Comparative Risk Projects: A Methodology for Cross-Project Analysis of Human Health Risk Rankings

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Abstract

Public agencies at all levels of government have conducted comparative risk projects to inform environmental priority-setting efforts. Using the analytic policy tool, comparative risk analysis (CRA), most projects have ranked environmental problems in terms of the relative risks they pose to human health and other endpoints. Differences in project design complicate cross-project analysis of the risk ranking results. This paper discusses important project design variations that complicate cross-project analysis and presents a methodology that provides a simple, straightforward approach for comparing risk ranking results that overcomes some of these project-specific idiosyncrasies. The methodology provides a mechanism to help practitioners of CRA determine how their risk ranking results compare with other projects. The paper also illustrates how the methodology can be applied to develop a consolidated ranking of the most often ranked environmental health problems. Thirty-nine completed human health CRAs are analyzed to determine which ten environmental problems have most often been cited in comparative risk projects as posing the most significant threats to human health.

Key Words: comparative risk analysis, human health risk rankings, environmental health priorities, cross-project analysis

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COMPARATIVE RISK PROJECTS: A METHODOLOGY FOR CROSS-PROJECT ANALYSIS OF HUMAN HEALTH RISK RANKINGS

David M. Konisky[1]

INTRODUCTION

In the current political environment, public agencies in the United States increasingly face tightening budgetary and resource constraints. In response, there has been burgeoning momentum at all levels of government--federal, state, and municipal--to engage in priority-setting efforts to ensure that spending and programmatic activities are targeted appropriately. This trend has been, and continues to be, prevalent in the realm of addressing environmental problems that pose risks to human health.[2] A major advance that facilitated priority-setting efforts in environmental protection was the development of the analytic policy tool of comparative risk analysis (CRA).[3] Also known as risk ranking or relative risk ranking, CRA debuted in 1987 with the publication by the U.S. Environmental Protection Agency (EPA) of *Unfinished Business: A Comparative Assessment of Environmental Problems* (*Unfinished Business*). This report represented the first effort by a federal agency to explicitly evaluate and compare the risks posed by a set of environmental harms. The primary objective of *Unfinished Business* 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" [U.S. EPA, 1987: hereinafter *Unfinished Business*]. The basic premise underlying CRA is that through the identification of the relative risks posed by environmental problems, risk reduction efforts can be directed to the worst problems first, and not instead squandered on low risk problems.

Although *Unfinished Business* did not immediately change public perception of risk or lead to a re-allocation of resources at EPA, environmental policymakers recognized the utility of the CRA method for setting environmental priorities.[4] As evidence, CRA has since been widely adopted on the regional, state, and local level as an instrument to assist governments in

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[2] For example, to implement the Government Performance and Results Act of 1993 (GPRA), the EPA Office of the Chief Financial Officer is working to incorporate risk-based priority-setting into budgetary decision-making.

[3] There are two primary types of comparative risk analysis. One type consists of comparing two relatively-well defined types of risks (e.g., the cancer risk from exposure to two different pesticides). The second type of comparative risk analysis is programmatic and is used for setting priorities. This type involves comparison of a large number of risks. Unless stated otherwise, comparative risk analysis as used in this paper refers to the second type. For a discussion see Davies (1996), pp. 5-6.

[4] Minard [1996], pp. 30-31; U.S. EPA [1990], p. 16 [hereinafter *Reducing Risk*].

their efforts to identify the environmental risks of most concern in their respective jurisdictions. To date, all ten EPA regional offices and over thirty states and municipalities have completed comparative risk projects, with scores more in the planning or implementation phase. Although there has been considerable effort to summarize the approaches and methods employed to conduct CRAs,[5] less attention has been given to either comparing the results of the risk rankings themselves or analyzing the results to determine the environmental problems most often selected as posing significant risk. The primary objective of this paper is to address these issues and illustrate a methodology for comparing the risk rankings of one CRA with another. Additionally, the paper will describe how the methodology can be applied to develop a consolidated ranking of the environmental problems judged in CRAs as presenting the most serious risks to human health.

