EEG-80

RECOMMENDATIONS TO ADDRESS AIR SAMPLING ISSUES AT WIPP

Jim W. Kenney

Environmental Evaluation Group
New Mexico

January 2001

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and

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January 2001

FOREWORD

The purpose of the New Mexico Environmental Evaluation Group (EEG) is to conduct an independent technical evaluation of the Waste Isolation Pilot Plant (WIPP) Project to ensure the protection of the public health and safety and the environment. The WIPP Project, located in southeastern New Mexico, became operational in March 1999 for the disposal of transuranic (TRU) radioactive wastes generated by the national defense programs. The EEG was established in 1978 with funds provided by the U. S. Department of Energy (DOE) to the State of New Mexico. Public Law 100-456, the National Defense Authorization Act, Fiscal Year 1989, Section 1433, assigned EEG to the New Mexico Institute of Mining and Technology and continued the original contract DE-AC04-79AL10752 through DOE contract DE-ACO4-89AL58309. The National Defense Authorization Act for Fiscal Year 1994, Public Law 103-160, and the National Defense Authorization Act for Fiscal Year 2000, Public Law 106-65, continued the authorization.

EEG performs independent technical analyses of the suitability of the proposed site; the design of the repository, its operation, and its long-term integrity; suitability and safety of the transportation systems; suitability of the Waste Acceptance Criteria and the compliance of the generator sites with them; and related subjects. These analyses include assessments of reports issued by the DOE and its contractors, other federal agencies and organizations, as they relate to the potential health, safety and environmental impacts from WIPP. Another important function of EEG is the independent environmental monitoring of radioactivity in air, water, and soil, both on-site and off-site.

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ACRONYMS

bq/m^3	Becquerels per cubic meter
cfm	cubic feet per minute
CH	Contact-Handled
CEMRC	Carlsbad Environmental Monitoring and Research Center
DOE	Department of Energy
EEG	Environmental Evaluation Group
m^3/sec	cubic meter per second
mg/m^3	milligram per cubic meter
MOC	Management and Operating Contractor
mrem/yr	millirem per year
R-Sq	Coefficient of Determination, a statistic to measure the fraction of variance explained by the regression equation
TRU	Transuranic
WIPP	Waste Isolation Pilot Plant

EXECUTIVE SUMMARY

The Waste Isolation Pilot Plant (WIPP) has been certified by the U. S. Environmental Protection Agency for the disposal of transuranic waste in large rooms carved into a deep salt formation by underground mining. The activities of mining and waste emplacement inherently require ventilation. During normal operations the air and particulates from the underground are released directly to the atmosphere through the exhaust shaft. In the event of a radiological release from the emplace containers, the facility is designed to reroute the exhaust air through high efficiency filters. Regulations require monitoring the exhaust to determine that the system is working as designed and provide a measure of the release of radionuclides should such an event occur. This is accomplished at Station A, which was designed to collect particle samples on filters near the surface point of discharge into the atmosphere.

During the year 2000, the effluent WIPP air sample extraction probes and transport lines used to collect particulates from the unfiltered effluent repository air were periodically removed, inspected, and cleaned. Five of 12 inspections of probe A-3 (sample of record) revealed brine and salt encrustation sufficient to compromise the ability of the probe to collect a representative sample. In addition to probe fouling, a more obvious failure occurs when sampling filters become wet and lose air flow capability. It also appears that skid A-3 deposits disproportionate amounts of material between the three filters. Regression analysis of September and October 2000 gravimetric data from the three legs of skid A-3 resulted in correlation of determination values (or R-squared value) of 0.773 (leg 1 vs leg 2), 0.229 (leg 1 vs leg 3), and 0.254 (leg 2 vs leg 3).

In an effort to supplement the air sampling program at WIPP, an additional single point air sampling system known as Station D-1 was constructed at the base of the air exhaust shaft. Air at this location does not have entrained water droplets such as those observed at the Station A location and thus probe fouling is not a significant failure mechanism. Station D-1 samples air flowing down the East 300 drift from the waste emplacement room before it reaches the exhaust

shaft but does not sample air flowing east down the South 400 drift from the waste shaft or air from the north end of the mine. Regression analysis of the September and October 2000 gravimetric data from the three legs of skid D-1 resulted in higher correlations with calculated R-squared values of 0.978 (leg 1 vs leg 2), 0.939 (leg 1 vs leg 3) and 0.946 (leg 2 vs leg 3).

The Environmental Evaluation Group (EEG) recommends that the U. S. Department of Energy (DOE) collect the sample of record on skid A-1 instead of skid A-3. Also DOE should investigate the reasons for unequal particulate split among the three legs of skid A-3 which could be related to differential pressure caused by filter supports, corroded transport lines, or the lack of uniformity in dessication and weighing methodology. EEG also recommends that DOE continue exploring the use of Station D-1 pending resolution of the exhaust shaft water inflow problem. Station D-1 should be formally evaluated against the ANSI N13.1 1999 standard, and additional skids should be considered to sample air from the waste shaft and northern area of the mine.

