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Environmental Monitoring at the WIPP Site CY 1976

Lial W. Brewer, James H. Metcalf

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ENVIRONMENTAL MONITORING AT THE WIPP SITE
CY 1976

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ABSTRACT

A preliminary study of the radiation background and air quality of the area proposed for the possible construction and operation of a Waste Isolation Pilot Plant was begun early in CY 1976. Measurements of direct radiation and airborne radioactivity are being made, and the levels of air pollutants are being determined to ascertain the present air quality at the site. A description of the monitoring methods used and the data obtained during CY 1976 are presented.

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CONTENTS

	<u>Page</u>
Summary	7
Introduction	9
Radiation Monitoring Program	14
Reuter-Stokes Ionization Chamber	14
Thermoluminescent Dosimeters	25
Gross Beta Concentrations in Air	29
Assessment of Dose to Public	32
Evaluation	34
Air-Quality Program	39
Analysis of Samples	41
Calibration	43
Results	44
Discussion	80
Appendix A - Determination of Sulfur Dioxide	81
Appendix B - Determination of Nitrogen Dioxide	87
Appendix C - Determination of Hydrogen Sulfide	91
Appendix D - Air-Quality Standards	95
References	97
Bibliography	97

SUMMARY

Measurements made in the WIPP study area indicate background exposure levels of 8-9 $\mu\text{R/hr}$. These measured data are in good agreement with calculated exposure rates (7.5-9.6 $\mu\text{rad/hr}$). Airborne gross beta concentrations, which were low (0.02 pCi/m^3), confirmed the presence of global fallout from the Chinese nuclear tests conducted in the atmosphere during the fall.

The air-quality measurements, except for a few unexplained excursions, were less than State and/or Federal air-quality standards.

ENVIRONMENTAL MONITORING AT THE WIPP SITE CY1976

INTRODUCTION

The U.S. Energy Research and Development Administration (ERDA) is evaluating a site in southeastern New Mexico for the possible construction and operation of a Waste Isolation Pilot Plant (WIPP). The purpose of this facility would be to test and demonstrate the operational and technical principles of a permanent repository in bedded salt for ERDA-generated low-level transuranic (TRU) and intermediate-level TRU radioactive waste. High-level waste or waste from commercial sources is excluded from the mission; however, there will be experiments in the WIPP with limited quantities of high-level waste.

The WIPP site is 42 km (26 miles) east of Carlsbad, New Mexico, and is reached from State Highway 128 (see Figure 1). All the land is Federal or State land. In appearance, the site is a gently rolling plain covered by windblown sand and by desert vegetation such as mesquite, sand sage, shinnery oak, and forbs and grasses. The climate is cool in the winter and hot in the summer. Rainfall is about 33 cm (13 inches) per year. There are no perennial streams in the immediate area; the nearest is the Pecos River 24 km (15 miles) to the west and southwest. The customary surface use of the land is for grazing cattle at a density of about nine head per section.

Early in 1976, measurements of air quality and of background radioactivity were started in the vicinity of the WIPP site. From January 1976 to June 1976, measurements were made at the AEC #8 drilling pad in Section 11, T 22S, R 31 E. In June the station was relocated to the old Badger well site in Section 15 (see Figure 2). At each of these locations a meteorological station was established that consisted of instrumentation for measuring such parameters as wind, temperature, barometric pressure, precipitation; a trailer for recording equipment; and portable diesel generators to provide electrical power for the station. As a part of this on-site meteo-

rological program, radiation background and air-quality measurements are being made. These background studies, which are only preliminary at present, will be expanded in the years before the facility becomes operational so that we may develop a better understanding of the natural variability of the radiation background and the regional air quality. Figure 3 is a photograph of the present station.

Figure 1. General Location of WIPP Land Withdrawal

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Figure 2. WIPP Study Area

Figure 3. Present Meteorological Station at WIPP Site

RADIATION-MONITORING PROGRAM

Direct radiation measurements are being made at the WIPP meteorological station with a Reuter-Stokes pressurized ionization chamber. Also, a limited number of thermoluminescent dosimeters have been fielded in the area. Sampling to determine average gross beta concentrations in air has been initiated. Summaries of the analytical procedures and the data collected are presented in the following sections.

Reuter-Stokes Ionization Chamber

Natural radiation background rates can vary considerably with time. In order to document this variation in the background in the study area, a Reuter-Stokes pressurized ionization chamber (RSS-111) is being operated continuously at the WIPP meteorological station. This unit is calibrated by the manufacturer and has a reported accuracy of ± 5 percent at $10 \mu\text{R/hr}$.

The power supply and readout equipment are located in the trailer that houses the recording equipment for the meteorological instruments. The ion chamber, located outside the trailer, is about 3 metres from it, with the centerline of the chamber 1 metre above the ground surface. The output from the detector is recorded on an Esterline Angus 2020 data logger every 20 minutes. Data taken on the hour are transferred to IBM cards for data processing and storage.

The hourly data obtained from the ion chamber during CY 1976 have been averaged on a weekly basis and are presented in Table I and Figure 4. The data obtained at the same time of day have been averaged on a monthly basis to provide an average diurnal variation of the background radiation for each month. These data are presented in Figures 5-12.

TABLE I

CY 1976 Radiation Background at WIPP Site
as Measured With a Reuter-Stokes Pressurized Ion Chamber

Exposure Period		Radiation Exposure ($\mu\text{R/hr}$)		
Begin	End	Average	Maximum	Minimum
04/26	05/02	8.29	12.88	6.80
05/03	05/09	8.32	13.83	6.84
05/10	05/16	8.13	11.55	6.76
05/17	05/23	8.08	11.10	6.61
05/24	05/30	8.08	9.92	6.46
05/31	06/03	7.98	9.46	6.50
06/03	07/14	Off the line		
07/14	07/18	7.92	10.56	5.93
07/19	07/25	8.33	10.34	6.61
07/26	08/01	9.21	14.78	6.84
08/02	08/08	9.39	14.78	6.84
08/09	08/15	10.00	19.68	7.07
08/16	08/22	8.81	11.10	6.69
08/23	08/29	9.05	16.07	7.07
08/30	09/05	8.74	12.24	6.65
09/06	09/12	8.65	12.08	6.12
09/13	09/19	8.72	12.62	6.80
09/20	09/26	8.58	13.38	7.11
09/27	10/03	8.32	11.32	6.46
10/04	10/10	7.96	10.07	6.19
10/11	10/17	8.13	11.51	6.61
10/18	10/24	8.11	10.94	6.69
10/25	10/31	8.59	15.16	6.12
11/01	11/07	8.03	10.41	6.38
11/08	11/12	8.36	12.62	6.76
11/12	11/15	No data - lost power on met station		
11/15	11/21	7.93	9.96	6.00
11/22	11/28	7.89	9.88	6.12
11/29	12/05	8.55	11.25	6.54
12/06	12/12	8.75	10.94	7.37
12/13	12/19	8.83	10.75	7.41
12/20	12/26	8.64	11.89	7.18
12/27	12/31	8.80	10.60	7.33

Yearly Average - 8.48

Figure 4. Weekly Average Reuter-Stokes Readings

Figure 5. Diurnal Variation in Background Radiation, May 1976

Figure 6. Diurnal Variation in Background Radiation, June 1976

Figure 7. Diurnal Variation in Background Radiation, July 1976

Figure 8. Diurnal Variation in Background Radiation, August 1976

Figure 9. Diurnal Variation in Background Radiation, September 1976

Figure 10. Diurnal Variation in Background Radiation, October 1976

Figure 11. Diurnal Variation in Background Radiation, November 1976

Figure 12. Diurnal Variation in Background Radiation, December 1976

Thermoluminescent Dosimeters

Six thermoluminescent dosimetry stations have been established in the WIPP study area to determine the uniformity of the radiation background. The locations of these stations are as follows: near the drill holes designated ERDA #6, AEC #7, AEC #8, and ERDA #9; near the meteorological station; and outside the Sandia Office located in the southwest part of the city of Carlsbad (see Figures 1 and 2).

Five LiF thermoluminescent dosimeter (TLD) chips are placed at each location and are exchanged and evaluated on a quarterly basis. The TLD-100 chips are wrapped in aluminum foil and placed inside a small plastic vial. The vial is placed inside a 50-cm³ polyethylene bottle, which is then suspended inside a 1-1/4-inch-diameter, thin-walled aluminum conduit (see Figure 13). The conduit is driven vertically into the ground so that the dosimeters are approximately 1 metre above the ground surface. The holder system provides about 240-mg/cm² absorption for the radiation incident on the dosimeters.

In the evaluation of the exposures measured by the dosimeters, both the background while the dosimeters are in storage and the background while they are being transported to the field location are considered. The TLDs used for calibration are exposed to an NBS-traceable cobalt-60 source midway through the field cycle. Output from the five chips in a package is averaged to obtain the reported exposure for each station. The data are presented in Table II and Figure 14.

Figure 13. Sandia Laboratories Environmental Dosimeter

TABLE II

TLD Data From WIPP Site - CY 1976

		<u>First Quarter</u>		<u>Second Quarter</u>		<u>Third Quarter</u>		<u>Fourth Quarter</u>	
		<u>1/13/76 to 4/26/76</u>	<u>(mR)</u>	<u>4/26/76 to 7/14/76</u>	<u>(mR)</u>	<u>7/14/76 to 10/13/76</u>	<u>(mR)</u>	<u>10/13/76 to 1/10/77</u>	<u>(mR)</u>
		<u>(μR/hr)</u>		<u>(μR/hr)</u>		<u>(μR/hr)</u>		<u>(μR/hr)</u>	
Sandia Office									
Carlsbad		---	---	---	---	Data lost in Readout		26.5±1.6	12.4±0.76
Meteorological Station		---	---	---	---	"		21.5±1.6	10.1±0.76
ERDA	6	20.0±4.6	8.0±1.8	14.5±2.2	7.6±1.1	"		20.0±1.5	9.4±0.66
AEC	7	22.0±5.0	8.8±2.0	16.0±2.1	8.4±1.1	"		24.5±1.6	11.5±0.76
AEC	8	23.0±4.7	9.2±1.9	15.0±2.1	7.9±1.1	"		22.5±1.6	10.5±0.76
ERDA	9	---	---	---	---	"		22.5±1.6	10.5±0.76

Figure 14. TLD Data-1976, WIPP Study Area

Gross Beta Concentrations in Air

Airborne gross beta concentrations are being determined in the WIPP study area using a high-volume air sampler. This sampler is operated on the roof of the trailer that houses the recording equipment for the meteorological measurements. The samples are taken approximately 5 metres above the ground surface.

Samples are taken 3 times each week, with each sample collected for 24 hours at a sampling rate of $18.5 \text{ ft}^3/\text{min}$. Since the air samples are also used for air-quality measurements, a combination of Whatman 41 and MSA Type 1106 BH (without organic binder) fiberglass filter media have been used. The data have not been corrected for differences in estimated collection efficiency for these media.

After the air samples have been taken, the filters are held for at least 7 days before analysis to allow the radon-thoron daughters to decay. The samples are then counted with a beta proportional counter. If the sample indicates an activity greater than 0.060 pCi/m^3 , a gamma scan may also be taken. The data obtained in 1976 are summarized in Table III and in Figure 15.