Evaluation of CRA risk-ranking results in a comparative manner is difficult for two important reasons. For one, the degree to which a problem presents a risk to health, the quality of the environment, or any other endpoint, is dependent on numerous factors that vary by geographic area. These factors include physical characteristics (e.g., size of area, background environmental conditions), demographic composition (e.g., degree of susceptible populations), and risk perception (e.g., historical factors, political concerns). In other words, the magnitude of risk from an environmental problem depends, in part, on where it is occurring. The disparity in local conditions represents a key reason there has been a proliferation of comparative risk projects on the state and local level in recent years, as policymakers attempt to match management priorities with the problems presenting the most risk in their respective areas. A second difficulty that complicates comparison of CRA ranking results is the extensive variability in project designs. As this paper demonstrates, design variability has important implications for the resulting risk rankings.

The methodology described in this paper provides a simple, straightforward approach for comparing risk ranking results that overcomes some of these project-specific idiosyncrasies. Though not without limitations, the methodology provides a mechanism to help practitioners of CRA determine how their risk ranking results "stack up" vis-à-vis those of other projects. The paper will also illustrate how the methodology can be applied to develop a consolidated ranking of the top ten environmental health concerns as determined by existing risk rankings. The purpose of a consolidated list is not to replace or undermine the legitimacy of the locally-specific rankings of individual comparative risk projects, but rather to provide a benchmark that can be used to approximate the most important environmental health risks as ranked by constituencies throughout the United States.

Section I of the paper provides a brief background on CRA and describes its basic components. Section II addresses the obstacles that complicate cross-project analysis. As will be illustrated, though CRAs generally follow a common procedural framework, differences in project design are numerous and have a profound impact on risk ranking results. Section III of the paper introduces a methodology which allows for comparison of the risk rankings of one CRA with

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[5] See among others: Feldman, Perhac, and Hanahan [1996]; Minard [1996]; and Dea and Thomas [1997].

another, while section IV illustrates how these comparable risk rankings can be quantitatively analyzed to determine a consolidated top ten list of environmental health risks. Lastly, section V of the paper discusses conclusions and points to areas that deserve further analysis.

TERMINOLOGY

To avoid confusion, it is necessary to first define a couple of important concepts. "Risk" is an often defined term with wide-ranging conceptualizations depending on the perspective (e.g., toxicological/epidemiological, actuarial, economic, social, etc.).[6] For the purposes of this paper, risk can be broadly understood to mean the potential unwanted hazard associated with a particular substance, technology, or activity [Davies, 1996, p. 5]. More specifically, since this paper concentrates on the human health impacts posed by environmental problems, risk in this paper is conceptualized as the potential--a function of toxicity and exposure--for an environmental stressor to cause health problems.

"Environmental problem area" is another concept referred to throughout this paper that requires clarification. A critical component of CRA project design is the delineation of what to rank. Although a CRA could conceivably rank a variety of things, most comparative risk projects have opted to consider the risks posed by environmental problems. "Environmental problem areas," thus, is a logical term to describe those items whose risk is typically assessed, compared, and ranked in CRAs. A related concept, "environmental problem category," refers specifically to the aggregated units of "environmental problem areas" created as part of the methodology described in section III and applied in section IV.

I. BACKGROUND

Governments conduct comparative risk projects for a variety of reasons.[7] In general, there have been four commonly referred to objectives:

1. involve the public in the priority-setting process and identify and incorporate their concerns;
2. identify the greatest environmental threats and rank them accordingly;
3. establish environmental priorities; and
4. develop action plans/strategies to reduce risks [Feldman et al., 1996, pp. 34-35].

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[6] For a detailed discussion see Renn [1992], pp. 53-79.

