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RISK ASSESSMENT OF MIXED WASTE SITES

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INTRODUCTION

As part of its ongoing efforts to ensure environmental regulation compliance at DOE facilities, DOE published on April 26, 1985, a notice of intent to write an Environmental Impact Statement on Waste Management Activities for Groundwater Protection (Groundwater EIS) at the Savannah River Plant (SRP). In order for the EIS to be prepared, it was necessary for E. I. du Pont de Nemours & Co. (DuPont) to conduct a cost/benefit human health risk assessment of the several SRP waste sites being considered for closure. To perform a human health risk assessment of each waste site for each closure action considered, DuPont organized a project team led by personnel from the Savannah River Laboratory (SRL) and supported by outside contractors specializing in risk assessment work. As part of that team, JBF Associates, Inc. (JBFA) performed an atmospheric containment transport analysis and human health risk assessment of nonradioactive contaminants from SRP waste sites.

Eighty waste sites, categorized into 26 waste site functional groupings (Table 1) were being considered for closure. For each waste site, three closure actions were examined: (1) excavate the site, backfill it, and cap it followed by regular groundwater monitoring (Option 1); (2) backfill and cap the site followed by regular groundwater monitoring (Option 2); and (3) no remedial action, regular groundwater monitoring, and some site maintenance work (Option 3). The human health risk assessment performed by JBFA estimated the public and worker risks from contaminants released to the atmosphere from each waste site for each closure option.

This paper first presents the methodology JBFA used to estimate the public and worker risks attributable to the inhalation and ingestion of airborne, nonradioactive contaminants. Following the description of our analysis methodology, we present the risk results for the waste sites that were due to atmospherically released nonradioactive contaminants. Both worker risks and public risks are presented. (Public and occupational risks from airborne, radioactive releases were estimated by others and are not presented herein.) Finally, we present the results and conclusions derived from our analysis of the risk from airborne, nonradioactive contaminants.

METHODOLOGY

The waste sites at the Savannah River Plant contained a variety of wastes that posed some risk to the public and to workers who would be involved in cleanup activities at the sites. To determine the public and worker risks attributable to nonradioactive contaminants that could be atmospherically released from the sites in a functional grouping, we

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Table 1 The 26 Waste Site Functional Groupings Defined for Analysis

Functional Grouping Name	DPST No.[a]	Number of Sites Considered for Closure
SRL Seepage Basins	688	3
Metallurgical Laboratory Basin	689	1
Burning/Rubble Pits	690	15
Metals Burning Pit/Misc Chemical Basin	691	2
Old F-Area Seepage Basin	692	1
Separations Area Retention Basins	693	2
Radioactive Waste Burial Grounds	694	2
Bingham Pump Outage Pits	695	7
Hydrofluoric Acid Spill Area	696	1
SRL Oil Test Site	697	1
New TNX Seepage Basin	698	1
Road A Chemical Basin	699	1
L-Area Oil and Chemical Basin	700	1
Waste Oil Basins	701	2
Silverton Road Waste Site	702	1
M-Area Settling Basin & Vicinity	703	3
F-Area Seepage Basins	704	3
Acid/Caustic Basins	705	6
H-Area Seepage Basins	706	4
Reactor Seepage Basins	707	7
Ford Building Waste Site	708	1
Ford Building Seepage Basin	709	1
Old TNX Seepage Basin	710	2
TNX Burying Ground	711	4
CMP Pits	712	7
Gun Site 720 Rubble Pit	713	1
		80 TOTAL

[a]This number is a Savannah River Laboratory document number and is used in this paper to designate functional groupings.

What year? CJB

used the following five-step procedure: (1) estimating the contaminant source terms for the sites, (2) modeling the atmospheric transport of contaminants from the sites, (3) estimating the public exposure to airborne contaminants, (4) estimating the public risk associated with exposure to these contaminants, and (5) estimating the worker risk associated with exposure to airborne contaminants generated during site cleanups. (Similar methodology was used to estimate risks from atmospherically released radioactive contaminants.)

We accomplished the five steps of the procedure with the aid of computer programs contained within the automated CHEMTREX Exposure Analysis Methodology. The programs modeled various physical processes that were associated with each step. For example, the XOQDOQ program[1] was used to estimate contaminant atmospheric dispersion and deposition (Step 2). Figure 1 shows the program(s) used for each step of the analysis, the interface between programs, and the inputs and outputs for each program.

The source term estimation step initially involved selecting the contaminants of concern for each site based on site waste disposal history, groundwater monitoring results, and core drilling analysis results provided by SRL and SRL-developed screening criteria.[2] After the contaminants of concern had been selected, we estimated initial site contaminant concentration profiles using either (1) core sample results for the site (if this information was available) or (2) historical inventory data and contaminant transport modeling techniques (SESOIL[3] and HISTORY*). After the initial concentration profiles had been determined, we used the SESOIL computer program and regression models (REGRES†) to determine a time-dependent concentration profile and volatilization for each site. These profile and volatilization results, in conjunction with a saltation model and excavation-dust generation models (MARIAH), were used to estimate the contaminant loading to the atmosphere for each site.

The second step of the analysis, modeling the atmospheric transport of contaminants from the waste sites to potential receptor sites, was accomplished with the use of the XOQDOQ computer program. XOQDOQ uses a modified Gaussian plume model to estimate atmospheric contaminant concentrations as a function of distance and direction from a waste site. Inputs to the program included the time-dependent contaminant source strength (our source term estimate) and site meteorological conditions (taken from SRL data).

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*HISTORY is a simple LOTUS® 1-2-3® program that uses historical SESOIL results from several years to determine the contaminant inventory at a given time.

†REGRES is a simple linear regression model that estimates regression parameter values.