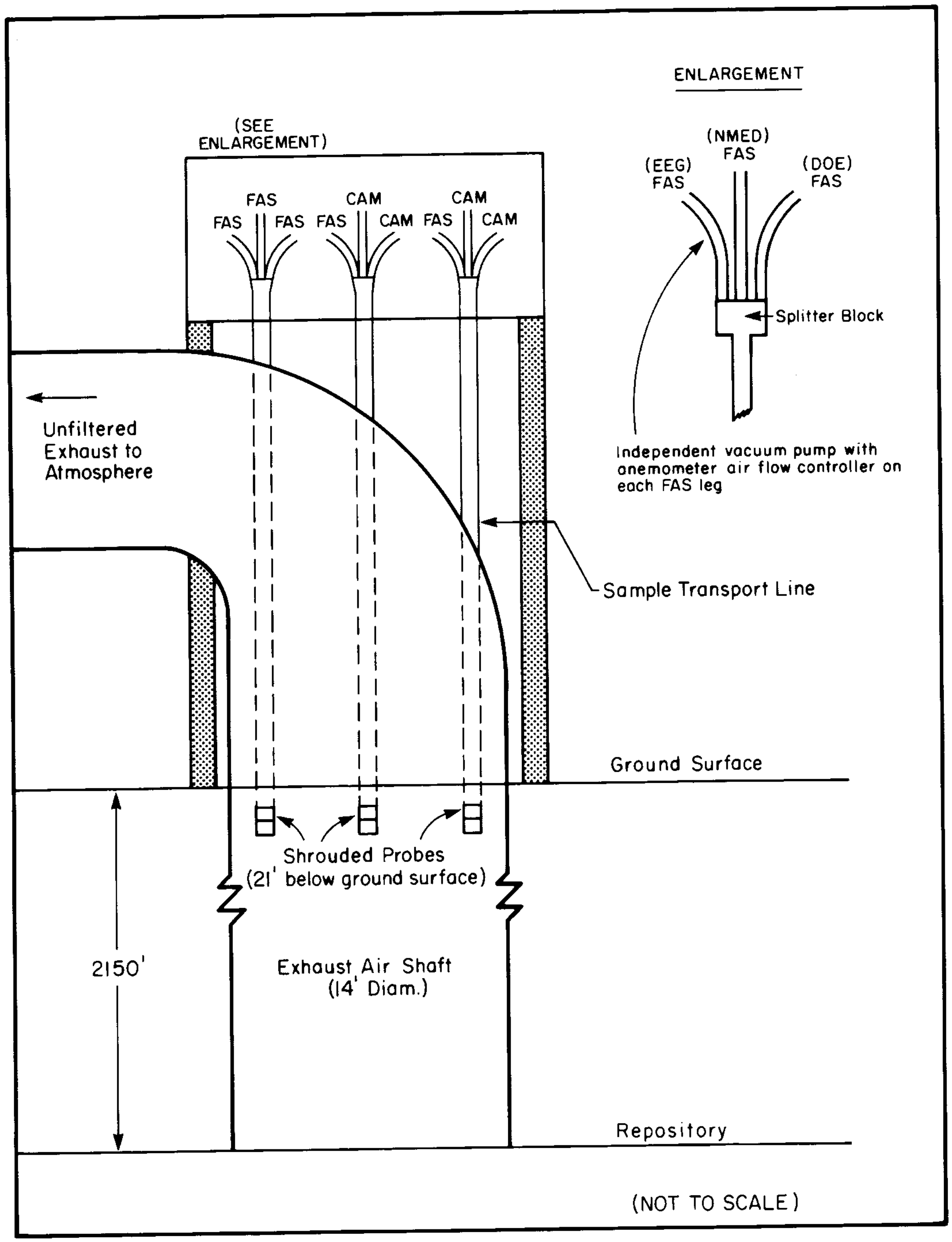
Many of these recommendations have been or are currently under consideration by DOE and the management and operating contractor.

INTRODUCTION

The Waste Isolation Pilot Plant (WIPP) is a geologic repository located near Carlsbad, New Mexico, owned by the U. S. Department of Energy (DOE). The Environmental Evaluation Group (EEG) has conducted independent oversight of the facility since 1978 and conducted environmental monitoring at and near the facility since 1985. The EEG program for radiation monitoring has been described in Spiegler (1984) and several preoperational environmental reports. The first operational environmental data report is Gray et al. (2000).

The WIPP facility is designed for the disposal of several alpha-emitting transuranic elements including approximately 13 metric tons of ^{239}Pu. The inhalation hazards associated with alpha-emitting particles are well recognized and after revision 5 to the Waste Acceptance Criteria (DOE 1996), there is no limit to the amount of respirable material in a container of contact-handled transuranic (CH-TRU) waste. Hence, the WIPP facility includes air monitoring at the top of the exhaust shaft at a location referred to as Station A. Station A consists of three sampling systems or skids, each skid with a shrouded probe and three legs (Figure 1). Each leg leads to a filter designed to accumulate a sample of particulate material discharged through the exhaust shaft.

Operations at the WIPP facility are regulated under provisions of 40 CFR 191 Subpart A which establishes 25 mrem/year as the maximum dose to the public from all sources and 40 CFR 61 Subpart H which establishes 10 mrem/year as the maximum dose to the public resulting from air emissions. To demonstrate compliance with these regulations, the management and operating contractor (MOC) continuously samples the effluent air. EEG collects the sampling filter each day from leg A-3-1 at Station A. The particulates on the filters are independently analyzed by the EEG and the Carlsbad Environmental Monitoring and Research Center (CEMRC), as well as by the MOC. Sample collection is conducted using the single point sampling method (McFarland 1993) for extraction of representative samples from the exhaust air which is being released to the environment at a flow rate of approximately 200 m^3/sec (425,000 cfm). Sample filters which collect particulates from the effluent air are then independently analyzed by each organization and results are provided to the public. Sample volume, exhaust volume, representative particulate collection, and radionuclide activity are all required to report accurate radionuclide concentrations (Bq/m^3) in effluent air and ultimately estimate the annual dose (mrem/yr) to the public in the event any airborne radionuclides are released from the underground.



DISCUSSION

Since 1995, video inspections of the WIPP air exhaust shaft have shown water seeping into the shaft through cracks in the concrete line. Water droplets are entrained in the exhaust airflow, enter the Station A sampling line, and wet the sampling filters. A detailed description of the problem of water leakage in the exhaust shaft was provided in EEG-73 (Kenney et al. 1999). The source of water seeping in the shaft appears to be the groundwater which has saturated the sandstones and the mudstones of the lower Santa Rosa and upper Dewey Lake Redbeds Formations at a depth approximately 15 meters below the ground surface in a large area in the central part of the WIPP site.

Since 1995, the EEG has observed that salt and moisture in the exhaust shaft intermittently causes the loss of airflow through the sampling filter at Station A. Reduced airflow adversely affects ample collection efficiency (Bartlett & Walker 1996) and necessitates frequent filter changes. The DOE is considering various remedies to minimize water in-leakage in the exhaust shaft. Proposals include grouting the shaft, de-watering the "perched" aquifer in the area of the shaft by pumping, or mitigating water infiltration from the surface by lining the evaporation ponds or diverting the water off-site. The DOE is conducting a feasibility study with current emphasis on grouting the shaft. The DOE is also testing an alternative air sampling location, designated as Station D, at the bottom of the exhaust shaft. Preliminary testing of Station D began in August 2000.

During calendar year 2000, the effluent WIPP air sample extraction probes and transport lines at Station A were periodically removed for inspection and cleaning (Table 1). Five of twelve inspections of probe A-3 (the skid of record) revealed salt encrustation (Figure 2) sufficient to compromise the ability of the probe to collect a representative sample (Farthing 1989, Appendix A).