[7] Jones [1997] identifies the following reasons: strengthening linkages between different environmental agencies; developing linkages between government agencies and stakeholders; providing a baseline of information about the environment for multiple (often undefined) uses; establishing a starting point from which to develop new strategies to address environmental problems; bringing more science into policy discussions; changing public misperceptions about relative risk; building trust between environmental agencies, the regulated community, and the public; and improving environmental conditions.

Despite this general agreement on the rationale for undertaking comparative risk projects, CRA processes can vary substantially. Practitioners must make important decisions regarding the specific design of CRAs, and these decisions may have significant implications for the resultant risk rankings. Accordingly, it is necessary to dissect the CRA process in order to establish the connection between project design and risk ranking results.

A CRA generally is comprised of three components:

1. *Problem list*--Determination of the set of environmental problem areas to be analyzed and compared. This list is often wide-ranging in scope and typically consists of about two dozen problems.
2. *Criteria for evaluating problems*--A set of analytical criteria define what the participants think is important to measure, such as pollution levels or various types of risks to human health, to ecosystems, or to quality of life. These criteria often specify what type of units analysts should use for measuring impacts under each criterion (e.g., lives lost, dollars lost, rate of change, recovery time, etc.). Some of the criteria will allow for quantitative estimates of harm or risk (e.g., water quality), but others will require qualitative descriptions of such impact (e.g., aesthetic degradation or injustice).
3. *Ranking*--Process that participants use to sort out the data and draw conclusions about the relative severity of the problems or their sub-components. The ranking inevitably involves comparing problems along several dimensions or criteria at once. The ranking most often is in the form of an ordered (e.g., 1-10) or categorized (e.g., high, medium, and low) list.[8]

While it is true that all CRAs are comprised of these basic components, individual CRAs may vary significantly in methodological approach. As the next section explains, seemingly minor differences in project design can profoundly influence risk ranking results and complicate efforts to analyze their results comparatively.

II. PITFALLS OF COMPARING AND ANALYZING RISK RANKINGS

The more than forty comparative risk projects thus far completed have differed considerably in terms of the lists of environmental problems considered, the evaluative criteria applied to assess their respective risks, and the ranking schemes used to compile the results. Project design varies according to the judgment of project organizers and sponsors. Not surprisingly, CRA practitioners seek to tailor the CRA process to their specific circumstances (e.g., geographic/demographic dimensions, institutional frameworks, resource constraints). An inevitable consequence of these methodological variations are dissimilar risk

[8] Based largely on Minard [1991].

ranking results. This section of the paper briefly discusses those methodological aspects of CRAs, summarized in Figure 1, that most frequently are the sources of these dissimilarities.

Figure 1. Taxonomy of Selected Potential Methodological Variations, by Stage of Process

Stage of Process	***Methodological Variations***
Problem List	• Environmental problem areas included • Environmental problem area definitions
Criteria for Evaluating Problems	• Types of risk analyzed—human health, ecosystem, quality of life • Scope of risk considered—inherent vs. residual • Participants conducting the ranking—public vs. expert
Ranking	• Scheme used to compile rankings—numerical or categorical

1. Environmental Problem Areas

An important initial decision for those undertaking a CRA is the determination of what is going to be ranked. Among the options are a broad range of categories including: environmental problems, agency programs, geographical areas, specific problem sites, proposed actions or risk reduction solutions, economic sectors or sources, and affected populations [Davies, 1996, p. 13]. To date, most completed CRAs have focused on environmental problems, yet the variability of those selected for comparison is considerable. Though most lists of environmental problem areas generally resemble the one used in *Unfinished Business*, no two CRAs have utilized the exact same list for their ranking exercises.

Two elements in particular contribute to the differences in environmental problem area lists: local conditions and definitional dissimilarities. With respect to the former, each list will, in part, be area-specific in that it will reflect issues of particular local salience. Since, of course, these issues will vary by project, it is not surprising that many CRAs analyze one or more environmental problems not considered by any other CRA (e.g., feedlots by the State of Minnesota, allergens and valley fever by the State of Arizona).