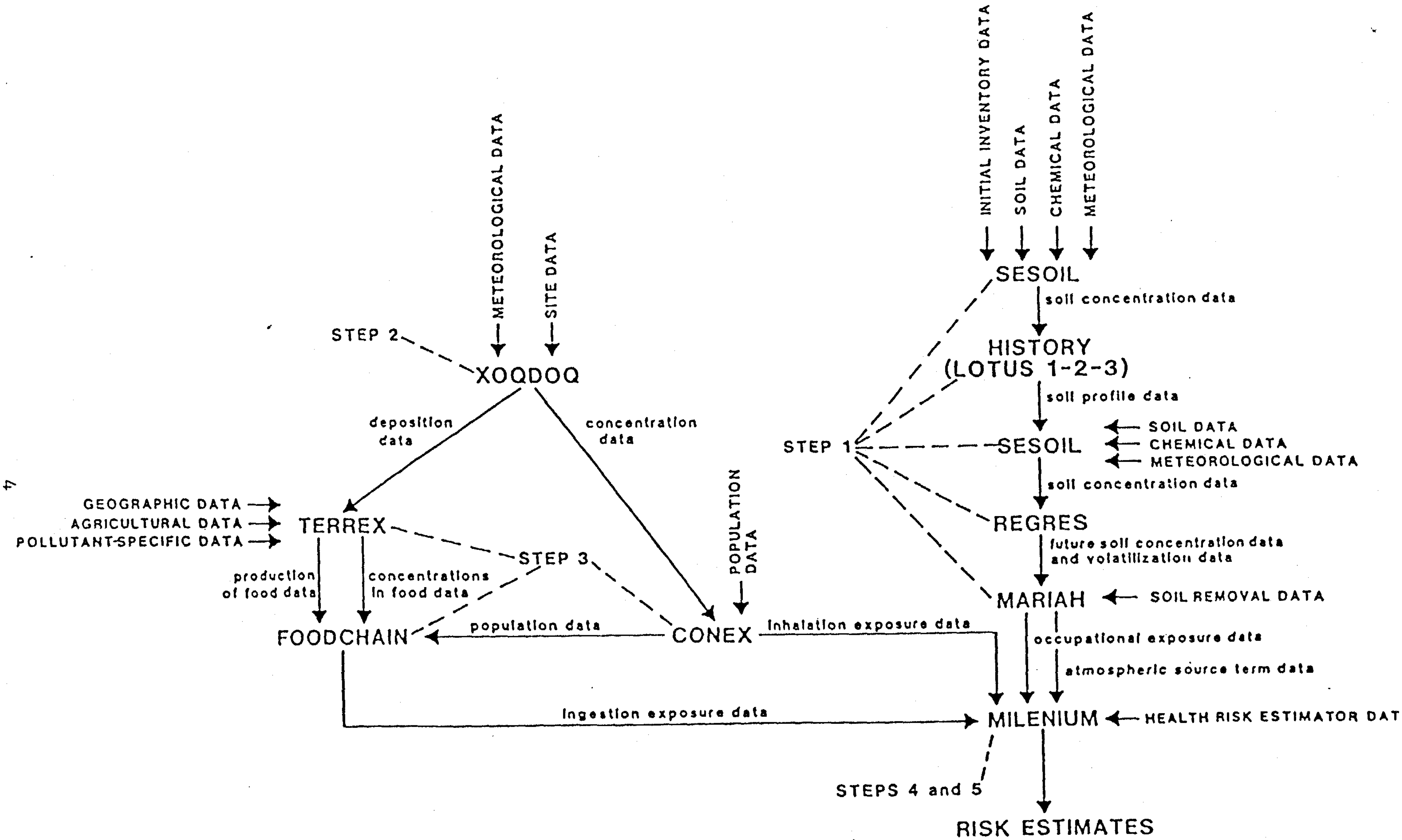

Figure 1 The Computer Programs (with Input and Output Files) Used To Estimate Risks

After determining contaminant concentrations at potential receptor sites, we translated these results into population exposures (Step 3 of the analysis). We considered population exposures to airborne contaminants via two pathways: (1) the inhalation of polluted air and (2) the ingestion of contaminated foodstuffs. We used the CONEX computer program[4] to (1) combine the XOQDOQ atmospheric concentration results with the local population demographics and (2) estimate time-dependent population inhalation exposures to polluted air. To estimate exposures to contaminated foodstuffs, we first used the TERREX computer program[4] to combine the XOQDOQ[1] deposition results with local crop production data. We then used the FOODCHAIN program[4] to combine TERREX results with local population demographics and estimate population ingestion exposures to contaminated foodstuffs.

The risk posed to the public by the waste sites for each of the three cleanup options was estimated in Step 4 using the MILENIUM program. For carcinogenic contaminants, MILENIUM translated time-dependent exposure results into a population dose and into a maximally exposed individual dose. It then used these dose results and appropriate unit carcinogenic risk factors (UCRs) to estimate the population risk and maximally exposed individual risk that were due to exposure to carcinogens. Moving-average, 50-year (lifetime) inhalation and ingestion doses were multiplied by inhalation and ingestion UCRs to estimate carcinogenic risk. The total carcinogenic risk posed to the public by a functional grouping, for a given year, was estimated by summing the carcinogenic risk results for all contaminants at a waste site, for all waste sites in the functional grouping.

For noncarcinogenic contaminants, MILENIUM translated time-dependent exposure results into a maximally exposed individual dose only. Using these dose results and the appropriate acceptable daily intakes (ADIs), MILENIUM then estimated the maximally exposed individual risk. Individual year daily inhalation and ingestion doses were divided by inhalation and ingestion ADIs to estimate noncarcinogenic risk. As with the carcinogenic contaminants, the total noncarcinogenic risk posed to the public by a functional grouping, for a given year, was estimated by summing the noncarcinogenic risk results for all contaminants at a waste site, for all waste sites in the functional grouping.

In the last step of the analysis, the risk posed to workers who would be involved in excavating the sites was estimated using the MARIAH results from Step 1 and the MILENIUM program. MARIAH had estimated the amount of contaminated dust that would be generated during the excavation of the sites and the time that would be required for excavating the sites. MILENIUM then used these results and appropriate UCRs and ADIs to estimate worker risk. Risk estimates were computed for two cases: (1) workers wearing no special, protective clothing and (2) workers wearing a full facepiece, air purifying negative pressure respirator.

RISK ASSESSMENT RESULTS

The human health risk assessment calculated the following for each of the waste sites:

1. population exposures and health risks, by site and closure option, attributable to releases of contaminants for a 1000-year assessment period. (These exposures and risks were determined for the public within 50 mi of the SRP waste sites)

2. worker exposures and risks attributable to releases of contaminants during site excavations

The results presented in this section are the human health risks by waste site and closure option attributable to atmospherically released nonradioactive contaminants. In particular, the results contained in this section are (1) tables that summarize, for the public risks, the total carcinogenic and noncarcinogenic risks for each functional grouping for three selected years--1986, 2085, and 2985;* (2) summaries of the functional groupings that dominate the risk for each closure option analyzed; (3) summaries of the contaminants that are the major contributors to these risks for each functional grouping; and (4) a table that summarizes worker risks attributable to atmospheric releases of nonradioactive contaminants during site excavations.

While it was desirable to portray the health risks for each waste site/closure option as a single value, research performed by the analysis team determined that there was no rigorously defendable method for combining the health impacts associated with chemical carcinogens, noncarcinogens, and radioactive contaminants and reporting these impacts as a single risk value. Thus, the results presented herein are in terms of chemical carcinogenic risk and noncarcinogenic risk for the functional groupings.

Also, this analysis was one designed to obtain data upon which risk comparisons for each of three closure options could be made. Caution should be exercised in interpreting the results of our analysis. Mitigating actions, such as population diurnal movement, indoor

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*The three years for which the risk results are reported represent the following: 1986 - the assumed year in which remedial actions would occur and the waste site be closed; 2085 - 100 years after closure of the waste site, at which time the SRP reservation is assumed open for public habitation; 2985 - 1000 years after closure of the waste site and the end of our assessment period.

sheltering, and dust control were not considered in the assessment of human exposures. Also, the "rule-of-reason" was applied at all sites when contaminant input data were quantified (i.e., we usually selected average or most-likely input parameter values and conditions for our analyses versus worst-case values). When contaminant input data had not been previously quantified, conservative assumptions regarding the contaminant's chemical form, transport, and fate were made. Consequently, the assessment results reported herein are appropriate for making relative risk comparisons but not appropriate for drawing conclusions about the absolute risk posed by any cleanup option considered for any SRL waste site. In addition, because of inherent uncertainties associated with the data input to this analysis (and hence the risk estimates) caution should also be exercised when making relative risk comparisons.

