Final Report of the Philadelphia Integrated Environmental Management Project

Executive Summary

Regulatory Integration Division
Office of Policy Analysis
Office of Policy, Planning, and Evaluation
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EXECUTIVE SUMMARY

Philadelphia Integrated Environmental Management Project

INTRODUCTION

The Philadelphia Integrated Environmental Management Project (IEMP) was an innovative study designed to analyze and address the problems posed by toxic chemicals in the Philadelphia area. This project became a prototype for a series of IEMPs that the U.S. Environmental Protection Agency (EPA) has conducted over the last four years. The Project's goals were, therefore, both to provide insights on particular environmental issues and to develop new general methods. Our objectives were:

- To develop a methodological approach to evaluating and comparing the risks to human health caused by exposure to toxic pollutants in the environment, as measured by cancer and, to a lesser degree, other chronic health effects

- To use this evaluation to help local officials in the process of setting priorities for more detailed analysis and, where appropriate, regulatory controls

- To involve local government agencies in the development and review of the analysis

The concept of integrated environmental management developed out of EPA's recognition that there are drawbacks to the traditional approach that EPA and the states have used to develop environmental regulations. That approach has focused on individual industries, pollutants, and media. While very useful, it has nevertheless limited our ability to determine where among the various media our resources are best employed to get the most health protection. It does not ensure that pollution controls are not merely shifting risk from one medium to another. In addition, we have often used national standards that do not adequately address all site-specific situations.

In contrast, the IEMP approach provides a multimedia analysis of issues and accounts for transfers of toxics across media--in land, air, surface water, and ground water. It is founded principally on the concepts of risk assessment and risk management. Risk assessment requires a systematic evaluation of the potential for adverse effects to human health from exposure to pollution. Risk management is a process for evaluating pollution controls in terms of their projected cost and the level of risk reduction they afford. Finally, we use the IEMP approach to focus on the issues of one community at a time, so we can develop environmental management strategies tailored to each area's unique problems and characteristics.

Risk Assessment

The IEMP uses risk assessment techniques to evaluate and compare the potential problems from toxic pollutants in the air, land, and water. In Philadelphia, we focused specifically on assessing the risks in air, surface water, and drinking water. At times this work was qualitative in nature. However, in other situations, we were able to provide quantitative estimates of the probability that an individual would contract cancer and of the expected cancer incidence in the entire population. Our techniques for estimating health effects are in accordance with standard EPA practices, as described in the proposed EPA risk assessment guidelines. Despite these standards, our analysis has some significant uncertainties, which we elaborate below. The goals of our risk assessment in Phase I of the Philadelphia IEMP were (1) to determine which toxics issues were suitable for a more detailed examination of risks and control options in Phase II and (2) to identify study topics for which we would initiate ambient monitoring programs to better assess exposure levels and, in some cases, potential risks.

Risk Management

Risk management is the process by which policymakers balance programs to reduce human health risks against the available resources to support those programs. In its simplest form, it requires an examination of how large the risks are, how much the risks can be reduced by various regulatory controls, and the costs of these controls. However, it often entails a lot more. It can involve consideration of the strength of evidence we have that a health problem could exist or whether effective regulatory controls can be enforced. Risk management is a process that requires an assessment of all pertinent information before decisions are made to control pollution. Sometimes the appropriate decision may be to conduct further analysis of the problem. In Phase II of this study, we dedicated a significant amount of effort to providing the data and analysis that serve risk management needs. This is especially true of areas where we carried out further problem definition through ambient monitoring or performed cost-effectiveness analyses to allow local policymakers to examine risk reductions and costs of controls for general policy evaluation.

Choice of Location

Philadelphia was chosen as the site of this pioneering study because it provided a good setting for the examination of multimedia issues. The City offered the benefits of several relatively good toxics databases and local officials who we believed provided a strong technical resource for project implementation. Philadelphia was not chosen because it had significant environmental problems. Local officials had already demonstrated exemplary leadership in some areas. EPA and local officials wanted to explore ways to identify, assess, and manage human health risks in an area where significant progress had been made in understanding and controlling toxics issues.

Conclusions

In the following sections we discuss the methodological and substantive conclusions from the Philadelphia IEMP. First, we review our activities in Phase I, largely devoted to screening pollution issues, and report our findings. Second, we present findings from our Phase II risk assessment and control-options analysis. We also discuss the limitations in conducting risks assessments of toxics. Third, we summarize our methodological findings from the ambient monitoring programs and the substantive insights gained from these activities. Finally, we close with observations on our application of the IEMP methodology in Philadelphia.

SUMMARY OF PHASE I OF THE PHILADELPHIA IEMP PROCESS AND FINDINGS

Phase I consisted of three major activities:

- Establishing two intergovernmental committees. The first was the Steering Committee, which included primarily senior appointed officials from all participating jurisdictions and EPA. The other group, the Technical Committee, consisted of technical staff from the environmental agencies. The Steering Committee directed the study. The Technical Committee reviewed and guided the technical and scientific activities.

