miles)

P = population (1000's)

Annual Model Application

Annual average concentrations of TSP, SO_2, and NO_2 were predicted for a rectangular receptor grid with a 4 mile grid spacing overlying the study region The study region was separated into two subareas based on the proximity of sources within a subarea and the similarity of topographic features and, hence, dispersion conditions within the subarea. The annual model was exercised to predict annual average concentrations for sources located within each subarea using a meteorological joint frequency distribution most representative of the subarea. Model predictions for the different subareas were added together to produce continuous pollutant concentration isopleths for the entire study region.

Surface meteorological observations taken at Farmington (1959-1967) and at Gallup (1973-1975) are the only meteorological data sets in a format that can be easily used to calculate joint frequencies of wind speed, wind direction and stability class for input to the annual model. Farmington data was used to perform annual average dispersion modeling for sources north of Crownpoint. For the southern subarea, Gallup data was used.

Mixing heights for the annual model were calculated according to the scheme recommended by the U. S. Environmental Protection Agency with data tabulated by Holzworth (1972).

The calculated mixing heights corresponding to each of the stability classes are listed in Table A-5.

Table A-5

MIXING HEIGHTS FOR FARMINGTON AND GALLUP, NEW MEXICO

Stability	Mixing Height (meters) Farmington, New Mexico	Gallup, New Mexico
A	3975	3975
B	2650	2650
C	2650	2650
D day	2650	2650
D night	1525	1525
E & F	400	400

Short-Term Statistical Model Application

Larsen statistics (Larsen, 1971) were applied to annual average modeling results with baseline concentrations added to determine maximum 24-hour TSP levels around the towns and mines. Statistical relationships between concentrations for different averaging times derived from air quality data measured at Denver, Colorado, were used.

Denver data was applied because Denver was considered to be the city most representative of air quality conditions occurring in the western states included in the EPA study. A single standard geometric deviation for nitrogen dioxide (NO_2) was used to determine short-term concentrations. TSP, SO_2, and NO_2 concentration distributions in Denver were assumed to be more representative of pollutant concentration distributions in northwest New Mexico than the distributions of TSP and SO_2 reported for Denver.

Short-term Gaussian Model (CRSTER) Application

The CRSTER model was exercised to predict maximum 24-hour, 3-hour, and 1-hour pollutant concentrations from the power plants. Concentrations were predicted for receptors located in each of the 36 downwind directions from each of the three power plants. Predictions were made for receptors spaced 1 km apart out to distances of 50 km from the sources.

Values of wind speed, wind direction and stability class were computed from observations of surface meteorological parameters for every hour during 1964 at Farmington, New Mexico. These parameters, as well as mixing depths for Farmington, collected twice daily in 1964, were input to CRSTER.

Baseline Concentrations

Baseline concentrations, described in Chapter 2 of the Regional Assessment of Air Quality, Vol. II (Radian, 1977) were added to levels predicted with the dispersion models to determine total ambient quality impacts for annual and 24-hour periods. It was assumed that these baseline pollutant levels, estimated from mean long-term monitored concentrations, would be representative of baseline levels during periods of highest predicted short-term as well as annual average pollutant concentrations.

In applying the statistical model (Larsen, 1971) to determine maximum short-term pollutant concentrations around towns and mines, baseline concentrations were added to predicted levels before the scale factors were applied.

Visibility Modeling Techniques

Visibility levels in the ES region resulting from increased ambient total suspended particulate concentrations were determined from a relationship

developed by the Los Alamos Scientific Laboratory (Ettinger, et al, 1972). For low concentrations the following equation which relates visual range (L_v) and ambient particulate concentrations was derived:

$$L_v = \frac{24}{\left(0.2 + 0.01^{+.01}_{-.003}\right) M^{*}}$$

where

L_v = visual range in miles

M = ambient TSP concentration, $\mu g/m^3$

This relationship was developed from integrating nephelometer measurements of visual range in the Los Alamos, New Mexico area and is useful for predicting visibilities in rural areas with relatively low TSP levels such as southcentral Wyoming.

The range of regional visibilities or visual ranges resulting from ambient particulate levels was predicted for 1980, 1985, and 1990. Total annual average and maximum 24-hour suspended particulate concentrations for each of the cases and years were examined by using the Los Alamos relationship to determine regional visibilities.

Maximum short-term visibility reductions in the region will occur in the immediate vicinity of dispersing groundlevel particulate emissions at or very near the sources. However, visibilities calculated from the average TSP concentrations occurring within the region are more representative of the region-wide visibility. These annual average TSP levels are essentially the average particulate levels most likely to be measured in the region on any one day.

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* The form of the equation as used in this study in determining regional visibilities does not include the +.01 or -.003 in the parenthetical term in the denominator.