Figure 2. Probe A-3 as found on December 11, 2000. Samples are taken through the innermost opening shown here, representative sampling requires less than 2 mm on this orifice (Farthing 1989).

In addition to fouling, a more obvious failure occurs when sampling filters from skid A-3 become wet and lose air flow.

In contrast to the typical encrusted probe conditions at skid A-3, skid A-1 is frequently found with little accumulation of salt as shown in Figure 3, December 11, 2000. This is most likely due to the location of brine flow into the shaft being nearest to the probe serving skid A-3 (Figure 4). Past video inspection of the shaft interior noted visible inflow in the northeast quadrant of the shaft from 80 to 100 feet below ground surface. The proximity of the probes just above this area does not allow for uniform distribution of water droplets across the cross section of the shaft before they encounter the probes.

Figure 3. Probe A-1 as found on December 11, 2000. The inner annulus, while not completely clean, is much less occluded than that seen on Probe A-3.

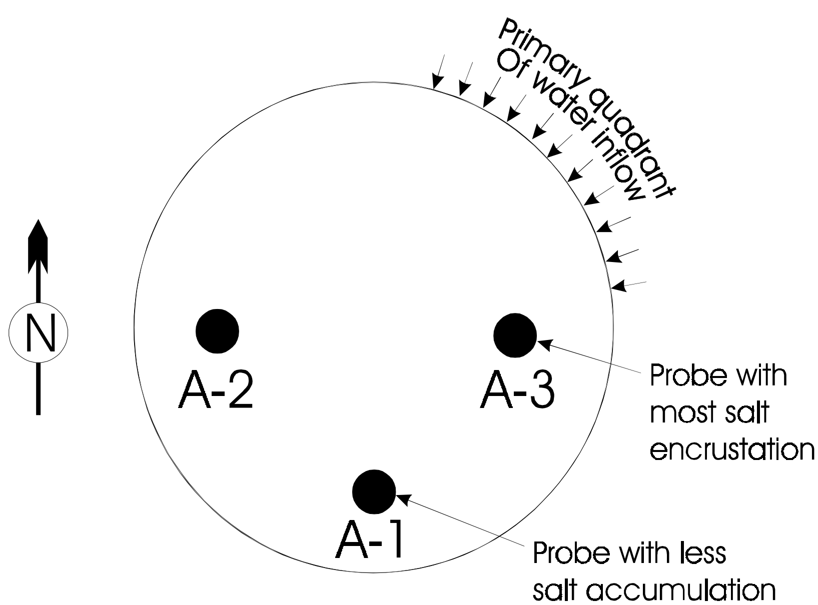


Figure 4. Location of Station A sampling skids at top of exhaust shaft.

Table 1. Skid A-3 & A-1 As Found Condition During CY2000

Last Inspection	Inspection Date	A-3 Condition	A-1 Condition
12/13/99	01/10/00	Probe Encrusted	N/A[1]
01/10/00	02/07/00	Probe Encrusted	OK
02/07/00	03/13/00	OK	N/A[1]
03/13/00	04/10/00	OK[2]	OK[2]
04/10/00	05/08/00	OK	OK
05/19/00	06/12/00	OK	OK
06/12/00	07/10/00	OK	OK
07/25/00	08/14/00	OK	OK
08/14/00	09/11/00	Marginal	OK
09/11/00	10/09/00	Probe Encrusted	OK
10/09/00	11/13/00	OK	OK
11/13/00	12/11/00	Probe Encrusted	OK

[1] no photographic or written record
[2] no photo (memo Kenney to Neill April 10, describing probe condition)

Gravimetric data collected during September and October 2000 from filters on all legs of A-3 shows disproportionate amounts of material among the three filters. R-squared values calculated from linear regression analysis of September and October gravimetric data reported by EEG, the MOC, and the CEMRC are shown in Figures 5, 6 & 7.

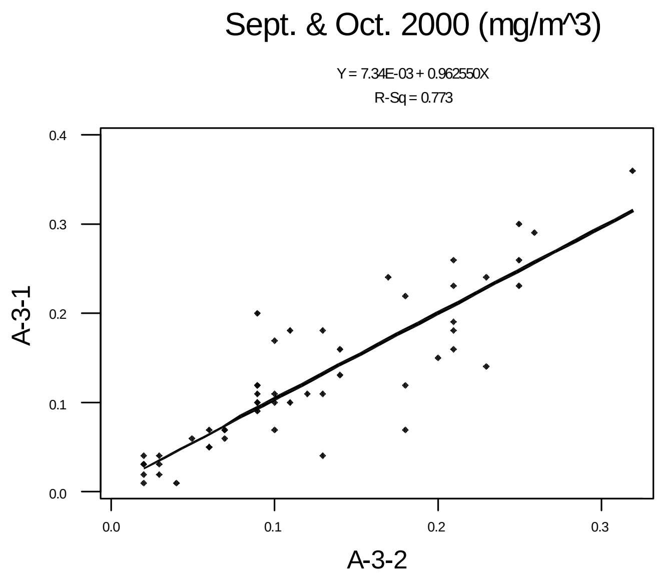


Figure 5. Comparison of mass collected on legs A-3-1 (MOC sample) and A-3-2 (CEMRC sample) during September and October 2000. An "R-Sq" (coefficient of determination) of 1 would represent a perfect correlation between legs.

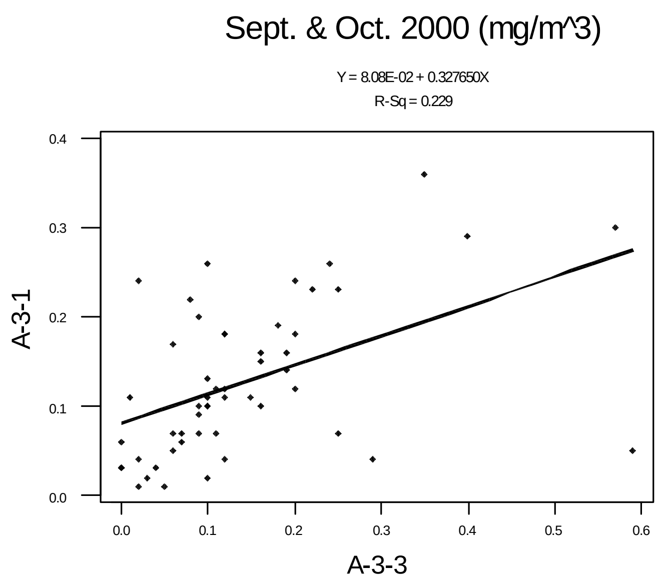


Figure 6. Comparison of mass collected on legs A-3-1 (MOC sample) and A-3-3 (EEG sample) during September and October 2000. An "R-Sq" (coefficient of determination) of 1 would represent a perfect correlation between legs.