PUBLIC EXPOSURE AND RISK FROM CARCINOGENS

Two measures of public risk were calculated for exposures to carcinogens: (1) the risk to a maximally exposed individual and (2) the risk to the population as a whole. These measures represent (1) the maximum insult to any one individual and (2) the averaged, total insult to the population as a whole.

For the Years 1986, 2085, and 2985 in the assessment period, Tables 2 through 4 contain summaries of the calculated carcinogenic risks, by site closure option, for both the maximally exposed individual and the population, for each functional grouping. The risk to the maximally exposed individual is the "health effects per lifetime," or the probability that the maximally exposed individual will suffer a health effect due to exposure to a specified carcinogen (if the individual were to receive the calculated dose over his lifetime). The risk to the population is the "health effects" the population would experience in the 50-year period beginning in the year represented, because of exposure to site releases of carcinogens (if the population were to receive the calculated average dose over the 50-year period).

Option 3 involves the least amount of remedial action for the three closure options analyzed. Risk results for Option 3 (allowing the waste sites to remain undisturbed) also show the highest calculated risk to the public for all functional groupings (except for 694, the Radioactive Waste Burial Grounds). The five functional groupings with the highest calculated risk for Option 3 are, by year:

Year 1986

Functional Grouping	Population	Max. Exposed Indiv.
703	1.38E-03	2.17E-08
688	1.34E-03	2.31E-08
700	5.88E-04	8.59E-09
706	2.26E-04	3.30E-09
710	1.33E-04	1.92E-09

Table 2 Summary of Public Risks Attributable to Atmospherically Released Carcinogens, by Option, for the Year 1986[a]

Functional Grouping	Waste Removal and Closure		No Waste Removal and Closure		No Action	
	Population	Max. Exposed Indiv.	Population	Max. Exposed Indiv.	Population	Max. Exposed Indiv.
688	6.31E-07[b]	1.12E-11	0.00E-01	0.00E-01	1.34E-03	2.31E-08
689	1.23E-09	1.86E-14	0.00E-01	0.00E-01	9.01E-06	1.33E-10
690	1.12E-06	1.89E-11	3.31E-05	4.87E-10	3.31E-05	4.87E-10
691	2.74E-11	3.65E-16	0.00E-01	0.00E-01	3.54E-11	5.07E-16
692	4.72E-10	8.39E-15	0.00E-01	0.00E-01	7.21E-07	1.22E-11
693[c]	-	-	-	-	-	-
694	8.22E-08	1.46E-12	0.00E-01	0.00E-01	0.00E-01	0.00E-01
695[c]	-	-	-	-	-	-
696[c]	-	-	-	-	-	-
697[d]	-	-	-	-	-	-
698	1.59E-09	2.82E-14	0.00E-01	0.00E-01	1.37E-05	1.92E-10
699[c]	-	-	-	-	-	-
700	1.03E-07	1.83E-12	0.00E-01	0.00E-01	5.88E-04	8.59E-09
701	1.42E-15	2.53E-20	1.20E-14	2.13E-19	1.20E-14	2.13E-19
702	8.32E-16	1.48E-20	0.00E-01	0.00E-01	4.41E-11	6.98E-16
703	9.06E-04	1.52E-08	9.06E-04	1.52E-08	1.38E-03	2.17E-08
704	9.77E-09	1.74E-13	0.00E-01	0.00E-01	1.97E-05	2.90E-10
705	2.06E-09	3.67E-14	8.54E-13	1.52E-17	6.32E-06	1.04E-10
706	1.18E-07	2.10E-12	0.00E-01	0.00E-01	2.26E-04	3.30E-09
707[c]	-	-	-	-	-	-
708[d]	-	-	-	-	-	-
709	1.36E-09	2.42E-14	0.00E-01	0.00E-01	7.75E-06	1.14E-10
710	7.06E-08	1.26E-12	0.00E-01	0.00E-01	1.33E-04	1.92E-09
711[c]	-	-	-	-	-	-
712	1.29E-07	2.31E-12	0.00E-01	0.00E-01	1.22E-05	2.17E-10
713[d]	-	-	-	-	-	-

[a]Risks to the population are the health effects; risks to the maximally exposed individual are the health effects per lifetime. The risks for a functional grouping are the total risks posed by all sites in the functional grouping.

[b]The value 6.31E-07 is read 6.31×10^{-7}; this same notation applies to all values in this table.

[c]There were no carcinogens (among the nonradioactive contaminants) selected for analysis for this functional grouping.

[d]This functional grouping was not analyzed.

Table 3 Summary of Public Risks Attributable to Atmospherically Released Carcinogens, by Option, for the Year 2085[a]

Functional Grouping	Waste Removal and Closure		No Waste Removal and Closure		No Action	
	Population	Max. Exposed Indiv.	Population	Max. Exposed Indiv.	Population	Max. Exposed Indiv.
688	5.01E-12[b]	1.24E-15	5.01E-12	1.24E-15	6.50E-05	1.61E-08
689	1.16E-09	2.88E-13	1.17E-09	2.89E-13	1.98E-06	4.92E-10
690	7.28E-08	1.80E-11	7.54E-06	1.87E-09	7.54E-06	1.87E-09
691	8.74E-12	2.17E-15	8.74E-12	2.17E-15	8.74E-12	2.17E-15
692	4.60E-13	1.14E-16	4.62E-13	1.15E-16	4.69E-08	1.16E-11
693[c]	-	-	-	-	-	-
694	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
695[c]	-	-	-	-	-	-
696[c]	-	-	-	-	-	-
697[d]	-	-	-	-	-	-
698	4.20E-17	1.04E-20	4.20E-17	1.04E-20	7.13E-06	1.77E-09
699[c]	-	-	-	-	-	-
700	2.36E-22	5.85E-26	2.36E-22	5.85E-26	1.49E-04	3.70E-08
701	3.88E-27	9.63E-31	3.88E-27	9.63E-31	3.88E-27	9.63E-31
702	2.52E-12	6.25E-16	2.52E-12	6.25E-16	2.52E-12	6.25E-16
703	1.74E-06	4.30E-10	1.74E-06	4.30E-10	3.72E-04	9.22E-08
704	0.00E-01	0.00E-01	0.00E-01	0.00E-01	4.56E-06	1.13E-09
705	1.84E-18	4.56E-22	1.84E-18	4.56E-22	6.05E-07	1.50E-10
706	0.00E-01	0.00E-01	0.00E-01	0.00E-01	5.52E-05	1.37E-08
707[c]	-	-	-	-	-	-
708[d]	-	-	-	-	-	-
709	0.00E-01	0.00E-01	0.00E-01	0.00E-01	1.85E-06	4.58E-10
710	1.01E-13	2.51E-17	1.01E-13	2.51E-17	4.44E-05	1.01E-08
711[c]	-	-	-	-	-	-
712	7.94E-17	1.97E-20	1.37E-11	3.40E-15	1.37E-11	3.40E-15
713[d]	-	-	-	-	-	-

[a]Risks to the population are the health effects; risks to the maximally exposed individual are the health effects per lifetime. The risks for a functional grouping are the total risks posed by all sites in the functional grouping.