- Gathering and reviewing data. We collected data to assess the potential effects of human exposure to toxic chemicals. In some instances, data directly useful for measuring exposure were already available, e.g., data on the quality of finished drinking water. In other cases, especially in the case of air, we estimated the expected concentration of a compound in the environment using data on pollutant sources and the manufacturing processes, which were used to run fate and transport models. After gathering available data, we organized it to facilitate easy review by those on our project committees who had considerable knowledge about the quality of the data. We relied heavily on their expert judgment.

- Developing a screening process for identifying critical toxics issues for detailed assessment in Phase II. Once we had collected, organized, and reviewed the preliminary data, we narrowed the project's geographic and analytical scope. We set project priorities on the basis of the primary criteria: quantitative and qualitative measures of risk. Then we applied secondary criteria. These criteria included EPA, state, and local program objectives, the analytical feasibility of examining the issues, and our ability to control environmental impacts.

After applying the screening criteria, which narrowed down our original list of 170 pollutants associated with over 376 point and area sources, we arrived at a subset of 17 sources of nine toxic chemicals released to the ambient air and surface water and contained in drinking water. These sources and chemicals constituted our Phase II study topics, which, along with our analytical activities and objectives, are set out in Table 1.

We emphasize that not all study topics had the same objectives. We also note that we could not analyze each issue with the same degree of technical rigor. Finally, the Phase I results warrant two concluding remarks:

- We successfully identified a manageable set of multimedia topics that could be usefully examined with available EPA resources and analytical methods and that would address issues of interest to the community. Our Phase II efforts would focus on toxic chemicals in air from point and area sources, toxics in finished drinking water, and intermedia transfers of toxics from the City's major POTW.

- We had to exclude some important environmental issues early in Phase I of the Philadelphia IEMP, for several reasons. First, limited resources required that we set priorities among possible topics. Second, limited data

Table 1

PHILADELPHIA IEMP

OVERVIEW OF PHASE II STUDY TOPICS AND ACTIVITIES

Study Topics	Analytical Activities	Objectives
Risk And Control-Options Analysis		
--Identified through screening of available data --Addressed 7 of the 11 initial screening issue papers - Benzene emissions - Area sources of solvents - Refinery, pipeline, and terminal emissions - Baxter drinking water - Queen Lane/Belmont drinking water - Multimedia discharges of 1,2-DCE and 1,2-DCP - Haloforms (chloroform)	--Monitor ambient air --Monitor ambient water --Validate emission estimates --Recalculate exposures and risks using air dispersion models --Identify feasible controls --Calculate control costs and removal efficiencies --Develop model to evaluate and rank cost-effective control option strategies --Provide results in useful format for review by decision makers	--Determine baseline exposures --Identify which sources, pollutants, and exposure pathways contribute most significantly to estimated human health risk --Develop cost-effective strategies for reducing risks to human health: - Aggregate excess cancer incidence - Risks to the Most Exposed Individual --Examine noncarcinogenic risks --Identify limitations of analysis
Monitoring		
1. **Benzene Emissions** (specifically from gasoline marketing) --Identified by Philadelphia as a topic of interest	--Short-term benzene ambient air monitoring at selected intersections with and without service stations	--Determine significance of observed concentrations - Philadelphia air guidelines - Cancer risk
2. **Formaldehyde Releases to the Ambient Air** --Identified by Philadelphia as a topic of interest	--Ambient air monitoring	--Determine significance of observed concentrations - Philadelphia air guidelines - Cancer risk
3. **Combustion of Used Oil** --Identified by all study participants as a topic of interest	--Sampling at points of distribution and use --Analysis of samples for metals and organics	--Compare observed used oil concentrations with EPA fuel specifications
4. **Air Emissions from Landfills** (focusing specifically on New Jersey landfills) --Identified by New Jersey and EPA as a topic of interest --Satisfied EPA interest in testing the applicability of a mobile monitoring system for use in future geographic studies	--Short-term monitoring at a select number of sanitary and hazardous waste landfills in New Jersey (but within geographic boundary of project)	--Identify compounds and observed concentrations --Determine significance of measured concentrations

restricted the extent of our analysis. Third, certain research and analytical methods now in practice were not available at the time of the study. Changes in any of these factors probably would have altered our selection of issues. We wish to emphasize that the absence of an issue from our list of study topics does not mean that the issue is insignificant.

PHASE II FINDINGS

In the following sections we present the findings of the analytical efforts to characterize risks to human health and examine the cost-effectiveness of control options to reduce these potential hazards. We also discuss our conclusions from the ambient monitoring programs. In each area, we summarize both methodological and quantitative results. Since the Philadelphia IEMP was a pilot study, we believe that both types of findings are important for consideration.

Baseline Risk and Control-Options Analysis for Policy Development

Methodology

We were successful in designing an analytical approach that could be used by decision makers to identify which environmental issues present the most significant risks, roughly quantify the magnitude of these risks, and evaluate the cost-effectiveness of various control strategies to reduce the risks that we could quantify. We were successful for several reasons:

- We were able to enlist the critical participation of the members of our project committees, most notably the representatives of the Philadelphia Water Department and Air Management Services (AMS).