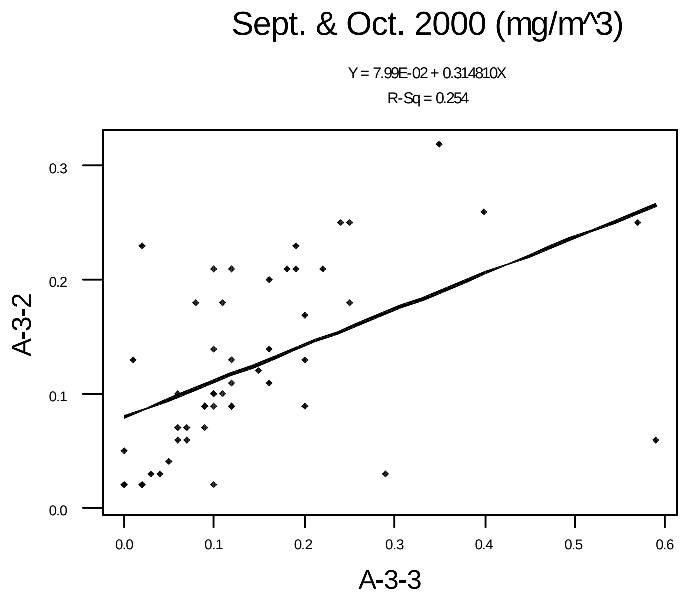


Figure 7. Comparison of mass collected on legs A-3-2 (CEMRC sample) and A-3-3 (EEG sample) during September and October 2000. An "R-Sq" (coefficient of determination) of 1 would represent a perfect correlation between legs.

In an effort to supplement the air sampling program at WIPP, an additional single point air sampling system identified as skid D-1 was installed at the base of the air exhaust shaft near the intersection of the East 300 and South 400 drifts (Figure 8). The air stream in the East 300 drift does not have the entrained water droplets observed near the top of the exhaust shaft at the level of the Station A sampling probes, and thus probe/transport line fouling is not a problem mechanism at skid D-1. The shrouded probe at skid D-1 samples air that is flowing north down the East 300 drift (downstream of the emplaced waste in Panel 1) before the air is diluted with air coming from the waste shaft or from the north end of the mine. Skid D-1 therefore, offers a less dilute sample. However, a final report to confirm skid D-1 compliance with ANSI N13.1 (ANSI 1999) has not been received from the contractor.

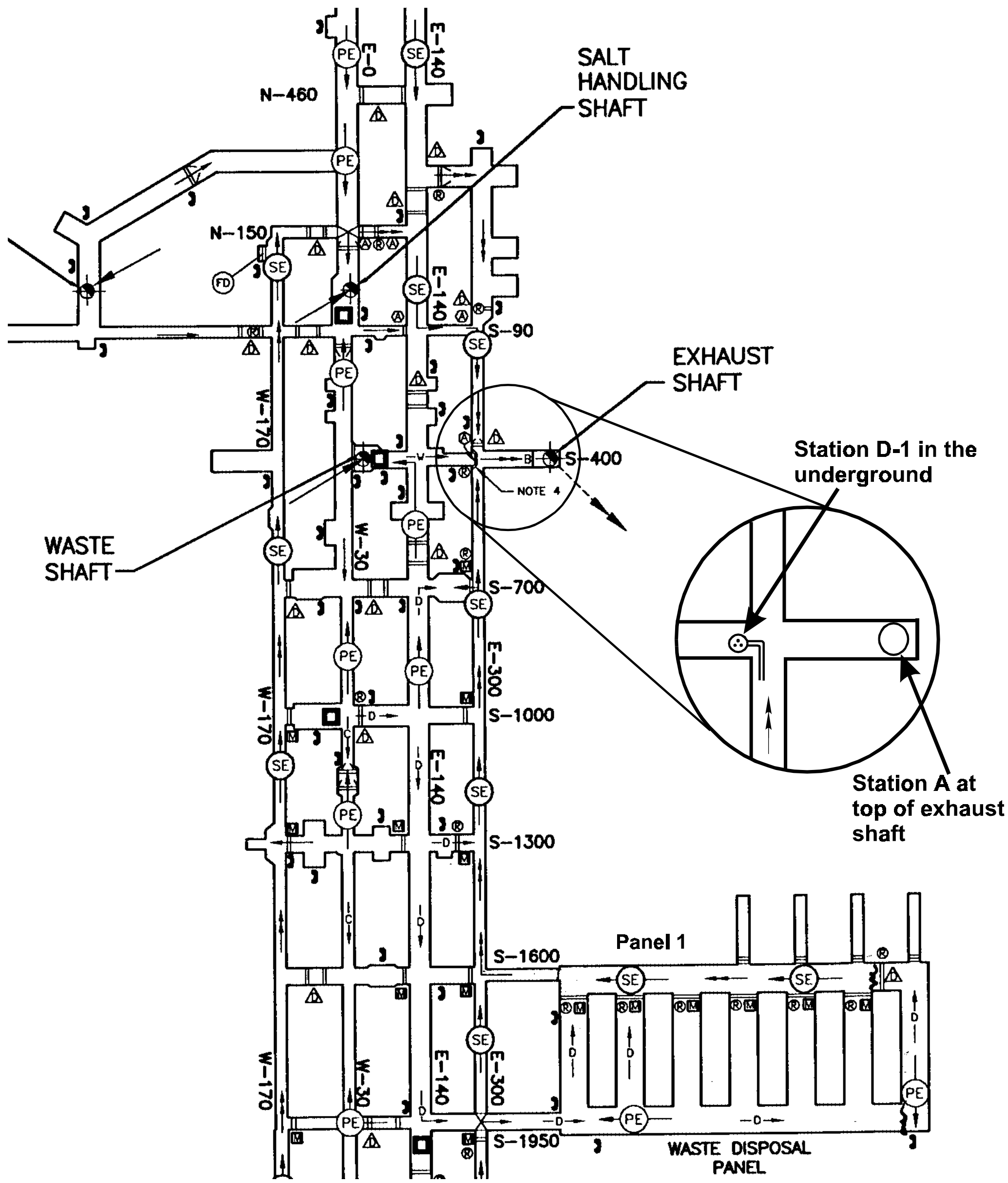


Figure 8. Map of the WIPP underground. Station D-1 located at East 300 and South 400 drifts (no scale).

