4962

United States
Environmental Protection
Agency

Office of Policy Analysis
Office of Policy, Planning
and Evaluation

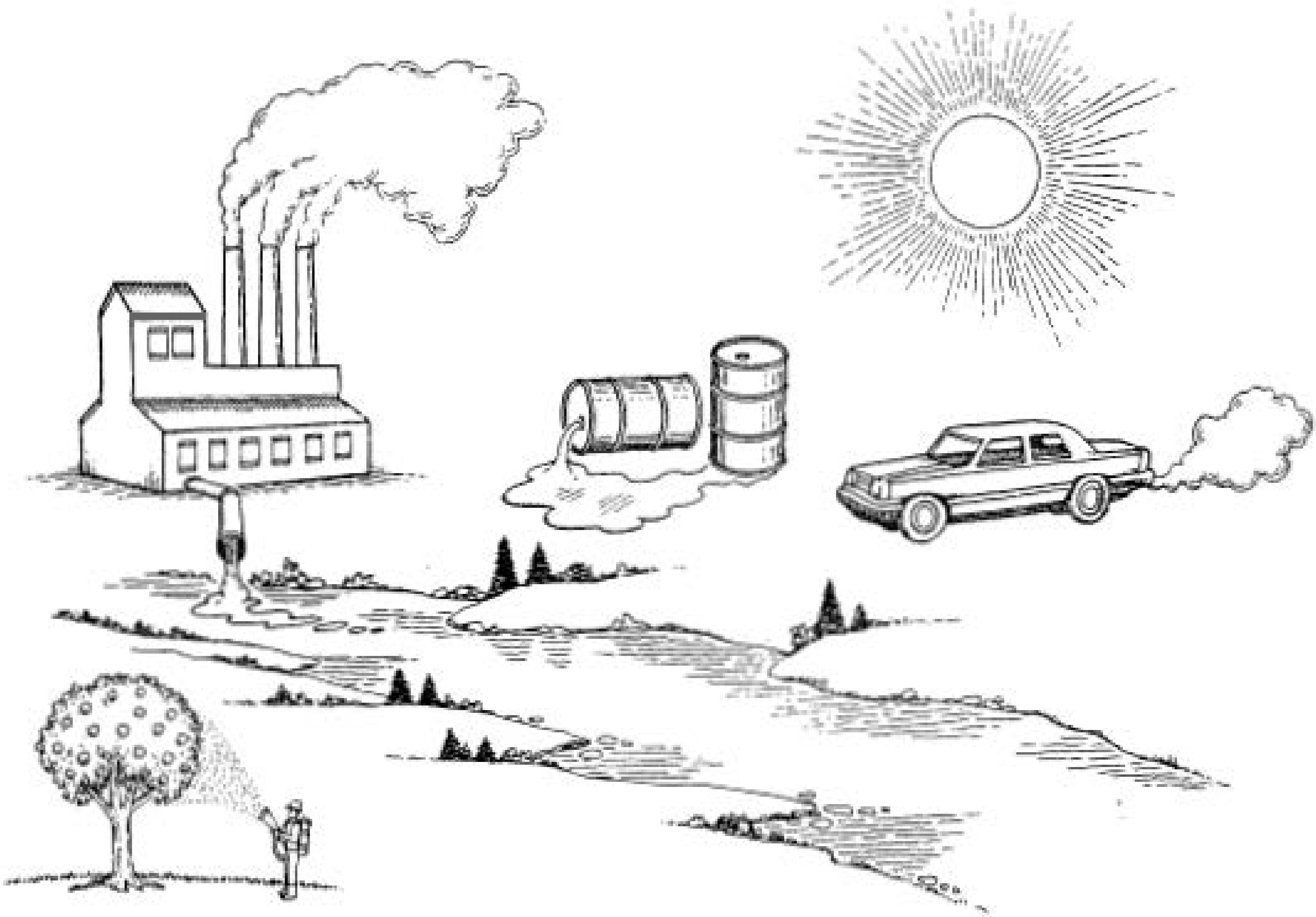
February 1987

000R87901

EPA

Unfinished Business: A Comparative Assessment of Environmental Problems

Overview Report



PB88-127048

U.S. ENVIRONMENTAL PROTECTION AGENCY

UNFINISHED BUSINESS:
A COMPARATIVE ASSESSMENT OF ENVIRONMENTAL PROBLEMS

VOLUME I

OVERVIEW

February, 1987

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA/230/2-87/025a		PB88 127048/AS

4. TITLE AND SUBTITLE	5. REPORT DATE
Unfinished Business: A Comparative Assessment of Environmental Problems — Overview Report	February 1987
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT NO.
Same as (12)	11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
Office of Policy Analysis Office of Policy, Planning and Evaluation, U.S. EPA Washington, DC 20460	14. SPONSORING AGENCY CODE EPA/400/02

15. SUPPLEMENTARY NOTES

16. ABSTRACT

Since 1970 the Nation has done much to abate the most visible forms of pollution, but there is still much unfinished business. New problems have also been "discovered" or have risen in importance. Many of these new problems are difficult to evaluate; many involve toxic chemicals that can cause cancer or birth defects at levels of exposure that are hard to detect; and many involve persistent contaminants that can move from one environment medium to another, causing further damage even after controls have been applied for one medium.

The complexity and gravity of these issues make it particularly important that EPA apply its finite resources where they will have the greatest effect. Thus, the Administrator of EPA commissioned a special task force of senior career managers and technical experts to assist him and other policy makers in this task. The assignment was to compare the risks currently associated with major environmental problems.

In conducting this project, the universe of environmental problems was divided into 31 pieces. Four different types of risks were considered for each problem area. Each risk was analyzed and the findings published in separate volumes as:

Appendix I — Report of the Cancer Risk Work Group
Appendix II — Non-Cancer Risk Work Group
Appendix III — Ecological Risk Work Group
Appendix IV — Welfare Risk Work Group

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS (This Report)	21. NO. OF PAGES
RELEASE TO PUBLIC	UNCLASSIFIED	122
	20. SECURITY CLASS (This page)	22. PRICE
	UNCLASSIFIED	

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

NOTICE

This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

TABLE OF CONTENTS

PREFACE
BY
LEE M. THOMAS
ADMINISTRATOR
U.S. ENVIRONMENTAL PROTECTION AGENCY

The mission of the Environmental Protection Agency is broad. The challenges we face are complex and varied. Operating under nine basic statutes and portions of several others, we have in place major programs to protect every environmental medium.

Over the past 16 years, we have seen significant improvements in the quality of our air, water, and land resources. Still, much remains to be done.

Although EPA's mission enjoys broad public support, our agency nonetheless must operate on finite resources. Therefore, we must choose our priorities carefully so that we apply those resources as effectively as possible.

While we have made much progress to date, the cost of further environmental improvements in many areas will be high. For example, removing additional increments of toxics from industrial effluents or cleaning up contaminated ground water to background levels can be enormously expensive. The unit cost of moving ever closer to the point of zero discharge, zero contamination, and zero risk increases exponentially.

Yet this agency must proceed to carry out its mandates and to set its priorities. With this in mind, last spring I asked a task force of EPA career staff members to examine relative risks to human health and the environment posed by various environmental problems. I am grateful to the 75 agency professionals who helped in this effort.

Preceding page blank

These employees assembled available data and applied their best professional judgment on this complex and controversial subject. Their report -- although subjective and based on imperfect data -- represents a credible first step toward a promising method of analyzing, developing, and implementing environmental policy. That is why I am presenting it to the public as I have received it.

In a world of limited resources, it may be wise to give priority attention to those pollutants and problems that pose the greatest risks to our society. That is the measure this study begins to apply. It represents, in my view, the first few sketchy lines of what might become the future picture of environmental protection in America.

This study is not the definitive work on the subject of risk-based programs, but we hope it will initiate an important discussion of the concept. In time, with better data and more discusssion, I believe the merit in this idea may prove to be an invaluable tool.

In sharing this report I hope that it will stimulate an informed discussion. We plan no immediate changes in priorities until this discussion takes place. We welcome your reactions.

TRANSMITTAL MEMO

MEMORANDUM TO LEE M. THOMAS, ADMINISTRATOR

Nine months ago you asked us to look at the various environmental problems that EPA is mandated to address and report back to you on the relative risks of each of them. Since that time we and over seventy other career managers and experts have been working to prepare the report that we hereby transmit to you.

Preparing this report has been a challenge. Many times we found that the data we would like to have had simply do not exist. For that reason this report can best be described as being based on "informed judgment." But collectively we have a feeling of reasonable confidence in what we are giving you.

Just as this project made us stretch to deal with the lack of good data, it also stretched us to think about the full range of environmental problems that EPA faces. We believe that our product is useful for purposes of general priority-setting. We hope that you and others will also find it so.

Richard D. Morgenstern, Director
Office of Policy Analysis

Don R. Clay, Deputy Assistant Administrator
for Air and Radiation

Gerald A. Emison, Director
Office of Air Quality Planning and Standards

Rebecca W. Hanmer, Deputy Assistant
Administrator for Water

Marcia E. Williams, Director
Office of Solid Waste

ACKNOWLEDGEMENTS

Project Leaders

Richard D. Morgenstern - Director, Office of Policy Analysis
(overall project direction and coordination)

Don R. Clay - Deputy Assistant Administrator for Air and Radiation
(Chairperson, Cancer Work Group)

Marcia E. Williams - Director, Office of Solid Waste
(Chairperson, Non-cancer Work group)

Rebecca W. Hanmer - Deputy Assistant Administrator for Water
(Chairperson, Ecological Work Group)

Gerald A. Emison - Director, Office of Air Quality Planning and Standards (Chairperson, Welfare Work Group)

Work Group Members and Project Staff

(see following pages)

Key to Abbeviations Used on Following Pages

OAR	Office of Air and Radiation
OEA	Office of External Affairs
OPPE	Office of Policy, Planning and Evaluation
OPTS	Office of Pesticides and Toxic Substances
ORD	Office of Research and Development
OSWER	Office of Solid Waste and Emergency Response
OW	Office of Water

Cancer Risk Work Group

Don Clay (chairperson)	Deputy Assistant Administrator for Air and Radiation	OAR
Anne Barton	Deputy Director, Hazard Evaluation Division, Office of Pesticide Programs	OPTS
Jim Berry	Special Assistant to the Deputy Assistant Administrator for Air and Radiation	OAR
Carey Carpenter	Environmental Protection Specialist, Office of Ground Water Protection	OW
Reto Engler	Chief, Scientific Mission Support, Section, Toxicology Branch, Office of Pesticide	OPTS
Bill Farland	Director, Carcinogen Assessment Group, Office of Health Environmental Assessment	ORD
Robert Fegley	Regulatoy Impact Analyst, Office of Policy Analysis	OPPE
Jack Fowle	Acting Director, Water and Toxic Substances Health Research Division, Office of Health Research	ORD
Frank Gostomski	Chief, Water Quality Criteria Section, Office of Water Regulations and Standards	OW
Fred Hauchman	Environmental Health Specialist, Pollutant Assessment Branch, Office of Air Quality Planning and Standards	OAR
Francine Jacoff	Former Section Chief, Waste Characterization Branch, Office of Solid Waste	OSWER
Jeff Kolb	Economist, Analysis and Evaluation Staff, Office of the Assistant Administrator	OSWER

Arnold Kuzmack	Director, Program Development and Evaluation Division Office of Drinking Water	OW
A. W. Marks	Chief, Economic, Policy Analysis, and Data Management Branch, Office of Drinking Water	OW
Carl Mazza	Science Advisor, Office of Toxic Substances	OPTS
Dave Patrick	Former Chief, Pollutant Assessment Branch, Office of Air Quality Planning and Standards	OAR
Peter Preuss	Director, Office of Health and Environmental Assessment	ORD
Tom Purcell	Environmental Scientist, Criteria and Standards Division, Office of Water Regulations and Standards	OW
Jerry Puskin	Chief, Bio-Effects Analysis Branch, Office of Radiation Programs	OAR
John Quest	Team Leader, Scientific Mission Support Section, Toxicology Branch, Office of Pesticide Programs	OPTS
James Repace	Chief, Technical Services for Indoor Air Program, Office of Air and Radiation	OAR
Art Spratlin	Director, Air and Toxics Division	Reg. 7 (Kansas City)
Donn Viviani	Chief, Regulatory Analysis Branch, Office of Standards and Regulations	OPPE
Jeanette Wilste	Air Toxics Coordinator, Office of the Assistant Administrator	OAR
Craig Zamuda	Environmental Protection Specialist, Office of Emergency and Remedial Response	OSWER

Non - Cancer Health Effects Work Group

Marcia Williams (chairperson)	Director, Office of Solid Waste	OSWER
Don Barnes	Science Advisor, Office of the Assistant Administrator	OPTS
Anne Barton	Deputy Director, Hazard Evaluation Division, Office of Pesticide Programs	OPTS
Gary Burin	Toxicologist, Science Integration Staff, Hazard Evaluation Division, Office of Pesticide Programs	OPTS
Ila Cote	Toxicologist, Office of Air Quality Planning and Standards	OAR
Joe Cotruvo	Director, Criteria & Standards Division, Office of Drinking Water	OW
Alex Cristofaro	Chief, Air Economics Branch, Office of Policy Analysis	OPPE
Kim Devonald	Oceanographer, Office of Marine and Estuarine Protection	OW
David Fege	Section Chief, Policy Analysis Section, Office of Solid Waste	OSWER
Susan Goldhaber	Toxicologist, Office of Drinking Water	OW
Michael Gruber	Director, Office of Policy, Planning and Information, Office of Solid Waste	OSWER
Stephanie Irene	Section Chief, General Toxicology Section, Oncology Branch, Office of Toxic Substances	OPTS
Bruce Jordan	Chief, Ambient Standards Branch, Office of Air Quality Planning and Standards	OAR
Stacey Katz	Regulatory Impact Analyst, Office of Policy Analysis	OPPE

Carl Mazza	Science Advisor, Office of Toxic Substances	OPTS
Hugh McKinnon	Acting Director, Office of Health Research	ORD
Paul Milvy	Senior Analyst/Expert, Office of Assistant Administrator	OSWER
Bruce Mintz	Biologist, Office of Drinking Water	OW
Dorothy Patton	Executive Director, Risk Assessment Forum	ORD
Harvey Richmond	Environmental Specialist, Ambient Standards Branch, Office of Air Quality Planning and Standards	OAR
Dale Ruhter	Chief, Economic Analysis Staff, Office of Solid Waste	OSWER
Randy Smith	Chief, Hazardous Waste Policy Branch	Reg. 10 (Seattle)
Larry Zaragosa	Environmental Scientist, Office of Assistant Administrator	OSWER

Ecological Effects Work Group

Rebecca Hanmer (Chairperson)	Deputy Assistant Administrator	OW
Dennis Athayde	Chief, Non-Point Source Control, Office of Marine and Estuarine Protection	OW
Robert Bastian	Environmental Engineer, Office of Municipal Pollution Control	OW
Jay Benforado	Ecologist	ORD
Peter Caulkins	Environmental Economist, Economic Studies Branch, Office of Policy Analysis	OPPE
Wendy Blake-Coleman	Environmental Protection Specialist Office of Ground Water Protection	OW
Dave Davis	Deputy Director, Office of Federal Activities	OEA
Robert Davis	Environmental Scientist	Region 3 (Philadelphia)
Charles Delos	Environmental Scientist, Office of Regulatory and Standards	OW
Jim Gilford	Chief, Environmental Effects Branch Office Toxic Substances	OPTS
Charles Gregg	Special Assistant, Office of the Assistant Administrator	OW
Norbert Jaworski	Director, Environmental Research Lab, Narragansett	ORD
Deborah Martin	Program Analyst, Program Operations Staff, Office of Solid Waste	OSW
Brian McLean	Chief, Implementation Issues Staff Office of Program Development	OAR
Jim Plafkin	Biologist, Office of Water Regulation and Standards	OW

Mike Slimak	Chief, Ecological Effects Branch Office of Pesticide Programs	OPTS
Jim Weigold	Policy Analyst, Office of Air Quality Planning and Standards	OAR
Robert Wolcott	Director, Economic Regulatory and Analysis Division, Office of Policy Analysis	OPPE
Robert Zeller	Policy Advisor, Office of Marine and Estuarine Protection	OW

Welfare Effects Work Group Members

Name	Title	Office
Gerald A. Emison (Chairperson)	Director, Office of Air Quality Planning and Standards	OAR
Allen C. Basala	Chief, Regulatory Impact Analysis Section, Office of Air Quality Planning and Standards	OAR
John Calcagni	Chief, Economic Analysis Branch, Office of Air Quality Planning and Standards	OAR
Gary J. Foley	Director, Acid Deposition and Atmospheric Research Division	ORD
Jeffrey A. Kolb	Economist, Analysis and Evaluation Staff	OSWER
Peter J. Kuch	Leader, Industrial and Natural Resource Economics Section, Office of Pesticide Programs	OPTS
Robert E. Lee II	Chief, Regulatory Impacts Branch, Office of Toxic Substances	OPTS
Ralph A. Luken	Chief, Economic Studies Branch, Office of Policy Analysis	OPPE
Mark A. Luttner	Chief, Economic Analysis Branch, Office of Water Regulations and Standards	OW
John L. Malanchuk	Team Leader, Acid Deposition and Atmospheric Research Division	ORD
William B. O'Neil	Economist, Economic Studies Branch, Office of Policy Analysis	OPPE
Michael G. Shelby	Economist, Air Economics Branch, Office of Policy Analysis	OPPE

Project Staff

Frederick W. Allen	-	Assoc. Director, Office of Policy Analysis (OPA), OPPE
Robert W. Fegley	-	Senior Analyst, OPA, OPPE (Cancer Work Group)
Stacey A. Katz	-	Regulatory Impact Analyst, OPA, OPPE (Non-cancer Work Group)
Peter P. Caulkins	-	Environmental Economist, OPA, OPPE (Ecological Work Group)
Michael G. Shelby	-	Economist, OPA, OPPE (Welfare Work Group)
Deloris A. Swann	-	Secretary, OPA, OPPE

Special thanks also due to Stuart L. Sessions (consultant) and Joan O'Callaghan (editor).