- The AMS emissions inventory allowed us to select a limited number of pollutants and sources that contributed most significantly to ambient air releases of the toxic pollutants included in our analysis. Without this inventory, it would have been extremely difficult to narrow the scope of the project.

- We employed existing EPA analytical methods used in Agency research and rulemaking activities to generate much of the data and our analytic results. We tailored their application to our site-specific needs.

Limitations and Uncertainties

The success of providing an analytical approach to evaluate the risks to human health and the cost-effectiveness of alternative control options to reduce these risks must be appreciated in the context of the uncertainties associated with this work. We discuss below the limitations in the project scope, exposure data, toxicological data, and estimates of the cost of controls.

Limitations in Scope. The Philadelphia IEMP was not an epidemiological study. We did not collect data on diseases that occurred in local populations or attempt to trace their causes, environmental or otherwise. Instead, we combined local data and engineering estimates of environmental exposure to toxic chemicals with toxicological data to estimate the risks to human health.

The Philadelphia IEMP only attempted to estimate the health risks from exposure to toxic chemicals in the ambient environment. For example, we did not estimate risks resulting from occupational and indoor air exposures. We also did not include exposures through the food chain. The omission of these routes of exposure in our study does not imply that they are unimportant. It is quite possible that risks from any of these exposure pathways could exceed risks from the exposures we considered. We decided not to assess these exposure routes because of resource constraints and because these areas were generally outside of EPA's traditional regulatory purview and area of expertise.

We chose not to analyze the exposure and risks from conventional pollutants in air and water (such as ozone and sulfur oxides in air, and oxygen-depleting substances and oil and grease in water) because we believed that we could make a more significant contribution by concentrating on toxic chemicals, which are neither as well understood nor as well regulated. Future projects, however, may want to consider these pollutants.

Limitations in Exposure Data. Another important limitation to our analysis is that we did not examine exposures associated with all sources and pollutants. While we tried to identify and assess the cancer risks from the most significant sources and pollutants, some of those for which we were unable to estimate exposure, such as combustion of used oil, may also pose health risks.

Even where exposure data were available, those data varied significantly in quality. As a result, the exposure estimates vary in their reliability. Those based on extensive monitoring, such as for trihalomethanes in drinking water and selected chlorinated solvents in air, are the best exposure estimates we have. The exposure data from short-term ambient air monitoring for benzene from service stations and formaldehyde are much more uncertain.

Exposure estimates derived from modeling also vary in their reliability. Estimates of exposure to toxic organic chemicals in air derived from dispersion models are dependent primarily on the quality of the emissions data and a few other factors, such as meteorological data. In general, the uncertainties introduced by the exposure data are probably much smaller than those associated with the dose-response information used to estimate human health risks.

Limitations in Toxicological Data. Estimates of health effects are designed to be conservative in several ways. When evaluating potential health hazards from a chemical, EPA scientists assume that health effects observed in laboratory animals are a reasonable indicator of potential effects in humans. In converting the animal data to estimate predicted human responses, and in extrapolating from high doses to low doses, we use models that yield a plausible, upper-bound estimate of potency rather than a "best guess" estimate.

Many substances of potential concern have never been evaluated scientifically, or have not been evaluated in sufficient detail to allow estimation of effects on humans. For example, lead (present in air, water, and dust) is thought to pose a health risk to children at ambient levels; however, at the time we conducted this project, we had no way of estimating individual risks or numbers of possible cases.

The addition of new toxicological data and revised scientific interpretations of previous animal studies often leads to revised potency values. This makes risk assessment of various chemicals subject to changes in scientific understanding. Since the time we completed our Phase II analysis, several unit risk factors used have been revised by EPA's Carcinogen Assessment Group (CAG). However, these revisions do not appear to change our findings dramatically.

We relied on CAG unit risk factors for all chemicals except 1,2-dichloropropane. We developed the inhalation and ingestion unit risk factors for 1,2-dichloropropane using the (potency) q_1* value found in EPA's Drinking Water Criteria Document on 1,2-dichloropropane (March 2, 1984). The Drinking Water Criteria Document is nearing completion of external review and, as a result, the unit risk factor for 1,2-dichloropropane could change.

Despite these uncertainties, our risk estimates are useful policy analysis results for comparing issues with one another; setting priorities among environmental issues and concerns that we examined; and roughly assessing the potential magnitude of the overall risks from particular pollutants, sources, and pathways.

Limitations In Estimates of the Cost of Controls. For a variety of reasons, we were unable to obtain complete site-specific control cost information for all plants in our control-options analysis. We were able to gather, with the assistance of AMS, detailed information about the manufacturing process and variations in production levels for many plants. Many of the estimates are based on best engineering judgments, using standard cost estimation techniques employed in EPA regulatory activities.