Linear regression analysis of September and October 2000 gravimetric data from all three legs of skid D-1 resulted in higher correlation of determination values (or R-squared value) than determined at Station A in sample mass collected among the three legs as can be seen in Figures 9, 10 & 11.

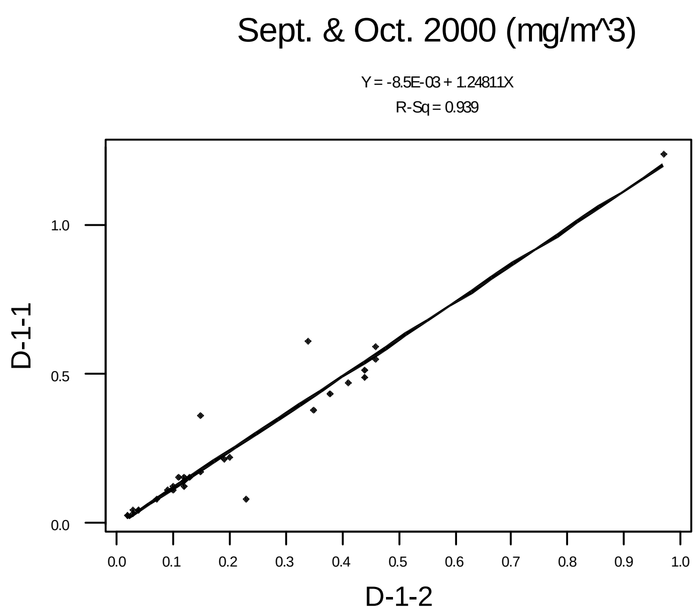


Figure 9. Comparison of mass concentration on legs D-1-1 and D-1-2 during September and October 2000

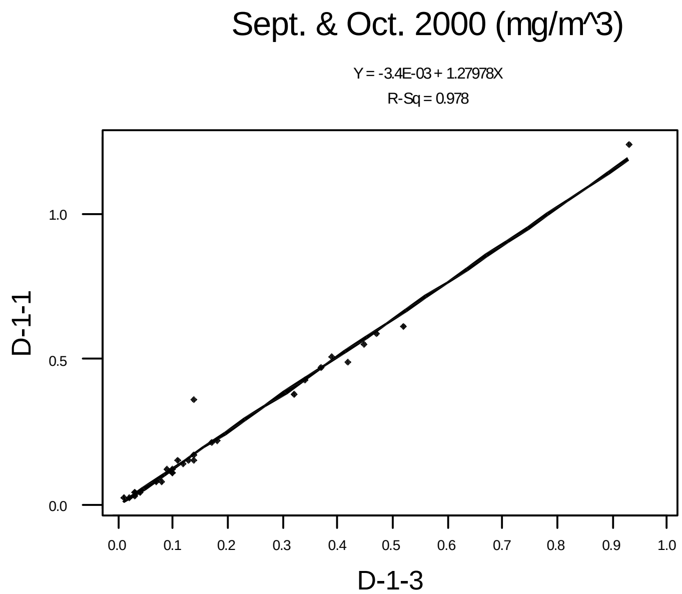


Figure 10. Comparison of mass concentration on legs D-1-1 and D-1-3 during September and October 2000

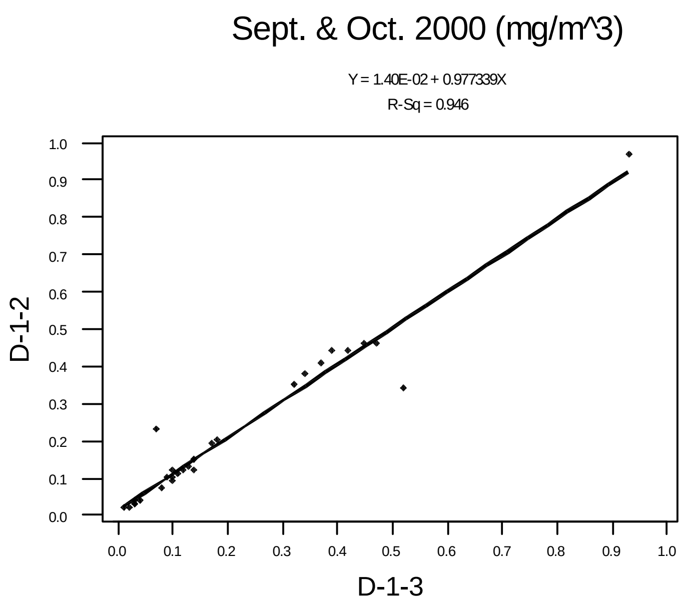


Figure 11. Comparison of mass concentration on legs D-1-2 and D-1-3 during September and October 2000

The poor correlation noted between the three legs on skid A-3 could result from any one of several causes or a combination of causes. The pressure differential across each separate leg of the skid is not available and comparisons can not be made. Due to a clogged filter support, air flow has been lost without a filter in place. Differences in pressure differential between the three legs could lead to a disproportionate particulate split and consequently differences in mass accumulation. A second possible cause could be inconsistencies in dessication and weighing methods used by the three organizations collecting the mass data. A third possible cause could be corrosion and fouling between the splitter and filter housings (Figure 12). Chavez et al. (1997) conclude that the effect of a rough transport line interior surface degraded aerosol penetration through the transport line. When sandpaper was attached to the wall of a transport line particulate collection decreased from almost 100% with a smooth interior surface to less than 40% (with 6 µm diameter particles).

Figure 12. Skid A-3 three-way splitter and transport line to filter housing (1999)

IMPROVEMENTS

At the present time the MOC is discussing several improvements to the air monitoring systems at WIPP. Skid A-3 will be removed once each calendar quarter for disassembly, cleaning and leak testing. A procedure for routine cleaning of the metal filter support will be developed. Consideration is being given to moving the skid of record (compliance sample) from skid A-3 to the skid with a history of least fouling, skid A-1.