EXECUTIVE SUMMARY

When the Environmental Protection Agency (EPA) was established in 1970, the nation's most pressing environmental problems were obvious. Important polluters and pollutants were the visible ones: soot and smoke from cars and smokestacks, and the raw sewage and chemicals from municipal and industrial wastewater.

Since 1970 the nation has done much to abate the most visible forms of pollution, but there is still much unfinished business. Moreover, new problems have also been "discovered" or have risen in importance, such as indoor radon, global climatic change from the buildup of carbon dioxide in the atmosphere, acid precipitation and hazardous waste. Many of these new problems are difficult to evaluate, as they involve slow, cumulative changes with very serious possible ultimate effects, amidst considerable scientific uncertainty. Many involve toxic chemicals that can cause cancer or birth defects at levels of exposure that are hard to detect. And many involve persistent contaminants that can move from one environmental medium to another, causing further damage even after controls have been applied for one medium.

The complexity and gravity of these issues make it particularly important that EPA apply its finite resources where they will have the greatest effect. Thus, the Administrator of EPA commissioned a special task force of senior career managers and technical experts to assist him and other policy makers in this task. The assignment was to compare the risks currently associated with major environmental problems, given existing levels of control. However, there was no thought that risks alone ought to determine agency priorities. Thus, the results of this project cannot be used by themselves to set priorities.

Methodology

In conducting the project, we organized and limited our work in four important ways. First, we divided the universe of environmental problems into 31 pieces. Each of the pieces represents an environmental problem area defined along lines corresponding generally with existing programs or statutes. For example, some of our 31 problem areas are: criteria air pollutants, hazardous air pollutants, contaminants in drinking water, abandoned hazardous waste (e.g., Superfund) sites, pesticide residues on food, and worker exposures to toxic chemicals.

Second, we considered four different types of risk for each problem area: cancer risks, non-cancer health risks, ecological effects, and welfare effects (visibility impairment, materials damage, etc.). Each type of risk was analyzed separately. There were no decisions that one type was more important than another, and we made no attempt to "add" risks for a problem area across the four risk types.

Third, in view of the already massive scope of the project, we decided to limit it by not considering:

- o the economic or technical controllability of the risks;

- o the qualitative aspects of the risks that people find important, such as the degree to which the risks are voluntary, familiar, or equitable;

- o the benefits to society of the activities that cause the environmental problems; and

- o the statutory and public mandate (or lack thereof) for EPA to deal with the risks. Some problems among the 31 are primarily within the purview of other agencies.

Finally, because the intent of the project was to identify areas of unfinished business, we assessed risks as they exist now -- given the levels of control that are currently in place. We did not aim to assess risks that have been abated.

The method we used to compare environmental problem areas can best be described as systematically generating informed judgments among Agency experts. About 75 career managers and experts representing all EPA programs participated over a period of about nine months. The participants assembled and analyzed masses of existing data on pollutants, exposures, and effects, but ultimately had to fill substantial gaps in available data by using their collective judgment. In this sense, the project represents expert opinion rather than objective and quantitative analysis. But despite the difficulties caused by lack of data and lack of accepted risk assessment methods in some areas, the participants feel relatively confident in their final relative rankings.

Results

The major results from the project are rankings of the 31 problem areas for each of four types of risk. The rankings are based on risks existing today, assuming that current controls stay in place. We found the following:

- o No problems rank relatively high in all four types of risk, or relatively low in all four. Whether an environmental problem appears large or not depends critically on the type of adverse effect with which one is concerned.

- o Problems that rank relatively high in three of four risk types, or at least medium in all four include: criteria air pollutants; stratospheric ozone depletion; pesticide residues on food; and other pesticide risks (runoff and air deposition of pesticides).

- o Problems that rank relatively high in cancer and non-cancer health risks but low in ecological and welfare risks include: hazardous air pollutants; indoor radon; indoor air pollution other than radon; pesticide application; exposure to consumer products; and worker exposures to chemicals.

- o Problems that rank relatively high in ecological and welfare risks, but low in both health risks include: global warming; point and non-point sources of surface water pollution; and physical alteration of aquatic habitats (including estuaries and wetlands) and mining waste.

- o Areas related to ground water consistently rank medium or low.

In some respects, these rankings by risk do not correspond closely with EPA's statutory authorities. For example, in two relatively high health risk areas EPA shares jurisdiction with other agencies that have more direct responsibility: consumer products (the Consumer Product Safety Commission) and worker exposures to toxic chemicals (the Occupational Safety and Health Administration).

The rankings by risk also do not correspond well with EPA's current program priorities. Areas of relatively high risk but low EPA effort include: indoor radon; indoor air pollution; stratospheric ozone depletion; global warming; non-point sources; discharges to estuaries, coastal waters, and oceans; other pesticide risks; accidental releases of toxics; consumer products; and worker exposures. Areas of high EPA effort but relatively medium or low risks include: RCRA sites; Superfund; underground storage tanks; and municipal non-hazardous waste sites.

This divergence between what we found in terms of relative risks and EPA's priorities is not necessarily inappropriate. Some problems appear to pose relatively low risks precisely because of high levels of program effort that have been devoted to controlling them. And these high levels of attention may remain necessary in order to hold risks to current levels.

Overall, EPA's priorities appear more closely aligned with public opinion than with our estimated risks. Recent national polling data rank areas of public concern about environmental issues as follows:

- o High: chemical waste disposal, water pollution, chemical plant accidents, and air pollution;

- o Medium: oil spills, worker exposure, pesticides, and drinking water;

- o Low: indoor air pollution, consumer products, genetic radiation (except nuclear power), and global warming.

A final item resulting from the project is the agenda it has given EPA for improving data and methods for performing environmental risk assessments. We have found it impossible to perform this project in a quantitatively rigorous fashion. The best information we have is on the environmental causes of cancer, but it is weak even here. There is a general lack of information on and attention to welfare and ecological effects. Exposure data are often poor in all four areas, even in problem areas where major regulatory efforts are under way. No generally accepted methods exist for assessing ecological or non-cancer health effects.

Despite the numerous difficulties involved in performing this project, the participants are confident in its general results and are enthusiastic about organizing environmental protection more around the goal of reducing risks. This study should stimulate discussion among policy makers and the public as to what EPA's priorities should be. A collective resolve that the debates about environmental policy should include more information of the type in this report would be a very significant outcome of this project.

CHAPTER I

INTRODUCTION

The fundamental mission of the Environmental Protection Agency (EPA) is to reduce risks - to health, ecosystems and welfare. When the EPA was established in 1970, Congress set specific priorities based on the most visible polluters and pollutants: soot and smoke from motor vehicles and smokestacks, and raw sewage and chemicals from municipal and industrial wastewater.

Substantial progress has been made in controlling these more visible problems, but much unfinished business remains. Now "newer" issues, such as hazardous waste, toxic air emissions, indoor radon, global climatic change and acid rain, beg for attention alongside the old ones. It is not immediately clear which problems pose the greatest risks and which should be given the greatest priority by an agency that now administers nine major statutes and has programs that address dozens of environmental problems.

This is why the EPA Administrator commissioned a task force of senior career officials and technical experts staff to carry out what became known as the "Comparative Risk Project." The objective was to develop a ranking of the relative risks associated with major environmental problems that could be used as one of several important bases on which EPA could set priorities. Until this project was launched, there was no systematic comparison of the different risks the Agency is addressing or could address.

From the outset the project team recognized that it is impossible to directly compare the risks of different environmental problems. While great amounts of information do exist, the inconsistencies in the ways the data have been prepared, the data gaps and uncertainties, and the lack of an adequate risk assessment methodology in some areas prevent a scientifically precise analysis. Great differences in types of damages also hamper comparisons. In the face of these problems, the project team was often required to make professional judgments on the basis of available data. Because of these uncertainties the results of this project should be regarded as not analytically pure but rather as judgmentally correct and unlikely to be far wrong.

The project team was willing to make these judgments and stand behind them because for the purposes of priority setting, absolute precision is not mandatory. Sufficient precision to allow a general comparative ranking is all that is needed. Indeed, by its very nature, the process of setting agency priorities is multifaceted and imprecise. This report provides insight into only one factor, risk, of the many which must be considered in setting priorities. Other factors are also critical. Except as noted, these factors were not studied in this project:

- the benefits to society of the activities that cause the environmental problems;
- the technical feasibility, likely effectiveness, and projected cost of available control options;

- the nature and extent of current legislative authority and the mandate of political and public opinion to act on each identified problem (partly covered in this report);
- EPA's own ability to make a difference, as well as the extent to which effective action could be or is already being taken by others to address the problem; and
- the intangible aspects of the risks that people find important--the degree to which the risks are voluntary, controllable by the individual, familiar, generally accepted, equitable, etc., and the extent to which people value a resource for its own sake or for future generations.

Within this context, the results of this project are intended to serve as a guide to broad, long-term priority setting. Depending on how a problem appears against the criteria cited above, EPA's response to a risk might involve one or more of the following activities:

- conducting research to understand the problem and/or develop methods of control;
- disseminating information and educating the public;
- initiating or increasing program activity, such as issuing regulations, writing permits, or enforcing regulations and permits;
- asking or helping others (e.g., Congress, state and local governments, individual citizens) to legislate or take appropriate action; or even
- taking no action, where the risk is low.

For these reasons, setting priorities will always require managerial judgment. It will also be a subject of public debate. This report is intended to assist in those processes.

This overview report discusses the general analytical approach followed in the project and the specific methods used to assess cancer, non-cancer health, ecological and welfare risks (Chapter 2); the results of the comparative ranking of environmental problems (Chapter 3); public perception of the environmental problems (Chapter 4); and overall observations and recommendations (Chapter 5). Four appendices include the detailed reports from individual work groups on cancer, non-cancer health, ecological and welfare risks.

CHAPTER II

HOW THE ANALYSIS WAS STRUCTURED

A. General Analytical Approach

When planning began for this project in early 1986, the task force made several important decisions about the general analytical approach to be used. They decided (1) to consider four major types of health and environmental risks, (2) to define a specific set of environmental problems for which these risks would be assessed, (3) to focus on risks that exist today, (4) to use both quantitative data and expert judgment, and (5) to set common analytical guidelines for analyzing the different risks.

(1) Consider four major types of risk: cancer risks, non-cancer health risks, ecological effects and welfare effects

Many studies of risk associated with EPA programs have tended to focus only on health risks, and more specifically on cancer risks. Obviously, EPA's role is much bigger than that. EPA is also legislatively responsible for protecting natural ecosystems and the general public welfare as well as public health. Thus, the task force decided to look at four major types of risks that environmental problems present. Each type of risk was analyzed separately; no decision was made that one type is more important than another and no attempt was made to "add" across risk types.

- Cancer risks, as examined in this study, are self-explanatory. Numerous chemicals are either proven or suspected to be human carcinogens, and people may come into contact with these chemicals through environmental exposures. In certain instances, where data exist, both cancer cases and cancer deaths from environmental issues were studied.

- Non-cancer health risks span a very large range. Toxic substances in the environment can cause numerous adverse health effects in addition to cancer. The project looked at eleven types of effects: cardiovascular, developmental, hematopoietic, immunological, kidney, liver, mutagenic, neurotoxic/behavioral, reproductive, respiratory, and "other." These adverse health effects can range from acute (e.g., immediate pesticide poisoning) to chronic (e.g., kidney disfunction from prolonged exposure to cadmium).

- Ecological effects on natural ecosystems result from both habitat modification and environmental pollution. Pollutants of concern can range from toxics (e.g., mercury and pesticides) to conventional pollutants (e.g., salt and sediment). They are produced by such diverse sources as runoff, effluents and air deposition. The ecosystems that they can affect include salt water, fresh water, terrestrial and avian systems, both plant and animal.

- Welfare effects include a variety of damages to property, goods and services or activities to which a monetary value can often be assigned. These include natural resources (e.g., crops, forests and fisheries), recreation (e.g., tourism, boating), materials damage and soiling (e.g., building materials), aesthetic values (e.g., visibility) and various public and commercial activities.

While this four-part typology of risk reflects many of the tangible characteristics of environmental risks, it does not reflect most of the intangible characteristics that people often find just as important. These include such qualitative aspects as the degree to which the risks are voluntary, controllable by the individual, familiar or generally accepted. Another important aspect of environmental problems is equity. Frequently environmental problems affect some people or ecosystems more than others and the most efficient way of dealing with them (the greatest good for the greatest number at the least total cost) is judged unfair to some.

A related aspect that we did not fully consider because of data limitations is the risks environmental problems pose to what are often called "options values" and "existence values." The benefits of something that has a use value are realized when that thing is used. In contrast, intrinsic, "nonuser" benefits are derived from something with option and existence values. An option value is based on the benefit of preserving the option to use a resource in the future. Existence value is based on the knowledge that a resource merely exists or that it exists in a pristine form.

In many instances, people value environmental quality to a greater degree than the tangible benefits they derive from a clean environment would seem to suggest. This is because of the intangible characteristics of the risks. People place intrinsic value on a clean environment. The public's vehement insistence on cleaning up contaminated ground-water aquifers even when they are not currently being used is an example of these important intangible values.

The fact that we did not fully consider these intangible characteristics in this project should in no way suggest that they are unimportant. In fact, a number of studies have found that they are a significant component of what the public perceives as the total value derived from environmental protection. Rather, we did not fully consider them here merely because not enough work has been done in this area to enable the project participants to assess them fairly for all the environmental problems examined in the project.

(2) Define a specific set of environmental problems for the analysis

The second key decision concerned how the universe of environmental problems was divided up to be analyzed. There are many ways to slice the pie. The most consistent ways to define environmental problems are by sources (e.g., power plants or refineries), by pollutants (e.g., sulfur dioxide or benzene), by pathways (e.g., air or water) or by receptors (e.g., people or forests). But we chose another approach. We defined the problems on the general basis of how the laws are written and environmental programs are organized. Since the goal of the project was to put together a useful tool to compare the risks with which EPA is concerned, the project team decided to draw up a list of environmental problems that reflect how people think of the problems, even though it turns out that people do not think of them in an entirely consistent manner.

The list of problems that the group chose to examine is shown in Table 2-1. Some of these problems are diffuse mixtures of sources, effects and a variety of different problems. This has led to some "double counting" of risks in more than one problem area. For example, health risks from inactive hazardous waste sites (problem area #17) often result when people either drink contaminated water or inhale volatile toxic chemicals. Such health risks will be double counted by the drinking water problem area (#15) or by the hazardous air pollutant problem area (#2). We made these definitional decisions because we thought it important to define the environmental problems as they are commonly perceived -- that is, from a variety of overlapping points of view. The major instances of double counting are noted in the body of the report. Further definitions of the problems are given in Chapter III of this Overview Report.

There is no special reason why the group chose to examine exactly 31 problems (in theory it could have been 11 or 111). The project team simply decided that a number between two and three dozen represented an appropriate balance between the quest for detail and the necessity of keeping the analysis manageable. In this context, it is also important to note that how the universe of environmental problems was divided up had an important effect on the relative ranking of the problems. The broader the category, the more impacts it covers, and vice-versa.

Table 2-1

List of Environmental Problems Studied in This Project
(Not in Rank Order)

Reference Number	Environmental Problem
1.	Criteria air pollutants from mobile and stationary sources (includes acid precipitation)
2.	Hazardous/toxic air pollutants
3.	Other air pollutants (includes fluorides, total reduced sulfur, substances not included above that emit odors)
4.	Radon - indoor air only
5.	Indoor air pollutants - other than radon
6.	Radiation - other than radon
7.	Substances suspected of depleting the stratospheric ozone layer - CFC's, etc.
8.	CO_2 and global warming
9.	Direct, point source discharges (industrial, etc.) to surface water
10.	Indirect, point source discharges (POTW's) to surface water
11.	Nonpoint source discharges to surface water
12.	Contaminated sludge (includes municipal and scrubber sludge)
13.	To estuaries, coastal waters and oceans from all sources
14.	To wetlands from all sources
15.	From drinking water as it arrives at the tap (includes chemicals, lead from pipes, biological contaminants, radiation, etc.)
16.	Hazardous waste sites - active (includes hazardous waste tanks) (groundwater and other media)
17.	Hazardous waste sites - inactive (Superfund) (groundwater and other media)
18.	Non-hazardous waste sites - municipal (groundwater and other media)
19.	Non-hazardous waste sites - industrial (includes utilities) (groundwater and other media)
20.	Mining waste (includes oil and gas extraction wastes)
21.	Accidental releases - toxics (includes all media)
22.	Accidental releases - oil spills
23.	Releases from storage tanks (includes product and petroleum tanks - above, on and underground)
24.	Other groundwater contamination (includes septic systems, road salt, injection wells, etc.)