Risk Assessment and Control-Options Analysis Results

Within the limitations described earlier, we are able to draw the following conclusions about the nine pollutants and 17 sources we investigated.[1] The reader should be careful not to construe any risk estimates presented below as predictions of actual cancer risk in Philadelphia. Actual risks may be significantly lower; in fact, they could be zero. The unit risk factors used in this analysis are based on conservative assumptions that generally produce upper-bound estimates. Because of limitations in data and methods in several areas of the analysis, such as exposure calculations and pollutant selection, risk estimates were calculated as aids to policy development. The proper function of the estimates is to help local officials select and evaluate issues, set priorities, and develop control strategies for the topics examined.

1. Our upper-bound estimate of aggregate excess cancer incidence for the general population of about 1.7 million in Philadelphia was close to three cases per year.[2] Drinking water accounted for over four-fifths of the estimated excess cancer risks we found in our analysis. Table 2 shows the upper-bound excess cancer risks by source category and exposure pathway. The

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[1]Unless otherwise noted, all conclusions on risk and control strategies are based on the results from our original (1984) analysis using the environmental and health data available at that time.

[2]It is important to consider the opening caveat in the beginning of this section as each risk number is read.

Table 2

PHILADELPHIA IEMP

PHASE II RESULTS INTENDED FOR POLICY DEVELOPMENT[1]

UPPER-BOUND ESTIMATES OF EXCESS ANNUAL CANCER INCIDENCE BY SOURCE

CURRENT CONTROL

(1984 analysis)[2]

Sources	Estimated Excess Annual Cancer Incidence[5] (cases/year)		Percentage Breakdown of the Total 2.8 Cases	
Air (point)				
Pharmaceutical Manufacturer	.006		.2%	
Chemical Manufacturer	.007		.2%	
Garment Manufacturer	.001		.0%	
Plastic Cabinet Manufacturer	.000		.0%	
Industrial Dry Cleaner	.000		.0%	
Refinery B	.066		2.3%	
Refinery A	.007		.2%	
Northeast WPCP[3]	.090		3.2%	
Subtotal		.177		6.3%
Air (area)				
Degreasing	.049		1.7%	
Dry Cleaning	.064		2.3%	
Other Industrial Usage	.003		.1%	
Gasoline Marketing (excluding self-service)	.053		1.9%	
Sewer Volatilization (NEWPCP)	.021		.7%	
Delaware River (receiving NEWPCP effluent)	.024		.8%	
Subtotal		.214		7.6%
Drinking Water				
Baxter DWTP	1.221		43.1%	
Belmont DWTP	.447		15.8%	
Queen Lane DWTP	.770		27.2%	
Subtotal		2.438		86.2%
Total[4]	2.8		100.0%	(Note: 100% is equal to 2.8 cases/year)

WPCP = Water Pollution Control Plant.
DWTP = Drinking Water Treatment Plant.

Note: Numbers have three decimal places not as an indication of precision, but to identify source contribution to the risks.

[1]THE UNIT RISK FACTORS USED IN THIS ANALYSIS ARE BASED ON CONSERVATIVE ASSUMPTIONS THAT GENERALLY PRODUCE UPPER-BOUND ESTIMATES. BECAUSE OF LIMITATIONS IN DATA AND METHODS IN SEVERAL AREAS OF THE ANALYSIS, SUCH AS EXPOSURE CALCULATIONS AND POLLUTANT SELECTION, RISK ESTIMATES WERE CALCULATED AS AIDS TO POLICY DEVELOPMENT, NOT AS PREDICTIONS OF ACTUAL CANCER RISKS IN PHILADELPHIA. ACTUAL RISKS MAY BE SIGNIFICANTLY LOWER; IN FACT, THEY COULD BE ZERO. THE PROPER FUNCTION OF THE ESTIMATES IS TO HELP LOCAL OFFICIALS SELECT AND EVALUATE ISSUES, SET PRIORITIES, AND DEVELOP CONTROL STRATEGIES FOR THE TOPICS EXAMINED.

[2]The risk estimates presented in this table were calculated using unit risk factors from 1984.

[3]Recent reductions in discharges to the NEWPCP may result in lower risk numbers than presented in this table.

[4]Columns may not sum due to rounding.

[5]IEc, Inc., Cost-Effectiveness Analysis of Strategies to Reduce Human Health Risk in Philadelphia, U.S. EPA. May 1985.

compound responsible for most of the estimated upper-bound excess cancer incidence in drinking water was chloroform, a trihalomethane. Chloroform's presence in finished drinking water is a byproduct of the process for disinfecting the water. Chloroform concentrations in the Philadelphia drinking water are less than half of EPA's primary interim drinking water standard.

2. For the nine pollutants and 17 sources we investigated, we estimated an upper-bound incidence of nearly three cases per year of cancer in a city that had about 4,500 die of cancer in 1984.[3,4] This point helps place our analysis in context. Additional perspective on our findings could be gained by examining estimated cancer risks from environmental exposures developed independently of this study. For example, recently available data suggest that it is quite possible that the risks from indoor air exposures may be significantly higher than those from ambient air exposures and those of the other risks we examined in this study.

3. Less than one-fifth of the estimated three cases (upper-bound) per year were attributable to exposures in air and are divided about evenly between point and area air sources.[3] Table 2 shows the different air source categories we analyzed and the estimated cancer incidence associated with exposures to ambient air releases from each. The traditional point sources (i.e., smokestack industries) were accountable for a modest percentage (nearly 3 percent) of the risks we could quantify.