[b]The value 5.01E-12 is read 5.01×10^{-12}; this same notation applies to all values in this table.

[c]There were no carcinogens (among the nonradioactive contaminants) selected for analysis for this functional grouping.

[d]This functional grouping was not analyzed.

Table 4 Summary of Public Risks Attributable to Atmospherically Released Carcinogens, by Option, for the Year 2985[a]

Functional Grouping	Waste Removal and Closure		No Waste Removal and Closure		No Action	
	Population	Max. Exposed Indiv.	Population	Max. Exposed Indiv.	Population	Max. Exposed Indiv.
688	2.07E-26[b]	5.14E-30	2.07E-26	5.14E-30	1.14E-09	2.82E-13
689	5.02E-10	1.24E-13	5.03E-10	1.25E-13	5.04E-10	1.25E-13
690	9.40E-18	2.33E-21	9.74E-16	2.42E-19	9.74E-16	2.42E-19
691	7.32E-22	1.82E-25	7.32E-22	1.82E-25	7.32E-22	1.82E-25
692	1.24E-34	2.90E-38	1.25E-34	2.92E-38	5.39E-18	1.34E-21
693[c]	-	-	-	-	-	-
694	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
695[b]	-	-	-	-	-	-
696[c]	-	-	-	-	-	-
697[d]	-	-	-	-	-	-
698	0.00E-01	0.00E-01	0.00E-01	0.00E-01	3.93E-10	9.74E-14
699[c]	-	-	-	-	-	-
700	0.00E-01	0.00E-01	0.00E-01	0.00E-01	1.70E-09	4.21E-13
701	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
702	5.19E-28	1.29E-31	5.19E-28	1.29E-31	5.19E-28	1.29E-31
703	2.36E-10	5.87E-14	1.94E-09	4.80E-13	4.13E-08	1.03E-11
704	0.00E-01	0.00E-01	0.00E-01	0.00E-01	8.61E-16	2.14E-19
705	0.00E-01	0.00E-01	0.00E-01	0.00E-01	6.84E-17	1.70E-20
706	0.00E-01	0.00E-01	0.00E-01	0.00E-01	1.47E-14	3.65E-18
707[c]	-	-	-	-	-	-
708[d]	-	-	-	-	-	-
709	0.00E-01	0.00E-01	0.00E-01	0.00E-01	3.74E-16	9.28E-20
710	0.00E-01	0.00E-01	0.00E-01	0.00E-01	2.16E-09	5.37E-13
711[c]	-	-	-	-	-	-
712	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
713[d]	-	-	-	-	-	-

[a] Risks to the population are the health effects; risks to the maximally exposed individual are the health effects per lifetime. The risks for a functional grouping are the total risks posed by all sites in the functional grouping.

[b] The value 2.07E-26 is read 2.07×10^{-26}; this same notation applies to all values in this table.

[c] There were no carcinogens (among the nonradioactive contaminants) selected for analysis for this functional grouping.

[d] This functional grouping was not analyzed.

Year 2085

Functional Grouping	Population	Max. Exposed Indiv.
703	3.64E-04	9.22E-08
700	1.49E-04	3.70E-08
688	6.50E-05	1.61E-08
706	5.52E-05	1.37E-08
710	4.44E-05	1.01E-08

Year 2985

Functional Grouping	Population	Max. Exposed Indiv.
703	4.13E-08	1.03E-11
710	2.16E-09	5.37E-13
700	1.70E-09	4.21E-13
688	1.14E-09	2.82E-13
689	5.04E-10	1.25E-13

Functional Groupings 688, 700, 703, and 710 have higher risks (than the other analyzed functional groupings) over the entire 1000-year assessment period because these sites contain carcinogenic metals, such as chromium VI and nickel, which are relatively immobile.

Option 1 involves the greatest amount of remedial action (excavating wastes, backfilling the waste site[s], and usually covering the site[s] with a low-permeability cap) of the three closure options analyzed. All remedial action was assumed started and completed in 1986. The highest risk results in 1986 for the functional groupings when closed under Option 1 were as follows:

Functional Grouping	Population	Max. Exposed Indiv.
703	9.06E-04	1.52E-08
690	1.12E-06	1.89E-11
688	6.31E-07	1.12E-11
712	1.29E-07	2.31E-12
706	1.18E-07	2.10E-12

The major contributors to risk for these functional groupings were also carcinogenic metals.

To illustrate the effect that each of the three site closure options would have on the public carcinogenic risks, we calculated a "total" public carcinogenic risk value for each closure option for the three selected years in the assessment period--Years 1986, 2085, and 2985. These totals assume that either Option 1, Option 2, or Option 3 would be selected for all sites as a whole.

	Year 1986	Year 2085	Year 2985
Option 1			
Population	9.08E-04	1.81E-06	7.38E-10
Max. Exposed Indiv.	1.52E-08	4.48E-10	1.83E-13
Option 2			
Population	9.39E-04	9.28E-06	2.44E-09
Max. Exposed Indiv.	1.57E-08	2.30E-09	6.05E-13
Option 3			
Population	3.77E-03	7.09E-04	4.72E-08
Max. Exposed Indiv.	6.02E-08	1.75E-07	1.18E-11

We expected total risks from Option 1 to be higher than Option 2 for Year 1986. However, the total risks for Option 2 as shown are higher than those for Option 1, primarily because of the risks associated with Functional Grouping 690, Option 2. This occurs even though the calculated public risk for many of the waste sites was lower for Option 2 than for Option 1 in the Year 1986 (the year in which site remedial action was assumed to occur). (See Table 2.) Closure Option 2, for the thinly backfilled waste sites in Grouping 690, does not include the emplacement of additional backfill or a cap, so relatively more contamination would be released to the atmosphere from these sites than from other sites where more extensive remedial actions are planned for Option 2. As expected, the Option 1 risks in later years are lower than the Option 2 risks and the Option 3 risks.

For Years 1986, 2085, and 2985 in the assessment period, Table 5 presents the major contributors to risk by site closure option. For many of the functional groupings, chromium VI was the prevalent major contributor to risk for Options 1 (waste removal and closure) and 3 (no action) in 1986. For Option 2 (no waste removal and closure), 1986, the prevalent major contributors to risk were the volatile species, such as tetrachloroethylene and trichloroethylene. Chromium VI dominated the risk for Options 1 and 3 for 1986 because it is fairly immobile and it possesses a high UCR. Volatile species dominated the risk for Option 2 because upward volatilization through the backfill is the only release of contamination to the atmosphere for this option.