Table 2-1 (continued)

25. Pesticide residues on foods eaten by humans and wildlife
26. Application of pesticides (risks to applicators, which includes workers who mix and load, as well as apply, and also consumers who apply pesticides)
27. Other pesticides risks, including leaching and runoff of pesticides and agricultural chemicals, air deposition from spraying, etc.
28. New toxic chemicals
29. Biotechnology (environmental releases of genetically altered materials)
30. Consumer product exposure
31. Worker exposure to chemicals

Another point to note is that when we were able to, we tried to take account of intermedia transfers and secondary effects. Some pollutants easily cross the boundaries of environmental media (e.g., air, water). Sulfur dioxide (SO_2) emissions are a good example. Our estimate of risk from criteria air pollutants, including SO_2, covers risks from SO_2 in the air (e.g., health effects from breathing it), as well as damages from the deposit of sulfates on structures (e.g., materials damage) and from their eventual arrival in water (e.g., ecological damages from acid rain). Essentially, we attempted to follow the pollutant "from the cradle to the grave." Secondary effects occur when pollutants such as SO_2 are chemically transformed by natural processes after being emitted and do damage in a new form.

While counting intermedia transfers and secondary effects may have resulted in some double counting of effects (as the same environmental problems are evaluated in different media), it should provide a more comprehensive assessment of comparative risks. Unfortunately, for some environmental problems data are simply too scarce to allow for such a comprehensive assessment.

(3) Focus on risks present now

Because the intent of the project was to identify areas of unfinished business, we focused on risks that are present now, or that are being generated by present activities. We assumed the maintenance of the existing environmental programs (i.e., their existing stages of development and at existing levels of resources and compliance). We thus examined residual risks rather than inherent risks (total uncontrolled risks) or risks that have already been or could be controlled. We did not assume that all current statutory and regulatory requirements are being complied with; instead, we tried to judge the actual degree of compliance. Put differently, we looked at where EPA might be able to have an impact in the future, not where it already has had an impact. This assumption is very important. Many environmental problems show up in this analysis as moderate or low risks precisely because extensive controls are already in place and are being maintained, often at considerable expense.

Within these bounds, we decided against putting strict statutory or regulatory bounds on the analysis. We assessed environmental risks broadly defined, whether or not EPA or some other governmental agency had the mandate or the ability to address them. The advantage to this approach is that it can point us toward areas we need to develop and seek statutory authority to address. In addition, it does not prejudge the policy and legal issues related to EPA's regulatory authority. Thus, for example, we assessed environmental risks over which other agencies have lead responsibility (e.g. worker and consumer exposures). Even in an area where EPA does have clear statutory authority, such as in assessing the risks of abandoned hazardous waste sites, we tried to the extent possible to address (1) waste sites that are currently on the National Priorities List, as well as (2) sites that states are handling because they did not rank high enough on the Superfund Hazard Ranking System.

Further, as mentioned in Chapter I, we looked only at risks, and not at the feasibility or costs of controlling those risks. Thus, we repeat, the information collected in this report is not by itself sufficient to support an analysis of agency priorities.

(4) Use both quantitative data and expert judgment

The results of this project can best be described as being based on "informed judgment." From the outset we recognized that the data available for this analysis are incomplete and of highly variable quality. For this reason, making very precise quantitative comparisons is impossible. In some problem areas, risk estimates exist only for a portion of the problem; for example, to our knowledge no one has produced a nationwide estimate of the risks from abandoned hazardous waste (Superfund) sites. In some problem areas data exist on risks from one but not another route of exposure. In other problem areas, risk data may exist for some chemicals but not others. Even where data do exist on risks, they have frequently been generated somewhat differently and are therefore difficult to compare. Thus, the we frequently had to extrapolate risks from incomplete analyses and had to compare estimates of disparate quality.

In doing so, we took several precautions. We collected quantitative information available within the Agency, interpreted the types and qualities of data, stated our assumptions, and, finally, made educated judgments. We also compared our results with those of other studies. Because our use of qualitative judgment was extensive, the results of this study are not scientifically "reproduceable." Nevertheless, we are generally confident in the overall rankings, given the way the problem areas were defined. In each case we have stated our confidence in the data and in our judgments.

(5) Set Common Analytical Guidelines

To ensure consistency in the analyses, we tried whenever possible to apply similar methods across the four areas when estimating risks. However, in many cases we were not able to do this, and had to resort to our collective professional judgment. In general, our attempts in this respect included using common assumptions about emissions, exposure and dose/response relationships; measuring effects whenever they occur from current problems; and presenting the risks in terms of both the risk to the total population and the maximum risk to an individual, where possible and appropriate.

a. Using Assumptions About Emissions, Exposure and Dose/Response Relationships

EPA analyses have made differing assumptions about emissions of various pollutants, the exposure that people, ecosystems and objects receive and dose-response relationships. Comparing estimates generated under incompatible assumptions was difficult. In some instances where there were sufficient data, we tried to coordinate assumptions. In other instances, we simply tried to judge the magnitude of the bias produced by the incompatible assumptions and compared risks without reworking the underlying quantitative estimates.

b. Measuring Effects Whenever They Occur From Current Problems

The time frame during which exposures (and subsequent damages) occur may bias an analysis either in favor of or against certain problems. For example;

- many of the effects associated with various air pollutants take place at essentially the same time as they are emitted into the environment;
- ground water contamination from hazardous waste sites may not affect human health for years, even decades, after contaminants have leached from a site.

To facilitiate a fair representation of the damages from all environmental hazards, we tried to estimate all the damages that will occur from the problem as it exists now. Instead of discounting or using some other method of indicating time preference, we simply presented damages in terms of their magnitude, sometimes with a notation about the time at which they occur. If, for example, damages from exposure to various air pollutants begin to accrue in year 1, while those associated with Superfund sites do not begin for 30 years, we simply recognize those facts, without any accompanying judgment on their policy importance.

Just as there may be a time lag between emissions and exposure, there may also be a time lag between exposure and damages. Latency, which is the time lag between exposure and final effect, has been a very controversial issue, particularly for carcinogens. It is also relevant to mutagenic and certain reproductive effects. Latent effects should not be confused with damages from chronic exposures, which require long periods of exposure before effects are noted. We have chosen again to assess damages whenever they will occur from current environmental problems, and thus do not discount latency periods.

c. Considering Total Population and Maximum Individual Risks

The first priority in this project was to evaluate risks to the total population. However, the cancer and non-cancer work groups characterized both the risk to the total population and the risk to the most exposed individual. For certain environmental problems only a relatively small number of people may be exposed (e.g., pesticide applicators); however, the risks those individuals face may be significant. Therefore, we were interested in descriptions of both aggregate population and individual risk.

B. How the Project Was Organized - The Four Work Groups

The general analytical approach determined how the project would be organized. Four work groups -- on cancer, non-cancer health effects, ecological effects and welfare effects -- were established and given the task of ranking the 31 problem areas according to each type of risk. The work groups were given the common analytical ground rules discussed in the previous section, but were otherwise left to develop their own approaches to ranking.

The work groups were selected with great care. Each was chaired by a senior EPA official who had many years of Agency experience covering multiple program areas. The work group chairpeople were:

- o Cancer: Don Clay, at first Director of the Office of Toxic Substances, and now Deputy Assistant Administrator for Air and Radiation;
- o Non-cancer: Marcia Williams, Director of the Office of Solid Waste;
- o Ecological: Rebecca Hanmer, Deputy Assistant Administrator for Water;
- o Welfare: Gerald Emison, Director of the Office of Air Quality Planning and Standards.

Each work group had at least one representative from each of EPA's program offices. The work groups had expertise appropriate to their subject areas. For the most part, health scientists were on the cancer and non-cancer groups, biological scientists were on the ecological group, and the welfare group consisted mostly of economists. Most of these individuals were either managers or senior scientists who were chosen because of their extensive knowledge of data and methods for assessing risks in their program areas.

Although each work group devised its own approach to assessing risks and ranking the 31 problem areas, there were some similarities among the processes that each eventually followed. All of the work groups proceeded through three basic steps:

1. Agreeing on an overall conceptual approach for comparing risks among the problem areas. For cancer and welfare effects this task was more straightforward than for

the other two groups. Standard or agency-approved methods already existed for assessing cancer risks and for valuing welfare damages. Common denominators for comparing cancer risks (numbers of cases) and welfare effects (dollar losses) also already existed. Developing the conceptual approaches in the non-cancer and the ecological areas was much more difficult.

2. Accumulating and organizing existing data on risks for each problem area. Each work group prepared "summary sheets" on the 31 problem areas, typically describing existing information on risks, sources of data and major uncertainties. The summary sheets were prepared by the program office most knowledgeable about each problem area, and they were then circulated to the entire work group to provide a common base of information for ranking the problem areas.

3. Combining the data from the summary sheets with the judgment of work group members to produce a relative ranking of the problem areas. In all four work groups, gaps and uncertainties in the available quantitative information made it impossible to produce a purely objective ranking. The groups typically had data on only portions of environmental problem areas, e.g., on some chemicals, some exposures, some health effects, or some impacts. The four groups each had to face the issue of how to extrapolate from the portion of the problem that they could assess to the likely extent of the entire problem.

The differences in how the work groups approached their tasks were largely the result of the characteristics of the risk areas they studied and the available data. For instance, as outlined in the following section of this chapter, the non-cancer and ecological groups dealt with many different effects. The non-cancer group developed a special severity index to help rank problems. The ecological group created a special panel of outside experts to help organize their data.

Throughout this process, the work group chairpersons sought to create conditions that would make the judgments as informed, expert and systematic as possible. The work groups successfully developed a spirit of striving for objectivity in this project; the participants generally have not pursued parochial interests or sought to make their own programs "look good." Work group judgments have all been arrived at collectively.

Central direction for the work groups, on matters such as the project schedule, common definitions of problem areas and methodological ground rules, was provided from three sources. First, Richard Morgenstern, Director of the Office of Policy Analysis (OPA), provided overall coordination for the project. Second, one OPA analyst was assigned to each work group to serve as a primary staff member and to provide linkage among the work groups. Finally, the four work group chairpersons and Dr. Morgenstern met frequently to compare progress and resolve crosscutting issues.

The entire project took about nine months. Significant amounts of managerial and staff time were spent on it. Besides providing a sense of the comparative risks of various environmental problems and a basis for establishing better environmental priorities, the project was an especially valuable experience for the participants, many of whom knew relatively little about environmental problems beyond those in their own program areas when they started this project.

The next section of this chapter summarizes the methods used by each of the four work groups to rank the 31 problem areas and their results.

C. Specific Approaches of the Workgroups and Results

(1) Cancer Risk

In one sense, the cancer work group faced an easier task in comparing the risks of the 31 environmental problems than did the other work groups. A basic method for assessment of carcinogenic risk has been adopted by the Agency. Furthermore, the agency has generally followed a policy of aggregating different forms of cancer with the exception of skin cancers. The result was that the work group began this project with a base of a single common currency for comparing disparate environmental problems, and an approved procedure for estimating this quantity.

The work group initially aimed to assess the cancer incidence associated with environmental exposures to carcinogens for each of the 31 problem areas. As was true for some of the other several environmental problems. Wetlands and estuaries (environmental problems 13 and 14) were eliminated from consideration as their inclusion would necessitate double counting. It was assumed that the cancer risk attributed to these environmental problems, largely through the consumption of contaminated seafood, would be captured by other problems which investigate discharges into surface and ground waters.

Because this project drew only on existing quantitative information, and did not involve research to generate new information, the group had to do without quantitative information on several programs that do not generally conduct cancer risk assessments. In general, it was the consensus of the committee that these environmental problems posed relatively low cancer risks, but the reader should be aware that this assessment may be biased by a lack of quantitative information. Problems that fell into this category were direct and indirect point source discharges to surface waters (#9 and #10), and other groundwater contamination (#24).

There were three environmental problems for which no cancer risk could be identified. "Other air pollutants" (#3) were not considered in this analysis, as it was assumed that carcinogenic air pollutants, by definition, would be captured under problem #2 (hazardous/toxic air pollutants). While the implications of CO_2 and global warming (#8) may be large for the ecological and welfare assessments, no information on how this problem may increase cancer incidences is known. Finally, no cancer risk was identified for biotechnology (#29).

The first phase of this exercise involved the compilation of the results of existing analyses to estimate cancer risks for each of the remaining environmental problems. In general, this information was taken from risk assessments performed in support of specific regulatory activities performed by the Agency. Individual committee members from each program office took responsibility for gathering information specific to each environmental problem. This information was then condensed into short summaries of the cancer risk information for each of the environmental problems investigated.

Each of these summaries begins with a short definition of the nature of the environmental problem, describing the boundaries and giving examples of the problem to the extent possible. This is followed by a discussion of the specific contaminants assessed, and the reasons why these substances were chosen. Following this introductory material, each summary outlines the methods by which quantitative risk estimates were developed. Cancer potencies, where different from the approach taken by EPA's Carcinogen Assessment Group (CAG), are presented, along with an explanation of why a different approach was taken. In the cases where risk estimates are based on "non-CAG" methods, comparisons are made to the model used by CAG. Methods used to estimate exposure are also outlined in this section of the summary, including the extrapolation from specific exposure situations to nationwide estimates, whether contaminant concentration estimates are based on measured or modelled data, and what assumptions are made with respect to human intake of air, food, or water. The final section of each summary presents the results of the risk assessment for both population and maximum individual risk, where possible.

Throughout the summaries, uncertainties and caveats specific to each environmental problem are addressed as they arise in the discussion. Where there are particular uncertainties and/or caveats that do not easily fit into the structure of the summary, they are addressed at the end of the discussion of the environmental problems.

These summary estimates of cancer risks by problem area provided an initial basis for ranking the problem areas. The ranking could not, however, simply follow these quantitative estimates mechanistically. The estimates fell short of the ideal in a number of respects.

1. Risk estimates in different program areas were not directly comparable. They often relied on different models and reflected differing degrees of conservatism. Some relied on epidemiologically-developed potency estimates, some on data from animal studies. Some estimates were clearly of better quality and more certain than others.

2. Many of the estimates of risks in a problem area were incomplete, covering only some of the carcinogens or some of the exposures comprising the entire problem area. Some environmental problem areas, such as radon

(#4), were based on nationwide assessments of the issue, theoretically accounting for 100% of the problem. On the other hand, the estimate for inactive hazardous waste (Superfund) sites (#17) was an extremely rough nationwide extrapolation from limited data, covering only exposures via drinking water. And for worker exposure to chemicals (#31), risk estimates were generated for only four of the thousands of potential workplace carcinogens, and no attempt was made to develop a quantitative nationwide risk estimate.

3. Finally, all of the estimates were subject to the massive and well known uncertainties inherent in quantitative cancer risk analysis, inter-species comparison, choice of low dose extrapolation model, estimation of emissions, ambient concentrations and exposures, etc.

The result was that the work group had to do a great deal of qualitative weighing of the quantitative evidence in order to produce a ranking of problem areas.

After the group gathered the quantitative risk estimates, it reviewed the information presented on each of the environmental problems. A full-day work group meeting was held. The first part of this meeting was devoted to a discussion of the information presented, focusing on specific questions about the methods used by program offices to estimate risks for each environmental problem.

The work group then systematically worked through each of the problems and ranked them as to their relative severity. The ranking depended upon the available quantitative risk estimates, a judgment about how risk for an entire problem area related to the risk for these portions of the problem that had been covered in the estimates, and a judgment about the quality and certainty of these estimates. In a number of instances, the work group ranked problem areas in a manner different than the quantitative estimates alone would suggest.

The work group based its ranking of environmental problems primarily on population risk. In general, regulation of environmental problems may be warranted by either high population or high individual risks. Exposure of large numbers of individuals to relatively small cancer risks may result in an unacceptable number of "expected" cancers associated with an environmental problem. Conversely, very high excess cancer risks to even a few individuals may prove unacceptable, even if the expected number of cases is small. The work group decided to recognize the importance of high individual risks, not in the basic rankings, but by separately noting those problems with very high potential risks to individuals.

The first stage of the ranking was performed in terms of general qualitative categories (i.e., high/medium/low). When a consensus was reached at this level of specificity, ordinal ranking of each problem was undertaken, with pairwise comparisons used within categories to ferret out differences between closely ranked problems. Following this meeting, the ranking results were circulated for review by the committee. Work group members reviewed the results, generated additional information on some problem areas, and reconvened to produce the final rankings.

Table 2-2

Consensus Ranking of Environmental Problem Areas
On the Basis of Population Cancer Risk*

CATEGORY 1

RANK	PROBLEM AREA	SUBSTANCES/ EXPOSURES INVESTIGATED	COMMENTS
1 (tied)	Worker Exposure to Chemicals	Formaldehyde Tetrachloroethylene Asbestos Methylene chloride	Ranked highest of any single environmental problem, along with Indoor Radon -- based on work group consensus. About 250 cancer cases were estimated annually from four substances, but workers face potential exposures to over 20,000 substances. Individual risk can be very high.
1 (tied)	Indoor Radon	Radon and its decay products	Also ranked the highest. Current estimates are 5,000 to 20,000 lung cancers annually from exposures within homes. Some of these are a consequence of the joint action of radon and tobacco smoke. Individual risks can be very high.
3	Pesticide Residues on Foods	1 Herbicide 3 Fungicides 1 Insecticide 1 Growth regulator	Cancer incidence estimate of about 6,000 annually, based on exposure to 200 potential oncogens (one-third of total pesticides in use) -- extrapolated from seven known oncogens. Assessment does not account for so-called inert materials in pesticides.
4 (tied)	Indoor Air Pollutants Other than Radon	Tobacco smoke Benzene p-Dichlorobenzene Chloroform Carbon tetrachloride Tetrachloroethylene Trichloroethylene	Quantitative assessment estimates 3,500-6,500 cancers annually. Environmental tobacco smoke is responsible for the majority. Risks from organics estimated on the basis of monitoring 600 U.S. homes. Individual risks can be very high. Potential for some double counting with Consumer Exposure to Chemicals and with Drinking Water.

* The five categories represent decreasing magnitude of cancer risk, with Category 1 representing problem areas with the highest relative risk, and Category 5 representing problem areas for which no cancer risk has been identified. Problems are also ranked numerically within each category.