TABLE III

Average Gross Beta Concentrations in Air at WIPP Site - CY 1976

Sampling Period		Type of Filter	Gross Beta (pCi/m ³)	Monthly Average (pCi/m ³)	Sampling Period		Type of Filter	Gross Beta (pCi/m ³)	Monthly Average (pCi/m ³)
From	To				From	To			
2/04	2/05	G	0.010±0.002	0.016±0.003	8/05	8/06	W	0.020±0.003	0.019±0.003
2/10	2/11	G	0.008±0.002		8/09	8/10	G	0.026±0.004	
2/17	2/18	G	0.021±0.004		8/10	8/11	G	0.026±0.004	
2/19	2/20	G	0.022±0.003		8/11	8/12	W	0.022±0.003	
2/23	2/24	G	0.017±0.003		8/16	8/17	G	0.008±0.003	
3/03	3/04	G	0.018±0.003	0.024±0.003	8/18	8/19	G	0.008±0.003	0.017±0.003
3/09	3/10	G	0.016±0.004		8/19	8/20	W	0.017±0.003	
3/11	3/12	G	0.032±0.004		8/23	8/24	G	0.030±0.004	
3/15	3/16	G	0.026±0.003		8/24	8/25	G	0.030±0.004	
3/16	3/17	G	0.032±0.004		8/25	8/26	W	0.016±0.003	
3/17	3/18	G	0.040±0.004	0.019±0.003	8/30	8/31	G	0.012±0.003	0.017±0.003
3/23	3/24	W	0.011±0.003		8/31	9/01	G	0.018±0.003	
3/25	3/26	G	0.029±0.003		9/02	9/04	W	0.016±0.002	
3/30	3/31	W	0.013±0.003		9/07	9/08	G	0.010±0.003	
4/06	4/07	W	0.020±0.003		9/08	9/09	G	0.006±0.003	
4/12	4/13	G	0.019±0.003	0.019±0.003	9/09	9/10	W	0.013±0.003	0.017±0.003
4/13	4/14	G	<0.002		9/14	9/15	G	0.014±0.003	
4/14	4/15	W	0.010±0.003		9/15	9/16	G	0.014±0.003	
4/18	4/19	G	0.024±0.003		9/16	9/17	W	0.010±0.002	
4/19	4/20	G	0.026±0.003		9/20	9/21	G	0.023±0.003	
4/20	4/21	MF	0.021±0.003	0.020±0.003	9/21	9/22	G	0.035±0.004	0.226±0.007
4/25	4/26	G	0.032±0.004		9/22	9/27	W	0.021±0.001	
5/03	5/04	G	0.029±0.003		9/28	9/29	G	0.010±0.003	
5/04	5/05	G	0.019±0.003		9/29	9/30	G	0.029±0.004	
5/05	5/06	W	0.012±0.003		9/30	10/01	W	0.023±0.003	
5/10	5/11	G	0.006±0.003	0.017±0.003	10/04	10/05	G	0.095±0.005	0.075±0.005
5/11	5/12	G	0.023±0.003		10/06	10/07	W	0.247±0.008	
5/12	5/13	W	0.020±0.003		10/13	10/14	W	0.119±0.006	
5/17	5/18	G	0.024±0.003		10/14	10/15	W	0.100±0.005	
5/18	5/19	G	0.025±0.003		10/20	10/21	W	0.674±0.013	
5/19	5/20	W	0.018±0.003	0.012±0.003	10/21	10/22	G	1.069±0.016 ^a	0.427±0.009
5/24	5/25	G	0.032±0.004		10/25	10/26	G	1.044±0.010	
5/25	5/26	G	0.029±0.003		10/26	10/27	G	0.474±0.011	
5/26	5/27	W	<0.002		10/27	10/28	W	0.021±0.003	
6/01	6/02	G	0.028±0.003		11/01	11/02	G	0.642±0.012	
6/02	6/03	G	0.021±0.003	0.017±0.003	11/02	11/03	G	0.585±0.011	0.226±0.007
6/03	6/04	W	0.018±0.003		11/03	11/04	W	0.348±0.009	
6/14	6/15	G	0.017±0.003		11/08	11/09	G	0.354±0.009	
6/15	6/16	G	0.012±0.003		11/09	11/10	G	0.306±0.009	
6/16	6/17	W	0.012±0.003		11/10	11/11	W	0.210±0.007	
6/21	6/22	G	0.021±0.003	0.012±0.003	11/15	11/16	G	0.050±0.004	0.075±0.005
6/22	6/23	G	0.019±0.003		11/16	11/17	G	0.152±0.006	
6/23	6/24	W	0.013±0.003		11/17	11/18	W	0.168±0.006	
6/28	6/30	G	0.014±0.002		11/18	11/19	G	0.179±0.007	
6/30	7/01	W	0.008±0.003		11/19	11/20	G	0.085±0.005	
7/01	7/02	G	0.013±0.003	0.012±0.003	11/20	11/21	G	0.136±0.006	0.075±0.005
7/06	7/07	G	0.026±0.003		11/21	11/22	G	0.159±0.006	
7/07	7/08	G	0.016±0.003		11/22	11/23	G	0.176±0.007	
7/08	7/09	W	<0.003		11/23	11/24	G	0.157±0.006	
7/12	7/13	G	0.014±0.003		11/24	11/28	G	0.091±0.002	
7/13	7/14	G	0.004±0.003	0.012±0.003	11/29	11/30	G	0.203±0.007	0.075±0.005
7/14	7/15	W	<0.003		11/30	12/01	G	0.085±0.005	
7/19	7/20	G	0.017±0.003		12/01	12/02	G	0.046±0.004	
7/20	7/21	G	0.011±0.003		12/06	12/07	G	0.086±0.005	
7/21	7/22	W	0.007±0.002		12/07	12/08	G	0.072±0.005	
7/26	7/27	G	0.018±0.003	0.012±0.003	12/08	12/09	W	0.076±0.004	0.075±0.005
7/27	7/28	G	0.014±0.003		12/13	12/14	G	0.087±0.005	
7/28	7/29	W	0.013±0.003		12/14	12/15	G	0.084±0.005	
8/03	8/04	G	0.016±0.003		12/15	12/16	W	0.072±0.004	
8/04	8/05	G	0.018±0.003						

Type of Filter: G - MSA Type 1106BH (without organic binder) fiberglass

W - Whatman 41

MF - Millipore, Type HA

^a Pump quit during run - concentration actually higher than shown.

Figure 15. Average Gross Beta Activity in Air

ASSESSMENT OF DOSE TO PUBLIC

The major components of the background radiation environment of any location are cosmic rays, terrestrial radiation sources such as potassium-40 and the decay products of the uranium and thorium series in the earth's crust, and global fallout from nuclear weapons testing in the atmosphere. Each of these components contributes to the background exposure rate being measured at the WIPP site, and each is discussed individually.

Cosmic radiation varies with latitude and altitude, with the latter being the significant factor. The intensity of cosmic radiation increases from equatorial to polar latitudes and also increases with increasing altitudes. Within the United States the latitude effect may be neglected for all practical purposes.¹ At the altitude of the WIPP site (1.06 km), the absorbed dose rate in air due to cosmic radiation is estimated to be 37 mrad/yr.²⁻⁴

The principal radioactive elements that contribute to the radiation emanating from the surface of the ground are potassium-40, members of the uranium series, and members of the thorium series. This terrestrial gamma background is not uniform over the surface of the earth, but rather depends on the soil concentration of the naturally occurring radionuclides in the region of interest.

The estimated average absorbed dose rate in air from terrestrial sources for the United States is 44 mrad/yr.² Evaluation of aerial radiological monitoring system (ARMS) data taken in the Carlsbad area implies that this area may have a somewhat lower dose rate than the average value for the United States. Based on the ARMS data, an estimate of 26 mrad/yr^{2,5} has been made for the terrestrial component of the radiation background in the WIPP area.

The content of uranium, thorium, and potassium in the soil and rocks of any specific geographical region is essentially constant; however, the dose rate in air depends upon a number of factors. Variations are related to such meteorological conditions as atmospheric stability, rainfall, moisture in the soil, temperature, barometric pressure, and relative humidity—all of which affect the concentration of radon and thoron and their daughter products in the surface layer of the atmosphere. Determination of the exposure rate from this source therefore requires

the determination of the process that most significantly affects the radon and thoron concentration in the surface air layer at a given moment.

The absorbed dose rate in air due to radon and thoron and their associated daughter products ranges from 0.4 mrad/yr for conditions in which strong mixing occurs, to 11 mrad/yr for strong inversion conditions. An average value for the absorbed dose rate in air from this source is 1.7 mrad/yr.²

The other major component of the background radiation environment is global fallout. Average external gamma radiation doses in the United States due to fallout is estimated to be 1 mrad/yr.⁶

Based on the information given above, the estimated annual whole-body exposure to members of the public in the vicinity of the WIPP site is 66-84 mrad/yr (7.5-9.6 μ rad/hr) from external sources. This estimate does not include internally deposited radionuclides, such as potassium-40, which would add another 20 mrad/yr to the estimated exposures.

EVALUATION

The high-pressure ionization chamber and the thermoluminescent dosimeters used in this study are calibrated with cobalt-60; therefore, all data given are expressed in terms of exposure rate, usually in microroentgens per hour ($1 \mu\text{R/hr} = 8.77 \text{ mR/yr}$). Data from the literature have been expressed in terms of absorbed dose rates in soft tissue, with $\mu\text{rad/hr}$ being the basic measurement unit. In order to compare the measured exposure rates with the values cited, a conversion factor of 1 R being equivalent to 0.95 rad should be applied.

The average exposure rate in 1976, as measured in the WIPP area with the Reuter-Stokes pressurized ionization chamber, was $8.5 \mu\text{R/hr}$ (74 mR/yr), with a maximum of $20 \mu\text{R/hr}$ and a minimum of $6 \mu\text{R/hr}$. The fluctuations between these two extremes appear to be related to the concentrations of radon and thoron (with their associated daughter products) in the near-ground air. These fluctuations in turn are dependent upon meteorological conditions, with a different parameter assuming importance at any one time.

Atmospheric stability is one of the more important parameters,² with the radon-thoron concentrations in the near-ground air increasing as the atmosphere becomes more stable. As the atmosphere typically becomes more stable during the night (inversion conditions), an increase is noted in radon concentration, with a resultant increase in the exposure rate measured at one metre above the ground surface.

When the inversion vanishes and turbulent diffusion moves the radon into a larger volume, effectively diluting the radon-rich, near-surface air with air having a lower concentration of radon, the exposure rate decreases. This diurnal variation of the radiation background with atmospheric stability as the important variable can be noted in the average "diurnal" radiation background for the month of May (Figure 5).

Another important meteorological parameter is the amount of precipitation. In the atmosphere, natural radioactive particulates (primarily daughters of radon) attach themselves to dust particles, which may then become "condensation centers" for moisture in the air. If these droplets become large enough to fall to the ground

as precipitation, the exposure rate above the surface of the ground will increase as a result of the accumulation of radon daughters (the "rainout" phenomenon).

Another phenomenon associated with precipitation is the buildup of radon and thoron and their daughters in the surface layers of the soil. As the pores of the soil become saturated with water, the migration to the atmosphere of the radon and thoron in the soil gas is decreased, thereby increasing the concentration of these radioactive species in the soil and causing a resultant increase in the exposure rate above the soil surface. If precipitation is heavy, the additional shielding offered by the water in the soil may result in some decrease in radiation levels at the surface.

As Figure 7 shows (diurnal variation in background radiation - July 1976), heating of the surface of the ground also contributes to an increase in exposure rate above the surface. As the soil gas in the surface layers of the ground is heated, it tends to rise, causing a resultant drop in the local pressure of the soil gas and increasing the escape of radon to the atmosphere. These micro-oscillations of the barometric pressure effectively "pump" the radon out of the ground, thereby increasing the radon content of the atmosphere. If this "pumping" effect occurs in conjunction with little or no wind so that there is very little vertical diffusion of the radon, very high ground-level concentrations can be attained. This could be the reason for the high exposure rate measured the afternoon of August 14 ($20 \mu\text{R/hr}$).

The data obtained through the use of TLDs agree favorably with the Reuter-Stokes data. Both sets of data indicate average exposure rates of 8-9 $\mu\text{R/hr}$ in the WIPP study area. Minor variations in the exposure rate from station to station are reflected (see Table II), but not enough data have been accumulated to determine whether these variations are statistically significant. Based on one set of data, the exposure rate indicated by the station located in the city of Carlsbad is 20 percent higher than the stations in the WIPP study area. Again, not enough data have been accumulated to determine whether this difference is significant.

The TLD data obtained in the fourth quarter show an increase of 20-25 percent over data obtained in the previous quarters, all stations indicating approximately the same magnitude of increase. This increase has been attributed to the presence of global fallout from the Chinese nuclear tests (conducted September 26, 1976, and

November 17, 1976), which air-sampling data indicated was present in the area almost all of the fourth quarter. If data from the next quarter return to the pretest levels, this conclusion may be justified.

The air-sampling data indicate that gross beta concentrations in air at the WIPP site are typically 0.02 pCi/m^3 . Although the data have not been corrected for differences in filter media, this oversight should introduce only a 2-percent error in the concentrations calculated (efficiencies for Whatman 41 and MSA Type 1106 BH are 98 percent and 99.978 percent, respectively).⁷

First indications of fallout from the Chinese nuclear test conducted on September 26 were obtained from the sample taken October 4-5. Gamma spectra of the filter media confirmed the presence of short-lived fission products (Figures 16 and 17). The presence of this fission product activity caused the gross beta concentrations in air to increase to a maximum of 1.07 pCi/m^3 (October 21-22), gradually decreasing throughout the rest of the calendar year. No clear indication of the second test, conducted on November 17, was received. Gross beta concentrations in air at the end of the year were still approximately 3 times higher than those obtained before the abovementioned atmospheric tests.