4. Roughly one-third of the 0.4 estimated annual cancer cases (upper-bound) from exposure to air toxics risks is attributable to intermedia transfers (from water to air) resulting from industrial wastewater discharges to the Northeast Water Pollution Control Plant (NEWPCP).[3] Roughly two-thirds of the estimated upper-bound excess cancer risks from these intermedia transfers occur at the sewage treatment plant itself. The remaining one-third is split fairly evenly between volatilization from the major sewer line into the NEWPCP and volatilization from the discharge to the Delaware River.

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[3]It is important to consider the opening caveat in the beginning of this section as each risk number is read.

[4]We should note that on average the annual number of cancer cases could be nearly twice the number of annual deaths from cancer (based on 1983 American Cancer Society national data).

Recent reductions in discharges to the NEWPCP and operational changes may result in lower risk numbers than presented in the report.

5. We found that the cumulative upper-bound cancer risks from multiple chemical exposures are greater than single-chemical risks by a factor of 10 and, in some cases, by a factor of 100. EPA's regulatory actions often focus on individual pollutants, such as the listing and control decisions for hazardous air pollutants under Section 112 of the Clean Air Act, and do not account for the cumulative risks that may occur from exposure to multiple chemicals.

6. We found no concentrations of toxic chemicals that warrant increased concern about noncarcinogenic effects. However, independent monitoring information (e.g., AMS's breathing zone study) indicated that benzene concentrations could pose some concern. A better determination of the significance of these concentrations will depend on where the "no-effect" thresholds for benzene, which are currently under internal EPA review, are finally set.

7. People could experience upper-bound individual lifetime risks of cancer of around 1 in 10,000 from their drinking water and in some cases of air exposure.[5] However, upper-bound risks to the maximum exposed individuals in air generally are above 1 in 100,000. Table 3 shows the upper-bound risks to the maximum exposed individual (MEI) from air and drinking water.

8. Decision makers wanting to achieve different levels of risk reduction will need to employ different control strategies. For example, to reduce risks by less than 20 percent, the most cost-effective control strategies focus solely on lowering ambient air releases of toxics. However, to achieve significantly greater reductions in risk, some previously recommended air controls may be replaced by controls at the drinking water treatment plants. Controls at the drinking water treatment plants can achieve large, discrete reductions in risk, as opposed to the smaller, incremental reductions achievable through air emission controls at different sources.

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[5] It is important to consider the opening caveat in the beginning of this section as each risk number is read.

Table 3

PHILADELPHIA IEMP

PHASE II RESULTS INTENDED FOR POLICY DEVELOPMENT[1]

UPPER-BOUND ESTIMATES OF CUMULATIVE LIFETIME CANCER RISKS
TO THE MOST EXPOSED INDIVIDUAL

(1984 analysis)[2]

MEI Location	Cumulative Lifetime Cancer Risk (Upper-Bound) Inhalation	Cumulative Lifetime Cancer Risk (Upper-Bound) Ingestion	Cumulative Lifetime Total Cancer Risk (Upper-Bound) Inhalation and Ingestion
Northeast WPCP[3]	5.6×10^{-5}	1.0×10^{-4}	1.6×10^{-4}
Refinery B	1.4×10^{-5}	1.0×10^{-4}	1.1×10^{-4}
Chemical Mfr.	2.2×10^{-4}	1.0×10^{-4}	3.2×10^{-4}
Plastic Cabinet Mfr.	6.5×10^{-6}	1.0×10^{-4}	1.1×10^{-4}
Pharmaceutical Mfr.	4.5×10^{-5}	1.0×10^{-4}	1.4×10^{-4}
Garment Manufacturer	1.2×10^{-5}	1.0×10^{-4}	1.1×10^{-4}
Refinery A	3.0×10^{-5}	1.0×10^{-4}	1.3×10^{-4}
Industrial Dry Cleaner	2.2×10^{-5}	1.0×10^{-4}	1.2×10^{-4}

[1]THE UNIT RISK FACTORS USED IN THIS ANALYSIS ARE BASED ON CONSERVATIVE ASSUMPTIONS THAT GENERALLY PRODUCE UPPER-BOUND ESTIMATES. BECAUSE OF LIMITATIONS IN DATA AND METHODS IN SEVERAL AREAS OF THE ANALYSIS, SUCH AS EXPOSURE CALCULATIONS AND POLLUTANT SELECTION, RISK ESTIMATES WERE CALCULATED AS AIDS TO POLICY DEVELOPMENT, NOT AS PREDICTIONS OF ACTUAL CANCER RISKS IN PHILADELPHIA. ACTUAL RISKS MAY BE SIGNIFICANTLY LOWER; IN FACT, THEY COULD BE ZERO. THE PROPER FUNCTION OF THE ESTIMATES IS TO HELP LOCAL OFFICIALS SELECT AND EVALUATE ISSUES, SET PRIORITIES, AND DEVELOP CONTROL STRATEGIES FOR THE TOPICS EXAMINED.