RANK	PROBLEM AREA	SUBSTANCES/ EXPOSURES INVESTIGATED	COMMENTS
4 (tied)	Consumer Exposure to Chemicals	Formaldehyde Methylene chloride p-Dichlorobenzene Asbestos	The risk from these four chemicals is about 100-135 cancers annually. There are an estimated 10,000 chemicals in consumer products. Even though exposures are generally intermittent, risks are believed to be high, given the concentrations to which individuals are exposed. Consumers are exposed through such products as cleaning fluids, pesticides, particleboard and other building materials, and numerous asbestos-containing products. Considerable double counting with Indoor Air and Other Pesticide Risks.
6	Hazardous/ Toxic Air Pollutants	20 substances, classes of substances, or waste streams	A quantitative assessment of 20 substances estimates approximately 2,000 cancer cases annually. This is a subset of the large total number of pollutants to which people are exposed in ambient air. Individual risks can be very high. Potential for some double counting with Active Hazardous Waste Sites Municipal Hazardous Waste Sites, and Contaminated Sludge.
	Category 2		
7	Depletion of Stratospheric Ozone	Increased UV radiation (Chlorofluorocarbons, Halon 1301, Chlorocarbons)	Current nonmelanoma and melanoma skin cancer deaths at 10,000 annually. Ozone depletion projected to result in steadily increasing risks, with an additional 10,000 annual deaths projected for the year 2100. This problem is ranked in Category 2 because of the considerable uncertainties concerning estimates of future risk. If estimates are correct, would rank higher. Needs further research.
8	Hazardous Waste Sites - Inactive	Trichloroethylene Vinyl chloride Arsenic Tetrachloroethylene Benzene 1,2-Dichloroethane	Nationwide cancer incidence from six chemicals estimated at just over 1,000 annually. Considerable uncertainty, since nationwide risk estimates are based on extrapolating from 35 sites to about 25,000 sites nationwide. Individual risks can be very high. Potential for some double counting with Drinking Water.

RANK	PROBLEM AREA	SUBSTANCES/ EXPOSURES INVESTIGATED	COMMENTS
9	Drinking Water	Ingestion and/or inhalation of 23 substances	Quantitative assessment estimates about 400-1,000 cancer cases annually, based on home surveys of public water systems. Most cases are from radon and trihalomethanes. Potential for some double counting with Indoor Radon, Indoor Air Pollution, and several categories related to contaminated ground water.
10	Application of Pesticides	1 Herbicide 3 Fungicides 1 Insecticide 1 Growth regulator	Approximately 100 cancers annually estimated by a method analogous to that used for Pesticide Residues on Food. Small population exposed, but uniformly high individual risks.
11	Radiation Other than Indoor Radon	Occupational exposures Consumer products Industrial emissions	Risks associated with medical exposures and natural background levels excluded; would rank higher if these were included. Two-thirds of assessed risk of 360 annual cancers results from building materials. Individual risks can be very high. Nonionizing radiation not considered due to lack of data.
12	Other Pesticide Risks	Consumer use Professional exterminator use	Few quantitative estimates available. Consensus estimate of 150 cancers annually, based loosely on discussion of termiticide risks. Less data here than for other pesticide areas.
13	Hazardous Waste Sites - Active	Several carcinogens from each of the following: Hazardous waste storage tanks Hazardous waste in boilers/ furnaces Hazardous waste incineration Waste oil	No nationwide risk estimates are available, but probably fewer than 100 cases annually. Risk estimates are sensitive to assumptions regarding the proximity of future wells to waste sites. Solid waste management units were excluded from analysis. Individual risks can be very high. Possible double counting with Drinking Water and Hazardous/Toxic Air Pollutants.

RANK	PROBLEM AREA	SUBSTANCES/ EXPOSURES INVESTIGATED	COMMENTS
14	Nonhazardous Waste Sites - Industrial	Arsenic 1,1,2,2-Tetrachloroethane Chloroform Benzene	No analysis of cancer incidence. Instead, based on the consensus of the work group. Judged less severe than hazardous waste, worse than municipal. Potential for some double counting with Drinking Water.
15	New Toxic Chemicals	None	Very difficult to assess future uses of new chemicals and the risks of using chemicals never manufactured. Consensus was that this problem poses moderate risks.
	Category 3		
16	Nonhazardous Waste Sites - Municipal	Several pollutants/waste streams from the following: Municipal landfills Municipal sludge incineration Municipal waste incineration	Quantitative estimate of about 40 cancers annually. This estimate does not include risks from municipal surface impoundments. Potential for some double counting with Hazardous/Toxic Air Pollutants, Contaminated Sludge, and Drinking Water.
17	Contaminated Sludge	Up to 22 carcinogens from the following: Land application Distribution and marketing Landfilling Incineration Ocean disposal	Analyses and regulatory development are ongoing. Preliminary results estimate approximately 40 cancers annually. Most of this risk comes from incineration and landfilling. Potential for some double counting with Hazardous/Toxic Air Pollutants, Nonpoint Source Discharges to Surface Water, and Nonhazardous Waste Sites - Municipal.

RANK	PROBLEM AREA	SUBSTANCES/ EXPOSURES INVESTIGATED	COMMENTS
18	Mining Waste	Arsenic Cadmium	Estimate of 10-20 cancer cases annually largely due to arsenic. Severity of problem is relatively low because remote locations expose a relatively small population. This assessment excludes oil and gas operations. Individual risks can be very high. Potential for double counting with Drinking Water.
19	Releases from Storage Tanks	Benzene	Preliminary analysis suggests relatively low cancer incidence (< 1 annually), but exposure modeling not as conservative as several other solid waste problems (behavior that limits exposure is assumed). Potential for double counting with Drinking Water.
20	Nonpoint Source Discharges to Surface Water	None	Judged to be more serious than other surface water categories, but no quantitative analysis is available.
21	Other Ground-Water Contamination	Methylene chloride from septic systems	Generally, risks from other ground-water contamination are not estimated due to a lack of information with respect to sources, their locations, and concentration levels. Individual risks generally less than 10^{-6}, with rough estimate of population risk well under 1 case per year. However, this is an estimate of a small portion of total risk, as we examined one chemical at just one of many sources (septic systems). Potential for some double counting with Drinking Water.
22	Criteria Air Pollutants	Lead Ozone Particulate matter Nitrogen oxides Sulfur oxides Carbon monoxide	This assessment excludes carcinogenic particles and VOCs (controlled to reduce ambient ozone), which are considered under Hazardous/Toxic Air Pollutants. Ranked relatively low because none of the criteria pollutants has been adequately shown to cause cancer. If any are shown to be carcinogenic (e.g., lead), or if VOCs and carcinogenic particles are included in the definition of Criteria Air Pollutants, this problem would move to a higher category.

32

Category 4

RANK	PROBLEM AREA	SUBSTANCES/ EXPOSURES INVESTIGATED	COMMENTS
23	Direct Point Source Discharges to Surface Water	None	No quantitative assessment is available. Only ingestion of contaminated seafood was considered, since the impact of drinking water was covered elsewhere.
24	Indirect, Point Source Discharges to Surface Water	None	Same as above.
25	Accidental Releases - Toxics	None	Because of the short duration of personal exposure to accidental releases, cancer risk judged to be very small. Long-term effects on ground-water exposures were not considered here. Non-cancer health effects are of much greater concern. Nature of substances and exposures ranks this problem above oil spills.
26	Accidental Releases - Oil Spills	None	See above. Oil spills will be of greater concern for welfare and ecological effects.

Category 5 (Listed Alphabetically)

PROBLEM AREA	SUBSTANCES/ EXPOSURES INVESTIGATED	COMMENTS
Biotechnology	None	Dilemma of ranking this problem is similar to that for new chemicals, but even less information is available. No known instances of carcinogenic bioengineered substances.
CO_2 and Global Warming	None	Cancer is not considered a significant aspect of this environmental problem. No assessment was undertaken.
Other Air Pollutants	None	By definition, carcinogenic pollutants in the outdoor air are considered under Hazardous/Toxic Air Pollutants. Therefore, no cancer risk was assessed here.

Not Ranked

PROBLEM AREA	SUBSTANCES/ EXPOSURES INVESTIGATED	COMMENTS
Discharges to Estuaries, Cosatal Waters and Oceans	None	This category represents a conglomeration of other categories. The work group chose not to rank it to to minimize double counting.
Discharges to Wetlands	None	See Discharges to Estuaries, Coastal Waters, and Oceans, above.

(2) Non-Cancer Risk

The non-cancer group had to develop a special approach for ranking the 31 environmental problems reflecting the relative magnitude of the different non-cancer health risks associated with each problem. The methodology addressed a number of complex issues relevant to evaluating non-carcinogenic health risks.

There are thousands of different chemicals in the environment that may cause adverse human health effects. Little is known about the toxicological properties of most of these chemicals; only a few have good information on health endpoints, potency and human exposure. Nevertheless, the work group was interested in all of these factors.

Different chemicals produce different adverse effects, ranging from effects of lesser concern (e.g., dental mottling from fluoride in drinking water) to severe ones (e.g., death from pesticide poisoning). Entirely different health effects may arise from a single chemical when exposure occurs at different levels or by different routes. Effects for a given dose may differ depending on whether the exposure was acute, subchronic, or chronic. Different individuals may react differently to the same chemical; some substances at typical ambient concentrations are of concern only to sensitive subpopulations such as asthmatics or infants. And, a health effect may even be more specific, for example depending on whether or not the asthmatic is exercising.

In short, to the extent we do have knowledge about non-cancer health effects from toxic chemicals, it is highly particularized and difficult to aggregate. In constrast to analyzing cancer or welfare effects, there is no accepted common denominator by which to compare different health effects. Because of thresholds instead in non-cancer does-response functions, we can make no simplifying linear assumptions to allow us to aggregate non-cancer effects over time and over people.

EPA has therefore had great difficulty in analyzing non-cancer health effects, and has not yet been able to develop the guidelines on how to assess risks from "systemic toxicants" (i.e., non-cancer effects excluding reproductive, developmental and mutagenic effects).

Most program offices do not actually assess risks from non-carcinogens. Instead, they identify a "safe" level for which no adverse effects are expected to occur in humans. This is often determined by reducing the no observed adverse effects level (NOAEL) seen in animals by one or more uncertainty factors. Most programs aim to control levels down to this "safe" level, sometimes known as an acceptable daily intake (ADI) or reference dose (RfD). Most programs merely evaluate the extent to which a regulatory option prevents exposures above the RfD without an explicit calculation of risk. This type of analysis may not be well suited to comparisons of aggregate risks across environmental problem areas because RfDs for different chemicals may protect against different health effects that vary widely in their severity. And, the shape of the dose response function at levels above the RfD probably varies substantially across chemicals.

As a result, the non-cancer effects work group had to break new ground to compare the non-cancer risks associated with major environmental problem areas. With established methods and data lacking, the work group relied extensively on its judgment.

Shortly after starting this project, it became clear to the work group that the 31 problem areas involved numerous different substances with the ability to cause numerous different health effects. There appeared to be no strong pattern to the sorts of health effects associated with a particular environmental problem; the association was much stronger between health effects and specific chemicals, with a problem representing the sum of the diverse effects caused by its component chemicals. The work group made an early decision to focus on a limited number of substances associated with each environmental problem that are representative of the problem and are reasonably well understood. The work group would then scale up from the representative substances to the entire problem.

The work group developed a format for recording existing data on representative substances. These summary sheets were prepared for nearly all of the 31 environmental problems. The summary sheets included the following information:

- A selection of 3-6 substances to represent the environmental problem, and a description of the rationale for selecting these substances.

- An estimate of the proportion of risk associated with the entire problem that is accounted for by the selected substances.

- Data on health endpoints, levels of toxicological concern (e.g., RfD, NOEL, etc.), ambient concentrations, exposed populations, incidence and other information bearing on the magnitude and severity of the risks from each selected substance.

- Sources and methods for the data on the selected substances.

The work group aimed to assess the risks from each selected substance via a logic akin to that used in calculating the number of cases expected from a chemical:

$$\text{Exposure} \times \text{Potency} = \text{Incidence}$$

The differing health effects caused by a single substance could then be aggregated into a total risk from that chemical through use of a severity index.

The data available on health effects from and exposures to toxic substances were far from adequate to perform these calculations in a quantitatively precise way. Exposure or potency data were frequently not available for the substances of interest. When data were available, they were of highly variable quality. They were often generated using different and incompatible procedures by different programs, and they reflected very different degrees of conservatism.

The work group added its judgment to these data and developed a semi-quantitative scoring system with which to represent key attributes for each selected substance. Scores were developed to cover:

- The severity of the health endpoints caused by the substance. Severity indexes have been developed in many ways, and they are invariably controversial. One approach that has been used estimates severity in economic terms, reflecting the lost earning power and added medical expenses associated with different diseases. Another approach relies on polling people about which health effects they would least like to suffer. For this project, a subcommittee of health scientists developed a severity index reflecting primarily a judgment about the extent to which the health effect was life threatening and secondarily about whether it was permanent, reversible and manageable therapentically.

  Over 100 health endpoints associated with the selected substances were scored from 1 (mild) to 7 (very severe) through use of this index. A few of the mild health effects, with scores of 1 or 2, included: non-infectious herpes, increased liver enzyines, reduced corneal sensitivity and dental motthing. Some of the severe health effects with scores of 6 or 7 included: kidney or liver necrosis, emphysema, teratogenicity and mortality. This scale of 1-7 was ultimately converted to a scale of 1-4 to be comparable to the other two factors.

- The population exposed to the substance.

  The exposed population was converted into a score ranging from 1 to 4 as follows:

Population score	Number of people exposed
1	<1000
2	1000 - 100,000
3	100,000 - 10,000,000
4	>10,000,000

- The potency of the substance at the ambient concentration or dose to which this population is exposed. This potency was represented by the ratio between the ambient concentration at which exposure occurs and the RfD for the substance. The higher this ratio, the greater the probability of the health effect occurring, or the greater the potency. This ratio can also be thought of as an index of the individual risk at a specific ambient concentration of a substance.

Here also a score ranging from 1 to 4 was developed:

Ratio score	Ambient dose divided by RFD
1	1 - 10
2	10 - 100
3	100 - 1,000
4	> 1,000

Developing this score also was highly controversial. The work group implicitly assumed that dose-response functions for different chemicals have the same shapes and slopes. In effect, the work group assumed that a dose of ten times the RFD is twice as bad as a dose of five times the RFD, no matter what the chemical.

We tried to develop these three scores consistently for all the selected substances. We used a different method when available data covered incidence of a health effect from a substance rather than exposure and potency (for example, when we had data on numbers of pesticide poisonings or on numbers of deaths from accidental releases of toxics). When data on individual substances was lacking, the work group used its best judgment to score a problem area as a whole without reference to its component substances. In a few other cases when available information was minimal, the entire problem area was ranked without developing component scores. Finally, we did not rank at all some problem areas where we could not deelop any way to estimate risks.

We combined these three scores -- representing the severity of the endpoints, the exposed population, and the likelihood of an effect given an exposure -- in various alternative ways to produce tentative risk rankings of substances and of problem areas. We paid special attention in sensitivitiy analysis to ascertaining whether ranking by individual risk would yield results much different from ranking by population risk. It did not. In addition, different approaches were used to aggregate scores from selected substances into scores for an entire problem. With different approaches, a few problems (hazardous air pollutants, drinking water, worker and consumer exposures) moved between the medium and high risk categories. All were ultimately ranked high.

We reviewed the various tentative rankings of problem areas and developed our own qualitative ranking of problem areas that was consistent with most of the tentative rankings. We assigned problem areas to categories of high, medium or low non-cancer risks. The available quantitative data underlying the scores suggest that there is about a 2+ order of magnitude difference in risk between each sucessive risk category. As a final step in the ranking, we adjusted the rankings slightly to reflect the quality of data on each problem and the proportion of each problem and the proportion of each problem we had covered with the substances we studied.

Table 2-3

Relative Ranking of Environmental Problem Areas

Problem Area	Level of Confidence*	% of Problem Covered*
High Non-Cancer Risks		
Criteria air pollutants (#1)	High	30-100
Hazardous air pollutants (#2)	Medium	<3
Indoor air pollutants - not radon (#5)	Medium	30-100
Drinking water (#15)	High	30-100
Accidental releases - toxics (#21)	High	30-100
Pesticide residues on food (#25)	Medium	<3
Application of pesticides (#26)	High	3-10
Consumer product exposure (#30)	Medium	3-10
Worker exposure to chemicals (#31)	High	<3
Medium Non-Cancer Risks		
Radon - indoor air (#4)	Low	30-100
Radiation - not radon (#6)	Medium	30-100
UV radiation/ozone depletion (#7)	Low	30-100
Indirect discharges (POTWs) (#10)	Medium	3-10
Non-point sources (#11)	--	--
To estuaries, coastal waters, oceans (#13)	Medium	30-100
Municipal non-hazardous waste sites (#18)	Medium	10-30
Industrial non-hazardous waste sites (#19)	Low	30-100
Other pesticide risks (#27)	Medium	10-30
Low Non-Cancer Risks		
Direct discharges (industrial) (#9)	Medium	3-10
Contaminated sludge (#12)	Medium	30-100
To wetlands (#14)	--	--
Active hazardous waste sites (#16)	Medium	10-30
Inactive hazardous waste sites (#17)	Medium	10-30
Mining waste (#20)	Low	30-100
Releases from storage tanks (#23)	--	--
Unranked		
Other air pollutants (#3)	--	--
CO_2 and global warming (#8)	--	--
Accidental releases - oil spills (#22)	--	--
Other ground-water contamination (#24)	--	--
New toxic chemicals (#28)	--	--
Biotechnology (#29)	--	--

* For some problem areas, the work group did not believe it had sufficient information to fill out these columns.