#762182

Taken 10/6/76 to 10/7/76 Ge(Li) 2 keV/Channel
 Counted 10/26/76 Background Subtracted

Figure 16. Air Sample From WIPP Meteorological Station

Figure 17. Air Sample From WIPP Meteorological Station

AIR-QUALITY PROGRAM

Atmospheric samples are taken for the following pollutants: sulfur dioxide (SO_2), nitrogen dioxide (NO_2), hydrogen sulfide (H_2S), total weight particulate, carbon monoxide (CO), and ozone (O_3). Air samplers are located on or above the roof of the meteorological instrument trailer (see Figure 18). The high-volume air-sample collection head is attached to the tower 4 feet above the trailer roof. The wet chemistry sampler is located about 3 feet above the trailer roof. The Sierra Cascade impactor is also located on the roof, with the collection surface located 2-1/2 feet above the roof. The sample inlet for the CO monitor is positioned inside the Sierra Cascade impactor housing and is 2 feet above the trailer. The ozone sample inlet is located at the roof level of the trailer.

Figure 18. Air-Quality Instrumentation on Roof of Meteorological Station

ANALYSIS OF SAMPLES

The total particulate samples are collected with the high-volume air sampler either on glass fiber (MSA #1106BH w/o organic binder) or on Whatman #41 4-inch filters. Samples are collected for 24 hours, with a constant $18.5\text{-ft}^3/\text{min}$ sampling rate used. These samples are collected 3 times per week. Each filter is weighed before collection and reweighed after sample collection, the total weight of particulate being the difference in weights. The total particulate samples are then analyzed for elemental composition, which includes sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), silicon (Si), iron (Fe), aluminum (Al), chloride (Cl^-) and sulfates ($\text{SO}_4^{=}$). All chemical species are reported in micrograms per cubic metre of air sampled.

The analysis of high-volume filters consisted of a procedure to quantify both water- and acid-soluble metals, as well as sulfate and chloride levels. Water-soluble metals and sulfate and chloride were extracted from the filter media by heating in aqueous solution for 2 hours. Metals were quantified by atomic absorption spectrophotometry. Sulfates and chlorides were analyzed by turbidimetric and colorimetric methods, respectively. Following aqueous extraction, the filters were completely digested in concentrated nitric acid, and the solutions were subsequently analyzed for acid-soluble metals by atomic absorption spectrophotometry.

The samples for H_2S , SO_2 , and NO_2 analyses are taken by wet chemistry methods one time per week on a random-day selection. The samples are collected for 24 hours at a sampling rate of approximately 200 mL/min in high-efficiency bubblers containing appropriate collecting media. The SO_2 and NO_2 samples are analyzed colorimetrically and the H_2S sample is determined by titration (for methods, see Appendixes A, B, and C).

The carbon monoxide content of the ambient air is analyzed by means of an automatic nondispersive infrared analyzer that measures carbon monoxide levels continuously. The computer readout lists the carbon monoxide level measured on the hour, and the average for 24 hours is computed.

The ozone level in the air is measured continuously by means of an automated ultraviolet detector. The data are treated exactly as above for carbon monoxide.

Air samples for particle size and mineralogical analysis, collected by the Sierra Cascade impactor of five stages for a 5- to 7-day period once each month, are being analyzed by the McCrone and Associates consulting firm.

CALIBRATION

The two continuous monitors (for carbon monoxide and ozone), are calibrated weekly. The ozone monitor uses an electronic calibration system that applies to the detector a voltage equivalent to a known concentration of ozone in air. The carbon monoxide monitor is calibrated by means of a standardized CO-in-nitrogen gas.

The high-volume air sampler and the Sierra Cascade impactor use electronic flow controllers to assure constant flow, regardless of filter resistance.

The wet chemical methods are standardized through the use of known concentrations of SO_2 , NO_2 , and H_2S to prepare standard curves to which the atmospheric samples are compared.

RESULTS

Ozone concentrations for the sampling period June 11 through December 31, 1976, are shown in Tables IV through X. Hours where the ozone concentration exceeded the allowable level* are marked. As can be noted, the ozone levels generally peak during the afternoon and with an average wind direction of 146° (from the southeast). The ozone concentrations appear to be temperature-dependent, with the ozone levels increasing as the temperature increases. The average monthly diurnal concentrations of ozone are shown in Figures 19-25.

Carbon monoxide concentrations from June 11 through December 31, 1976, are shown in Tables XI through XVII. The carbon monoxide levels usually peak during the morning hours and when the wind direction is 150°. The diurnal variations of the concentrations of carbon monoxide are shown in Figures 26-32.

The data for SO₂, NO₂, and H₂S will be found graphically in Figures 33, 34, and 35. Since the analyses are not continuous, the data indicate only the average level present during actual sampling. The average 24-hour concentrations for the period sampled are:

$$\text{NO}_2 - 32.19 \mu\text{g}/\text{m}^3$$

$$\text{SO}_2 - 4.29 \mu\text{g}/\text{m}^3$$

$$\text{H}_2\text{S} - 0.110 \mu\text{g}/\text{m}^3$$

The data from the analyses of particulate matter are found in Table XVIII. No specific mineralogical analysis has been performed; however, seven sets of sized samples have been collected.

* See Appendix D for Federal and State Standards.

TABLE IV.

Ozone Concentration (ppm) for June 1976

<u>Date</u>	<u>Time of Maximum</u>	<u>Wind Direction for Maximum (°)</u>	<u>24-Hour Maximum</u>	<u>24-Hour Minimum</u>	<u>24-Hour Average</u>
6/11	0900	164	0.015	0	0.005
6/12	0800	346	0.016	0	0.002
6/13	1000	194	0.026	0	0.012
6/14	1000	265	0.025	0.006	0.013
	1100	270	0.025		
6/15	1700	53	0.038	0	0.017
6/16	1100	172	0.045	0.001	0.025
	1200	175	0.045		
6/17	1400	162	0.048	0.016	0.030
6/18	1700	29	0.054	0.015	0.031
6/19	2000	135	0.064	0.024	0.040
6/20	1800	141	0.052	0.028	0.040
6/21	1300	205	0.043	0.020	0.033
6/22	1900	270	0.038	0.012	0.022
6/23	2000	268	0.044	0.016	0.029
6/24	1300	34	0.056	0.003	0.033
6/25	1400	130	0.051	0.015	0.034
6/26	1800	113	0.044	0.014	0.039
6/27	1500	135	0.039	0.009	0.030
6/28	1600	157	0.035	0.009	0.022
	1700	108	0.035		
6/29	1300	140	0.042	0.013	0.027
6/30	1400	124	0.048	0.011	0.029
Average June		165°	0.040	0.011	0.026

TABLE V
Ozone Concentration (ppm) for July 1976

<u>Date</u>	<u>Time of Maximum</u>	<u>Wind Direction for Maximum (°)</u>	<u>24-Hour Maximum</u>	<u>24-Hour Minimum</u>	<u>24-Hour Average</u>
7/1	1500	135	0.038	0.010	0.023
7/2	1500	173	0.041	0.007	0.021
7/3	1700	95	0.065	0.009	0.033
7/4	1500	81	0.060	0.006	0.037
7/5	1500	146	0.059	0.010	0.034
7/6	1500	99	0.051	0.011	0.031
7/7	1000	130	0.074	0.014	0.040
7/8	1300	157	0.054	0.014	0.020
7/9	1400	130	0.039	0.006	0.021
	1500	119	0.039		
7/10	1900	113	0.035	0.009	0.018
7/11	1700	- a	0.022	0.009	0.013
7/12	1400	- a	0.021	0.011	0.016
	1700	119	0.021		
7/13	1400	103	0.038	0.010	0.020
7/14	1900	83	0.033	0.002	0.020
7/15	1600	65	0.040	0.009	0.023
7/16	1400	73	0.030	0.004	0.018
7/17	1600	115	0.041	0	0.017
7/18	1700	151	0.047	0	0.018
7/19	1800	124	0.037	0	0.021
7/20	1400	146	0.035	0.010	0.022
7/21	1700	124	0.034	0.015	0.023
7/22	1400	92	0.046	0	0.022
7/23	1300	151	0.040	0.010	0.026
	1400	189	0.040		
7/24	1800	124	0.038	0	0.024
	1900	140	0.038		
7/25	1600	134	0.015	0	0.027
7/26	1500	124	0.064	0.010	0.035
7/27	1100	109	0.046	0.021	0.033
7/28	1500	86	0.051	0	0.021
7/29	1400	211	0.039	0	0.015
7/30	1600	211	0.039	0.010	0.023
7/31	1600	162	0.044	0.014	0.025
Average July		127°	0.043	0.007	0.024

^a No wind direction data recorded.

TABLE VI

Ozone Concentration (ppm) for August 1976

<u>Date</u>	<u>Time of Maximum</u>	<u>Wind Direction for Maximum (°)</u>	<u>24-Hour Maximum</u>	<u>24-Hour Minimum</u>	<u>24-Hour Average</u>
8/1	1400	130	0.047	0.006	0.027
8/2	1300	135	0.042	0.015	0.025
8/3	1300	167	0.048	0.002	0.027
	1400	167	0.048		
8/4	1200	178	0.035	0.012	0.027
8/5	1300	286	0.040	0.009	0.029
8/6	1700	135	0.052	0.014	0.034
8/7	1400	173	0.043	0.018	0.033
	1500	151	0.043		
8/8	1300	113	0.040	0.011	0.028
	2100	124	0.040		
8/9	1500	178	0.040	0.018	0.032
8/10	1900	135	0.043	0.025	0.036
8/11	1400	157	0.045	0.017	0.037
	1500	124	0.045		
8/12	1900	130	0.060	0.026	0.043
8/13	1700	151	0.054	0.023	0.036
8/14	1500	126	0.050	0.012	0.030
8/15	1500	89	0.047	0.011	0.026
8/16	1600	0	0.036	0.012	0.024
8/17	1700	130	0.042	0.016	0.025
8/18	1500	140	0.039	0.003	0.020
8/19	1500	140	0.062	0.004	0.030
8/20	1700	157	0.057	0.019	0.043
8/21	1800	146	0.055	0.035	0.046
8/22	1800	108	0.064	0.029	0.047
8/23	1800	140	0.061	0.017	0.042
8/24	1500	142	0.061	0.016	0.040
8/25	1300	124	0.060	0.017	0.042
8/26	1300	178	0.052	0.016	0.036
8/27	1600	184	0.037	0.010	0.024
	2100	81	0.037		
8/28	1600	83	0.038	0.001	0.022
8/29	2000	92	0.043	0	0.023
8/30	2000	140	0.048	0.011	0.028
8/31	2200	61	0.044	0.007	0.027
Average August		136°	0.047	0.014	0.032

TABLE VII

Ozone Concentration (ppm) for September 1976

<u>Date</u>	<u>Time of Maximum</u>	<u>Wind Direction for Maximum (°)</u>	<u>24-Hour Maximum</u>	<u>24-Hour Minimum</u>	<u>24-Hour Average</u>
9/1	1600	83	0.052	0.006	0.029
9/2	1700	162	0.055	0.002	0.030
9/3	2100	135	0.052	0.013	0.027
9/4	0400	113	0.095 ^a	0.001	0.027
9/5	1300	151	0.028	0.008	0.017
9/6	1400	194	0.024	0.007	0.014
9/7	1300	119	0.028	0.004	0.017
	1400	126	0.028		
9/8	1400	130	0.037	0.003	0.019
9/9	O ₃ Catalyst depleted - no data				
9/28	1700	346	0.013	0	0.006
	1800	189	0.013		
9/29	2100	173	0.018	0	0.006
9/30	1500	200	0.022	0	0.009
Average September		163°	0.036	0.004	0.018

^aExceeded air-quality standard.