PUBLIC EXPOSURE AND RISK FROM NONCARCINOGENS

One measure of public risk was calculated for exposures to noncarcinogens: the risk to a maximally exposed individual. As with

Table 5 Summary of the Major Contributors to Public Carcinogenic Risk, by Option

		Waste Removal and Closure		No Waste Removal and Closure		No Action	
EID	Year	Contaminant	Percentage of Risk	Contaminant	Percentage of Risk	Contaminant	Percentage of Risk
688	1986	Arsenic	89	a		Arsenic	81
		Chromium VI	10			Chromium VI	17
	2085	Trichloroethylene	100	Trichloroethylene	100	Chromium VI	76
						Nickel	24
	2985	Trichloroethylene	100	Trichloroethylene	100	Nickel	100
689	1986	Chromium VI	65	a		Chromium VI	100
		Carbon tetrachloride	20				
	2085	Carbon tetrachloride	57	Carbon tetrachloride	57	Chromium VI	100
		1,1,1-Trichloroethane	40	1,1,1-Trichloroethane	40		
	2985	1,1,1-Trichloroethane	69	1,1,1-Trichloroethane	69	1,1,1-Trichloroethane	69
		Carbon tetrachloride	28	Carbon tetrachloride	28	Carbon tetrachloride	28
690	1986	Chromium VI	100	Chromium VI	100	Chromium VI	100
	2085	Chromium VI	100	Chromium VI	100	Chromium VI	100
	2985	Chromium VI	100	Chromium VI	100	Chromium VI	100
691	1986	Trichloroethylene	84	a		Trichloroethylene	83
	2085	Trichloroethylene	82	Trichloroethylene	82	Trichloroethylene	82
	2985	Trichloroethylene	70	Trichloroethylene	70	Trichloroethylene	70
		Tetrachloroethylene	30	Tetrachloroethylene	30	Tetrachloroethylene	30
692	1986	Cadmium	81	a		Cadmium	71
		Chromium VI	19			Chromium VI	29
	2085	Trichloroethylene	100	Trichloroethylene	100	Chromium VI	99
	2985	Trichloroethylene	100	Trichloroethylene	100	Chromium VI	100
693[b]		-		-		-	

[a] There were no major contributors to risk here because the calculated risk was 0.0 (zero).
[b] There were no carcinogens (among the nonradioactive contaminants) selected for analysis for this functional grouping.

Table 5 (continued)

		Waste Removal and Closure		No Waste Removal and Closure		No Action	
EID	Year	Contaminant	Percentage of Risk	Contaminant	Percentage of Risk	Contaminant	Percentage of Risk
694	1986	Cadmium	100	a		a	
	2085	a		a		a	
	2985	a		a		a	
695[b]		–		–		–	
696[b]		–		–		–	
697[c]		–		–		–	
698	1986	Chromium VI	63	a		Chromium VI	55
		Nickel	37			Nickel	45
	2085	Chloroform	100	Chloroform	100	Nickel	76
						Chromium VI	24
	2985	a		a		Nickel	100
699[b]		–		–		–	
700	1986	Chromium VI	97	a		Chromium VI	97
	2085	Tetrachloroethylene	100	Tetrachloroethylene	100	Chromium VI	92
	2985	a		a		Nickel	100
701	1986	Tetrachloroethylene	100	Tetrachloroethylene	100	Tetrachloroethylene	100
	2085	Tetrachloroethylene	100	Tetrachloroethylene	100	Tetrachloroethylene	100
	2985	a		a		a	

[a]There were no major contributors to risk here because the calculated risk was 0.0 (zero).
[b]There were no carcinogens (among the nonradioactive contaminants) selected for analysis for this functional grouping.
[c]This functional grouping was not analyzed.

Table 5 (continued)

EID	Year	Waste Removal and Closure: Contaminant	Waste Removal and Closure: Percentage of Risk	No Waste Removal and Closure: Contaminant	No Waste Removal and Closure: Percentage of Risk	No Action: Contaminant	No Action: Percentage of Risk
702	1986	Chloroform	63	a		Trichloroethylene	69
		Trichloroethylene	36			Chloroform	31
	2085	Trichloroethylene	78	Trichloroethylene	78	Trichloroethylene	78
		Chloroform	22	Chloroform	22	Chloroform	22
	2985	Trichloroethylene	96	Trichloroethylene	96	Trichloroethylene	96
703	1986	Trichloroethylene	84	Trichloroethylene	84	Trichloroethylene	55
		Tetrachloroethylene	15	Tetrachloroethylene	15	Nickel	27
	2085	Nickel	83	Nickel	83	Nickel	91
		Chromium VI	10	Chromium VI	10	Chromium VI	5
	2985	Nickel	68	PCB's	92	Nickel	81
		PCB's	32	Nickel	8	PCB's	18
704	1986	Chromium VI	96	a		Chromium VI	98
	2085	a		a		Chromium VI	100
	2985	a		a		Chromium VI	100
705	1986	Arsenic	71	Tetrachloroethylene	100	Arsenic	57
		Chromium VI	29			Chromium VI	43
	2085	Tetrachloroethylene	100	Tetrachloroethylene	100	Chromium VI	100
	2985	a		a		Chromium VI	100
706	1986	Chromium VI	100	a		Chromium VI	100
	2085	a		a		Chromium VI	100
	2985	a		a		Chromium VI	100
707[b]		-		-		-	

[a]There were no major contributors to risk here because the calculated risk was 0.0 (zero).
[b]There were no carcinogens (among the nonradioactive contaminants) selected for analysis for this functional grouping.

Table 5 (continued)

EID	Year	Waste Removal and Closure: Contaminant	Waste Removal and Closure: Percentage of Risk	No Waste Removal and Closure: Contaminant	No Waste Removal and Closure: Percentage of Risk	No Action: Contaminant	No Action: Percentage of Risk
708[a]		-		-		-	
709	1986	Chromium VI	100	b		Chromium VI	100
	2085	b		b		Chromium VI	100
	2985	b		b		Chromium VI	100
710	1986	Chromium VI	94	b		Chromium VI	83
						Nickel	16
	2085	Trichloroethylene	97	Trichloroethylene	97	Chromium VI	56
						Nickel	44
	2985	b		b		Nickel	100
711[c]		-		-		-	
712	1986	Toxaphene	93	b		Toxaphene	99
	2085	Vinyl chloride	100	Vinyl chloride	100	Vinyl chloride	100
	2985	b		b		b	
713[a]		-		-		-	

[a]This functional grouping was not analyzed.
[b]There were no *major contributors* to risk here because the calculated risk was 0.0 (zero).
[c]There were no carcinogens (among the nonradioactive contaminants) selected for analysis for this functional grouping.

the public risk that is due to exposures to carcinogens, this measure is the maximum insult to any one individual. (The risk to the population was not calculated for noncarcinogens [as was the case for the carcinogens] because there was, and is, no accepted methodology for correctly relating individual toxic pollutant exposures to health effects in the population.)

For the Years 1986, 2085, and 2985 in the assessment period, Tables 6 through 8 contain summaries of the calculated noncarcinogenic risk, by site closure option, for the maximally exposed individual, for each functional grouping.