(3) <u>Ecological Risk</u>

No generally applicable methodology for evaluating ecological risk currently exists. The workgroup therefore undertook to develop a pragmatic methodology for evaluating ecological risk that incorporated a structured logical process and featured frequent, open debate among workgroup members. The development and refinement of methodology took place over the course of several months as the workgroup conducted successive rankings of the environmental problems.

This process took place in three phases. The workgroup began by conducting an initial assessment that included a redefinition and modification of the list of environmental problems to be evaluated, and evaluated the risks of those problems to a set of ecological systems and other objects of concern. At the end of this phase, at the request of the workgroup, the Cornell Ecosystems Research Center convened a panel of scientific experts to conduct an independent evaluation. While the expert panel determined that, principally for lack of adequate information, it could not rank the problems as such, the panel did provide an evaluation of the potential for effects on ecological systems presented by various environmental stresses. To do this, the panel prepared a list of stress agents and a set of ecosystems against which the potential impacts of the stress agents would be assessed. The panel also developed and applied the concept of scale of impact of risk (local ecosystem, region, biosphere).

The workgroup benefitted greatly from this approach and employed much of it.

In the third phase of activity leading up to its final ranking, the workgroup settled on the methodology that it applied for this ranking.

There follows a more detailed statement of how the workgroup approached its task and developed a methodology and rankings of the ecological risks associated with a set of environmental problems.

o The workgroup modified the initial list of environmental problems by dropping five which presented little or no ecological risk (e.g., indoor air pollution); by combining other problems whose risks could usefully be assessed together (e.g., all point source discharges to water, both direct and indirect); and redefining other problems to account better for ecological risk (e.g., redefining discharges to estuaries, near coastal waters and wetlands as physical modification of aquatic habitat). The resulting list contained 22 problems (Table 3 of the workgroup report). The workgroup noted that the original list (as well as the modified list) included disparate and overlapping environmental problems of different magnitudes, and that this tends to bias the rankings.

o A task that the workgroup addressed early was to define a set of ecosystems against which the ecological risk presented by the problems could be evaluated. For its first ranking, the workgroup developed and used 19 categories of ecosystems and other objects of ecological concern. In its final ranking, following the lead of the expert panel, the workgroup used the panel's reasonably similar breakout into 16 ecosystems of concern (4 freshwater, 3 marine and estuarine, 4 wetland and 5 terrestrial).

o The expert panel, in its evaluation of the potential risk to ecosystems, broke out the types of stress agents associated with the problem list into 26 airborne, waterborne and other stress agents (for example, waterborne toxic organics, radionuclides, gaseous phytotoxicants). The workgroup used this categorization of stress agents in its final ranking.

o As noted above, the panel had developed geographical scales of potential impact of stress agents. The stress agents' impacts could be on local ecosystems, on broader geographical regions or on the entire biosphere. In its final ranking, the workgroup applied this scalar concept. It did not, however, attempt to formulate a precise definition of the lines between these scalar categories. The workgroup did not, for instance, set a radius or other specific boundary between local and regional risk.

o To evaluate and rank the estimated ecological impacts that actually derive from the 22 problem areas (as distinct from assessing the <u>potential</u> impact of particular <u>stress agents</u> on individual ecosystems), problem-related information was needed concerning the sources and extent of emissions and discharges from individual problems, and especially information concerning exposures of ecosystems created by those problems. Ideally, this would include the geographical extent and location of exposure, its intensity, the length and frequency of exposure, and other factors. For this purpose, papers were prepared for the workgroup for each of the 22 problems. The workgroup used the information and judgments contained in these papers, as well as its own individual and collective knowledge. It is important to recognize that the information available was of variable depth and quality, and weak in many problem areas.

o To assess the ecological risk that derives from the various environmental stresses presented by an individual problem, workgroup members were asked to take into account in their individual ratings the basic changes that environmental stresses would cause in the structure and functions of the ecosystems being evaluated, as well as the reversibility of the impact and time required for the ecosystem to recover once the stresses were removed. The workgroup did not settle on a prescriptive or quantitative approach as to the weight that should be given these factors, or how to sum up impacts estimated to occur in varying degree across the range of exposed ecosystems. The individual rankings given by workgroup members were tabulated according to overall classifications of high, medium and low. A cluster analysis of these rankings showed good agreement, and consensus supporting the final rankings was reached in subsequent discussion. The workgroup also grouped the environmental problems according to scale of impact.

° The workgroup attempted to rank problems with the high-medium-low groupings. This resulted in dividing the problems ranked high into three rank groups and the problems ranked medium into two rank groups. Problems were not ranked within the six resulting rank groups. Three problems were not ranked because of the extent of uncertainty as to the severity of risk.

o The workgroup gave some effort to trying to rank ecosystems according to their inherent vulnerability to damage from environmental stresses. The workgroup concluded that this was not a useful approach. Even though some ecosystems tend to have about the same degree of resilience to different kinds of stresses, many (and perhaps most) ecosystems react differently to different kinds of stresses.

o To sum up the workgroup approach, the workgroup evaluated and attempted to rank the ecological risk posed by 22 environmental problems by estimating the significance of the impact of those problems on a set of ecosystems and on broader geographical regions and the biosphere. The estimated impacts are those that occur under current conditions of control as a result of exposure to the stress agents produced by the set of problem sources.

Table 2-4

Summary Ranking of Ecological Risks

Rank	Environmental Problem	Rationale for Ranking Position[1]
1	Stratospheric ozone depletion (7) CO_2 and global warming (8)	Intensity of impact: High (can severely damage all natural systems, particularly primary productivity). Scale of impact: Biospheric Ecosystem recovery: Recovery period extremely long; impacts may be irreversible. Control: Effective controls require coordinated, international effort that will be very difficult to obtain. Uncertainty: Effects of ozone depletion uncertain; ecological response to global warming is well characterized. Rate and timing of the problem is uncertain.
2	Physical alteration of aquatic habitats (13/14) Mining, gas, oil extraction and processing wastes (20)	Physical risks from problems #13/14 and #20 are similar, except #20 includes terrestrial impacts. Intensity of impact: High (can both degrade and completely destroy ecosystem structure and functions). Mining poses severe impacts on water ecosystems. Scale of impact: Local to regional. Ecosystem recovery: Physical impacts are generally irreversible. Control: Low degree of controllability. Uncertainty: High degree of certainty associated with effects.
3	Criteria air pollutants (1) Point-source discharges (9/10) Nonpoint-source discharges and in-place toxics in sediment (11) Pesticides (25/27)	While problems #1, #9/10, 11, and #25-27 do not share common characteristics, they are rank-grouped together. Intensity of impact: High (tend to directly affect ecosystem functions and indirectly affect ecosystem structure). Scale of impact: Local and regional. Ecosystem recovery: Impacts are generally reversible. Control: Degree of control varies among the problems in this rank group; more controllable than rank group #1. Uncertainty: Some uncertainty, but much is known about these effects.

1 Problems are presented in numerical order within each category of rank; no ranking inference should be made within these categories. The numbers in parentheses following the problems are those used in

Summary Ranking of Ecological Risks

Rank	Environmental Problem	Rationale for Ranking Position[1]
4	Toxic air pollutants (2)	Intensity of impact: Medium. Growing evidence to indicate that toxic air pollutants responsible for ecological damage. Scale of impact: Local to regional . Ecosystem recovery: Unknown. Control: Unknown, but likely to be difficult Uncertainty: Substantial.
5	Contaminated sludge (12) Inactive hazardous waste sites (17) Municipal waste sites (18) Industrial non-hazardous waste sites (19) Accidental Releases of Toxics (21) Oil spills (22) Other ground water contamination (24)	These problems overall have localized releases and effects Intensity of impacts: Medium (many sources; impacts generally low, but can be high locally). Ecosystem recovery: Uncertain. Control: Variable. Uncertainty: Moderate
6	Radiation other than radon (6) Active hazardous waste sites (16) Underground Storage tanks (23)	These problems are characterized by few large releases, a high degree of control for #6 and #16. Intensity of Impacts: usually low though could be moderate to severe locally in unusual circumstances. Scale of Impact: local Ecosystem recovery: uncertain Uncertainty: moderate

(4) Welfare Effects

The Welfare Effects work group began by filling out a set of fact sheets that detailed the types of welfare risks related to each of EPA's programs. The fact sheets briefly describe each environmental problem, note the studies that have been conducted on the welfare effects the problem poses, present an estimate of the damages expected from the problem, and point out any serious methodological limitations of the studies the damage estimate is based on. To draw out relevant studies and data and to ensure the accuracy of the work groups' conclusions, we circulated the fact sheets to all of the relevant program offices for review and comment.

Because one goal of this project was to generate cross-fertilization between program offices, we grouped the fact sheets by type of welfare effect, instead of along programmatic lines. The topics we examined encompassed the full range of welfare effects: soiling and other material damages; recreation; natural resources; damages to other public and commercial property and ground-water supplies, and losses in aesthetics and nonuser values. These fact sheets formed the basis for the body of the report.

Before ranking the environmental problems, we established the following ground rules to ensure consistency in accounting for the significance of environmental problems:

° Quantify effects as best as possible. Even when information about the extent of effects is sketchy or preliminary, weigh it so that the effects of alternative environmental problems can be projected.

- If possible, present a monetary estimate of damages. A monetary numeraire or unit provides a common basis for comparing effects across environmental settings.
- When possible, annualize monetary damages, and convert them into 1986 dollars.
- Aggregate damage estimates to a national basis whenever possible.
- Evaluate only current and future environmental effects--not effects that current EPA programs have already eliminated. This project is only concerned about ranking so-called uncaptured, or residual, effects.
- Rank future effects lower than present effects, all else being held constant.

We next ranked the 31 environmental problems. Each member first ranked the problems separately. Then, based on these individual rankings, the full work group constructed a composite ranking of the 31 environmental problems.

The original 31 environmental problems represent an overlapping set of sources, receptors, and pollutants. In many cases, we had difficulty classifying effects based upon the 31 problems. For instance, many of the welfare effects from pesticides are attributed to two environmental problems: Nonpoint Source Discharges to Surface Waters (a source category) and To Estuaries, Coastal Waters, and Oceans from All Sources (a receptor category).

As a result, the environmental problem Other Pesticide Risks is ranked lower than if these effects were considered as a separate source category. Thus, knowing what types of effects are included in each of the environmental problems is important for interpreting the rankings.

We also had difficulty ranking environmental problems with less severe welfare effects. Consequently, we are not confident of the relative rankings for this group of environmental problems.

Finally, it was not clear how to distinguish "welfare" effects from "health" or "ecosystem" effects. Often it is difficult to compartmentalize environmental problems into this set of categories. Partly, this is the result of the multidimensional nature of many environmental problems. Also, in many cases, the scientific literature and economic valuation techniques do not adequately distinguish effects by these separate categories.

For example, reductions in the property values of residences close to a hazardous waste disposal site may at first appear to be welfare losses. In this case, a welfare loss is defined as a loss in the commercial value of an asset or a good due to its exposure to an environmental pollutant. However, it could be argued that the reductions reflect peoples' responses to a "health" threat. Thus, the case could be made that reductions in property values indicate the amount people must be compensated to bear added cancer and noncancer risks and therefore should be evaluated in the health reports of this project.

Alternatively, suppose that risk assessments indicate that only small health effects can be documented as a consequence of the hazardous waste disposal site. This might be the case if many of the health effects were perceived but could not readily be identified. In this situation, it would be less clear as to whether to attribute the declines in property values to a "health" effect.

Similarly, problems result when attempting to distinguish "welfare" from "ecosystem" effects. In many cases, an environmental problem may fall into either type of effects. For instance, acid precipitation may reduce the diversity of forests (an ecoystem loss), thereby changing animal populations and limiting hunting opportunities (a welfare loss).

In cases of this sort, this report classifies welfare effects as those that are likely to result in losses to commercial activity or losses that can be monetized. On the other hand, ecosystem effects are effects that can be monetized in theory, but the techniques for doing so are too unreliable to be particularly useful or meaningful.

Given all the gaps in our knowledge, it was virtually impossible to sort out many of the complicated issues in evaluating welfare effects. We attempted to characterize welfare effects as accurately as possible, while explicitly recognizing the many difficulties associated with an effort of this nature. We generally included in our assessments welfare effects that are intertwined with health and ecosystem affects. Thus, double counting is likely to be present in the reports of the four work groups.

Table 2-5

Final Rankings of Welfare Effects Work Group

Rank	High Effects
1	Criteria Air Pollutants from Mobile and Stationary Sources (including acid precipitation)
2	Nonpoint Source Discharges to Surface Waters*
3	Indirect Point-Source Discharges (POTWs) to Surface Waters
4	To Estuaries, Coastal Waters, and Oceans from All Sources*
5	CO_2 and Global Warming
6	Stratospheric Ozone Depletion
7	Other Air Pollutants (odors and noise)
8	Direct Point-Source Discharges (industrial, etc.) to Surface Waters
	Medium Effects
9	Hazardous Waste Sites -- Inactive (Superfund)
10	Nonhazardous Waste Sites -- Municipal
11	Hazardous Waste Sites -- Active (RCRA)
12	To Wetlands from All Sources
13	Other Pesticide Risks -- leaching and runoff of pesticides and agricultural chemicals, air deposition from spraying, etc.
14	Biotechnology
	Low Effects
15	Nonhazardous Waste Sites -- Industrial
16	Releases from Storage Tanks (including product and petroleum tanks that are above, on, and underground)
17	Accidental Releases of Toxics
18	Accidental Oil Spills
19	Drinking Water as It Arrives at the Tap
20	Radon -- indoor only
21	Mining Wastes (including oil and gas extraction wastes)
22	Contaminated Sludge
23	Hazardous/Toxic Air Pollutants
	Minor Effects
	Other Ground Water Contamination
	Radiation Other Than Radon
	Indoor Air Pollutants other than Radon
	Pesticide Residuals on Foods Eaten by Humans
	Applicators of Pesticides (risks to applicators and consumers)
	New Toxic Chemicals
	Consumer Product Exposure
	Worker Exposure to Chemicals

* Includes effects from Pesticides.

CHAPTER III

SUMMARY OF WHAT WE LEARNED ABOUT THE 31 ENVIRONMENTAL PROBLEMS

This chapter summarizes and brings together the findings of the four work groups concerning each of the thirty-one environmental problems studied. For a full understanding of the information presented here, as well as references on which it is based, the reader is directed to the four work group reports. The information on public opinion is explained in Chapter IV. Several other points should also be remembered when reading this chapter:

- Each group looked at risks existing now, given existing controls, and not at inherent risks or at risks that have been or could be controlled. Existing controls are assumed to be maintained. This is a key assumption. Many environmental problems show up in this analysis as posing moderate or relatively low risks precisely because extensive controls are in place and are being maintained, often at considerable expense.
- All of the work groups ranked problems in general categories, such as relatively high, medium or low. (The reader should note that the ecological group called the first three of their six rank groupings "relatively high", groups four and five "medium" and group six "relatively low".) In addition, two of the groups, cancer and welfare, ranked problems ordinally. The reader is cautioned not to place great weight on the

precision that may appear to be implied between closely ranked problems. In various cases, further study might cause the the rankings of closely-ranked problems to be reversed. However, the work groups are confident in the differences implied by rankings that are farther apart.

- How we divided up the universe of environmental problems significantly affected the ranking of the problems - the broader the category the more impacts it covers, and vice-versa. As noted earlier, there are also substantial overlaps among the thirty-one problems. The reader is reminded that the universe of environmental problems was divided the way it was because the project participants felt that these categories most closely approximate how people generally think of the problems. Also, while the work groups generally used the same definitions of categories, they did not always do so; the major cases where this happened are noted.
- The rankings of the different environmental problems are based on the risks to the entire U.S. population in terms of total incidence of disease, etc. Where risks to individuals (as opposed to the population at large) can be relatively high, that is noted. It is important to understand that because local situations vary widely, the risks faced by any particular individual or community probably do not rank the same as shown here.

1. Criteria Air Pollutants

Description of Problem

The criteria air pollutants are sulfur dioxide, total suspended particulates, carbon monoxide, nitrogen oxides, ozone, and lead. Acid precipitation is included in this problem area. Major sources of these pollutants are combustion from motor vehicles, electrical utilities, and industrial boilers and smelters.

Cancer Risks

Ranked in category 3 of 5 (#22 of 29).
Ranked low because none of the criteria pollutants has been adequately shown to cause cancer. If any shown to be carcinogenic (e.g., lead), it would move this problem to a much higher category due to high population exposure. This assessment excludes carcinogenic particles and volatile organic compounds, considered under #2 (Hazardous/Toxic Air Pollutants).

Non-cancer Health Risks

Relatively high risk. High level of confidence in data/judgment, compared with other problems examined.
Large populations exposed, with moderate to severe health effects. Ranked relatively high, mostly on the basis of ozone and acid aerosols. Large numbers of people exposed to ozone at levels far above safe levels. Large numbers of people exposed to acid aerosols, with increased mortality possible.

Ecological Effects

Relatively high risk (#3 out of 6 rank groupings).
Scale of impact - regional.
Acid deposition and ozone most important.
Risks tend to affect ecosystem functions and structures.
Impacts not considered irreversible, except for impacts of ozone on forests and natural ecosystems.
Some uncertainty, but a fair amount is known about ecological effects.

Welfare Effects

Ranked relatively high (#1 of 31).
Multiple damage categories have been documented: materials damage and soiling to residential, industrial, and commercial property; visibility impairment; decreased sportfishing; reduced crop and forest yields. Materials damages estimated at over $20 billion/year. Damages are immediate, ongoing, and tangible.