TABLE VIII
Ozone Concentration (ppm) for October 1976

<u>Date</u>	<u>Time of Maximum</u>	<u>Wind Direction for Maximum (°)</u>	<u>24-Hour Maximum</u>	<u>24-Hour Minimum</u>	<u>24-Hour Average</u>
10/1	0800	113	0.033	0.006	0.017
10/2	0700	135	0.025	0.004	0.013
10/3	1500	227	0.014	0	0.008
	1700	238	0.014		
10/4	1400	335	0.018	0.001	0.010
10/5	1800	108	0.021	0	0.010
10/6	1400	184	0.020	0.007	0.013
	2200	50	0.020		
10/7	0000	23	0.016	0.003	0.008
10/8	1200	205	0.012	0	0.006
10/9	1700	146	0.028	0	0.012
10/10	1000	173	0.023	0	0.011
10/11	1200	162	0.031	0	0.012
	1300	184	0.031		
10/12	1600	115	0.031	0.002	0.014
10/13	1200	86	0.020	0	0.014
10/14	2100	140	0.031	0.004	0.014
10/15	1300	56	0.015	0	0.008
	1700	7	0.015		
10/16	1700	162	0.024	0	0.009
10/17	1900	130	0.039	0.003	0.020
10/18	1600	270	0.033	0.002	0.016
10/19	0300	7	0.022	0.001	0.010
10/20	1700	140	0.071	0	0.021
10/21	2200	124	0.032	0	0.018
10/22	0100	130	0.040	0.001	0.019
10/23	1700	227	0.029	0	0.010
10/24	2200	94	0.017	0	0.007
10/25	2200	135	0.029	0	0.016
10/26	1100	281	0.028	0	0.015
10/27	1700	34	0.021	0	0.008
10/28	0800	77	0.025	0	0.013
10/29	1700	270	0.030	0.001	0.010
10/30	1400	281	0.028	0.001	0.010
10/31	1400	115	0.040	0.006	0.023
Average October		148°	0.027	0.001	0.013

TABLE IX

Ozone Concentration (ppm) for November 1976

<u>Date</u>	<u>Time of Maximum</u>	<u>Wind Direction for Maximum (°)</u>	<u>24-Hour Maximum</u>	<u>24-Hour Minimum</u>	<u>24-Hour Average</u>
11/1	1300	189	0.036	0	0.018
11/2	0900	313	0.029	0	0.013
11/3	1600	13	0.033	0	0.015
	1700	110	0.033		
11/4	1300	178	0.050	0	0.021
11/5	0500	146	0.039	0.007	0.023
11/6	1400	205	0.035	0.007	0.017
11/7	1400	40	0.018	0.003	0.010
11/8	1800	157	0.033	0	0.018
11/9	1500	270	0.167 ^a	0.007	0.037
11/10	1400	216	0.043	0	0.019
11/11	1100	29	0.040	0.005	0.013
11/12	Incomplete data				
11/13	Lost power on station - no data				
11/14	Lost power on station - no data				
11/15	Incomplete data				
11/16	1000	227	0.055	0.006	0.023
11/17	0000	157	0.024	0.005	0.016
11/18	1800	113	0.038	0.003	0.017
11/19	1800	108	0.026	0.001	0.013
11/20	1100	173	0.055	0	0.014
11/21	1900	72	0.029	0.002	0.013
11/22	1800	162	0.035	0.001	0.016
11/23	1700	243	0.028	0.002	0.015
11/24	1900	194	0.039	0.006	0.019
11/25	2200	40	0.014	0.002	0.007
11/26	1900	194	0.039	0.006	0.019
11/27	2200	40	0.014	0.002	0.007
11/28	Incomplete data				
11/29	Incomplete data				
11/30	1800	146	0.030	0.001	0.014
Average November		149°	0.039	0.003	0.015

^a Exceeded air-quality standard.

TABLE X

Ozone Concentration (ppm) for December 1976

Date	Time of Maximum	Wind Direction for Maximum (°)	24-Hour Maximum	24-Hour Minimum	24-Hour Average
12/1	1900	61	0.026	0.003	0.013
12/2	1300	270	0.053	0	0.018
12/3	1900	56	0.064	0.001	0.021
12/4	1800	103	0.047	0.002	0.016
12/5	1800	108	0.057	0.004	0.023
12/6	2000	56	0.017	0.002	0.007
12/7	1900	97	0.046	0.002	0.021
12/8	1800	130	0.056	0.007	0.022
12/9	1500	211	0.092 ^a	0.009	0.028
12/10	0100	113	0.013	0	0.008
	0700	113	0.013		
	2100	356	0.013		
12/11	1700	232	0.043	0.001	0.013
	1800	238	0.043		
12/12	1800	59	0.036	0.001	0.014
12/13	1500	135	0.082 ^a	0.003	0.015
12/14	1800	97	0.048	0.001	0.016
	1900	184	0.048		
12/15	1900	50	0.044	0.001	0.014
12/16	1900	151	0.073	0.005	0.024
12/17	1800	135	0.048	0.005	0.024
12/18	0000	167	0.020	0.007	0.012
12/19	0000	157	0.012	0.001	0.006
	0900	340	0.012		
	1400	259	0.012		
	1700	50	0.012		
12/20	1800	104	0.037	0.002	0.015
12/21	1900	140	0.027	0.004	0.014
12/22	1800	61	0.049	0.002	0.012
12/23	1800	124	0.044	0.003	0.020
12/24	2300	184	0.032	0.001	0.015
12/25	1900	115	0.037	0.001	0.015
12/26	1700	151	0.036	0	0.018
	1800	151	0.036		
12/27	1700	292	0.037	0.008	0.020
12/28	1800	113	0.051	0.004	0.019
12/29	1900	146	0.027	0.002	0.015
12/30	1900	83	0.013	0	0.006
12/31	1800	157	0.014	0	0.007
	2000	113	0.014		
Average December		147°	0.037	0.003	0.016

^a Exceeded air-quality standard.

Figure 19. Diurnal Variation in Ozone, June 1976

Figure 20. Diurnal Variation in Ozone, July 1976

Figure 21. Diurnal Variation in Ozone, August 1976

Figure 22. Diurnal Variation in Ozone, September 1976

Figure 23. Diurnal Variation in Ozone, October 1976

Figure 24. Diurnal Variation in Ozone, November 1976

Figure 25. Diurnal Variation in Ozone, December 1976

TABLE XI

Carbon Monoxide Concentration (ppm) for June 1976

<u>Date</u>	<u>Time of Maximum</u>	<u>Wind Direction for Maximum (°)</u>	<u>24-Hour Maximum</u>	<u>24-Hour Minimum</u>	<u>24-Hour Average</u>
6/11	0800	166	11	1	5
6/12	0700	351	12	4	8
6/13	0800	135	14	9	12
6/14	0300	157	15	0	7
	0500	135	15	0	7
6/15	1700	53	4	0	2
6/16	0400	104	4	0	2
	0700	125	4	0	2
6/17	2000	140	9	0	5
	2200	135	9	0	5
6/18	0000	135	8	5	7
	0100	135	8	5	7
	0200	140	8	5	7
	0300	140	8	5	7
6/19	0300	56	8	6	7
	0900	77	8	6	7
	1000	86	8	6	7
6/20	1100	149	9	6	7
6/21	0700	121	9	3	6
6/22	0800	146	8	5	6
6/23	1000	162	8	3	6
6/24	0000	130	8	5	6
	1100	2	8	5	6
6/25	0800	94	9	5	7
	1000	108	9	5	7
6/26	1200	140	9	6	7
6/27	1100	140	11	1	8
6/28	0300	130	10	6	8
	0400	130	10	6	8
	0800	124	10	6	8
	1000	113	10	6	8
6/29	0300	130	10	6	8
6/30	0400	119	11	7	9
	0800	76	11	7	9
Average June		126°	9.4	3.9	7.0

TABLE XII

Carbon Monoxide Concentration (ppm) for July 1976

Date	Time of Maximum	Wind Direction for Maximum (°)	24-Hour Maximum	24-Hour Minimum	24-Hour Average
7/1	0800	145	10	6	9
7/2	0100	119	11	6	9
	0300	124	11	6	9
7/3	1100	184	12	9	10
	1900	121	12	9	10
	2100	110	12	9	10
7/4	1000	91	12	8	10
	2200	86	12	8	10
7/5	0900	104	13	9	10
7/6	0400	265	12	8	10
	1100	97	12	8	10
7/7	0200	88	12	7	9
	0300	77	12	7	9
7/8	0700	103	11	8	9
	2300	130	11	8	9
7/9	0200	130	11	8	10
	1200	135	11	8	10
	2000	108	11	8	10
	2200	103	11	8	10
7/10	0000	124	11	9	10
	0500	124	11	9	10
	0900	135	11	9	10
	2200	119	11	9	10
7/11	1700	-a	13	9	10
7/12	0200	-a	11	9	10
	1000	-a	11	9	10
	1200	-a	11	9	10
	1500	-a	11	9	10
7/13	0600	124	11	6	9
	1200	135	11	6	9
	1300	164	11	6	9
7/14	0900	127	13	1	4
7/15-21	No carbon monoxide data recorded				
7/22	1100	108	13	1	6
	1300	113	13	1	6
	1500	92	13	1	6
7/23	1400	189	10	4	8
7/24	0900	130	22	6	
7/25	0800	115	16	9	11
7/26	0900	135	19	9	12
7/27	1200	178	30	0	9
7/28	1200	375	6	0	3
7/29	1100	194	6	2	4
	1500	238	6	2	4
7/30	1800	140	6	3	5
	1900	140	6	3	5
7/31	0100	130	6	5	5
	0800	162	6	5	5
	1300	130	6	5	5
	2200	151	6	5	5
Average July		136°	12.4	5.9	8.5

^a No wind direction data recorded.

TABLE XIII

Carbon Monoxide Concentration (ppm) for August 1976

<u>Date</u>	<u>Time of Maximum</u>	<u>Wind Direction for Maximum (°)</u>	<u>24-Hour Maximum</u>	<u>24-Hour Minimum</u>	<u>24-Hour Average</u>
8/1	1900	56	7	5	6
	2100	61	7	5	6
8/2	1900	351	19	10	15
8/3-24	Carbon monoxide detector not operating; water in system				
8/25	0800	97	11	7	9
	0900	113	11	7	9
8/26	1000	146	12	6	8
8/27	1100	173	11	5	8
8/28	0800	2	11	8	9
8/29	1000	104	10	8	9
	1100	151	10	8	9
	1200	324	10	8	9
	1300	126	10	8	9
	2100	86	10	8	9
	2200	113	10	8	9
8/30	1200	61	11	9	9
8/31	1000	167	10	7	9
	1100	189	10	7	9
	2200	61	10	7	9
Average August		132°	10.6	7.3	8.9

TABLE XIV

Carbon Monoxide Concentration (ppm) for September 1976

Date	Time of Maximum	Wind Direction for Maximum (°)	24-Hour			Date	Time of Maximum	Wind Direction for Maximum (°)	24-Hour		
			Max	Min	Avg				Max	Min	Avg
9/1	0000	99	10	7	9	9/19	1100	346	6	3	5
	0100	169	10	7	9		1200	7	6	3	5
	0200	29	10	7	9	9/20	1600	45	5	2	4
	0500	351	10	7	9		1200	178	5	2	4
	0600	324	10	7	9	9/21	1400	243	5	2	4
	0800	2	10	7	9		1500	281	5	2	4
	0900	7	10	7	9		1700	189	5	2	4
	1000	18	10	7	9		1900	162	5	2	4
9/2	2300	151	11	8	9		2000	211	5	2	4
9/3	1000	216	12	9	10		2100	184	5	2	4
						9/22	1100	194	9	3	6
9/4	0700	103	18	8	11		0000	162	9	6	8
9/5	1500	157	14	10	11		1800	238	9	6	8
9/6	0000	259	12	9	10	9/23	2000	216	9	6	8
							2200	189	9	6	8
9/7	0200	119	11	9	10		1500	167	9	7	8
	0400	178	11	9	10		1900	135	9	7	8
	0900	178	11	9	10	9/25	1300	281	9	7	8
	1000	162	11	9	10		0200	184	8	6	7
	1100	189	11	9	10	9/26	0500	319	8	6	7
	1300	119	11	9	10		1000	238	8	6	7
	2000	113	11	9	10		1100	200	8	6	7
	2300	140	11	0	10		1200	18	8	6	7
9/8	1100	232	12	9	10	9/27	2000	146	8	6	7
9/9	0100	115	9	7	8		1100	270	8	5	7
	0200	340	9	7	8		2000	29	8	5	7
	0300	56	9	7	8		2100	23	8	5	7
	0600	99	9	7	8		2200	7	8	5	7
	0700	83	9	7	8		2300	13	8	5	7
	0800	83	9	7	8	9/28	1700	346	8	6	7
9/10	1100	140	10	7	9		1800	189	8	6	7
	1300	130	10	7	9		1900	a	8	6	7
	1400	184	10	7	9		1100	232	8	5	6
	1500	167	10	7	9	9/29	2200	151	8	5	6
	1700	173	10	7	9		0000	130	7	5	6
	1800	157	10	7	9	9/30	0100	97	7	5	6
	1900	173	10	7	9		0200	113	7	5	6
	2000	184	10	7	9		0400	108	7	5	6
9/11	1100	227	10	8	9		0500	130	7	5	6
	1200	194	10	8	9		0600	103	7	5	6
9/12	1100	281	11	7	9		0900	286	7	5	6
9/13	1000	205	11	5	8		1000	227	7	5	6
9/14	1000	135	9	7	8		2100	157	7	5	6
	1200	135	9	7	8		2200	140	7	5	6
	1400	158	9	7	8						
	1500	130	9	7	8						
Average September								159°	8.6	5.9	7.4

^a No wind direction data recorded.