Consideration is also being given to adding skid D-2 which would sample air flowing east through the South 400 drift from the waste shaft to the exhaust shaft. A third skid, D-3, would be located in the East 300 drift sampling air moving south from the experimental area of the mine toward the exhaust shaft. In the absence of a solution to the water inflow into the exhaust shaft, EEG expects that the use of Station D will greatly improve the reliability and sensitivity of samples collected from the WIPP underground effluent air.

CONCLUSIONS AND RECOMMENDATIONS

Conclusion 1:

Probe A-3 appears to consistently have the heaviest encrustation while probe A-1 typically is the least encrusted.

Recommendation 1:

In order to obtain more consistently representative samples through a less encrusted probe, consideration should be given to moving the sample of record from skid A-3 to skid A-1. Such a move would also have a high probability of reducing the frequency of wet filters and related loss of air flow through the sample filter.

Conclusion 2:

The particulate mass is not being equally divided between the three legs at skid A-3, however, new hardware of the same design is providing a uniform split of particulate mass among the three legs at Station D-1.

Recommendation 2:

A. Replace the filter supports on all skids in use and install instrumentation to measure the pressure differential on each leg of all skids in use at Stations A & D.

B. Investigate the possibility of a non-corroding material (ceramic or plastic) for use as a filter support at all skids at Stations A & D.

C. Establish uniformity in the methodology used for desiccation and weighing of filters used at Station A.

D. Clean and refinish the interior of the transport lines between the splitter block and filter housing.

Conclusion 3:

Station D-1 only samples air from the East 300 drift. There is presently no capability to sample air from the waste shaft (South 400 drift) and no capability to sample air from the north end of the East 300 drift.

Recommendation 3:

DOE should proceed with plans to install two additional skids at Station D. D-2 sampling the South 400 drift and the other sampling the air coming from the north end of the East 300 drift.

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APPENDIX A

Farthing Letter

Southern Research Institute

RECEIVED
JUL 24 1989
ENVIRONMENTAL EVALUATION GROUP
by Fed. Ex 10:30 am

Jim W. Kenny and
Robert H. Neill, Director
Environmental Evaluation Group
New Mexico Institute of
Mining and Technology
505 North Main Street
PO Box 3149
Carlsbad, NM 88221-3149

Re: Evaluation of the final stack probe design and placement of monitoring stations (A and B), Professional Services Contract RDD/EEG-0015.

Dear Jim:

I have carefully reviewed the reports and minutes of the peer review meeting related to WIPP which you sent to me for evaluation as requested. My comments and recommendations are given here. Also, as requested, the TAMU reports, enclosed herein, are being returned. In addition SRI's invoice for this work is enclosed. Please, see that it reaches the appropriate administrative officer as soon as possible; I believe that is Ms. West.

The superiority of the latest extraction probe design, placement thereof, and exhaust stack design over previous installations cannot be overstated. However, the important question is whether the system is sufficient to detect emissions (or releases) that may be harmful to the environment so that controls are activated and to quantify emissions that occur.

For aerosol sampling and transport to a detector or filter, the maximum relevant particle size is always a key parameter for design and evaluation. As of my last involvement with WIPP in 1987 this had been discussed without concensus. The minimum performance specification which apparently has been adopted is detection of 50% of the material at 10 μm with better performance expected for smaller sizes. The basis for this choice is apparently USEPA's recent ambient air standard for suspended particulate matter, which specifies acceptable ambient concentrations of particulate matter with aerodynamic diameter less than 10 μm. This USEPA standard is directed to all materials, natural, artificial, or regardless of potential for harm. Specific materials which are known to be potentially harmful outside of lung and trachial tissue are still intended to be regulated in terms of total mass concentration regardless of particle size. While I am not qualified to judge the potential effects of tranuranic materials in particles sizes greater than 10 μm, it appears that total mass emissions from WIPP as well as the fraction below 10 μm should be of concern. Of course, the smaller fraction is of greater importance and there are no reasons to expect emissions at the larger sizes to occur without concurrent significant amounts of emissions at sizes below 10 μm.

With proper maintenance the currently installed probes, including placement, can meet the above performance criteria concerning particles 10 μm and smaller. Questions remain concerning the performance at larger particle sizes but established performance at 10 μm and expected performance at larger sizes will be sufficient, provided plant operating procedures take the uncertainties for the larger sizes into account. This evaluation has addressed only the transport system upto and excluding the splitter block where the sample flow is split into three separate streams.

Cleaning of material from the shroud, probe, and transport line will be important for acceptable performance. My estimate of the maximum amount of acceptable buildup is 1/2 cm on the shroud, 1/5 cm on the probe nozzle, and 1/5 cm inside the transport tube. If buildup is slow, the limits should be smaller. Visual inspection can be used to evaluate the shroud and probe nozzle. Accurate pressure drop measurements across the transport line may be suitable for evaluating deposits in the transport line. SOP's should be developed which specifiy regular and frequent evaluation of the amount of buildup with specific criteria to indicate if cleaning should be performed. The level of Q/A on this should be as high as any procedures at the site.

FINAL STACK PROBE DESIGN

It appears that the final probe design incorporates the critical aspects of previous recommendations from my last involvement in sampling issues at WIPP in 1987 for EEG. The number of bends has been minimized to two at Station A and one at Station B, the main transport line is vertical, and the transport tube inside diameter has been set at about 5 cm before the first bend with minimum flow disturbances to the sample filters. The one recommendation that has not been incorporated is isokinetic sampling. For normal sampling at Station A (when shaft flowrate is 420,000 cfm and free stream velocity is 14 m/s) and at Station B (when duct flowrate is 60,000 cfm and free stream velocity is 11 m/s), there are sound reasons for the final design utilized and with the development of the probe shroud it is preferred to isokinetic sampling with traditional hardware. For sampling at Station A at the lower shaft flowrate (60,000 cfm, free stream velocity is 2 m/s), performance for 10 μm particles is not in question, but sampling efficiency of larger particles will be greatly reduced. This should be taken into account in interpreting results for establishing plant operating procedures in the event of an accidental release episode.