In these tables, the risks that are due to exposures to noncarcinogens are expressed relative to the acceptable daily intake (ADI) for the maximally exposed individual. The ADI is the recommended maximum amount (per unit time) of the specified contaminant that a person can intake without any deleterious health effects. The risk to the maximally exposed individual, for a given contaminant, is expressed as the fraction of the ADI. (This was calculated by dividing the annual daily dose for the specified contaminant by its ADI.) This value is a measure of the potential, adverse health effects associated with a noncarcinogen.

The risks in Tables 6 through 8 are cumulative totals for each functional grouping; that is, the risks to the maximally exposed individual associated with each noncarcinogen were summed for all waste sites in a functional grouping. Summing the ADI fractions in this manner gave a relative measure of the potential noncarcinogenic insult to the public. This relative measure is an EPA Hazard Index.

For Option 3, which involves the least amount of remedial action for the three closure options considered, the five functional groupings with the highest calculated risks are, by year:

Year 1986

Functional Grouping	Max. Exposed Indiv.
706	8.44E-05
704	3.53E-05
694	3.44E-05
703	1.55E-05
710	1.35E-05

Table 6 Summary of Public Risks Attributable to Atmospherically Released Noncarcinogens, by Option, for the Year 1986[a]

Functional Grouping	Waste Removal and Closure	No Waste Removal and Closure	No Action
688	2.22E-08[b]	0.00E-01	2.07E-06
689	4.76E-10	0.00E-01	1.40E-07
690	1.05E-08	2.24E-07	2.24E-07
691[c]	-	-	-
692	2.79E-09	0.00E-01	1.64E-07
693[c]	-	-	-
694	1.59E-07	0.00E-01	3.44E-05
695[c]	-	-	-
696	3.04E-10	2.02E-08	2.02E-08
697[d]	-	-	-
698	1.57E-08	0.00E-01	3.06E-06
699	1.41E-09	0.00E-01	0.00E-01
700	9.12E-09	0.00E-01	1.34E-06
701[c]	-	-	-
702	1.41E-09	0.00E-01	7.98E-08
703	1.69E-06	1.66E-06	1.55E-05
704	6.63E-07	0.00E-01	3.53E-05
705	5.89E-09	1.13E-17	6.66E-07
706	1.69E-06	2.11E-13	8.44E-05
707[c]	-	-	-
708[d]	-	-	-
709	2.70E-10	2.91E-18	3.99E-08
710	1.14E-08	0.00E-01	1.35E-05
711	1.01E-12	0.00E-01	0.00E-01
712	1.13E-09	0.00E-01	1.36E-09
713[d]	-	-	-

[a]These risks are risks to the maximally exposed individual. The risks for a functional grouping are the total risks posed by all sites in the functional grouping.
[b]The value 2.22E-08 is read 2.22×10^{-8}; this same notation applies to all values in this table.
[c]Noncarcinogens were not selected for analysis for this functional grouping.
[d]This functional grouping was not analyzed.

Table 7 Summary of Public Risks Attributable to Atmospherically Released Noncarcinogens, by Option, for the Year 2085[a]

Functional Grouping	Waste Removal and Closure	No Waste Removal and Closure	No Action
688	9.83E-15[b]	9.83E-13	5.24E-05
689	3.42E-16	3.42E-16	2.63E-06
690	3.37E-08	3.37E-06	3.37E-06
691[c]	-	-	-
692	1.00E-17	1.00E-15	2.97E-06
693[c]	-	-	-
694	4.76E-08	1.57E-06	1.57E-06
695[c]	-	-	-
696	3.46E-09	3.46E-07	3.46E-07
697[d]	-	-	-
698	0.00E-01	0.00E-01	2.75E-05
699	0.00E-01	0.00E-01	0.00E-01
700	6.01E-18	6.01E-16	1.72E-05
701[c]	-	-	-
702	0.00E-01	0.00E-01	1.40E-06
703	1.46E-06	1.46E-06	1.54E-04
704	2.92E-11	2.92E-09	1.19E-03
705	5.19E-18	5.19E-16	1.26E-05
706	9.65E-14	9.65E-12	3.63E-03
707[c]	-	0.00E-01	-
708[d]	-	-	-
709	1.34E-18	1.34E-16	1.24E-06
710	1.19E-15	1.19E-15	4.49E-04
711	0.00E-01	0.00E-01	0.00E-01
712	2.72E-17	1.01E-12	1.01E-12
713[d]	-	-	-

[a] These risks are risks to the maximally exposed individual. The risks for a functional grouping are the total risks posed by all sites in the functional grouping.

[b] The value 9.83E-15 is read 9.83×10^{-15}; this same notation applies to all values in this table.

[c] Noncarcinogens were not selected for analysis for this functional grouping.

[d] This functional grouping was not analyzed.

Table 8 Summary of Public Risks Attributable to Atmospherically Released Noncarcinogens, by Option, for the Year 2985[a]

Functional Grouping	Waste Removal and Closure	No Waste Removal and Closure	No Action
688	6.42E-11[b]	6.42E-09	2.32E-05
689	2.63E-16	2.63E-16	4.41E-07
690	3.12E-12	3.12E-10	3.12E-10
691[c]	-	-	-
692	7.88E-18	7.88E-16	2.57E-07
693[c]	-	-	-
694	1.90E-17	1.90E-15	1.90E-15
695[c]	-	-	-
696	4.30E-13	4.30E-11	4.30E-11
697[d]	-	-	-
698	0.00E-01	0.00E-01	5.42E-11
699	0.00E-01	0.00E-01	0.00E-01
700	4.74E-18	4.74E-16	1.36E-06
701[c]	-	-	-
702	0.00E-01	0.00E-01	1.77E-10
703	1.16E-07	1.16E-07	1.23E-05
704	3.35E-08	3.35E-06	7.45E-04
705	4.28E-18	4.28E-16	2.69E-06
706	7.57E-14	7.57E-12	2.74E-03
707	-	-	-
708[d]	-	-	-
709	1.11E-18	1.11E-16	8.63E-07
710	7.76E-12	7.76E-12	3.00E-04
711	0.00E-01	0.00E-01	0.00E-01
712	0.00E-01	3.39E-30	3.39E-30
713[d]	-	-	-

[a]These risks are risks to the maximally exposed individual. The risks for a functional grouping are the total risks posed by all sites in the functional grouping.

[b]The value 6.42E-11 is read 6.42×10^{-11}; this same notation applies to all values in this table.

[c]Noncarcinogens were not selected for analysis for this functional grouping.

[d]This functional grouping was not analyzed.

Year 2085

Functional Grouping	Max. Exposed Indiv.
706	3.63E-03
704	1.19E-03
710	4.49E-04
703	1.54E-04
688	5.24E-05

Year 2985

Functional Grouping	Max. Exposed Indiv.
706	2.74E-03
704	7.45E-04
710	3.00E-04
688	2.32E-05
703	1.23E-05

For Option 1, which involves the greatest amount of site remedial action of the three closure options analyzed, the five functional groupings with the highest calculated risk in 1986 were as follows:

Functional Grouping	Max. Exposed Indiv.
703	1.69E-06
706	1.69E-06
704	6.63E-07

The prevalent major contributors to risk for these functional groupings are lead and mercury.