TABLE XV

Carbon Monoxide (Concentration in Air (ppm) for October

Date	Time of Maximum	Wind Direction for Maximum	24-Hour			Date	Time of Maximum	Wind Direction for Maximum	24-Hour			
		(°)	Maximum	Minimum	Average			(°)	Maximum	Minimum	Average	
10/1	1000	135	8	5	7	10/18	0200	130	9	5	7	
	1100	146	8	5	7		0800	108	9	5	7	
10/2	0200	151	8	6	7		1000	173	9	5	7	
	0400	108	8	6	7		1100	211	9	5	7	
	1100	259	8	6	7		1200	216	9	5	7	
	1300	292	8	6	7		1300	216	9	5	7	
	1400	302	8	6	7	10/19	1100	357	6	4	5	
	1500	292	8	6	7		1200	40	6	4	5	
	1600	313	8	6	7		1300	346	6	4	5	
	1700	216	8	6	7		1400	72	6	4	5	
	1800	173	8	6	7		1500	335	6	4	5	
	1900	108	8	6	7							
10/3	0000	162	7	5	6	10/20	0900	200	6	3	5	
	0400	130	7	5	6		2300	108	6	3	5	
	0500	135	7	5	6	10/21	1000	140	7	5	6	
	0700	157	7	5	6		1200	146	7	5	6	
	0800	200	7	5	6		1800	108	7	5	6	
	0900	227	7	5	6		1900	108	7	5	6	
	1000	238	7	5	6	10/22	0000	162	7	6	6	
	1100	238	7	5	6		1100	189	7	6	6	
	1200	157	7	5	6		1200	189	7	6	6	
	1300	248	7	5	6		1400	184	7	6	6	
					2100		140	7	6	6		
10/4	0000	140	7	4	6	2200	130	7	6	6		
	0300	157	7	4	6	2300	113	7	6	6		
	0400	162	7	4	6	10/23	0000	158	8	6	7	
	0700	173	7	4	6		0900	137	8	6	7	
	0900	335	7	4	6		1000	216	8	6	7	
	1100	356	7	4	6		1100	227	8	6	7	
10/5	0000	56	6	4	5	10/24	1000	270	7	5	6	
	1900	97	6	4	5							
	2000	92	6	4	5	10/25	0100	126	7	4	6	
10/6	1200	194	6	5	5		0200	126	7	4	6	
	1300	221	6	5	5		0900	121	7	4	6	
	1400	184	6	5	5		1000	126	7	4	6	
	1600	227	6	5	5		1100	140	7	4	6	
	1800	346	6	5	5	10/26	0900	162	6	3	4	
	1900	29	6	5	5		1000	277	6	3	4	
	2100	99	6	5	5		10/27	1100	2	6	3	5
	2200	50	6	5	5							
	2300	29	6	5	5		10/28	0200	18	5	3	5
10/7	0000	23	7	3	5	0300		50	5	3	5	
						0800	77	5	3	5		
	10/8	0100	34	4	2	3	0900	83	5	3	5	
		0800	158	4	2	3	1000	83	5	3	5	
		0900	232	4	2	3	1200	88	5	3	5	
		1000	216	4	2	3	1300	77	5	3	5	
1100		238	4	2	3	1400	77	5	3	5		
1200	205	4	2	3	1600	72	5	3	5			
10/9	2100	140	4	2	3	1700	56	5	3	5		
						1800	72	5	3	5		
10/10	0100	151	3	1	2	1900	67	5	3	5		
	0900	173	3	1	2	2000	50	5	3	5		
10/11	0800	124	3	1	2	2200	72	5	3	5		
	0900	162	3	1	2	10/29	0100	29	5	2	4	
10/12	2300	126	10	2	5		0900	346	5	2	4	
							1300	238	5	2	4	
10/13	1000	302	11	7	9		1400	238	5	2	4	
10/14	1200	173	11	8	9		1500	248	5	2	4	
	1300	232	11	8	9		1600	243	5	2	4	
10/15	0000	130	10	8	9		1800	248	5	2	4	
	1100	346	10	8	9		1900	254	5	2	4	
	1200	7	10	8	9		2100	248	5	2	4	
	1500	23	10	8	9		2200	227	5	2	4	
10/16	0100	29	8	6	7	10/30	0100	208	5	3	4	
	0600	313	8	6	7		0800	18	5	3	4	
	0800	45	8	6	7		0900	313	5	3	4	
	1200	40	8	6	7		1000	324	5	3	4	
	1300	7	8	6	7		1100	319	5	3	4	
	1700	162	8	6	7		1200	313	6	3	4	
	1900	103	8	6	7		1300	292	5	3	4	
							1900	124	5	3	4	
10/17	1300	151	9	7	8	10/31	2000	81	5	3	4	
	1400	151	9	7	8		2300	97	5	3	4	
	1500	167	9	7	8							
	1600	162	9	7	8	0700	103	6	5	5		
	1700	157	9	7	8	0800	108	6	5	5		
	1800	146	9	7	8	0900	113	6	5	5		
	1900	130	9	7	8	1200	130	6	5	5		
	2200	130	9	7	8	1300	130	6	5	5		
	2300	135	9	7	8	2300	103	6	5	5		
Average (October								182°	6.7	4.5	5.6	

TABLE XVI

Carbon Monoxide Concentration (ppm) for November 1978

Date	Time of Maximum	Wind Direction for Maximum (°)	24-Hour			Date	Time of Maximum	Wind Direction for Maximum (°)	24-Hour			
			Max	Min	Avg				Max	Min	Avg	
11/1	0800	157	6	4	5	11/11 (cont.)	1600	67	5	4	5	
	0900	104	6	4	5		1800	72	5	4	5	
	1000	104	6	4	5		1900	61	5	4	5	
	1200	178	6	4	5		2000	77	5	4	5	
11/2	0000	119	5	3	4	2100	72	5	4	5		
	0800	119	5	3	4	2200	88	5	4	5		
	0900	313	5	3	4	2300	61	5	4	5		
	1100	292	5	3	4	11/12-15 Power Failure						
	2000	108	5	3	4	11/16	1800	67	6	4	5	
	2100	140	5	3	4		1700	83	6	4	5	
	2200	70	5	3	4		2000	72	6	4	5	
11/3	1200	324	8	0	3	2100	356	6	4	5		
11/4	1200	356	8	0	4	2200	99	6	4	5		
	2200	167	8	0	4	2300	94	6	4	5		
	2300	216	8	0	4	11/17	0100	29	7	3	5	
11/5	1000	189	9	6	7		0300	40	7	3	5	
11/6	0000	108	8	6	7		0500	13	7	3	5	
	0100	135	8	6	7		0800	351	7	3	5	
11/7	0300	140	8	6	7	11/18	0800	38	4	3	3	
	0400	140	8	6	7		1000	227	4	3	3	
	0500	119	8	6	7		1700	173	4	3	3	
	0800	187	8	6	7		1800	187	4	3	3	
	0900	324	8	6	7	11/19	1500	275	5	3	4	
	1000	270	8	6	7		11/20	0300	2	4	3	3
	1100	324	8	6	7			0600	18	4	3	3
	2100	97	8	6	7			0800	356	4	3	3
	2200	97	8	6	7	1600		216	4	3	3	
	2300	103	8	6	7	2000	135	4	3	3		
	11/8	0000	18	8	7	8	11/21	0000	103	3	2	2
		0100	40	8	7	8		0100	103	3	2	2
0200		40	8	7	8	0200		65	3	2	2	
0500		351	8	7	8	0300		65	3	2	2	
0900		29	8	7	8	0400		59	3	2	2	
1000		40	8	7	8	1100		67	3	2	2	
1100		45	8	7	8	1600		140	3	2	2	
1300		29	8	7	8	11/22	0100	113	3	1	2	
1400		40	8	7	8		0500	108	3	1	2	
1500		29	8	7	8		0700	113	3	1	2	
1600		40	8	7	8		0800	135	3	1	2	
1800		61	8	7	8	11/23	2200	83	3	1	2	
1900		61	8	7	8		2300	164	3	1	2	
2000		61	8	7	8		11/24	0500	130	3	1	2
2100		72	8	7	8	0800		113	3	1	2	
2200		292	8	7	8	0900		194	3	1	2	
11/9	0200	142	8	4	6	11/25	0000	136	2	1	2	
11/10	0500	45	6	4	5		0100	335	2	1	2	
	0700	40	6	4	5		0200	61	2	1	2	
	0800	351	6	4	5		0500	115	2	1	2	
	1100	216	6	4	5		0600	121	2	1	2	
	1200	292	6	4	5		0700	169	2	1	2	
	1300	286	6	4	5		0800	346	2	1	2	
	2200	108	6	4	5		0900	173	2	1	2	
2300	108	6	4	5	1000		194	2	1	2		
11/11	0000	297	5	4	5		1100	216	2	1	2	
	0100	76	5	4	5		1400	360	2	1	2	
	0200	103	5	4	5		1600	238	2	1	2	
	0300	108	5	4	5		2100	205	2	1	2	
	0500	313	5	4	5	11/26	0000	227	1	0	1	
	0600	45	5	4	5		0100	270	1	0	1	
	0700	18	5	4	5		0200	303	1	0	1	
	0800	346	5	4	5		0300	254	1	0	1	
	0900	346	5	4	5		0700	248	1	0	1	
	1000	308	5	4	5		0900	238	1	0	1	
	1200	275	5	4	5		1000	240	1	0	1	
	1300	211	5	4	5		1100	248	1	0	1	
	2000	162	5	4	5		1500	243	1	0	1	
	2100	162	5	4	5		1600	248	1	0	1	
	2200	174	5	4	5		1700	243	1	0	1	
	2300	146	5	4	5		1800	130	1	0	1	
	11/12	0000	140	5	4		5	1900	194	1	0	1
0100		140	5	4	5		2000	216	1	0	1	
0200		211	5	4	5		2100	45	1	0	1	
0300		81	5	4	5	11/27	0000	18	1	0	0	
0400		2	5	4	5		0100	18	1	0	0	
0500		351	5	4	5		1100	72	1	0	0	
0700		7	5	4	5		1400	72	1	0	0	
0800		13	5	4	5	11/28-29	Less than 24 hours of operation.					
0900		7	5	4	5		11/30	0800	108	24	9	16
1000		23	5	4	5			Average November				
1100		29	5	4	5			147°				
1200		40	5	4	5	5.0						
1300		40	5	4	5	3.2						
1400		40	5	4	5	4.3						
1500		45	5	4	5							