As described in my report to EEG in 1987, and subsequently on page 71 of John Rodger's report on the subject (DOE/AL/10752--37), the greatest sampling errors expected from our previous design involved the transition from an isokinetic nozzle inlet diameter (about 1 cm) to the 5 cm required to keep deposition in the bend and transport tube within tolerable limits. TAMU's approach of making the probe inlet diameter larger (to within a factor of 2 of the transport tube diameter) reduces the extent of the required transition and this reduced transition length reduces particle deposition (i.e., negative sampling error). Increasing the probe inlet diameter necessitates anisokinetic sampling (nozzle velocity/free stream velocity less than 1) and, with traditional hardware (i.e., without the shrouded probe), would cause high positive sampling error. However, the probe shroud keeps the magnitude of this positive error relatively small for 10 μm particles. Thus, in this type of situation and with the availability of the probe shroud, there is an advantage in abandoning the traditional isokinetic sampling approach (ANSI N13.1).

In the notation of the TAMU report, the fraction of the duct aerosol that is delivered is represented by T with components,

$$T = A - F_{wl}$$

where A is the aspiration coefficient and F_{wl} is the fraction lost to walls of the probe inlet and transport line. With traditional probe geometries, attempts to reduce F_{wl} causes unacceptably high values of A. Isokinetic sampling with traditional hardware leads to a fundamental conflict with transporting the aerosol when the free stream velocity is high, above about 5 m/s. For any sample gas flowrate below several hundred cfm, there is a large mismatch between the small probe inlet diameter required for isokinetic sampling (to keep A near 1) and the larger diameter required for transport over reasonable distances without severe deposition (high F_{wl}). To transport 10 μm particles, design analysis shows that a diameter for the transport line of about 5 cm is needed at WIPP while the diameter for isokinetic sampling at 6 cfm (required for the FAS and CAMS) is about 1 cm. A divergence this large in the diameter of flow after the probe inlet causes additional deposition at this location keeping the net value of F_{wl} significant, even when the angle of divergence is low (3.5° to prevent flow separation). Use of the shroud allows a much larger probe inlet diameter, according to TAMU's data (Figs 4-5), without nearly as much increase in A that would occur without it. This reduces the extent of divergence required and significantly reduces F_{wl}. According to data presented by Dr. McFarland in the peer review meeting of Feb., 1988, F_{wl} for 10 üm particles was reduced from 0.34 to 0.10 while A was increased from 1 to only 1.2. The principle upon which the shroud is based is that the free stream velocity is reduced in a large sampling tube (the shroud) before approaching the probe inlet nozzle. Anisokinetic sampling error for the aerosol entering the shroud is limited due to the large shroud diameter and, according to the description in TAMU's report, most of this enrichment occurs near the shroud wall, away from the central region where the probe sample is obtained. The trade off which for 10 μm particles eliminates -24% of a potential -34% error while incurring an additional +20% error is preferred in this circumstance, especially in view of the severe problems which can be caused by deposits of salt in the probe and transport lines and the positive error, which is expected with the shrouded probe/anisokinetic sampling approach, is preferred to negative error when concerned with protecting life and the environment. Of course, for other particle sizes, these errors (probe wall losses and anisokinetic sampling) have the same signs, varying in magnitude from 10 üm as the square of the diameter.

The oversampling described above is relevant to normal shaft flowrate at Station A. If the shaft flowrate is reduced to 60,000 the nozzle velocity will then be 5 times the free stream velocity and particles will be undersampled. In addition, deposition due to settling in the 180° bend above the duct elbow will be significant. TAMU's data on the probe and my estimates of settling in the 180° bend indicate that performance for 10 μm particles will be adequate. However, performance will be low for larger particles and data should be interpreted taking this into account.

EXHAUST STACKS AND PLACEMENT OF SAMPLING PROBES

The recommendations resulting from TAMU's modeling work is adequate. Measurments using larger particles, at least 10 μm, are desired, however, it was shown that streamling of gas from leaks in the filter house will not occur. adequate mixing of particles with with the gas is expected due to the fans. No qualitative differences between TAMU's modeling results and my previous estimates were found.

I appreciate this opportunity to contribute further to bringing the WIPP facility into operation in which we can have confidence. If clarification is needed, please call me at (205) 581-2536.

Sincerely,

William E. Farthing

William E. Farthing
Head, Aerosol Physics Section

APPENDIX B

EEG, MOC and CEMRC Gravimetric Data

Mass Concentrations from Skid A-3-1, A-3-2, A-3-3

SKID A-3 FILTER START DATE	FILTER START TIME	FILTER STOP DATE	FILTER STOP TIME	A-3-1 WEIGHT CONC. (mg/m^3)	A-3-2 WEIGHT CONC. (mg/m^3)	A-3-3 WEIGHT CONC. (mg/m^3)
09/01/00	07:56 AM	09/05/00	09:57 AM	0.01	0.02	0.02
09/05/00	10:03 AM	09/05/00	02:43 PM	0.14	0.23	0.19
09/05/00	02:46 PM	09/06/00	09:53 AM	0.11	0.12	0.15
09/06/00	08:58 AM	09/06/00	02:46 PM	0.15	0.20	0.16
09/06/00	02:49 PM	09/07/00	08:45 AM	0.19	0.21	0.18
09/07/00	08:47 AM	09/07/00	02:32 PM	0.16	0.21	0.19
09/07/00	02:34 PM	09/08/00	07:15 AM	0.09	0.09	0.09
09/08/00	07:21 AM	09/08/00	02:10 PM	0.26	0.25	0.24
09/08/00	02:12 PM	09/11/00	07:39 AM	0.02	0.02	0.10
09/11/00	10:51 AM	09/11/00	02:31 PM	0.12	0.09	0.20
09/11/00	02:34 PM	09/12/00	07:25 AM	0.06	0.05	0.00
09/12/00	07:32 AM	09/12/00	02:33 PM	0.29	0.26	0.40
09/12/00	02:39 PM	09/13/00	08:24 AM	0.01	0.04	0.05
09/13/00	08:31 AM	09/13/00	02:31 PM	0.18	0.11	0.12
09/13/00	02:34 PM	09/14/00	09:43 AM	0.05	0.06	0.59
09/14/00	09:48 AM	09/14/00	02:29 PM	0.04	0.13	0.12
09/18/00	09:16 AM	09/18/00	02:17 PM	0.10	0.11	0.16
09/18/00	02:20 PM	09/19/00	08:37 AM	0.10	0.09	0.09
09/19/00	08:41 AM	09/19/00	02:38 PM	0.24	0.23	0.02
09/19/00	03:02 PM	09/20/00	09:05 AM	0.07	0.10	0.11
09/20/00	09:13 AM	09/20/00	02:47 PM	0.07	0.18	0.25
09/20/00	02:52 PM	09/21/00	08:56 AM	0.07	0.07	0.09
09/21/00	09:01 AM	09/21/00	02:35 PM	0.26	0.21	0.10
09/22/00	11:08 AM	09/23/00	11:03 AM	0.04	0.02	0.02
09/23/00	11:03 AM	09/24/00	08:26 AM	0.03	0.02	0.00
09/24/00	08:40 AM	09/25/00	08:50 AM	0.03	0.02	0.00
09/25/00	09:03 AM	09/25/00	02:53 PM	0.23	0.21	0.22
09/25/00	02:57 PM	09/26/00	09:25 AM	0.16	0.14	0.16
09/26/00	09:25 AM	09/26/00	02:32 PM	0.36	0.32	0.35
09/27/00	12:53 PM	09/28/00	07:51 AM	0.10	0.09	0.10
09/28/00	08:03 AM	09/28/00	02:22 PM	0.12	0.09	0.12
09/28/00	02:28 PM	09/30/00	08:10 AM	0.02	0.03	0.03
10/11/00	02:56 PM	10/12/00	08:52 AM	0.12	0.18	0.11
10/12/00	08:57 AM	10/12/00	02:28 PM	0.20	0.09	0.09
10/12/00	02:32 PM	10/16/00	08:53 AM	0.04	0.03	0.29
10/16/00	09:07 AM	10/16/00	02:32 PM	0.17	0.10	0.06
10/16/00	02:36 PM	10/17/00	09:40 AM	0.11	0.10	0.10
10/17/00	09:48 AM	10/17/00	02:34 PM	0.18	0.13	0.20
10/17/00	02:40 PM	10/18/00	09:40 AM	0.07	0.06	0.07
10/18/00	09:47 AM	10/18/00	02:30 PM	0.24	0.17	0.20