Comments

Compared with other environmental problems, these are well analyzed and understood. The public rates air pollution as a serious risk, but behind chemical waste disposal, water pollution, and chemical plant accidents.

2. Hazardous/Toxic Air Pollutants

Description of Problem

This problem area covers outdoor exposure (primarily through inhalation) to toxic and hazardous air pollutants. For purposes of this project, to the extent possible, this category excludes risks from pesticides, radioactive substances and chlorofluorocarbons. It includes emissions from treatment, storage, and disposal facilities, chemical plants, motor vehicles, metallurgical processes, and sewage treatment plants.

Cancer Risks

Ranked in category 1 of 5 (#6 of 29). Individual risk can be relatively high.
Ranked high largely as a result of quantitative assessment of approximately 2,000 cases annually from 20 substances. Large total number of pollutants to which people are exposed in ambient air.

Non-cancer Health Risks

Relatively high risk. Medium level of of confidence in data/judgment, compared with other problems examined. Ranked high although only a small proportion of the problem was covered by the substances studied.
Large exposed populations, but effects are often not severe (e.g., general pulmonary irritation).

Ecological Effects

Relatively medium risk (#4 out of 6 rank groupings).
Scale of impact - regional.
Growing evidence of adverse regional impacts (e.g., Great Lakes), though substantial uncertainty exists.
Recovery period - years to decades.
Substantial uncertainty (most of data developed have been for human health).

Welfare Effects

Ranked relatively low (#23 of 31).

Comments

This problem is not as well understood as criteria air pollutants. Cancer is responsible for much of the attention it receives.

3. Other Air Pollutants

Description of Problem

This group of air pollutants includes sulfuric acid mist, total reduced sulfur, fluorides and odor-emitting substances not included under problem areas #1 and #2, and noise.

Cancer Risks

Ranked in category 5 of 5 (no cancer risk identified). By definition, carcinogenic pollutants in the outdoor air are considered under #2 (Hazardous/Toxic Air Pollutants).

Non-cancer Health Risks

Not ranked. Thought to be quite a low risk compared with other problems examined.
Principal health effect is stress.

Ecological Effects

Not ranked. No significant risks to ecosystems.

Welfare Effects

Ranked relatively high (#7 of 31).
Over half the complaints received by state and local environmental agencies concern odors and noise; large exposed populations, particularly in urban areas.
Difficult to place monetary value on this problem, but value appears to be very significant.

Comments

These problems have been largely ignored at the federal level, in favor of others that pose larger health risks.

4. Radon - Indoor

Description of Problem

Radon is a radioactive gas produced by the decay of radium, which occurs naturally in almost all soil and rock. It migrates through the soil into buildings, where it is trapped by dense building materials. The decay products of radon, called radon daughters, can cause lung cancer. This category covers indoor radon only. Outdoor concentrations of radon are far lower.

Cancer Risks

Ranked in category 1 of 5 (tied for #1 of 29). Individual risk can be relatively high.

Current estimates of 5,000 to 20,000 lung cancers annually. Some of these cancers caused by the joint action of radon and tobacco smoke.

Non-cancer Health Risks

Relatively medium risk. Low level of confidence in data/judgment, compared with other problems examined.

Ranking derives from incidence modeling. Effects are related to cancer. Perhaps 200 cases per year of serious mutagenic and teratogenic effects. Very large population exposed. Effects are severe, but their probability is low.

Ecological Effects

Not ranked. No ecological effects.

Welfare Effects

Ranked relatively low (#20 of 31).

Could require average of $1,000-$1,500 modification per house for many houses or cause equivalent lowering in property values. But counting dollar costs for remedies may double-count the health risks by capitalizing the costs of their control.

Comments

Serious health problem in certain areas. Different from most other environmental problems, because individuals must decide to spend their own money on their homes.

5. Indoor Air Pollution Other Than Radon

Description of Problem

This category applies to indoor air pollutants (except radon) from sources in buildings (e.g., unvented space heaters and gas ranges, urea-formaldehyde foam insulation, pesticides, tobacco smoke, wood presevatives, fireplaces, solvents from cleaning and waxing agents). Pollutants that are indoors as a result of diffusion from outdoors are not included, unless indoor levels are a function of the building itself (e.g., poor ventilation). Some risks are double counted with those from Consumer Product Exposure (#30), Other Pesticide Risks (#27) and Drinking Water (#15).

Cancer Risks

Ranked in category 1 of 5 (tied for #4 of 29). Individual risk can be relatively high.

As people spend most of their time indoors and are exposed to a number of substances from a variety of sources, the risk is judged relatively high. Quantitative assessment indicates 3,500-6,500 cancers annually, with passive smoking responsible for the majority. Risks from organic chemicals estimated on the basis of monitoring 600 U.S. homes.

Non-cancer Health Risks

Relatively high risk. Medium level of confidence in data/judgment, compared with other problems examined.

Large populations exposed above level of concern. Effects are moderate to severe (from jaundice to teratogenicity and mortality). Ambient levels are often substantially above reference doses. Environmental tobacco smoke thought to contribute the largest portion of total risk.

Ecological Effects

Not ranked. No ecological effects.

Welfare Effects

Ranked as relatively minor. Not ranked numerically.

Comments

Important health problem, although not generally recognized as such by the public. For a variety of reasons (statutory, multitude of sources, difficulty of control, etc.), this has not been a major EPA priority.

6. Radiation from Sources Other Than Indoor Radon

Description of Problem

Occupational and consumer exposure to ionizing and nonionizing radiation (beyond natural background) are included here. Increased radiation from stratospheric ozone depletion/UV light is included in problem area #7. Medical exposures not counted.

Cancer Risks

Ranked in category 2 of 5 (#11 of 29). Individual risk can be relatively high.

Did not consider medical exposures and natural background levels, which could cause 10,000 cases/year; thus, would rank higher if these were included. Two-thirds of assessed risk of 360 annual cases from building materials. No information available on nonionizing radiation.

Non-cancer Health Risks

Relatively medium risk. Medium level of confidence in data/judgment, compared with other problems examined.

Ranking derives from incidence modeling; perhaps 200 serious mutagenic and teratogenic effects per year. Very large populations exposed to radiation; effects can be severe, but their probability is low. Incidence might increase by a factor of 15 if medical X-rays are counted. Nonionizing radiation not considered.

Ecological Effects

Relatively low risk (#6 out of 6 rank groupings).
Scale of impact - local.
Many uncertainties.

Welfare Effects

Ranked as relatively minor. Not ranked numerically.

Comments

Medical radiation risks (not subject to EPA regulation) are best understood and accepted. Together with natural background radiation they constitute the bulk of radiation most people receive.

7. Substances Suspected of Depleting the Stratospheric Ozone Layer

Description of Problem

The stratospheric ozone layer shields the earth's surface from harmful ultraviolet (UV-B) radiation. Releases of chlorofluorocarbons (CFCs) and nitrogen dioxide from industrial processes and solid waste sites could significantly reduce the ozone layer.

Cancer Risks

Ranked in category 2 of 5 (#7 of 29).
Current analysis projects that fatal skin cancers could rise steadily to perhaps an additional 10,000 per year in 2100. Considerable uncertainties concerning future estimates; would rank higher in future if projections are correct.

Non-cancer Health Risks

Relatively medium risk. Low confidence in data/judgment, compared with other problems examined.
Principal non-cancer effects are (1) cataracts (1% ozone depletion estimated to increase cataracts by 10,000-30,000/year); and (2) adverse effects on immune system (effects not estimated).

Ecological Effects

Relatively high risk (#1 out of 6 rank groupings).
Scale of impact - biosphere.
Could affect all natural systems, particularly primary productivity systems (e.g., phytoplankton). Recovery period extremely long, if recovery is possible at all. Effective controls require coordinated international effort. Severity of impact more than offsets uncertainties, which are considerable.

Welfare Effects

Ranked relatively high (#6 of 31).
Value of crop, livestock, and fish species at risk is very high.
Considerable uncertainty surrounding (1) UV-B dose-response relationships for different species and (2) projections for ozone depletion.

Comments

Issue of uncertainty is important, but risks are potentially very significant. While the issue has recently received some attention in the press, it is not well understood by the public.

8. CO_2 and Global Warming

Description of Problem

Atmospheric concentrations of carbon dioxide (CO_2) are projected to increase over the next century due to an increase in fossil fuel combustion and a decrease in tropical forests. Higher levels of CO_2 may raise climatic temperatures globally, raising the sea level.

Cancer Risks

Ranked in category 5 of 5 (no cancer risk identified).
Cancer not considered a significant aspect of this environmental problem. Thus, risk not assessed.

Non-cancer Health Risks

Not ranked.
Global warming would change heat stress and disease patterns.

Ecological Effects

Relatively high risk (#1 out of 6 rank groupings).
Scale of impact - biosphere.
1.5°-4.5° warming in next 50-75 years would raise sea level and alter the hydrological cycle, affecting all natural systems, particularly primary productivity systems. Recovery period is extremely long, if possible at all. Effective controls would require very significant coordinated international effort.

Welfare Effects

Ranked relatively high (#5 of 31).
Sea level rise threatens large investment in urban infrastructure and both urban and rural lands. Changes in weather patterns could also cause substantial welfare effects. Some positive effects (e.g. on crop yields) possible in some areas.
Considerable uncertainty with magnitude of projected effects. The speed with which they occur is also important.

Comments

Issue of uncertainty is important, but risks are potentially very significant. In addition to the risks described here, geopolitical risks are potentially serious. Partly because the risks are in the future and partly because they are difficult to understand, the public is not strongly concerned.

9. Direct, Point Source Discharges to Surface Waters

Description of Problem

"Point sources" are <u>specific</u> stationary sources of pollution, such as industrial plants which directly discharge toxic, acidic, and organic waste effluents into rivers, lakes, and coastal areas. Category excludes POTW's (#10). Substantial double-counting with #13-estuaries, near-coastal waters and oceans.

Cancer Risks

Ranked in category 4 of 5 (#23 of 29).
No quantitative assessment available. Only ingestion of contaminated seafood considered; drinking water impacts covered under #15.

Non-cancer Health Risks

Relatively low risk. Medium confidence in data/judgment, compared with other problems examined.
Risks from consumption of fish and shellfish that have bioaccumulated toxics or that are contaminated by pathogens thought to be generally low. Risks from consumption of drinking water contamined by surface water discharges thought to be minimal.
Ranked without data on specific substances.

Ecological Effects

Relatively high risk (#3 out of 6 rank groupings).
Scale of impact - regional.
Direct and indirect point sources (problems #9 and #10) release more toxics than any other sources and are major contributors of other pollutants.
Points sources have impaired or otherwise affected ecosystems in 41% of 328,000 stream miles analyzed; 15% of lakes; 49% of estuaries; 58% of coastal waters.
(Grouped with #10)

Welfare Effects

Ranked relatively high (#8 of 31).
Losses to recreational uses of surface waters (e.g. swimming, fishing, boating) estimated at $800 million/year. Commercial fishing yields can be reduced. Damages generally of the same type as nonpoint and indirect point sources (#10, #11), but less.

Comments

Low health risks due to extensive controls and the assumption that they stay in place (worldwide, a large proportion of diseases are waterborne). The public ranks water pollution as high risk, second only to chemical waste disposal.

10. Indirect, Point Source Discharges (POTWs) to Surface Waters

Description of Problem

Includes the discharges from specific points of pollution, after passing through municipal sewage treatment systems (Publicly Owned Treatment Works - "POTW's") into fresh, brackish or marine waters.

Cancer Risks

Ranked in category 4 of 5 (#24 of 29).
No quantitative assessment available. Only ingestion of contaminated seafood considered; drinking water impacts covered under #15.

Non-cancer Health Risks

Relatively medium risk. Medium confidence in data/judgment, compared with other problems examined.
Ranked without data on specific substances.
Problem considered mostly to be ingestion of seafood contaminated with pathogens from inadequate sewage treatment.

Ecological Effects

Relatively high risk (#3 out of 6 rank groupings).
Scale of impact - regional.
Direct and indirect point sources (problems #9 and #10) release more toxics than any other sources and are major contributors of other pollutants. Point sources have impaired or otherwise affected ecosystems in 41% of 328,000 stream miles analyzed; 15% of lakes; 49% of estuaries; 58% of coastal waters.

Welfare Effects

Ranked relatively high (#3 of 31).
Important contributor to loss of recreational uses of surface water (e.g. swimming, fishing, boating) -- estimated at $2.4 billion/year. Commercial fishing yields can be reduced. Damages generally similar to those from non-point source discharges to surface waters (#11), but somewhat less.

Comments

Low/medium health risks due to extensive controls and the assumption that they stay in place (worldwide, a large proportion of diseases are waterborne). The public ranks water pollution as high risk, second only to chemical waste disposal.

11. Nonpoint Source Discharges to Surface Water

Description of Problem

Includes pollutants that reach fresh, brackish or marine waters from such nonspecific sources as rainwater runoff of pesticides, herbicides and fertilizers from the land; infiltration from ground water; and air pollutants that settle into the water.

Cancer Risks

Ranked in category 3 of 5 (#21 of 29).
Judged to be more serious than other surface water categories, but no quantitative analysis is available.

Non-cancer Health Risks

Relatively medium risk.
Moderate concern for bacteriological contamination of shellfish and other fish from agricultural and urban runoff. Some concern for runoff and bioaccumulation of pesticides and other toxics in shellfish and other fish.
Ranked without data on specific substances.

Ecological Effects

Relatively high risk (#3 out of 6 rank groupings).
Scale of impact - regional.
Analysis includes in-place toxicants in sediments.
Ubiquitous problem affecting water quality in streams that do not have sufficient dilution to recover rapidly. However, since releases are not continuous, ecosystems may recover more quickly than from chronic, low-level releases from point sources.

Welfare Effects

Ranked relatively high (#2 of 31).
Major contributor to loss of recreational uses of surface waters (e.g., swimming, fishing, boating) -- estimated at $3.6 billion/year. Runoff can also decrease crop yields and downgrade agricultural lands.

Comments

Hard data on this problem are not as good as for some other problems. The public ranks water pollution as high risk, second only to chemical waste disposal.

12. Contaminated Sludge

Description of Problem

Sludge is generated by various sources, such as municipal sewage treatment plants and scrubbers used as pollution control devices. It may be recycled, impounded, landfilled, land-spread, dumped in the ocean or incinerated. Some double counting with Hazardous/Toxic Air Pollutants (#2), Nonpoint Sources (#11) and Non-Hazardous Municipal Waste Sites (#18).

Cancer Risks

Ranked in category 3 of 5 (#17 of 29).
Preliminary analysis estimates several dozen cases annually, primarily from incineration and landfilling.

Non-cancer Health Risks

Relatively low risk. Medium confidence in data/judgment, compared with other problems examined.
Human exposure to contaminants in sludge thought to be indirect and extremely limited.

Ecological Effects

Relatively medium risk (#5 out of 6 rank groupings).
Scale of impact - local.
Extensive damage not expected to natural ecosystems, where current plus reasonably anticipated control programs are properly implemented. However, the risk could be high locally if programs are not properly implemented.

Welfare Effects

Ranked relatively low (#22 of 31).
Disposal usually takes place in isolated areas.

Comments

Data on impacts are limited.

13. Discharges to Estuaries, Coastal Waters, and Oceans from All Sources

Description of Problem

This problem area includes a wide variety of pollutants and sources that reach such waters. Likely double counting with criteria air pollutants (#1); toxic air pollutants (#2); discharges from point (#9, #10) and nonpoint (#11) sources; sludge (#12); active (#16) and inactive (#17) hazardous waste sites; municipal (#18) and industrial (#19) nonhazardous waste sites; mining waste (#20); accidental releases of toxic pollutants (#21); oil spills (#22); releases from storage tanks (#23); and risks from pesticides (#27).

Cancer Risks

Not ranked. Because this category represents a conglomeration of other categories, the work group decided not to rank it to avoid double counting.

Non-cancer Health Risks

Relatively medium risk.
Moderate concern over consumption of fish and shellfish contaminated with pathogens, pesticides and other toxics. Large numbers of people exposed.
Ranked without data on specific substances.

Ecological Effects

Work group combined this problem with #14 and redefined it as "hydrological modification."
New category ranked as relatively high risk (#2 out of 6 rank groupings).
Scale of impact - regional.
Can result in profound, generally irreversible, physical destruction of ecosystems.
Difficult to control.
High degree of certainty.

Welfare Effects

Ranked relatively high (#4 of 31).
Damages include reductions in recreational uses and in commercial harvests of shellfish and other seafoods.
Damages have been estimated at $150-$500 million annually for six major estuaries, but no attempt has been made to extrapolate these figures to a national damage estimate.

Comments

This problem sometimes does not get the attention that others get because direct health risks are not dramatic. Ecological and welfare problems are the most important aspects.

14. To Wetlands from All Sources

Description of Problem

This problem area includes all risks from pollutants reaching wetlands. It includes double counting with criteria air pollutants (#1); toxic air pollutants (#2); discharges from point (#9, #10) and nonpoint (#11) sources; sludge (#12); active (#16) and inactive (#17) hazardous waste sites; municipal (#18) and industrial (#19) nonhazardous waste sites; mining waste (#20); accidental releases of toxic pollutants (#21); oil spills (#22); releases from storage tanks (#23); and risks from pesticides(#27).

Cancer Risks

Not ranked. Because this category represents a conglomeration of other categories, the work group decided not to rank it to avoid double counting.

Non-cancer Health Risks

Relatively low risk.
Minimal concern over consumption of contaminated food or water from wetlands. Exposure to contaminated food thought to be considerably less than from estuaries.
Ranked without data on specific substances.