To illustrate the effect that each of the three site closure options would have on the maximally exposed individual risks that are due to atmospherically released noncarcinogens, we calculated the total risk for all functional groupings (for each closure option), for the three years in the assessment period.

	Year 1986	Year 2085	Year 2985
Option 1	4.29E-06	1.54E-06	1.50E-07
Option 2	1.90E-06	6.75E-06	3.47E-06
Option 3	1.91E-04	5.55E-03	3.83E-03

These results revealed that noncarcinogenic risk is highest in all years for Option 3, lowest for Option 2 in Year 1986, and lowest for Option 1 in Years 2085 and 2985. Also, the risk to the maximally exposed individual increases in Year 2085 over the 1986 values for Options 2 and 3 but not for Option 1.

There are two reasons why these results occurred. First, in Year 2085, the maximally exposed individual will be much closer to the waste site than in the Year 1986. (We have assumed the site is inhabited by the public in 2085.) This causes higher exposures after 2085 even though the source strength may have decreased because of leaching over the previous 100 years. Second, Option 1 exposures and risks for 1986 included releases due to excavation (which usually generates a markedly higher source term for that year), so the maximally exposed individual received higher exposures for Option 1 than for Option 2 in 1986. In succeeding years, Option 1 exposures are less than those for Option 2 because the source strength in Option 1 has been reduced by the amount excavated. Thus, even though the maximally exposed individual will be closer to the waste sites in 2085 than in 1986, we do not see the same effect (of increased exposure and risk over the 1986 values) because the source strength for 1986 included excavation and the 2085 release has been reduced.

For the Years 1986, 2085, and 2985 in the assessment period, Table 9 presents the major contributors to risk for the cumulative results given in Tables 6 through 8. For many of the functional groupings, mercury and lead are the prevalent major contributors to risk. As shown in Table 9, mercury is a prevalent major contributor to risk in the later years of the assessment, especially for Options 1 and 2, which involve backfilling the sites. This is due to the volatile and immobile (because of leaching processes) nature of mercury.

WORKER EXPOSURE AND RISK

Option 1 (and, in some cases, Option 2) involves the excavation of contaminated soils from the waste sites. Workers participating in site remedial activities would be exposed to airborne contaminants that may pose a health risk. Two measures of risk were used to report these worker risks: (1) the maximally exposed individual worker risk and (2) the worker population risk. (Since workers would be in the area of the highest contaminant concentration during excavation, the average individual is the maximally exposed individual.) These two measures are (1) the maximum insult to an individual worker and (2) the total insult to the worker population as a whole.

The worker health risk results presented in the remainder of this section are for unprotected workers only; that is, no credit was given for workers wearing respirators. Risks to workers with respirator protection would be a factor of 50 less than the risks for unprotected workers, assuming workers wear a full facepiece, air purifying negative pressure respirator.

Table 9 Summary of the Major Contributors to Public Noncarcinogenic Risk, by Option

		Waste Removal and Closure		No Waste Removal and Closure		No Action	
EID	Year	Contaminant	Percentage of Risk	Contaminant	Percentage of Risk	Contaminant	Percentage of Risk
688	1986	Mercury	38	a		Mercury	39
		Lead	32			Lead	32
		Chromium	11			Chromium	11
	2085	Mercury	100	Mercury	100	Mercury	68
						Lead	21
	2985	Mercury	100	Mercury	100	Mercury	100
689	1986	Lead	85	a		Lead	84
	2085	Mercury	100	Mercury	100	Lead	77
						Mercury	22
	2985	Mercury	100	Mercury	100	Mercury	100
690	1986	Lead	85	Lead	85	Lead	85
		Chromium	15	Chromium	15	Chromium	15
	2085	Lead	96	Lead	96	Lead	96
	2985	Lead	100	Lead	100	Lead	100
691[b]		-		-		-	
692	1986	Sodium	77	a		Sodium	77
		Lead	15			Lead	15
	2085	Mercury	100	Mercury	100	Sodium	73
						Lead	14
						Mercury	11
	2985	Mercury	100	Mercury	100	Mercury	100

[a]There were no major contributors to risk here because the calculated risk was 0.0 (zero).
[b]There were no noncarcinogens selected for analysis for this functional grouping.

Table 9 (continued)

EID	Year	Waste Removal and Closure: Contaminant	Waste Removal and Closure: Percentage of Risk	No Waste Removal and Closure: Contaminant	No Waste Removal and Closure: Percentage of Risk	No Action: Contaminant	No Action: Percentage of Risk
693[a]		-		-		-	
694	1986	Lead	65	b		Tributyl phosphate	96
		Tributyl phosphate	34				
	2085	Tributyl phosphate	100	Tributyl phosphate	100	Tributyl phosphate	100
	2985	Mercury	100	Mercury	100	Mercury	100
695[a]		-		-		-	
696	1986	Lead	99	Lead	99	Lead	99
	2085	Lead	99	Lead	99	Lead	99
	2985	Lead	81	Lead	81	Lead	81
		Fluoride	19	Fluoride	19	Fluoride	19
697[c]		-		-		-	
698	1986	Barium	99	b		Barium	99
	2085	b		b		Barium	98
	2985	b		b		Sodium	86
						Barium	14

[a] Noncarcinogens were not selected for analysis for this functional grouping.
[b] There were no major contributors to risk here because the calculated risk was 0.0 (zero).
[c] This functional grouping was not analyzed.

Table 9 (continued)

EID	Year	Waste Removal and Closure		No Waste Removal and Closure		No Action	
		Contaminant	Percentage of Risk	Contaminant	Percentage of Risk	Contaminant	Percentage of Risk
699	1986	Lead	100	a		a	
	2085	a		a		a	
	2985	a		a		a	
700	1986	Lead	55	a		Lead	55
		Chromium	42			Chromium	42
	2085	Mercury	100	Mercury	100	Lead	77
						Chromium	13
	2985	Mercury	100	Mercury	100	Mercury	100
701[b]		-		-		-	
702	1986	Lead	100	a		Lead	100
	2085	a		a		Lead	100
	2985	a		a		Lead	100
703	1986	Barium	94	Barium	96	Barium	90
	2085	Barium	83	Barium	83	Barium	79
						Lead	10
	2985	Mercury	100	Mercury	100	Mercury	100

[a]There were no major contributors to risk here because the calculated risk was 0.0 (zero).
[b]Noncarcinogens were not selected for analysis for this functional grouping.

Table 9 (continued)

EID	Year	Waste Removal and Closure		No Waste Removal and Closure		No Action	
		Contaminant	Percentage of Risk	Contaminant	Percentage of Risk	Contaminant	Percentage of Risk
704	1986	Mercury	58	a		Mercury	58
		Sodium	35			Sodium	34
	2085	Mercury	100	Mercury	100	Mercury	79
						Sodium	17
	2985	Mercury	100	Mercury	100	Mercury	100
705	1986	Lead	63	Mercury	100	Lead	65
		Sodium	14			Sodium	14
	2085	Mercury	100	Mercury	100	Lead	61
						Mercury	26
						Sodium	13
	2985	Mercury	100	Mercury	100	Mercury	100
706	1986	Mercury	91	Mercury	100	Mercury	90
		Lead	9			Lead	9
	2085	Mercury	100	Mercury	100	Mercury	96
	2985	Mercury	100	Mercury	100	Mercury	100
707[b]		-		-		-	
708[c]		-		-		-	

[a]There were no major contributors to risk here because the calculated risk was 0.0 (zero).
[b]Noncarcinogens were not selected for analysis for this functional grouping.
[c]This functional grouping was not analyzed.