SKID A-3 FILTER START DATE	FILTER START TIME	FILTER STOP DATE	FILTER STOP TIME	A-3-1 WEIGHT CONC. (mg/m^3)	A-3-2 WEIGHT CONC. (mg/m^3)	A-3-3 WEIGHT CONC. (mg/m^3)
10/18/00	02:35 PM	10/19/00	08:13 AM	0.10	0.10	0.10
10/19/00	08:18 AM	10/19/00	02:40 PM	0.11	0.13	0.01
10/19/00	02:44 PM	10/20/00	08:37 AM	0.07	0.07	0.06
10/20/00	08:47 AM	10/20/00	02:02 PM	0.18	0.21	0.12
10/23/00	08:35 AM	10/23/00	02:21 PM	0.30	0.25	0.57
10/23/00	02:25 PM	10/24/00	08:26 AM	0.11	0.09	0.12
10/24/00	08:33 AM	10/24/00	02:26 PM	0.22	0.18	0.08
10/24/00	02:30 PM	10/25/00	08:10 AM	0.06	0.07	0.07
10/25/00	08:18 AM	10/25/00	02:36 PM	0.13	0.14	0.10
10/25/00	02:41 PM	10/26/00	08:13 AM	0.05	0.06	0.06
10/26/00	08:20 AM	10/26/00	02:26 PM	0.23	0.25	0.25
10/26/00	02:39 PM	10/30/00	09:33 AM	0.03	0.03	0.04

Mass Concentrations from Skid D-1-1, D-1-2, D-1-3

FILTER START DATE	FILTER START TIME	FILTER STOP DATE	FILTER STOP TIME	D-1-1 WEIGHT CONC. (mg/m^3)	D-1-2 WEIGHT CONC. (mg/m^3)	D-1-3 WEIGHT CONC. (mg/m^3)
09/07/00	07:48 AM	09/08/00	09:01 AM	0.59	0.46	0.47
09/08/00	09:07 AM	09/11/00	12:37 PM	0.11	0.10	0.10
09/13/00	10:20 AM	09/14/00	11:22 AM	0.43	0.38	0.34
09/14/00	11:29 AM	09/18/00	08:30 AM	0.15	0.12	0.14
09/14/00	11:29 AM	09/18/00	08:30 AM	0.04	0.04	0.03
09/18/00	08:36 AM	09/19/00	08:06 AM	0.38	0.35	0.32
09/19/00	08:12 AM	09/20/00	07:52 AM	0.61	0.34	0.52
09/20/00	08:00 AM	09/21/00	07:09 AM	0.49	0.44	0.42
09/21/00	07:15 AM	09/22/00	01:05 PM	0.55	0.46	0.45
09/22/00	01:12 PM	09/25/00	07:48 AM	0.02	0.02	0.01
09/25/00	07:55 AM	09/26/00	08:11 AM	0.47	0.41	0.37
09/26/00	08:20 AM	09/27/00	11:03 AM	0.51	0.44	0.39
09/28/00	07:14 AM	10/02/00	07:39 AM	0.04	0.04	0.04
10/02/00	07:44 AM	10/03/00	07:18 AM	0.21	0.19	0.17
10/03/00	07:24 AM	10/04/00	07:39 AM	0.36	0.15	0.14
10/05/00	07:45 AM	10/06/00	07:53 AM	0.11	0.09	0.10
10/06/00	08:01 AM	10/09/00	08:14 AM	0.04	0.03	0.03
10/09/00	08:18 AM	10/10/00	07:56 AM	0.12	0.12	0.10
10/10/00	08:00 AM	10/11/00	08:37 AM	0.22	0.20	0.18
10/11/00	08:44 AM	10/12/00	03:20 PM	0.15	0.13	0.13
10/12/00	03:22 PM	10/16/00	08:00 AM	0.02	0.02	0.02
10/17/00	08:45 AM	10/18/00	07:53 AM	0.08	0.23	0.07
10/16/00	08:06 AM	10/17/00	08:41 AM	0.14	0.12	0.12
10/18/00	07:57 AM	10/19/00	07:13 AM	0.17	0.15	0.14
10/19/00	07:19 AM	10/20/00	07:48 AM	0.15	0.11	0.11
10/20/00	07:55 AM	10/23/00	11:00 AM	0.03	0.03	0.03
10/24/00	07:49 AM	10/25/00	09:59 AM	0.08	0.07	0.08
10/25/00	10:05 AM	10/26/00	07:32 AM	0.12	0.10	0.09
10/30/00	08:20 AM	10/31/00	08:45 AM	1.24	0.97	0.93

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