Ecological Effects

Work group combined this problem with #13 and redefined it as "hydrological modification."
New category ranked as relatively high risk (#2 out of 6 rank groupings).
Scale of impact - regional.
Can result in profound, generally irreversible, physical destruction of ecosystems.
Impacts generally irreversible.
Difficult to control.
High degree of certainty.

Welfare Effects

Ranked relatively medium (#12 of 31).
Sizable quantities of harvestable shellfish and wildlife at risk. Damages are similar to those to estuaries, coastal waters, and oceans (ranked #4), but commercial products of wetlands and swimming are more limited.

Comments

This problem sometimes does not get the attention that others get because direct health risks are not dramatic. Ecological problems are the most important aspect.

15. Drinking Water As It Arrives at the Tap

Description of Problem

As drinking water arrives at the tap, it may contain a wide variety of volatile and synthetic organic contaminants, such as pesticides, lead from pipe corrosion, several organic chemicals falling under a group known as trihalomethanes, and several natural and man-made radionuclides, including radon. There may be some double counting of risks from this problem with those from Radon (#4), Indoor Air (#5), and several categories related to ground water contamination.

Cancer Risks

Ranked in category 2 of 5 (#9 of 29).
Cancer risks principally from disinfection by-products and radon.
Quantitative assessment estimate of 400-1000 cases annually, based on surveys of public drinking water systems.

Non-cancer Health Risks

Relatively high risk. High confidence in data/judgment, compared with other problems examined.
Generally very large exposed population. Serious health effects (neurotoxicity, mortality) are possible, but exposures are not often far above levels of concern. Primary concerns are over disinfection by-products, lead, and pathogens.

Ecological Effects

Not ranked because this is not an ecological problem.

Welfare Effects

Ranked relatively low (#19 of 31).
Corrosive water damages municipal water systems and household plumbing.

Comments

Concerns over chemical waste disposal, various forms of surface and ground-water pollution, and lead in drinking water have raised the public profile of this problem, but still not to the levels of many other environmental problems. It is important to note that on a national scale our analysis shows that most of the health risks result from contaminants from sources other than waste disposal, a belief that does not appear to be shared by the general public.

16. Hazardous Waste Sites - Active

Description of Problem

This category generally includes the risks posed by active hazardous waste sites regulated under the Resource Conservation and Recovery Act (RCRA). More specifically, it includes RCRA landfills and surface impoundments (both open and closed), hazardous waste storage tanks, hazardous wastes burned in boilers and furnaces, hazardous waste incinerators, waste oil and solid waste management units. Seepage and releases of substances from these sources contaminate surface and ground water and pollute the air. There is potential double counting of the risks from this problem with those from Drinking Water (#15) and Hazardous/Toxic Air Pollutants (#2).

Cancer Risks

Ranked in category 2 of 5 (#13 of 29). Individual risks can be relatively high.
Data very spotty. Extremely difficult to extrapolate to national estimate, but most likely fewer than 100 cases annually. Risk estimates are sensitive to assumptions regarding proximity of future wells to waste sites.
Solid waste management units were excluded from analysis.

Non-cancer Health Risks

Relatively low risk. Medium confidence in data/judgment, compared with other problems examined.
Very low number of humans potentially exposed around active hazardous waste sites. Exposure concentrations for non-carcinogens also thought to be low relative to levels of concern. Substances involved are generally of moderate toxicity.
Ranked without data on specific substances.

Ecological Effects

Relatively low risk (#6 out of 6 rank groupings).
Scale of impact - local.
Most sites probably adequately controlling releases to ecosystems (although problems can result if not properly controlled).

Welfare Effects

Ranked relatively medium (#11 of 31).
Sites can threaten nearby drinking water supplies and thus depresses property values in vicinity. Effects similar to inactive hazardous waste sites (ranked #9), but better controls are expected for new wastes in the future.
No monetary estimates of national impact exist.

Comments

The public is more concerned about chemical waste disposal than any other environmental problem. While health data are very spotty, total health impacts do not appear to match public concern in most areas. The importance of this problem, especially as it relates to public concerns, may not be fully reflected in the risk categories studied in this project.

17. Hazardous Waste Sites - Inactive (Superfund)

Description of Problem

This category includes Superfund sites that have reached any of the following stages: discovery, removal, preliminary assessment, site investigation, placement on the National Priorities List, remedial investigation, feasibility study, record of decision, remedial action, deletion. It also includes sites that states are addressing if they do not already fit into any of the categories listed above. As with active hazardous waste sites, these sites may contaminate ground and surface water, threaten nearby residents with exposure to toxic chemicals, and pollute the air. There may be some double counting of the risks from this problem with those from drinking water (#15) and hazardous air pollutants (#2).

Cancer Risks

Ranked in category 2 of 5 (#8 of 29). Individual risk can be relatively high.

Nationwide cancer incidence estimated at just over 1,000 cases annually on the basis of 6 chemicals. Considerable uncertainty since nationwide estimates are based on extrapolation from 35 sites to estimate of 25,000 total in the U.S.

Non-cancer Health Risks

Relatively low risk. Medium confidence in data/judgment, compared with other problems examined.

Moderate number of people potentially exposed around inactive hazardous waste sites, but exposure concentrations for non-carcinogens thought to be usually low relative to levels of concern. Substances involved are generally of moderate toxicity.

Ranked without data on specific substances.

Ecological Effects

Relatively medium risk (#5 out of 6 rank groupings).

Scale of impact - local. (Effects could be regional, depending on quantity and toxicity of contaminants and potential for migration.)

Estimated that 6% of sites are likely to significantly damage natural resources (wetlands, fisheries, etc.).

Lack of data makes it difficult to assess overall ecological effects.

Welfare Effects

Ranked relatively medium (#9 of 31).

Sites can threaten nearby drinking water supplies and can depress property values in vicinity. Effects are usually localized, most sites are not close to major urban populations or their drinking water supplies, and alternative water supplies often exist.

No monetary estimates of national impact exist.

Comments

The public is more concerned about chemical waste disposal than any other environmental problem. While health data are very spotty, total health impacts do not appear to match public concerns in most areas. The importance of this problem, especially as it relates to public concerns, may not be fully reflected in the risk categories studied in this project.

18. Nonhazardous Waste Sites - Municipal

Description of Problem

Consists primarily of 16,000 open and closed municipal landfills, municipal sludge and refuse incinerators and municipal surface impoundments, which contaminate ground and surface water and pollute the air. There is potential double counting of the risks from this problem with those from Hazardous/Toxic Air Pollutants (#2), Contaminated Sludge (#12), and Drinking Water (#15).

Cancer Risks

Ranked in category 3 of 5 (#16 of 29).
Very difficult to estimate national impact: quantitative estimate of about 40 cases per year.
Estimate excludes municipal surface impoundments.

Non-cancer Health Risks

Relatively medium risk. Medium confidence in data/judgment, compared with other problems examined.
Large number of people potentially exposed, due to large number of such sites and proximity to populations. Exposure concentrations thought to be very low relative to levels of concern because of low concentration of hazardous constituents in such sites and indirect routes of exposure. Substances involved are generally of moderate toxicity.
Ranked without reference to specific substances.

Ecological Effects

Relatively medium risk (#5 out of 6 rank groupings).
Scale of impact - local.
Ecosystems can be affected directly by surface water runoff and generation of gases; wastes can also enter surface waters indirectly via ground water.
Sheer number of sources (over 16,000) is largely responsible for medium ranking (as opposed to severity of risks at most sites).

Welfare Effects

Ranked relatively medium (#10 of 31).
Sites can threaten nearby drinking water supplies and depress local property values. Property value effects are hard to measure because other facilities, such as industrial plants, are often nearby and can also have the same effect.
No monetary estimates of national impact exist.

Comments

19. Nonhazardous Waste Sites - Industrial

Description of Problem

There are about 3,400 nonhazardous industrial landfills, 15,000 industrial surface impoundments, and 120,000 oil and gas waste impoundments throughout the country. This category includes nonhazardous wastes from the food industry, slaughterhouses, iron and steel industry, utilities, and the chemicals industry. There is some potential for double counting the risk from this category with those from Drinking Water (#15).

Cancer Risks

Ranked in category 2 of 5 (#14 of 29).
No analysis of cancer incidence exists, so ranked on the basis of committee consensus: less severe than hazardous waste, more severe than municipal non-hazardous waste.

Non-cancer Health Risks

Relatively medium risk. Low confidence in data/judgment, compared with other problems examined.
Moderate number of people potentially exposed. Exposure concentrations may not always be low relative to level of concern because wastes are concentrated in these sources and controls are often not extensive. Substances involved are generally of moderate toxicity.
Ranked without reference to specific substances.

Ecological Effects

Relatively medium risk (#5 out of 6 rank groupings).
Scale of impact - local.
Ecosystems can be affected directly by surface water runoff and air emissions; wastes can also enter surface water indirectly via ground water.
Sheer number of sources is largely responsible for medium ranking (as opposed to severity of risks at most sites).

Welfare Effects

Ranked relatively low (#15 of 31).
Leachates not as damaging to local ground-water supplies as are hazardous chemicals or toxics.

Comments

20. Mining Waste (Includes Oil and Gas Extraction Wastes)

Description of Problem

This category includes the risks posed by mining operations, wastes from oil and gas extraction and benefication (which dominate most of this category), and wastes from smelting and refining processes. Major contaminants include acid mine drainage, toxic inorganics, nutrients, turbidity, oils, and solids. There is some potential for double counting of the risks from this problem with those from Drinking Water (#15).

Cancer Risks

Ranked in category 3 of 5 (#19 of 29). Individual risk can be relatively high.
Principal risks analyzed were from smelting and refining wastes (oil and gas operations excluded). Estimate of 10-20 cases annually largely due to arsenic. Severity of problem is relatively low because remote locations expose relatively low population.

Non-cancer Health Risks

Relatively low risk. Low confidence in data/judgment, compared with other problems examined.
Low number of people potentially exposed due to distance of sites from population. Low concentrations when exposure does occur. Substances have low toxicity.
Ranked without reference to specific substances.

Ecological Effects

Work group redefined the problem to include all mining extraction processes.
New category ranked as relatively high risk (#2 out of 6 rank groupings).
Scale of impact - regional.
Can result in profound, generally irreversible, physical destruction of ecosystems.
Difficult to control.
High certainty.

Welfare Effects

Ranked relatively low (#21 of 31).
Leachate and runoff kill fish and degrade surface water quality. But most mining generally occurs in sparsely populated semi-arid areas, which mitigates runoff.

Comments

Principal risks are ecological (making this problem similar to #13 and #14).

21. Accidental Releases of Toxics

Description of Problem

Toxic chemicals are accidentally released into the environment in a variety of ways. For example, an industrial unit may explode, emitting toxics into the air, or a railroad tank car may turn over, spilling toxics into surface water, soil, and roads.

Cancer Risks

Ranked in category 4 of 5 (#25 of 29).
No information is available on which to base estimates of total potential cancer effects, but because of short duration of exposure, cancer risk judged to be very small. Nature of substances ranks it above oil spills. Longer-term exposure from contaminated groundwater not considered.

Non-cancer Health Risks

Relatively high risk. High confidence in data/judgment, compared with other problems examined.
Incidence data show substantial morbidity and mortality. Principal populations at risk are chemical plant and transportation workers. Believed that chronic risks are small compared with acute risks (most incidents counted result from fires and explosions). Perhaps 1%-4% of risks are borne by individuals other than chemical workers.
Ranked without reference to specific substances.

Ecological Effects

Relatively medium risk (#5 out of 6 rank groupings).
Scale of impact - local.
Toxic spills, such as tank cars overturning and spilling into streams, are perhaps more frequent than oil spills, but volumes are typically less. Spills in small, low-order streams can significantly damage stream ecology.
Data on incidence, exposure, and impact are limited.

Welfare Effects

Ranked relatively low (#17 of 31).
Damages to waterways and nearby property, but most releases affect only nearby property. Damages to industry often are the result of the accidents (e.g., fires) themselves, rather than the toxics released.

Comments

Individual events cause certain clearly identified problems and receive widespread attention. The public ranks this problem as a high risk, right behind chemical waste disposal and water pollution.

22. Accidental Releases - Oil Spills

Description of Problem

Oil spills from offshore drilling accidents or ruptures in storage tanks or tanker vesels can damage coastal and ocean sea life. Some oil spills have been extremely difficult to control and have occurred in prime fishing grounds.

Cancer Risks

Relatively very low risk (#26 of 29).
The likely cancer effects are negligible.

Non-cancer Health Risks

Not ranked.
Risks thought to be very small.

Ecological Effects

Relatively medium risk (#5 out of 6 rank groupings).
Scale of impact - local.
Oil spills can have spectacular consequences if of sufficient magnitude, but usually they occur in areas where there is sufficient dilution to result in only a short-term impact.
Data on overall impacts are limited.

Welfare Effects

Ranked #17 of 31.
Loss of recreational use of water areas, and danger to wildlife and some fish species. But tangible economic damages are usually limited, and most spills are small.

Comments

Overall, the public ranks this problem as a moderate risk.

23. Releases from Storage Tanks

Description of Problem

Includes product and petroleum tanks that are above, on, and underground, tanks owned by farmers, and the fuel oil tanks of homeowners. Does not include storage of hazardous wastes in tanks. The primary environmental hazard is contamination of ground water. Most of the data available are on underground storage of gasoline. There is some potential for double counting of the risks from this problem with those from Drinking Water (#15).

Cancer Risks

Ranked in category 3 of 5 (#20 of 29).
Preliminary analysis suggests relatively low cancer incidence (less than one annually), but exposure modelling not as conservative as for some other problems.

Non-cancer Health Risk

Relatively low risk.
Risk thought to be small. Relatively few health impacts have been reported, controls are fairly good, and people generally avoid drinking water known to be contaminated with motor fuel.
Ranked without reference to specific substances.

Ecological Effects

Relatively low risk (#6 out of 6 rank groupings).
Scale of impact - local.
While there are many storage tanks with hazardous chemicals, the limited volume of releases and known ecological effects resulted in a low ranking.

Welfare Effects

Ranked relatively low (#16 of 31).
Damage to local property from leakage. While these releases contaminate water supplies, they are less of a problem than releases from waste sites.

Comments

Overall, the public ranks this problem as a moderate risk.

24. Other Ground-Water Contamination

Description of Problem

A variety of sources of pollution not counted in other categories for this analysis also contaminate groundwater. These include septic systems, road salt, and underground injection wells. Some double counting with Drinking Water (#15).

Cancer Risks

Ranked in category 3 of 5 (#21 of 29).
Data very incomplete. Assessment of one chemical in septic systems indicates risks well under one case annually.

Non-cancer Health Risks

Not ranked.
Risks generally thought to be small. Difficult to assess magnitude of problem involving bacteriological contamination of private wells by septic systems.

Eological Effects

Relatively medium risk (#5 out of 6 rank groupings).
Scale of impact - local.
Large number of sources, few strict controls. Risks somewhat diminished because ecological impact occurs only when ground water contaminated by these sources is released to surface waters in sufficient volume and concentration to affect ecosystems. Soils also filter and streams dilute and disperse pollutants, further reducing ecological risk.

Welfare Effects

Ranked as minor. Not ranked numerically.

Comments

25. Pesticide Residues on Foods Eaten by Humans and Wildlife

Description of Problem

Humans and other animals are directly exposed to pesticides through residues on food. In addition, certain pesticides bioaccumulate and contaminate food chains.

Cancer Risks

Ranked in category 1 of 5 (#3 of 29).
Cancer incidence of 6,000 annually extrapolated from seven known oncogens to 200 potential oncogens (one-third of total pesticides in use). Assessment does not account for so-called "inert" materials in pesticides.

Non-cancer Health Risks

Relatively high risk. Medium confidence in data/judgment, compared with other problems examined.
High ranking due to large populations exposed and potentially serious health effects (e.g., acetylcholinesterase inhibition), rather than levels of exposure, which are often not much higher than levels of concern.

Ecological Effects

Work group combined this problem with #27 (other pesticide risks). New category ranked as relatively high risk (#3 out of 6 rank groupings).
Scale of impact - regional.
Since pesticides are designed to kill living organisms, unintended exposure can be very destructive, both to ecosystem functions and structures. Impacts are generally not irreversible. Certain pesticides bioaccumulate and contaminate food chains. Some uncertainty due to lack of data.

Welfare Effects

Ranked as minor. Not ranked numerically.

Comments

Despite many analytical uncertainties, this is clearly a relatively high risk problem. Public attention tends to focus on individual events and pesticides (e.g., EDB) and not on the overall problem (which the public ranks as moderate).

26. Application of Pesticides

Description of Problem

Risks to people applying pesticides, including farm workers (about 10,000-250,000) or other people who mix, load, and apply them. Major routes of exposure are inhalation and dermal exposure.

Cancer Risks

Ranked in category 2 of 5 (#10 of 29). Individual risks can be relatively high.

Individual risk for an applicator is usually much higher than for the general population consuming pesticide residues on food, but the population risk is lower because the population of agricultural workers is small by comparison.

Total cases estimated at 100/year (estimated by a method analogous to that used in pesticide residues on foods (#25)).

Non-cancer Health Risks

Relatively high risk. High confidence in data/judgment, compared with other problems examined.

Modest applicator populations exposed, but potentially very serious health effects (acute poisoning, fetotoxicity, teratogenicity). Exposures often far above levels of concern. Substantial incidence estimates (e.g., 350 annual poisonings from ethyl parathion, 100 from paraquat).

Ecological Effects

Problem not ranked because risks in this category only concern pesticide applicators.

Welfare Effects

Ranked as minor. Not ranked numerically.

Comments

Applicators (although moderate in total numbers) can face high risks. Public ranks problem as moderate risk.