TABLE XVII

Carbon Monoxide Concentration (ppm) for December 1976

Wind Direction for Maximum						Wind Direction for Maximum						
Time of Maximum		24-Hour		24-Hour		Time of Maximum		24-Hour		24-Hour		
Date	Maximum	(°)	Max	Min	Avg	Date	Maximum	(°)	Max	Min	Avg	
12/1	0600	351	12	9	11	12/18	1300	227	4	1	3	
	0700	351	12	9	11		12/19	0000	157	3	1	2
	0800	2	12	9	11			0500	356	3	1	2
	0900	356	12	9	11			0900	340	3	1	2
	1000	18	12	9	11			1200	335	3	1	2
12/2	0200	340	11	9	10	12/20		0900	18	2	0	1
	0300	108	11	9	10		1000	29	2	0	1	
	0400	173	11	9	10		1100	40	2	0	1	
	0500	92	11	9	10		12/21	0000	142	1	0	1
	0700	29	11	9	10	0100		137	1	0	1	
	0800	324	11	9	10	0200		99	1	0	1	
	0900	313	11	9	10	0300		153	1	0	1	
	1000	302	11	9	10	0400	148	1	0	1		
1400	259	11	9	10	0500	158	1	0	1			
12/3	0800	140	11	8	10	0600	142	1	0	1		
	0900	124	11	8	10	0700	115	1	0	1		
	1000	319	11	8	10	0900	151	1	0	1		
	1100	302	11	8	10	1000	157	1	0	1		
12/4	1000	61	11	8	9	1100	167	1	0	1		
12/5	0900	167	11	8	9	1200	157	1	0	1		
12/6	0000	29	10	8	9	1400	162	1	0	1		
	1000	23	10	8	9	12/22	0900	319	2	0	1	
12/7	0700	162	10	0	8		1100	324	2	0	1	
	0800	189	10	0	8		1200	340	2	0	1	
	0900	259	10	0	8		1300	340	2	0	1	
	1000	297	10	0	8		1400	340	2	0	1	
	1100	292	10	0	8	1500	351	2	0	1		
	1200	319	10	0	8	12/23	1000	216	3	0	1	
12/8	0900	194	14	2	8		12/24	1000	189	3	1	1
12/9	2000	130	6	3	4	12/25	1100	324	2	0	1	
	2300	119	6	3	4	12/26	0900	324	3	0	1	
12/10	0900	302	7	5	6		1000	292	3	0	1	
	1000	29	7	5	6	12/27	0500	130	1	0	0	
	1100	45	7	5	6		0800	292	1	0	0	
12/11	0300	335	6	4	5		0900	292	1	0	0	
	1000	29	6	4	5		1000	270	1	0	0	
12/12	0800	351	7	5	6		1300	238	1	0	0	
	0900	302	7	5	6		1400	238	1	0	0	
	1000	340	7	5	6	1500	248	1	0	0		
	1200	270	7	5	6	12/28	0600	29	1	0	1	
	1500	77	7	5	6		0700	40	1	0	1	
12/13	0000	61	6	2	4		0800	34	1	0	1	
	0100	67	6	2	4		0900	40	1	0	1	
	0200	34	6	2	4		1000	50	1	0	1	
	0300	2	6	2	4		1100	40	1	0	1	
	0400	18	6	2	4		1200	29	1	0	1	
	0500	34	6	2	4		1300	29	1	0	1	
	0600	29	6	2	4		1400	281	1	0	1	
	0800	67	6	2	4		1500	346	1	0	1	
	0900	88	6	2	4		1600	18	1	0	1	
	1000	72	6	2	4		2000	173	1	0	1	
	1100	67	6	2	4		2100	178	1	0	1	
	1200	351	6	2	4		2200	173	1	0	1	
	1300	167	6	2	4		2300	173	1	0	1	
12/14	0800	146	4	1	2	12/29	0900	259	2	0	1	
	0900	270	4	1	2		1000	7	2	0	1	
12/15	0800	335	3	1	2		1100	254	2	0	1	
	0900	335	3	1	2	12/30	0700	270	3	0	2	
	1000	308	3	1	2		0900	281	3	0	2	
	1200	18	3	1	2		1000	292	3	0	2	
12/16	0900	292	3	1	2		1100	286	3	0	2	
	1000	292	3	1	2		1200	259	3	0	2	
12/17	0800	67	3	1	2		1400	270	3	0	2	
	0900	281	3	1	2	12/31 No carbon monoxide data recorded.						
	1000	281	3	1	2	Average December 188° 4.8 2.3 3.8

Figure 26. Diurnal Variation in Carbon Monoxide, June 1976

Figure 27. Diurnal Variation in Carbon Monoxide, July 1976

Figure 28. Diurnal Variation in Carbon Monoxide, August 1976

Figure 29. Diurnal Variation in Carbon Monoxide, September 1976

Figure 30. Diurnal Variation in Carbon Monoxide, October 1976

Figure 31. Diurnal Variation in Carbon Monoxide, November 1976

Figure 32. Diurnal Variation in Carbon Monoxide, December 1976

Figure 33. Sulfur Dioxide Concentrations in Air at WIPP Site - CY 1976

Figure 34. Nitrogen Dioxide Concentrations in Air at WIPP Site - CY 1976

Figure 35. Hydrogen Sulfide Concentrations in Air at WIPP Site - CY 1976

TABLE XVIII

Elemental Composition of Total Particulate Samples at WIPP Site - CY 1976

Date	Type	Log No.	Volume Sampled (m ³)	Weight Part. (μg/m ³)	Sodium (μg/m ³)	Potassium (μg/m ³)	Calcium (μg/m ³)	Magnesium (μg/m ³)	Silicon (μg/m ³)	Iron (μg/m ³)	Aluminum (μg/m ³)	Chloride (ppm)	Sulfate (ppm)
01/06/76	G	760180	754	17.0	0.0	0.0	0.0	0.0				8	2
01/15/76	G	760410	754	26.1	0.097	0.297	0.0	0.0				58	1
01/20/76	G	760411	754	17.1	0.044	0.0	0.0	0.0				26	2
01/27/76	G	760412	754	8.0	0.0	0.0	0.0	0.0				3	0
02/04/76	G	760478	754	3.6	0.305	0.0	0.0	0.053				0	20
02/10/76	G	760577	754	7.6	0.517	0.255	0.0	0.269					12
02/17/76	G	760593	754	33.7	0.016	0.141	0.0	0.252				10	9
02/19/76	G	760677	754	30.5								0	3.9
02/23/76	G	760678	754	10.6								0	19
03/03/76	G	760753	754									5	32
03/09/76	G	761089	754	11.7	0.729	0.0	0.0	0.305				0	60
03/11/76	G	761090	754	28.4	1.127	0.082	0.0	1.101				0	66
03/15/76	G	761091	754	58.9	1.127	0.023	0.013	1.233				2.5	110
03/16/76	G	761092	754	18.3	1.061	0.0	0.0	0.869				0	73
03/17/76	G	761093	754	25.5	1.194	0.019	0.0	0.902				2.5	68
03/23/76	W	761025	566									0	17
03/25/76	G	761023	754									2.5	41
03/30/76	W	761024	754									5	22
04/06/76	W	761026	566									5	18
04/12/76	G	761085	754	7.3	0.729	0.0	0.0	0.259				0	72
04/13/76	G	761086	754	3.2	1.658	0.0	0.0	0.703				0	10.5
04/14/76	W	761087	754	1.2	0.099	0.0	0.0	0.259				2.5	32
04/18/76	G	761115	754	16.4	0.332	0.095	0.0	0.869				22.5	69
04/19/76	G	761116	754	39.1	0.597	0.0	0.0	0.869				2.5	64
04/20/76	MF	761117	754		0.048	0.0	0.0	0.0				0	40
04/25/76	G	761118	754	26.4	0.663	0.0	0.0	0.570				0	49
05/03/76	G	761270	754	6.5	0.796	0.0	0.0	0.537				0	38
05/04/76	G	761271	754	8.1	0.398	0.0	0.0	0.225				2.5	50
05/05/76	W	761272	754		0.042	0.0	0.0	0.0				15	13
05/10/76	G	761435	754	0.8	1.127	0.0	0.0	0.836				2.5	53
05/11/76	G	761436	754	8.8	0.663	0.0	0.0	0.471				0	39
05/17/76	G	761438	754	15.1	0.497	0.0	0.0	0.537				0	65
05/18/76	G	761439	754	13.4	0.729	0.0	0.0	0.537				0	63
05/19/76	W	761437	754		0.0	0.0	0.0	0.0				0	46

TABLE XVIII (cont)

Date	Type	Log No.	Volume Sampled (m ³)	Weight Part. (μg/m ³)	Sodium (μg/m ³)	Potassium (μg/m ³)	Calcium (μg/m ³)	Magnesium (μg/m ³)	Silicon (μg/m ³)	Iron (μg/m ³)	Aluminum (μg/m ³)	Chloride (ppm)	Sulfate (ppm)
05/12/76	W	761476	754		0.0	0.034	0.069	0.228				5	22
05/24/76	G	761477	754	16.7	0.0	0.0	0.0	0.040				0	48
05/25/76	G	761478	754	49.9	0.0	0.023	0.0	0.471				0	69
05/26/76	W	761479	754		0.0	0.001	0.034	0.0				0	0
06/01/76	G	761480	754	15.4	0.0	0.0	0.0	0.0				0	69
06/02/76	G	761481	754	11.0	0.0	0.0	0.0	0.0				0	52
06/03/76	W	761482	754		0.0	0.002	0.101	0.042				0	44
06/14/76	G	761558	754	30.2	4.310	0.049	0.0	0.915	0.398	0.174		10	40
06/15/76	G	761559	754	77.7	4.380	0.036	0.0	1.459	0.0	0.724		0	33
06/16/76	W	761560	754		0.074	0.008	0.300	0.218		0.219		0	17
06/21/76	G	761561	754	21.6	4.045	0.0	0.0	0.646		0.107		0	47
06/22/76	G	761562	754	29.4	3.382	0.0	0.0	0.516		0.107		0	39
06/23/76	W	761563	754		0.089	0.016	0.473	0.406		0.537		0	21
06/28/76	G	761586	1414	11.5	1.909	0.0	0.0	0.050	0.0	0.043		0	39
06/30/76	W	761587	754	12.3	3.183	0.042	0.658	1.081	0.332	0.146		0	25
07/01/76	G	761588	754		0.0	0.0	0.172	0.0		0.154		0	18
07/06/76	G	761640	754	13.3	2.321	0.020	0.0	0.431	0.0	0.008		0	45
07/07/76	G	761641	754	7.7	2.42	0.0	0.0	0.190	0.0	0.0		0	20
07/08/76	W	761642	628		0.107	0.005	0.083	0.049	0.0	0.0		0	
07/12/76	G	761669	754	8.5	0.0	0.093	0.0		0.0	0.0	0.166	0	42
07/13/76	G	761670	754	7.3	0.0	0.023	0.0		0.0		0.166	0	54
07/14/76	W	761671	566		0.0	0.018	0.046	0.023	0.0	0.053		0	41
07/19/76	G	761783	754		0.0	0.126		0.0	0.0	0.048	0.265	0	51
07/20/76	G	761784	754		0.0	0.102	0.0	0.0	0.0	0.0	0.265	0	48
07/21/76	W	761785	754		0.0	0.044	0.218	0.057	3.32	0.135	0.130	0	28
07/25/76	G	761916	754	11.0	0.0	0.045	0.0			0.034	0.130		
07/27/76	G	761917	754	9.0	0.0	0.038	0.0			0.0	0.130		25
07/28/76	W	761918	754	34.1		0.113	0.210	0.053		0.106	0.053		
08/03/76	G	761919	754	9.9	0.0	0.357		0.0	0.365		0.318	0	49
08/04/76	G	761920	754	12.5	0.0	0.060	0.0		0.0		0.166	0	50
08/05/76	W	761921	754	37.5	0.008	0.094	0.586	0.052		0.066			85
08/09/76	G	761964	754	11.5	0.0	0.111	0.0	0.0	0.365		0.265		39
08/10/76	G	761965	754	12.9	0.0	0.033	0.0			0.0	0.077		
08/11/76	W	761966	754	38.7	0.0	0.061	0.633	0.034		0.032			87
08/16/76	G	762053	754	6.4	0.424	0.0	0.0	0.0		0.0	0.345		35
08/19/76	W	762055	754	39.1	0.698	0.074	0.414	0.042	0.286	0.088	0.069		145
08/19/76	G	762054	754	8.8	0.690	0.0	0.0	0.0	0.0	0.0	0.414		51

TABLE XVIII (cont)