An additional source of variation, with more significance in terms of cross-project analysis, is how environmental problem areas are defined. There are several different ways to classify environmental problems. Among the more common are by pollutants (e.g., particulate matter, radon), by sources (e.g., motor vehicles, power plants), by pathways (e.g., air, water), or by receptors (e.g., people, forests). In compiling the environmental problem areas for analysis in *Unfinished Business*, EPA staff decided not to base their analysis on one of the above classifications, but rather to define environmental problem areas on the basis of how laws are written and environmental programs are organized [*Unfinished Business*, p. 8]. A clear benefit of this approach was that the environmental problem areas ranked in *Unfinished Business* represented those within the jurisdiction of EPA and results could be easily correlated with agency budget allocations. However, as indicated in *Reducing Risk: Setting Priorities and Strategies for Environmental Protection (Reducing Risk)*, the EPA Science Advisory Board report that evaluated *Unfinished Business*, a significant shortcoming of the approach taken in *Unfinished Business* was that it attempted to compare heterogeneous mixtures of pollutants (e.g., air pollutants, drinking water pollutants) to pollutant sources (e.g., oil spills, mining waste) to receptors (e.g., consumers, workers). In doing so, the EPA failed to establish a consistent basis for comparisons and did not address issues of double counting [*Reducing Risk*, p. 7]. Moreover, isolating environmental problem areas by category tends to over-simplify the complex, interrelated causes and manifestations of many environmental problems [Davies and Mazurek, 1998, p. 113]. Despite this criticism, *Unfinished Business* became the model for many subsequent comparative risk projects, including most of those conducted by EPA's regional offices.

In some CRAs, however, environmental problem areas have been defined differently to avoid some of the complicating factors intrinsic to the approach taken in *Unfinished Business*. One approach has been to define environmental problems broadly. For example, whereas *Unfinished Business* considered three groups of outdoor air pollutants--"criteria air pollutants," "hazardous/toxic air pollutants," and "other air pollutants," some CRAs (e.g., State of Vermont, Clinton County, Ohio) decided instead to consider outdoor air pollution for ranking purposes as a single environmental problem area. Still other CRAs have taken slightly different approaches, and, consequently, there is significant inconsistency in the makeup of the environmental problem area lists considered in CRAs.

Differences in environmental problem area lists, either due to location-specific or definitional issues, should be expected. As long as each environmental problem area is clearly defined and understood by those conducting the CRA, each approach is in itself legitimate. For the purposes of this paper, however, dissimilarities in environmental problem area definitions present a significant obstacle as they complicate cross-project analysis. Attempts to compare the risk ranking results of two different comparative risk projects is confounded by the inevitability of awkward comparisons. If one CRA, for instance, considers outdoor air pollution as a single category and another considers outdoor air pollution in terms of a set of pollutants, the result would be a comparison such as "outdoor air pollution" vs. "hazardous air pollutants." Additionally, efforts to develop a consolidated ranking of environmental health risks is impeded by the reliance of CRAs upon different conceptualizations of environmental problem areas, since results cannot easily be quantified without considerable aggregation or disaggregation. Thus, the fact that CRAs consider dissimilar sets of environmental problem areas is an important factor that must be addressed in cross-project analysis.

2. Types of Risk

Another key component of CRA project design is the determination of what types of risks should be considered (e.g., cancer, non-cancer health, environmental, socioeconomic, etc.). Choices regarding which risks to include and how they should be grouped together are critical to CRAs [Davies, 1996, p. 15]. Some CRAs have elected not to divide risks into specific types. Instead, these projects have simply considered the total risk posed by environmental problem areas irrespective of the endpoint, and ranked these problem areas in a single, overall category. The comparative risk projects that have chosen this approach include the *New Hampshire Comparative Risk Project* and the *Athens County, Ohio Environmental Priorities Project*.