[2]The risk estimates presented in this table were calculated using unit risk factors from 1984.

[3]Recent reductions in discharges to the NEWPCP may result in lower risk numbers than presented in this table.

Source: IEc, Inc., Cost Effectiveness Analysis of Strategies to Reduce Human Health Risk in Philadelphia, U.S. EPA, May 1985.

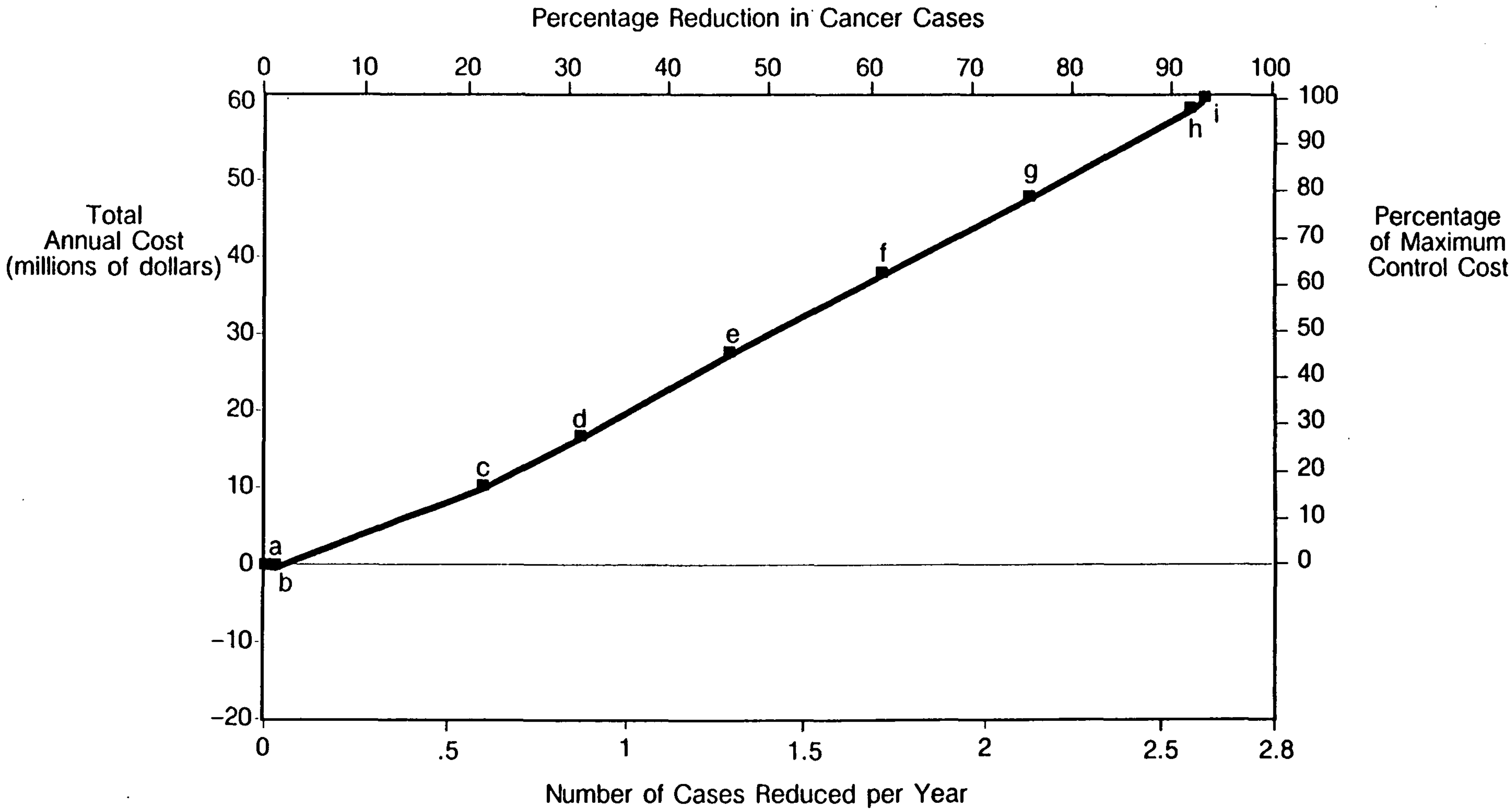
9. Philadelphia would have to implement controls at the drinking water treatment plants to reduce most of the estimated upper-bound excess cancer incidence for the sources and pollutants considered in our analysis. It is important to recognize, however, that the upper-bound estimated individual risk associated with ingestion of Philadelphia drinking water is smaller than the current nationally accepted risk for drinking water, based on the concentrations established by EPA's primary interim drinking water standards.