Date	Type	Log No.	Volume Sampled (m ³)	Weight Part. (μg/m ³)	Sodium (μg/m ³)	Potassium (μg/m ³)	Calcium (μg/m ³)	Magnesium (μg/m ³)	Silicon (μg/m ³)	Iron (μg/m ³)	Aluminum (μg/m ³)	Chloride (ppm)	Sulfate (ppm)
08/23/76	G	762067	754	15.6	0.0	0.0	0.0	0.0	0.0	0.0	0.345		85
08/24/76	G	762068	754	15.6	0.133	0.0	0.0	0.0	0.0	0.0	0.414		47
08/25/76	W	762069	754	32.4	0.050	0.061	0.467	0.049	0.531	0.098	0.069		60
08/30/76	G	762115	754	4.9	0.159	0.0	0.0	0.0	0.0	0.0	0.345		39
08/31/76	G	762116	754	13.5	0.0	0.286	0.0	0.0	0.0	0.0	0.414	0	50
09/02/76	W	762117	1445	23.2	0.026	0.028	0.226	0.025	0.277	0.046	0.036	0	90
09/07/76	G	762118	754	4.9	0.0		0.0	0.0	0.0	0.0	0.276	0	28
09/08/76	G	762119	754	3.3	0.371	0.0	0.0	0.0	0.0	0.0	0.345	0	42
09/09/76	W	762120	754	33.6	0.074	0.455	0.032	0.036	0.286	0.042	0.069	5	19
09/14/76	G	762130	754	9.4	0.785	0.127	0.0	0.0	0.175	0.0	0.082	0	60
09/15/76	G	762131	754	9.0	1.377	0.168	0.0	0.0	0.248	0.0	0.264	0	55
09/16/76	W	762132	754	30.6	0.191	0.034	0.241	0.042	0.0	0.038	0.0	0	40
09/20/76	G	762160	754	8.8	0.674	0.145	0.0	0.0	0.503	0.0	0.134	0	59
09/21/76	G	762161	754	13.5	0.0	0.182	0.0	0.0	0.284	0.0	0.134	0	140
09/22/76	W	762162	3582	13.7	0.113	0.224	0.161	0.101	0.0	0.041	0.0	15	175
09/23/76	G	762178	754	4.4	0.0	0.347	0.0	0.0	0.0	0.0	0.186	5	44
09/29/76	G	762179	754	7.8	1.050	0.369	0.0	0.011	0.0	0.0	0.005	5	61
09/30/76	W	762180	754	18.6	0.062	0.447	0.332	0.053	0.0	0.054	0.0	5	32
10/05/76	G	762181	754	16.3	0.416	0.102	0.0	0.0	0.095	0.027	0.265	0	50
10/07/76	W	762182	754	50.1	0.171	0.275	0.915	0.219	0.0	0.387	0.191	10.5	28
10/13/76	W	762296	754	18.7	0.063	0.088	0.103	0.033	0.0	0.080	0.0	3.5	23
10/14/76	W	762297	754	21.2	0.070	0.076	0.492	0.039	0.0	0.062	0.0	0.0	41
10/20/76	W	762298	754	21.9	0.336	0.119	0.0	0.0	0.0	0.081	0.265	7.0	54
10/21/76	G	762299	754	3.6	0.269	0.070	0.0	0.0	0.0	0.0	0.191	10.5	
10/25/76	G	762376	754	10.3	0.133	0.160	0.0	0.0	0.0	0.0	0.005	2.5	82
10/26/76	G	762377	754	43.4	2.080	0.635	0.142	0.313	0.647	0.280	0.549	5	51
10/27/76	W	762378	754	8.2	0.068	0.023	0.0	0.037	0.0	0.0	0.0	0	20
11/01/76	G	762379	754	6.1	1.390	0.712	0.0	0.069	0.175	0.0	0.005	5	62
11/02/76	G	762380	754	25.3	1.836	2.378	0.0	0.557	0.430	0.0	0.005	32.5	150
11/03/76	W	762381	754	31.0	0.541	0.806	0.492	0.509	0.0	0.211	0.0	25	54
11/08/76	G	762512	754	17.1	1.719	0.966	0.0	0.218	0.539	0.005	0.134	15	49
11/09/76	G	762513	754	30.2	1.857	1.264	0.0	0.233	0.466	0.0	0.082	20	69
11/10/76	W	762514	754	59.7	0.203	0.680	0.545	0.134	0.507	0.125	0.005	12.5	58
11/16/76	G	762541	754	10.7	0.0	0.44	0.0	0.0	0.0	0.0	0.04	0	150
11/17/76	G	762542	754	10.3	0.0	0.14	0.0	0.0	0.0	0.0	0.04	0	110

TABLE XVIII (cont)

Date	Type	Log No.	Volume Sampled (m ³)	Weight Part. (ug/m ³)	Sodium (ug/m ³)	Potassium (ug/m ³)	Calcium (ug/m ³)	Magnesium (ug/m ³)	Silicon (ug/m ³)	Iron (ug/m ³)	Aluminum (ug/m ³)	Chloride (ppm)	Sulfate (ppm)
11/18/76	W	762543	754	29.8	0.422	1.77	0.30	0.31	0.0	0.12	0.0	115	68
11/19/76	G	762544	754	8.0	0.0	0.58	0.0	0.0	0.0	0.0	0.12	10.5	60
11/20/76	G	762545	754	18.4	0.0	2.45	0.0	0.0	0.0	0.0	0.12	80.5	95
11/21/76	G	762546	754	19.0	0.0	0.24	0.0	0.0	0.0	0.0	0.19	3.5	57
11/22/76	G	762547	754	11.1	0.0	0.02	0.0	0.0	0.0	0.0	0.19	3.5	45
11/23/76	G	762548	754	9.5	0.0	0.04	0.0	0.0	0.0	0.0	0.12	0	52
11/24/76	G	762549	754	21.2	0.0	0.15	0.0	0.0	0.0	0.0	0.19	0	75
11/28/76	G	762576	3330	25.7	0.0	0.29	0.19	0.0	0.0	0.51	0.21	14	300+
11/30/76	G	762577	754	14.5	0.0	1.98	0.0	0.0	0.0	0.0	0.12	59.5	85
12/01/76	G	762545	754	15.3	0.0	0.76	0.0	0.0	0.0	0.0	0.27	21	50
12/02/76	G	762546	754	25.1	0.0	2.71	0.0	0.0	0.0	0.0	0.19	84	125
12/07/76	G	762700	754	11.5	0.0	0.74	0.0	0.0	0.0	0.03	0.37	16.7	42
12/08/76	G	762701	754	11.9	0.0	0.62	0.0	0.0	0.0	0.0	0.56	36.7	40
12/09/76	W	762702	754	13.5	0.0	0.13	0.23	0.05	0.0	0.15	0.0	3.3	43
12/14/76	G	762713	754	18.2	0.0	0.10	0.0	0.0	0.0	0.0	0.13	10	53
12/15/76	G	762714	754	19.0	0.0	0.81	0.0	0.0	0.0	0.0	0.30	66.7	57
12/16/76	W	762715	754	25.3	0.138	0.92	0.38	0.16	0.0	0.30	0.30	30	29

DISCUSSION

Water problems plagued the first several months of operation of the carbon monoxide and ozone monitors. In mid-July water began to condense in the sampling lines of the carbon monoxide monitor, necessitating the removal of all lines and air drying before reassembly. In August water again entered the system and reached the infrared detector cell before being noticed. The cell had to be removed, cleaned, dried, and reinstalled. A suitable dryer* was obtained and installed at the inlet to the sampling system, and all water problems were eliminated. In August a definite increase in carbon monoxide levels was noted, and after alignment and calibration it was found that the mechanical zero had changed and was equivalent to a 4-ppm CO level. Therefore, all readings for July, August, and September are probably high by 4 ppm.

Sulfur dioxide concentrations as presented in Figure 33 had an average 24-hour value of $4.29 \mu\text{g}/\text{m}^3$. The highest value occurred on August 13, 1976, when it reached $28 \mu\text{g}/\text{m}^3$. The sulfur dioxide levels for the year were below Federal and State standard levels (see Appendix D).

Based on 24-hour samples taken once per week, the average 24-hour concentration of nitrogen dioxide during the 1976 sampling period was $32.19 \mu\text{g}/\text{m}^3$. The highest value was $130 \mu\text{g}/\text{m}^3$, from a sample collected during a rainstorm on July 23, 1976 (Figure 34). Compared with the Federal and State regulations for air quality (Appendix D), the level of nitrogen dioxide at the WIPP site was not exceeded during the year.

Hydrogen sulfide data as presented in Figure 35 shows that the highest reading occurred on November 2, 1976, when the concentration reached $0.22 \mu\text{g}/\text{m}^3$. The average 24-hour value for the 7 months was $0.11 \mu\text{g}/\text{m}^3$ of air. Based on the 24-hour value of $0.22 \mu\text{g}/\text{m}^3$, the State standard of 0.003 ppm ($4.5 \mu\text{g}/\text{m}^3$) for a 1-hour average was probably not exceeded during the sampling periods.

*A filter for removing particulate matter (a pleated paper cartridge in a plastic holder).

Appendix A

DETERMINATION OF SULFUR DIOXIDE

Introduction

The method described is applicable to the determination of sulfur dioxide in outside ambient air in the concentration range from 0.0005 to 5.0 ppm. Sulfur dioxide is absorbed in 0.1 M sodium tetrachloromercurate. The addition of acid-bleached pararosaniline and formaldehyde to the complex ion produces red-purple pararosaniline methylsulfonic acid, which is measured spectrophotometrically at 548 nm.

Reagents

1. Absorbing Reagent, 0.1 M sodium tetrachloromercurate (0.04 M)
Dissolve 10.86 grams of mercuric chloride, 0.066 gram of EDTA (ethylenediaminetetracetic acid, disodium salt) and 6.0 grams of potassium chloride in 1 litre of distilled water. (Prepare fresh every 6 months.)
2. Sulfamic acid (0.6%)
Dissolve 0.6 gram of sulfamic acid in 100 mL of distilled water. (Prepare fresh daily.)
3. Formaldehyde (0.2%)
Dilute 1 mL of 36%-38% formaldehyde to 200 mL. (Prepare fresh daily.)
4. Stock Iodine Solution (0.1 N)
Place 12.7 grams of iodine in a 250-mL beaker. Add 40 grams of potassium iodide and 25 mL of distilled water. Stir until dissolved and dilute to 1 litre. (Store in amber bottle in refrigerator.)

5. Iodine Solution (0.01 N)

Dilute 50 mL of stock iodine solution (#4) to 500 mL with distilled water. (Store in amber bottle in refrigerator.)

6. Starch Indicator Solution

Dissolve 0.4 gram of soluble starch in 200 mL of boiling distilled water.

7. Stock Thiosulfate Solution (0.1 N)

Dissolve 25 grams of sodium thiosulfate in a small amount of distilled water in a 1000-mL volumetric flask. Add 0.1 gram of sodium carbonate and dilute to volume. Allow to stand 1 day before standardizing, which consists of the following:

- a. Accurately weigh to the nearest 0.1 mg, 1.5 grams of primary standard potassium iodate and dilute to 500 mL with distilled water in a volumetric flask.
- b. Pipet 50 mL of the iodate solution into a 500-mL glass-stoppered flask. Add 2.0 grams of potassium iodide and 10 mL of 1 N HCl. Stopper flask after 5 minutes and titrate with stock thiosulfate solution to a pale yellow color. Add 5 mL of starch solution and continue titration until the blue color disappears.
- c. Calculation of the normality of the stock thiosulfate solution:

$$N = \frac{W}{M} \times 2.80$$

N = normality of thiosulfate

M = volume of thiosulfate required (mL)

W = weight of potassium iodate in grams (~0.15 gram)

8. Sodium Thiosulfate Titrant (0.01 N)

The sodium thiosulfate titrant is prepared by diluting 10 mL of stock thiosulfate to 100 mL.

$$\text{Normality} = \text{normality of stock solution} \times 0.10$$

9. Sulfite Standard Solution

Dissolve 0.30 gram of sodium thiosulfate (or 0.40 gram of sodium sulfite) in 500 mL of distilled water in a volumetric flask. The exact concentration is determined as follows:

Pipet 50 mL of 0.01 N iodine solution (#5) into each of two 500-mL glass-stoppered flasks. To one flask (Blank) add 25 mL of distilled water. To the other flask, add 25 mL of sulfite solution (#9). Allow to react for 5 minutes, then titrate each with 0.01 N sodium thiosulfate solution (#8) to a pale yellow color. Add 5 mL of starch (#6) and continue titration until blue color disappears. (This solution contains the equivalent of 320-400 $\mu\text{g/mL SO}_2$.)

10. Working Sulfite/TCM Solution

Pipet 2 mL of the standard sulfite solution into a 100-mL volumetric flask and dilute to volume with absorbing reagent, 0.04 M (#1).

Calculate the SO_2 concentration in the sulfite solution as follows:

$$\mu\text{g SO}_2/\text{mL} = \frac{(A-B) (N) (32,000) \times 0.02}{25}$$

A = volume of thiosulfate for Blank (mL)

B = volume of thiosulfate for Sample (mL).

N = normality of thiosulfate titrant

32,000 = milliequivalent weight for SO_2 (μg)

25 = volume of standard sulfite used in
titration (mL)

0.02 = dilution factor

This solution is stable for 1 month if kept refrigerated.