To date, however, the majority of completed CRAs have assessed risks in terms of three endpoints: human health, ecosystems, and quality of life. Many CRAs have taken the additional step of attempting to combine the resulting rankings from the three separate endpoints into a single, integrated ranking. However, since the endpoints for the three categories are largely incommensurable, this has proven to be a difficult process [Feldman et al., 1996, p. 52]. Recently, there have been efforts to develop methodologies to facilitate integration [see, for instance, Deisler, 1997], but a consensus approach has yet to emerge.

Since this paper is primarily concerned with environmental health risks, of particular relevance is how the human health endpoint has been defined. Risk in terms of potential effects to human health is typically defined through risk assessment which generally includes the toxicity of an environmental stressor (e.g., pollutant), the extent of exposure (e.g., the number of people imperiled), and the size and duration of each exposure (e.g., acute vs. chronic) [Minard, 1991, p. 23]. Due to data constraints and the imperfect science of risk assessment, measuring risks to human health from environmental stressors is encumbered by considerable uncertainty. In *Unfinished Business,* the EPA divided risk rankings for human health into cancer risk and non-cancer risk categories. This approach, however, has not been the norm for most CRAs which have instead generally considered human health as a single endpoint.[9] That said, it would be incorrect to assume that CRAs have used a single set of criteria for evaluating human health risks. CRAs have, in fact, considered both carcinogenic and non-carcinogenic effects, but have just chosen to consider their effects cumulatively, yielding a single human health ranking.

Despite these differences in approach and the inherent limitations of risk assessment, the CRA method can produce a credible and useful analysis of human health risks that can be used to inform priority-setting efforts. While the precise reasoning for assigning a ranking to a particular environmental problem area will vary depending on the specifics of an individual CRA, if two projects both rank indoor air pollution as the most severe risk to human health, one can conclude that those involved in these two projects had relatively similar perceptions

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[9] A couple of CRAs (the *Wisconsin Tribes Comparative Risk Project* and the *Guam Comparative Risk Project*) did follow the approach taken in *Unfinished Business* and ranked risks to human health in terms of cancer and non-cancer risk categories.

of this risk. In other words, it is reasonable to presume that the human health endpoint used in CRAs is similar enough to allow for cross-project comparisons and analysis.

3. Inherent vs. Residual Risk

An additional element of CRAs that potentially complicates comparisons and analysis of risk ranking results regards whether inherent risk or residual risk was considered. Inherent risk refers to that risk which would exist without current control programs, whereas residual risk refers to the current level of risk, assuming reasonable compliance with present environmental laws and regulations. The EPA in *Unfinished Business* based its analysis on residual risk and chose to focus its attention on the prospective actions it could take to mitigate the risks not yet addressed [*Unfinished Business*, p. 13]. To date, nearly all comparative risk projects have utilized this approach and have elected to base their ranking exercises on residual risk.[10]

In large measure, the focus on residual risk has been a function of the decision by CRA project designers to rank environmental problems rather than alternative categories. If a CRA, for instance, was interested in analyzing a set of previously unknown hazardous waste sites, the concern would be on the total risk associated with these sites since such sites would not be subject to an existing management program. When ranking the relative risk posed by a set of environmental problems, however, it is only logical to take into account the environmental protection controls already in place to mitigate their threat. Since residual risk has been the norm, this potentially confounding factor is of lesser significance for this analysis although it remains important to bear in mind if evaluating other endpoints.