10. The City would need to make significant expenditures for controls at its treatment plants to reduce most of the estimated risks from drinking water. This situation presents local decision makers with a difficult

Figure 1

Philadelphia IEMP
Phase II Results Intended for Policy Development[1]
Cost vs. Reduction in Cancer Incidence

Air and Drinking Water



[1] The unit risk factors used in this analysis are based on conservative assumptions that generally produce upper-bound estimates. Because of limitations in data and methods in several areas of the analysis, such as exposure calculations and pollutant selection, risk estimates were calculated as aids to policy development, not as predictions of actual cancer risks in Philadelphia. Actual risks may be significantly lower; in fact, they could be zero. The proper function of the estimates is to help local officials select and evaluate issues, set priorities, and develop control strategies for the topics examined.

risk management decision, involving the examination of the amount of risk reduced, the control costs, and other factors. Reductions in the upper-bound estimated cancer risks from drinking water can be achieved by reducing chloroform levels through the use of granular activated carbon (GAC) filters. These controls reduce the chloroform that forms in drinking water following disinfection.

In our cost-effectiveness analysis, we incrementally added GAC controls to each drinking water treatment plant to achieve increasing levels of risk reduction. The results of our analysis suggest that implementing GAC at the Belmont drinking water plant only could reduce approximately one-fifth of the estimated drinking water risks. Implementing GAC at all three drinking water plants could reduce nearly all the estimated cancer risk. The annual costs of these controls would range from roughly $11 million to $58 million. The average cost per cancer case avoided ranges from around $24 million to $26 million, depending on the drinking water treatment plant controlled. The value of the reduction depends on what other risk reduction opportunities are possible for these same expenditures and the value of other social services that could use these resources.

11. For the range of control options we examined, we did not see any dramatic increase in the cost per case avoided as we pursued additional control strategies to reduce further increments of risk. Figure 1 illustrates our results. Typically one would not expect such a linear relationship; rather, one would expect that, as costs increase, a larger fraction of the potential risk could be reduced for a significantly smaller portion of the cost. We attribute this result to two factors affecting the dominant sources of risk (i.e., the drinking water treatment plants). First, the available inexpensive controls, such as switching from chlorine to chloramines as the residual disinfectant, have already been implemented. Second, as noted above, the increase in risk reduction would be achieved by applying the same control technology (i.e., GAC filters) to additional drinking water treatment plants. In practice, the City would most likely implement controls at all three drinking water treatment plants to further remove contaminants in the City's drinking water supply.

12. Some controls to reduce air risks would save money. These controls included product and solvent recovery. These controls would reduce the estimated cancer risks from inhalation exposures by close to a tenth of the air risks we quantified and save over one hundred thousand dollars annually.

13. From a different vantage point, decision makers who are concerned about the risks to the MEI could realize a risk reduction of roughly an order of magnitude by implementing controls costing about $23 million annually. Again, the value of that purchase depends on the community's priorities and the importance of providing everyone with protection above the current level.

14. Our evaluation of the risks and costs of control was initially completed in 1984. Our 1986 revision of the risk estimates, using more current environmental and health data, indicates that there would be little, if any, change in the conclusions discussed above. The major changes noted in our analysis were in the cancer unit risk factors and reductions in the discharges from the chemical manufacturer to the NEWPCP occurring after completion of our monitoring programs in Philadelphia. The reduction in the industrial indirect discharges have undoubtedly led to lower volatilization rates from sewer lines, the sewage treatment plant, and the Delaware River.

Readers of these conclusions should recognize that local officials will be considering other information outside our analysis in using this study's findings. They will evaluate the control-options analyses we performed in a broader context of other health, safety, and social services that they provide their citizens. We provide our findings to local policymakers to assist them in their continuing efforts to set priorities among environmental issues.

Monitoring Activities

Our completion of various ambient monitoring programs leads us to the following conclusions about our approach and about the substantive environmental issues we addressed in Philadelphia.

Insights for Future IEMP Studies

- Our ability to quantify differences between monitoring and modeling results highlighted the advantages of using both techniques together to improve exposures assessments substantially. Modeling, which relates source releases to ambient pollutant levels, is limited by the available information on sources and pollutant loads. Monitoring, on the other hand, provides information about pollutants and sources for which one may know very little, but is not necessarily well-suited to pinpoint the sources of toxic releases. The two in combination complement the strengths of each and reduce the inherent weaknesses of both when used independently.

- Difficult technical and scientific problems in determining ambient toxic pollutant concentrations can constrain attempts to quickly fill in missing data. In addition, one may be forced to use new and unproven monitoring techniques to gather the needed information. For example, our experience in Phase II showed that the ROSE system is not well-suited for measuring ambient air releases from landfills. In another example, the monitoring technique used by AMS to measure formaldehyde levels in the ambient air has not yet been proven to be reliable for quantifying formaldehyde concentrations at low levels representative of ambient conditions. Finally, in the two years since our use of Tenax for ambient air monitoring, its use, effectiveness, and reliability have been called into question by scientists inside as well as outside EPA. EPA is currently exploring alternatives to Tenax.

Monitoring Results

We gained important insights on environmental exposures from our examination of benzene, formaldehyde, used oil, and landfill air emissions. The most important findings are stated below.