Table 9 (continued)

EID	Year	Waste Removal and Closure: Contaminant	Waste Removal and Closure: Percentage of Risk	No Waste Removal and Closure: Contaminant	No Waste Removal and Closure: Percentage of Risk	No Action: Contaminant	No Action: Percentage of Risk
709	1986	Mercury	57	Mercury	100	Mercury	57
		Lead	24			Lead	24
	2085	Mercury	100	Mercury	100	Mercury	85
						Lead	13
	2985	Mercury	100	Mercury	100	Mercury	100
710	1986	Mercury	43	a		Mercury	55
		Lead	35			Lead	44
		Chromium	22				
	2085	Mercury	100	Mercury	100	Mercury	77
						Lead	23
	2985	Mercury	100	Mercury	100	Mercury	100
711	1986	Nitrate	100	a		a	
	2085	a		a		a	
	2985	a		a		a	
712	1986	Lead	89	a		2,4,5-TP	99
	2085	Endrin	99	Freon	100	Freon	100
	2985	a		Freon	100	Freon	100
713[b]		-		-		-	

[a]There were no major contributors to risk here because the calculated risk was 0.0 (zero).
[b]This functional grouping was not analyzed.

WORKER RISK FROM CARCINOGENS

Table 10 contains a summary of the calculated carcinogenic risks for the maximally exposed individual worker and for the worker population for each functional grouping. The risk to the maximally exposed individual is the "health effects per lifetime," or the probability that a worker will suffer a health effect due to exposure to a specified carcinogen (if the individual were to receive the calculated dose over the time period estimated for site cleanup).

The risk to the worker population, a population that is the number of workers in the cleanup crew, is the "health effects" the population would experience in the time period estimated for site cleanup, health effects that are due to exposure to site releases of carcinogens.

The risks in Table 10 are cumulative for each functional grouping; that is, the risk to the maximally exposed individual worker that is due to each carcinogen present at the waste sites within a given functional grouping were summed. Carcinogenic risks to the worker populations for all the waste sites in a given functional grouping were also summed.

The five functional groupings with the highest worker risks are:

Functional Grouping	Max. Exposed Indiv. Risk	Population Risk
703	1.91E-07	1.72E-06
688	1.71E-07	1.54E-06
700	9.54E-08	8.59E-07
712	7.26E-08	6.53E-07
710	5.63E-08	5.07E-07

As was the case with the public risk results, chromium VI is a prevalent major contributor to risk for many of the functional groupings.

WORKER RISK FROM NONCARCINOGENS

Table 10 also summarizes the calculated noncarcinogenic risks to the maximally exposed individual worker for each of the functional groupings analyzed. These risks that are due to exposures to noncarcinogens are expressed relative to the acceptable daily intake (ADI) in a manner similar to that for the public risks that are due to exposures to noncarcinogens. The five functional groupings with the highest worker risks that are due to exposure to noncarcinogens are as follows:

Table 10 Summary of Worker Risks Attributable to Atmospheric Releases of Contaminants During Site Excavations

EID	Carcinogens[a]: Max. Exposed Individual Worker Risk (Health Effects/Lifetime)	Carcinogens[a]: Worker Population Risk (Health Effects)	Noncarcinogens[b]
688	1.71E-07	1.54E-06[c]	1.23E-02
689	8.85E-10	7.97E-09	5.41E-03
690	5.24E-09	6.60E-08	1.08E-04
691	7.19E-17	6.47E-16	d
692	1.65E-10	1.49E-09	7.12E-04
693	e	e	d
694	1.91E-10	1.03E-07	2.92E-05
695	e	e	d
696	e	e	1.14E-02
697[f]	-	-	-
698	1.13E-09	1.02E-08	1.14E-01
699	e	e	2.25E-03
700	9.54E-08	8.59E-07	4.35E-02
701	5.65E-18	5.09E-17	d
702	1.20E-16	1.08E-15	3.04E-05
703	1.91E-07	1.71E-06	4.36E-02
704	7.47E-10	6.72E-09	2.48E-02
705	2.24E-09	2.02E-08	2.19E-02
706	4.40E-09	3.96E-08	1.19E-02
707	e	e	d
708[f]	-	-	-
709	8.69E-09	7.82E-08	3.56E-02
710	5.63E-08	5.07E-07	8.51E-03
711	e	e	4.36E-06
712	7.26E-08	6.54E-07	1.36E-01
713[f]	-	-	-

[a]Risks to the population are the health effects; risks to the maximally exposed individual are the health effects per lifetime.

[b]These risks are risks to the maximally exposed individual, and they are expressed as EPA Hazard Indexes.

[c]The value 1.54E-06 is read 1.54×10^{-6}; this same notation applies to all values in this table.

[d]Noncarcinogens were not selected for analysis for this functional grouping.

[e]There were no carcinogens (among the nonradioactive contaminants) selected for analysis for this functional grouping.

[f]This functional grouping was not analyzed because no contaminants were selected for analysis.

Functional Grouping	Max. Exposed Indiv. Risk
712	1.36E-01
698	1.14E-01
703	4.36E-02
700	4.35E-02
709	3.56E-02

The dominant contributors to risk for these waste sites are lead and barium.

SUMMARY AND CONCLUSIONS

Assessing the health hazards posed by the various remedial actions considered for mixed waste sites has required the development of new and increasingly more efficient assessment techniques. This is particularly true because of the large number of chemicals and radionuclides that are potentially present at mixed waste sites. This paper has presented those techniques that apply to atmospherically released nonradioactive chemicals. Other models and health risk procedures are used to assess radioactive releases and other applicable environmental media--surface and ground water.

As expected, the risks from nonradioactive contaminants that we calculated from the atmospheric pathway are low--no site or site remediation option, taken individually or summed, posed an unacceptable risk to the public. Risks to workers were also well below "thresholds" that we as a society accept.

The results of this assessment provided much information useful for resource prioritization, information that has aided SRP personnel in determining what level of remedial action that was needed at each waste site and in determining the priority for site cleanups. In terms of remedial action, the results of this assessment also answered the somewhat philosophical question of whether it is better to do nothing or do everything. More importantly, however, is the very fact that the atmospheric environmental pathway was analyzed to quantify public and occupational risk in the first place. All too often a particular environmental pathway is not analyzed in an assessment because the assessors know it will be unimportant. Public scrutiny of such assessments does not accept such treatment, however. Analyzing the waste sites in a thorough, scientifically-recognized manner--which of course includes the atmospheric pathway--does much to foster public goodwill and faith in appropriate steps being taken to maintain a safe environment and to prevent potential problems from being overlooked.

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