27. Other Pesticide Risks

Description of Problem

This problem includes leaching and runoff of pesticides and other agricultural chemicals, and air deposition from spraying. These chemicals contaminate ponds and affect water supplies, and can affect cattle, farm animals, and such wild birds as geese and ducks. Double counting with #11 (non-point sources), #15 (drinking water), #5 (indoor air) and #30 (consumer products).

Cancer Risks

Ranked in category 2 of 5 (#12 of 29).
Ranked medium largely due to use of termiticides and widespread consumer use of pesticides.

Non-cancer Risks

Relatively medium risk. Medium confidence in data/judgment, compared with other problems examined.
Large populations exposed to pesticides in drinking water, very large number exposed to pesticides in indoor air. Potential health effects range from moderate (e.g., increased liver weight) to serious (e.g., acetycholinesterase inhibition). Exposures typically low relative to levels of concern.

Ecological Effects

Work group combined this problem with #25 (pesticide residues on foods). New category ranked as relatively high risk (#3 out of 6 rank groupings).
Scale of impact - regional.
Since pesticides are designed to kill living organisms, unintended exposure can be very destructive, both to ecosystem functions and structures. Impacts are generally not irreversible. Certain pesticides bioaccumulate and contaminate food chains. Some uncertainty due to lack of data.

Welfare Effects

Ranked relatively medium (#13 of 31).
Damages to shellfish and certain fin fish from pesticide runoff and air deposition. Many damages already accounted for in other environmental problems (e.g., pesticides from non-point sources, and pesticides from all sources entering estuaries, coastal waters, and oceans). Ranking based largely on subjective judgment.

Comments

Large populations exposed (as opposed to high doses) is reason for "medium" ranking. Public also finds risks moderate.

28. New Toxic Chemicals

Description of Problem

This problem area includes new chemicals introduced into commerce. These chemicals are defined as chemicals not already listed on the TSCA Inventory of Existing Chemical Substances. New substances typically enter the market as substitutes for existing chemicals. Therefore, risks considered in this environmental problem category cover the range of risks presented by existing chemicals. The term "new chemicals" as used here refers to "industrial chemicals." New pesticides are considered elsewhere, and new food additives and drugs are not considered at all in this project.

Cancer risks

Ranked in category 2 of 5 (#15 of 29).
Extremely difficult problem to rank. The consensus is that with the existing TSCA program the risks are moderate.

Non-cancer Health Risks

Not ranked because no satisfactory method exists for projecting what risks will be. Risks probably low.

Ecological Effects

Not ranked. Potential effects and risks not well enough understood.

Welfare Effects

Ranked as minor. Not ranked numerically.

Comments

Very difficult to project national impacts, as it is hard to assess new chemicals' future uses and the risk of chemicals not yet manufactured. Risks are reduced by the following factors: (1) EPA's new chemicals program weeds out many potential problems; (2) new chemicals often replace riskier existing chemicals, thus giving net risk reduction; and (3) most new chemicals are produced in very low volumes, have specialty uses, and have little chance for broad exposure.

29. Biotechnology

Description of Problem

Category includes planned and accidental releases of genetically altered microorganisms.

Cancer Risks

Ranked in category 5 of 5 (no cancer risk identified).
Difficulty of assessing cancer risk is similar to that for new chemicals (#28), but even less information on which to base conclusions. No known instances of carcinogenic bioengineered substances.

Non-cancer Health Risks

Not ranked.
No satisfactory method for projecting risks. Suspect risks to be low.

Ecological Effects

Not ranked. Potential effects and risks not well enough understood. Effects could be very large or small.

Welfare Effects

Ranked relatively medium (#14 of 31).
Much disagreement on how to rank this problem.
Potentially severe danger to crops, livestock, trees, marine life accompanies introduction of new species into the environment. U.S. agriculture is highly concentrated in only a few major crops, increasing vulnerability.

Comments

Very difficult to assess overall risk. Public appears to rank this as a lower risk than a number of other environmental problems.
Generally, genetically engineered microorganisms are not expected to survive long in conditions other than those for which they were designed. However, there is a possibility that some of these organisms may both survive and multiply. Given the current system of monoculture, wherein U.S. farms specialize in producing a small number of crop varieties, a biological change could rapidly cause serious damage before countermeasures could be developed. The situtation is somewhat analogous to imported insects (e.g., gypsy moth) that have escaped and, in the absence of predators in their natural habitats, become major pests.

30. Exposure to Consumer Products

Description of Problem

Over 10,000 chemical substances are present in two categories of consumer products: (1) formulations and mixtures of various types (paints, solvents, glues, detergents, polishes, deodorizers, etc.) and (2) in manufactured articles (clothing, housewares, batteries, etc.). While exposure to substances in manufactured articles is usually limited, experience has shown that potential risks can sometimes be significant--e.g., TRIS used on pajamas, friable asbestos in building materials, DEHP in plastic articles that are mouthed by young children, formaldehyde emissions from pressed wood products. Not included in this category is exposure from substances released into the environment and transported beyond the immediate vicinity of the user--e.g., contamination of drinking water or non-point source air pollution. Where consumer products are used indoors and contaminate indoor air, any resulting risks are likely to be double counted with indoor air (#5).

Cancer Risks

Ranked in category 1 of 5 (tied for #4 of 29).
Risks from four substances in consumer products estimated at 100-135 cases annually. Even though exposures generally intermittent, risk believed to be high given concentrations to which individuals are exposed.

Non-cancer Health Risks

Relatively high risk. Medium confidence in data/judgment, compared with other problems examined.
Large populations exposed. Ambient exposures can be at levels well above RfD's. Serious health effects possible, including teratogenicity and hepatotoxicity.

Ecological Effects

Not ranked. Extent of effects not adequately known.
Scale of impact - local.
Discarded plastic materials can choke fish and wildlife.

Welfare Effects

Ranked as minor. Not ranked numerically.

Comments

Clear important health risks.
Public rates this problem as lower risk than other environmental problems.
EPA shares jurisdiction with Consumer Product Safety Commission.

31. Worker Exposure to Chemicals

Description of Problem

Humans are exposed to numerous chemical substances in a variety of occupational settings. These include chemical manufacturing, chemical processing, industrial uses, and the use of chemical substances in the trades. Because of the diverse nature of processes and equipment and great range of physical properties of chemicals, occupational exposure varies greatly in different settings.

Cancer Risks

Ranked in category 1 of 5 (tied for #1 of 29). Individual risks can be relatively high.

Large numbers of chemicals in the work place and concentrated exposures.

High ranking due more to the consensus of the work group than quantitative estimates. 250 cases annually from four substances, but workers face potential exposures to over 20,000 different substances.

Non-cancer Health Risks

Relatively high risk. High confidence in data/judgment, compared with other problems examined.

Exposed population of workers somewhat smaller than consumer category, but still large. Work place concentrations can be extremely high, exceeding RfD's by over three orders of magnitude in some cases.

Ecological Effects

Not ranked because this is not an ecological problem.

Welfare Effects

Ranked as minor. Not ranked numerically.

Comments

Clearly important health risks.

Public rates this problem as moderate risk.

EPA shares jurisdiction with the Occupational Safety and Health Administration.

CHAPTER IV

PUBLIC PERCEPTIONS OF THE ENVIRONMENTAL PROBLEMS

How the public perceives the seriousness of different environmental problems is very important to the setting of EPA priorities. Measuring these perceptions was not part of the main work of the Comparative Risk Project, but the results of a short study done by the project staff do provide an interesting comparison to the information developed by EPA experts as the principal product of the project.

In order to get a better idea of how the public ranks the problems, the project staff undertook a brief review of polling data collected over the past two years by the Roper Organization. Based on Roper's questions and the public's responses, the staff developed an ordinal ranking of public concerns covering 19 of the 31 problems studied in this project.

The questions Roper asked the public do not neatly match the 31 problem areas. Only 20 of the areas are directly or indirectly addressed by Roper. Roper frequently asked about an environmental issue that encompassed several of the 31 problem areas. For example, Roper's questions on chemical or toxic waste disposal typically cover both active and inactive hazardous waste sites (problems #16 and #17). Roper's questions on water pollution do not distinguish between direct and indirect dischargers and non-point sources (problems #9, #10 and #11). On the other hand, some of Roper's questions are more detailed than the 31 categories.

For example, Roper asked separate questions about acid rain, industrial air pollution and auto exhaust, all of which are components of criteria air pollutants (problem #1). As a result, we had to apply some judgement to translate Roper's results into as assessment of how the public ranks the 31 problem areas.

Our interpretation of Roper's results yields the ranking of the 31 problem areas shown in the chart on the following page. Twenty problem areas are ordinally ranked. In addition, we put these problem areas into groupings reflecting either generally high, medium, or low perceived risk by the public.

Our ranking was based initially on Roper questions that ask the respondent which of nine environmental problems are most serious. Other problem areas asked about in other questions were then fit into the ranking by how they compare to one of these original nine. Finally, some environmental problem areas are asked about in other contexts, without comparison to other environmental concerns. In these cases, we placed the problem area in the ranking according to the absolute level of public concern about it.

Table 4-1

Summary Ranking of Environmental Problem Areas by Level of Public Concern

Public Perception of Risk and Ranking		Roper Area	Corresponding EPA Environmental Problem Area
High	1.	Chemical waste disposal	Hazardous waste sites - active (#16) Hazardous waste sites - inactive (#17)
	2.	Water pollution	Direct point source discharges (#9) Indirect point source discharges (#10) Nonpoint source discharges (#11)
	3.	Chemical plant accidents	Accidental releases - toxics (#21)
	4.	Air pollution	Criteria air pollutants (#1) Hazardous air pollutants (#2)
Moderate	5.	Oil tanker spillage	Accidental releases - oil spills (#22)
	6.	Exposure on the job	Worker exposure (#31)
	7.	Eating pesticide-sprayed food	Pesticide residues on foods (#25)
	8.	Pesticides in farming	Application of pesticides (#26) Other pesticide risks (#27)
	9.	Drinking water	Drinking water (#15)
Lower	10.	Indoor air pollution	Indoor air pollution (#5)
	11.	Indoor air pollution	Consumer product exposure (#30)
	12.	Genetic engineering	Biotechnology (#29)
	13.	Strip mining	Mining waste (#20)
	14.	Non-nuclear radiation	Radiation - other than radon (#6)
	15.	The "greenhouse" effect	CO_2 and global warming (#8)

Note: Adequate information was not available from Roper to rank the following EPA problem areas: Other air pollutants (#3), Radon - indoor air (#4), Stratospheric ozone depletion (#7), Contaminated sludge (#12), Estuaries, coastal waters, and oceans (#13), Wetlands (#14), Non-hazardous waste sites - municipal (#18), Non-hazardous waste sites - industrial (#19), Releases from storage tanks (#23), Other groundwater contamination (#24), and New toxic chemicals (#28).

CHAPTER V

GENERAL OBSERVATIONS AND RECOMMENDATIONS

1. NO PROBLEMS RANKED CONSISTENTLY "HIGH" OR "LOW" ACROSS ALL FOUR RISK TYPES. Whether an environmental problem appears large or not depends critically on the type of adverse effect with which one is concerned. In many cases a problem is ranked high on one and/or the other health risk categories and low on ecological and welfare risk, or vice versa. This makes the job of using these rankings to set priorities especially tricky, and emphasizes the importance of value judgments.

   - Problems that received relatively high rankings in three of the four risk types, or at least medium in all four, include criteria air pollutants, stratospheric ozone depletion and pesticide residues on food and "other" pesticides risks.
   - Problems that ranked relatively high on health but low on ecological or welfare effects (or by definition are not an ecological problem) include radon, hazardous air pollutants, indoor air pollution, drinking water, pesticides application, and consumer and worker exposure to chemicals.
   - Problems that ranked relatively high on ecological and welfare effects but low/medium on health include global warming, point and nonpoint sources of water pollution, physical alteration of aquatic habitats (including estuaries and wetlands), and mining waste.

- ° Problems where EPA has programs to prevent future risks are difficult to rank on a risk basis - new toxic chemicals, biotechnology and pesticides.

2. THE PROJECT HAS DEVELOPED A USEFUL TOOL TO HELP SET PRIORITIES. Despite their limitations, the data and judgments assembled in this project are sufficiently well founded for EPA to use in the priority setting process. As noted in the Introduction, many factors (including laws, technology and cost) must be considered in setting priorities. Thus, while the results of this project are not sufficient by themselves to determine EPA's priorities, the feasibility of organizing environmental protection more around the fundamental goal of reducing risks is clear and the concept appears compelling.

3. RISKS AND EPA's CURRENT PROGRAM PRIORITIES DO NOT ALWAYS MATCH. In part, these differences seem to be explainable by public opinion on the seriousness of different environmental problems.

   - ° Areas of high risk/low EPA effort - radon, indoor air pollution, stratospheric ozone depletion, global warming, accidental releases of toxics, consumer and worker exposures to chemicals, non-point sources of water pollution, "other" pesticide risks.
   - ° Areas of medium or low risk/high EPA effort - active (RCRA) and inactive (Superfund) hazardous waste sites, releases from storage tanks and municipal non-hazardous waste.

- The data appear to support the contention that EPA has been more concerned about pollution that affects public health, as opposed to protection of natural habitats and ecosystems, in all programs except surface water protection.
- Problems related to ground water consistently ranked medium or low in most respects. This may be because of our lack of understanding of these issues. It is also because exposure to ground water -- whether of humans, ecosystems or economic values -- is significantly limited. Other types of exposure (e.g. air, pesticides) are simply much more direct and widespread. Groundwater protection also raises significant issues concerning intangible aspects of risks.
- This divergence between risks and priorities is not necessarily inappropriate. Not only must many factors beside risk (legislation, technology, etc.) be considered in setting priorities, but some problems appear to pose relatively low risks precisely because of the high levels of effort that have been devoted to controlling them. It may be necessary to continue to invest in permit processing, inspections and enforcement in order to maintain high level of compliance.
- In this context it is interesting to note that EPA's priorities appear more closely aligned with public opinion than with estimated risks. Public polls conducted over the last two years by the Roper Organization, indicate that the public appears to be most concerned

with chemical waste disposal, water pollution, chemical plant accidents and air pollution, in that order. Oil spills, worker exposure, pesticides and drinking water are rated as medium risks, and indoor air pollution, consumer products, genetic engineering, radiation and global warming are ranked as comparatively low risks.

4. STATUTORY AUTHORITIES DO NOT MATCH NEATLY WITH RISKS.

   ° In two relatively high health risk areas EPA shares jurisdiction with other agencies: consumer and worker exposures to chemicals. Good coordination with CPSC and OSHA is needed.

   ° In some other relatively high risk areas neither EPA nor other Federal agencies have extensive statutory authorities: indoor air pollution, CO_2 and global warming and non-point sources of water pollution.

5. NATIONAL RANKINGS DO NOT NECESSARILY REFLECT LOCAL SITUATIONS -- LOCAL ANALYSES ARE NEEDED. This analysis is not a guide to what may be the most serious problems in a particular area or for particular individuals. Any attempts to set local priorities should take into account local conditions (e.g. presence of Superfund sites, presence of wetlands, etc.). Indeed, more widespread use of risk as one basis for setting environmental protection priorities would be beneficial at all levels of government.

6. SOME CHEMICALS SHOW UP AS MAJOR CONCERNS IN MULTIPLE PROBLEM AREAS, notably lead, chromium, formaldehyde, solvents and some pesticides. This suggests the need for integrated strategies to deal with them.

7. MORE RESEARCH IS NEEDED IN SEVERAL AREAS. The basic data are on many subjects studied in this project are surprisingly poor. The general weakness of exposure data is a special problem because exposure is such an important determinant of risk. In addition, specific data on the different types of risks and environmental problems are often lacking. More research would be very useful to clarify the issue of how serious various environmental problems are, particularly in the instances described below:

   ° The best information available is for cancer risk. Even there, however, it was not nearly as good as one might expect.

   ° The data and methods available for assessing non-cancer health risks are poor. Exposure data are surprisingly poor, even on chemicals that are objects of major regulatory efforts. There is no general methodology for assessing non-cancer risks.

   ° There is no generally applicable methodology for ecological risk assessment. The number of different types of ecological systems, the relative scarcity of ecosystem exposure data and methods, and scientific uncertainties confound the problem. Moreover, the extraordinary complexity of ecological systems prohibits objective assessment of ecological risks.

- While there are generally accepted methods for assessing welfare effects, there is a general scarcity of data and analysis in this area. Many programs have paid little or no attention to these effects.
- Intangible aspects of risk play a very important part in the way the public values environmental problems, particularly those related to groundwater. However we do not understand them very well and perhaps underestimate them.
- The data on active and inactive hazardous waste sites, biotechnology, and new chemicals are very poor.
- There are two areas where the risks could be very great, but our understanding of the problems is not very good: global warming and stratospheric ozone depletion.
- The overall impact of pesticides on health and ecosystems is both large and not well understood, either by the science community or the public.

8. EPA SHOULD NOW STUDY OTHER AREAS IMPORTANT TO SETTING PRIORITIES. Had this exercise been conducted five, ten or twenty years ago, the results would have been rather different. For example:
   - only recently have some serious environmental problems been "discovered," such as radon and other indoor air; pollutants;
   - some problems that were once much more serious are now much better controlled, such as direct and indirect discharges to surface water; and

- some parts of the old problems are still serious, such as some of the criteria air pollutants and certain pesticide exposures.

Over time, as some problems are brought under better control and as more is learned about others the relative rankings of environmental problems described in this report are likely to change. But this is not likely to happen quickly. Thus, while EPA should carry out the research on specific items mentioned above, it should now focus more effort on the systematic study of the other factors involved in priority setting, such as costs and feasibility of addressing the unfinished business described in this report.