Benzene in the Ambient Air

- Average benzene concentrations at the Philadelphia intersections that we examined ranged from 5.4 micrograms per cubic meter (ug/m^3) to 22.3 ug/m^3. However, we were unable to distinguish between the influence of traffic versus gasoline marketing on ambient concentrations. From benzene concentrations at busy traffic intersections, we calculated rough approximations of average individual cancer risks (upper-bound, lifetime) that were in a range comparable to drinking water and air risks we studied in more depth.

- A breathing zone study showed benzene concentrations during 14 refueling episodes that ranged from a low of 1.5 ug/m^3 to a high of more than 88,714 ug/m^3. Because of the small numbers of sampling events, these values are only a limited indication of average benzene concentrations from refueling.

Formaldehyde in the Ambient Air

At the four sites monitored, average ambient formaldehyde concentrations ranged 2.8 ug/m^3 to 3.6 ug/m^3. These concentrations are significantly lower than those measured in several major cities nationwide.

- The average ambient formaldehyde concentrations are below the AMS ambient air quality guideline for formaldehyde. However, when we considered the individual sampling events at each site, we found a few days on which the ambient concentrations exceeded the guideline.

- Our 1984 rough approximations of average upper-bound lifetime individual cancer risks at each of the four monitoring locations showed risks roughly comparable to most of the air risks examined above in the control-options work. If we employ recent changes (1986) in the unit-risk factor for formaldehyde, we find the risk to be in a range that is roughly twice to 30 times that high. Therefore, we now see that formaldehyde may be a more significant health concern than many of the pollutants we looked at in our control-options work.

Combustion of Used Oil

A short-term sampling program (45 samples collected and analyzed) was conducted in coordination with Philadelphia, the State of Pennsylvania, and the State of New Jersey. Because of the limited data, we have not estimated exposure and risk. However, the data suggest that contaminated fuel oil contains lead at levels that warrant further investigation. For all samples, the lead concentrations exceeded the recently promulgated EPA standards for burning used oil. However, the lead concentrations in used oil will fall dramatically as the lead in gasoline is phased out.

Air Emissions from Landfills

As noted above, the EPA field monitoring using the ROSE system experienced serious equipment problems and resulted in poor results. Better data were collected by New Jersey using different monitoring equipment. While the New Jersey data are too limited to assess exposure or risk adequately, the results do indicate that a fairly large number of toxic pollutants can be emitted from landfills and that concentrations of volatile organic compounds (VOCs) around landfills can be above urban background levels.

OBSERVATIONS FOR THE FUTURE

The Philadelphia IEMP has shown us that exercises to set priorities across numerous environmental issues can be managed to provide useful information to local decision makers. The project has also revealed important practical limitations in our ability to apply the IEMP methodology. Three of the most important lessons we learned are discussed below.

- It is essential to define the objectives and scope of the project in its early stages. In Philadelphia we learned that, because of methodological and resource constraints, we cannot analyze every environmental issue. It is therefore important to identify at the beginning of an IEMP the areas of greatest concern to the project participants and to set priorities among this subset of issues for analysis. This allows the limited resources available to be used well on a manageable set of topics, rather than superficially on every potential issue in a community.

- The data and analytical methods available are very significant influences on the topics we analyze and how we analyze them. Major advances in methods for assessing noncarcinogenic risks and ecological damage could greatly increase the ability of IEMPs to aid local decision makers in priority setting. Some environmental concerns may be given a low priority because we either know little about them or do not currently have the capability to analyze these issues. Users of this analysis should not misconstrue our results as statements about priorities based on a comprehensive assessment.

When we have reasonable knowledge about an issue, we can conduct monitoring or perform analyses that may shed new light on a subject. Or, when data is the only concern, we can collect some data even with our limited resources if it appears that the increased base of knowledge will improve local decision making. For the IEMPs, methodological problems can be much more intractable, especially on very complex topics.

Two new methods, beyond the scope of any particular IEMP, would greatly enhance our assessments: (1) an ability to quantify the noncarcinogenic risks for compounds present in the environment at concentrations above the threshold, in ways analogous to carcinogenic risk assessment, and (2) an ability to assess ecosystem effects. Estimates of noncancer effects would allow comparisons between cancer and noncancer problems and provide insightful information for those responsible for public health protection policies. We then could treat noncancer health concerns more equally with cancer concerns, which often seem more important because they can be quantified. Methods for quantitatively measuring risks to ecosystems currently do not exist in any very sophisticated form. It is, therefore, difficult to assess very rigorously the cost-effectiveness of control options that reduce ecological risks or to clarify for local decision makers the implications of environmental issues that span cancer, noncancer, and ecological concerns.

- Finally, we found it essential to have representatives from state and local public health and environmental agencies participate in the project. Local participation in this IEMP greatly enhanced the quality of the analysis performed. It also increased the amount of available data, facilitated the communication of complex issues (such as risk assessment), and built credibility into the project. Also, since we cannot practically analyze all environmental issues, local involvement ensures that our limited resources are used for priority setting and issue evaluation in the areas most critical to the host community. We believe direct local involvement in this and future projects is vital to achieving sound results, essential to gaining local acceptance of the project findings, and critical for using the IEMP approach to aid better environmental policymaking in specific geographical locations.