11. Pararosaniline Stock Solution (0.2%)

To a 250-mL volumetric flask add 20 mL of pararosaniline (Harleco) - note the assay % - Add an additional 0.2 mL of pararosaniline for each percent the solution assays below 100%. Then add 25 mL of 3 M phosphoric acid* and dilute to volume with distilled water. (Reagent is stable for at least 9 months.)

*3M phosphoric acid is prepared by adding 20 mL of concentrated (85%) 14.7 M phosphoric acid to 60 mL of water and diluting to 100 mL.

Preparation of Sulfur Dioxide Standard Curve

1. Pipet 0, 0.5, 1.0, 1.5, 2.0 mL of sulfite-TCM solution (#10) into 25-mL volumetric flasks and dilute to 10 mL with absorbing reagent (#1).
2. Add 1 mL of 0.6% sulfamic acid (#2) to each flask and allow to react for 10 minutes (to destroy any nitrite formed by oxides of nitrogen). Add 2 mL of 0.2% formaldehyde solution (#3) and 5 mL of pararosaniline stock solution (#11). Dilute to volume with distilled water.
3. After 30 minutes determine the absorbance of the standard solutions spectro-photometrically at 548 nm using zero standard as the Blank.
4. The concentration of SO_2 in each flask is determined as follows:

$\mu\text{g SO}_2/\text{mL}$ in sulfite/TCM solution (#10) x mL added

5. Prepare a standard curve by plotting the concentrations in μg of SO_2/mL against the respective %T readings on graph paper.

Analysis of SO_2 Air Samples

1. Place 50 mL of absorbing reagent (#1) into black bubbler.
2. Sample at 200 mL/min for 24 hours.
3. After sampling, dilute sample to 50 mL, if needed, with absorbing reagent (#1).
4. Pipet 5 mL of the sample into a 25-mL volumetric flask. Add 5 mL of absorbing reagent (#1). Delay analysis for 20 minutes to allow any ozone to decompose.
5. For each set of determinations, prepare a reagent Blank by adding 10 mL of absorbing reagent (#1) to a 25-mL volumetric flask.
6. To each volumetric flask add 1 mL of 0.6% sulfamic acid (#2) and allow to react 10 minutes to destroy the nitrate formed from the oxides of nitrogen.
7. Add 2 mL of 0.2% formaldehyde (#3) and 5 mL of pararosaniline (#11). Dilute to volume with distilled water.
8. After 30 minutes determine the %T of the samples at 548 nm against the reagent Blank.
9. Read the concentration in $\mu\text{g SO}_2$ from the standard curve.

Calculation of volume of air sampled:

$$V = \left(\frac{F_1 + F_2}{2} \right) \times T \times 6 \times 10^{-5}$$

v = volume of air sampled (m^3)

F_1 = initial flow rate (cm^3/min)

F_2 = final flow rate (cm^3/min)

T = sampling interval (hours)

6×10^{-5} = conversion factor

Calculation of SO_2 concentration in air:

$$\mu g SO_2/m^3 = \frac{A \times 50}{V}$$

A = $\mu g SO_2/mL$ read from standard curve

50 = volume of absorbing reagent (mL)

V = volume of air sampled (m^3)

To convert $\mu g SO_2/m^3$ to ppm SO_2

$$ppm SO_2 = \mu g SO_2/m^3 \times 3.82 \times 10^{-4}$$

Appendix B

DETERMINATION OF NITROGEN DIOXIDE

Introduction

The method described is applicable to the determination of nitrogen dioxide in outside ambient air in the concentration range from 0.01 to 0.4 ppm. Nitrogen dioxide is absorbed in sodium hydroxide to form a stable solution of sodium nitrite. The nitrite ion is reacted with phosphoric acid, sulfanilamide and N-1-naphthylene diamine dihydrochloride and determined spectrophotometrically at 540 nm.

Reagents

1. Absorbing Solution (0.1 N)

Dissolve 4.0 grams of sodium hydroxide in distilled water in a 1-litre volumetric flask and dilute to volume.

2. Sulfanilamide

Dissolve 20 grams of sulfanilamide in 700 mL of distilled water. Add, with mixing, 50 mL of concentrated phosphoric acid (85%) and dilute to one litre. (Stable for one month if refrigerated.)

3. NEDA solution (0.1%)

Dissolve 0.5 gram of N-1-naphthylene diamine dihydrochloride in 500 mL of distilled water. (Stable for one month if refrigerated and protected from light.)

4. Hydrogen Peroxide

Dilute 0.2 mL of 30% hydrogen peroxide to 250 mL with distilled water. (Stable for one month if protected from light.)

5. Standard Nitrite Solution

Dissolve sufficient sodium nitrite in one litre of distilled water so that the solution contains 1000 $\mu\text{g NO}_2/\text{mL}$. The amount of sodium nitrite is calculated as follows:

$$\text{NaNO}_2 \text{ (gm)} = \frac{1.5 \times 100}{A}$$

A = assay (%)

1.5 = factor to convert NO_2 into NaNO_2

6. Working Nitrite Solution

Dilute 5 mL of the standard nitrite solution (#5) to 200 mL with absorbing reagent (#1) in a volumetric flask. This solution contains 25 $\mu\text{g NO}_2/\text{mL}$.

Preparation of the NO_2 Standard Curve

1. Pipet 0, 1, 2, 5 and 15 mL of the working nitrite solution (#6) into 25-, 50-, 50-, 100-, and 250-mL volumetric flasks and dilute each to volume with absorbing solution (#1). These solutions contain 0, 0.5, 1.0, 1.25, and 1.5 $\mu\text{g NO}_2/\text{mL}$, respectively.
2. Pipet 10 mL of each of the above standards into 40-mL test tubes.
3. Add 1 mL of hydrogen peroxide solution (#4), 10 mL of sulfanilamide (#2) and 1.4 mL of NEDA solution (#3) to each tube, mixing thoroughly after the addition of each reagent.
4. After a 10-minute color development interval, transfer solution to small colorimetric tubes and measure the absorbance at 540 nm against the zero standard.
5. Plot $\mu\text{g NO}_2/\text{mL}$ versus %T.

Sample Analysis

1. Add 50 mL absorbing reagent (#1) to the bubbler.
2. Draw air sample at 200 mL per minute for 24 hours.
3. Replace any water lost by evaporation during sampling.
4. Pipet 10 mL of collected sample into 40-mL test tube.
5. Add 1 mL of hydrogen peroxide solution (#4), 10 mL of sulfanilamide (#2) and 1.4 mL of NEDA solution (#3). Mix thoroughly after addition of each reagent.
6. Prepare a Blank in the same manner, using 10 mL of absorbing agent (#1) in place of sample.
7. After a 10-minute color development interval, transfer solution to colorimeter tubes and measure absorbance at 540 nm against the Blank.
8. Determine the $\mu\text{g NO}_2/\text{mL}$ from the standard curve.

Calculation of volume of air sampled:

$$V = \left(\frac{F_1 + F_2}{2} \right) \times T \times 6 \times 10^{-5}$$

v = volume of air sampled (m^3)

F_1 = initial flow rate (cm^3/min)

F_2 = final flow rate (cm^3/min)

T = sampling interval (hours)

6×10^{-5} = conversion factor

Calculation of NO₂ concentration in air:

$$\mu\text{g NO}_2/\text{m}^3 = \frac{A \times 50}{V \times 0.35}$$

$$A = \mu\text{g NO}_2/\text{mL}$$

50 = volume of absorbing reagent (mL)

V = volume of air sampled (m³)

0.35 = sampling train efficiency

To convert $\mu\text{g NO}_2/\text{m}^3$ to ppm NO₂

$$\text{ppm NO}_2 = \mu\text{g NO}_2/\text{m}^3 \times 5.32 \times 10^{-4}$$

Appendix C

DETERMINATION OF HYDROGEN SULFIDE

Reagents

1. 0.5 N Sodium Hydroxide

Dissolve 2 grams of sodium hydroxide in 100 mL of distilled water,

2. Cadmium Chloride

Dissolve 20 grams of cadmium chloride in 900 mL of distilled water,

3. Absorbing Reagent

Add 20 mL of 0.5 N NaOH to 900 mL of cadmium chloride solution and mix well.

4. 0.005 N Iodine Solution

Dilute 0.01 N iodine solution 1:1 with distilled water.

5. 0.005 N Sodium Thiosulfate Titrant

Dilute 0.01 N thiosulfate solution 1:1 with distilled water.

6. Starch Indicator Solution

Dissolve 0.4 gram of soluble starch in 200 mL of boiling distilled water.

Analysis

1. Place 50 mL of absorbing reagent into glass bubbler and sample for 24 hours at a known air-flow rate.

2. After sampling, transfer sample to a 250-mL titration flask. Rinse bubbler with 5-10 mL of distilled water and add to titration flask.
3. Prepare a Blank by adding 50 mL of absorbing solution to a titration flask.
4. Add 15 mL of concentrated HCl to both sample and Blank and mix well.
5. Add 25 mL of 0.005 N standard iodine solution to both Blank and sample solutions. Back titrate the excess iodine with 0.005 N sodium thiosulfate using starch as an indicator.

Calculations

1. Subtract the mL required for sample analysis from the mL required for Blank analysis and multiply the difference by 84.6. This corresponds to $\mu\text{g H}_2\text{S}$ in the sample.
2. Multiply the sampling rate by the sampling interval; multiply this by 0.06 to express volume in cubic metres.
3. Divide $\mu\text{g H}_2\text{S}$ in the sample by the volume of air sampled for final concentration of $\mu\text{g H}_2\text{S}/\text{m}^3$.
4. The following equation describes the above procedures:

$$\frac{\mu\text{g H}_2\text{S}}{\text{m}^3} = \frac{(A-B) 84.6}{RT 0.06}$$

A = mL of titrant required for blank

B = mL of titrant required for sample

R = sampling rate (litres/min)

T = sampling interval (hours).

Appendix D

AIR QUALITY STANDARDS - APRIL 28, 1971

Federal Regulations - April 30, 1971

SO ₂	80 $\mu\text{g}/\text{m}^3$	(0.03 ppm)	annual arithmetic mean
(Primary)	365 $\mu\text{g}/\text{m}^3$	(0.14 ppm)	max 24 hr (1x)
SO ₂	60 $\mu\text{g}/\text{m}^3$	(0.02 ppm)	annual arithmetic mean
(Secondary)	260 $\mu\text{g}/\text{m}^3$	(0.1 ppm)	max 24 hr (1x)
	1300 $\mu\text{g}/\text{m}^3$	(0.5 ppm)	max 3 hr (1x)
CO	10 mg/m^3	(9 ppm)	max 8 hr (1x)
(Primary)	40 mg/m^3	(35 ppm)	max 1 hr (1x)
(Secondary)			
Oxidant	160 $\mu\text{g}/\text{m}^3$	(0.08 ppm)	max 1 hr (1x)
(Primary)			
(Secondary)			
NO ₂	100 $\mu\text{g}/\text{m}^3$	(0.05 ppm)	annual arithmetic mean
(Primary)			
(Secondary)			
Particulate	75 $\mu\text{g}/\text{m}^3$		annual geometric mean
(Primary)	260 $\mu\text{g}/\text{m}^3$		max 24 hr (1x)
Particulate	60 $\mu\text{g}/\text{m}^3$		annual geometric mean
(Secondary)	150 $\mu\text{g}/\text{m}^3$		max 24 hr (1x)

New Mexico Air Quality Control Regulations - June 2, 1974

A. Maximum allowable concentration of total suspended particulate:

24-hour average	150 $\mu\text{g}/\text{m}^3$
7-day average	110 $\mu\text{g}/\text{m}^3$
30-day average	90 $\mu\text{g}/\text{m}^3$
Annual geometric mean	60 $\mu\text{g}/\text{m}^3$

B. Air contaminants - maximum allowable concentration:

Sulfur Dioxide (SO_2)

24-hour average	0.10 ppm	260 $\mu\text{g}/\text{m}^3$
Annual arithmetic mean	0.02 ppm	53 $\mu\text{g}/\text{m}^3$

Hydrogen Sulfide (H_2S)

1-hour average	0.003 ppm	4.5 $\mu\text{g}/\text{m}^3$
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Carbon Monoxide (CO)

8-hour average	8.7 ppm
1-hour average	13.1 ppm

Nitrogen Dioxide (NO_2)

24-hour average	0.10 ppm	220 $\mu\text{g}/\text{m}^3$
Annual arithmetic mean	0.05 ppm	100 $\mu\text{g}/\text{m}^3$

Photochemical Oxidant (O_3)

1-hour average	0.06 ppm
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