4. Public vs. Expert Ranking

In addition to the issue of what is being ranked, an equally important consideration is who is doing the ranking. Studies indicate that risk perceptions vary extensively between the public and experts, a gap which has been researched extensively [see for instance, Slovic, 1992, pp. 117-152]. The reasons for the gap are complicated and based on a fundamental difference in the criteria used by the public and experts to define risk. Whereas experts generally perceive risk as the relative amount of damage a stressor poses to human health, the environment, or other valued goods, the public also considers a mix of other values such as whether the risk is voluntary or involuntary, catastrophic or chronic, or delayed or immediate.[11] Taking this into account, one would expect quite different results if experts and the public were asked to rank the same set of environmental problems. This gap between public and expert perception of risk was also recognized in *Unfinished Business* where it was found that, although EPA's budget and staff resources were found to be generally directed at

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[10] Some CRAs have included consideration of future risk, such as the Washington Environment 2010 project. For details, see State of Washington [1989].

[11] For more detailed discussion, see Davies [1994], pp. 10-14.

those environmental problems perceived to be the most important by the public, they were targeted inappropriately in terms of the scientific assessment of environmental problems posing the greatest risks [*Unfinished Business*, pp. 91-93].

The differences in public and expert risk perception, however, do not resolve the normative issue of who should be involved in the ranking of environmental problems. A discussion of this issue is beyond the scope of this paper and is available elsewhere [Fiorino, 1989; Perhac, 1998], but recent analyses have emphasized that public input is an integral component of managing environmental risks [National Research Council, 1996; Presidential/ Congressional Commission on Risk Assessment and Risk Management, 1997]. Incorporation of public input in comparative risk projects is particularly important since the process typically goes beyond characterizing and ranking risks to setting priorities, an inherently value-laden endeavor. The uncertainty associated with quantitative risk data is too substantial to methodically determine a risk ranking. These types of decisions inevitably involve subjective public values which go beyond simple mathematical calculations [Lash, 1994, p. 74]. Among the issues that may be neglected in a narrowly technical approach include: desire for equity, aesthetic quality, and intergenerational equity [Minard, 1991, p. 18]. Additionally, it should not be assumed that experts are basing their judgments on perfect information; often there is a high level of uncertainty in the scientific analysis underlying comparative risk assessment (e.g., level of exposure, toxicity, dose-response relationships, variations in susceptibility, cumulative exposure).

The increased recognition that comparative risk assessment is a value-laden process that necessitates public input is reflected in the evolution of use of the CRA process. Initially, the EPA in *Unfinished Business* and its subsequent regional comparative risk projects relied primarily on the expert judgment of staff scientists and program managers. However, since these initial comparative risk projects, there has been steady movement toward greater public involvement in the process [Perhac, 1998, pp. 221-222]. States and municipalities have made a concerted effort to incorporate public perceptions of risk through the engagement of citizens in the ranking component of their comparative risk projects. Although approaches have varied, the most common method for integrating public perception of risk has been through advisory committees which have provided non-government and non-expert actors the opportunity to participate in the ranking of environmental problems. Public advisory committees have actively participated in the risk ranking in numerous comparative risk projects including the *Arizona Comparative Environmental Risk Project*, the *Ohio Comparative Risk Project*, and the *Maine Environmental Priorities Project*. However, the public has less often been involved in the ranking of human health risks and has more often been given the task of determining overall or integrated rankings which synthesize the rankings of different endpoints.

Typically, technical committees have been established to characterize and rank the relative human health risks posed by environmental problems. Generally, these technical work groups utilize some combination of formal risk assessment and expert judgment [Feldman, et al., 1999, p. 488]. There have, however, been a few exceptions such as the

Minnesota's *Risk-Based Environmental Priorities Project* and Vermont's *Environment 1991: Risks to Vermont and Vermonters* in which the public participated more directly in the ranking.

5. Numerical vs. Categorical Ranking

Another methodological difference in the way environmental problems are ranked in CRAs is with respect to how the results are compiled. To date, completed comparative risk projects have arranged risk ranking results in one of two ways--numerically (e.g., 1-20) or categorically (e.g., high, medium, low). This has been the case irrespective of the endpoint of concern. This issue is of relatively lesser importance than the others described above, but nonetheless can hinder cross-project analysis of risk ranking results.

6. Collective Impact of Project Design Dissimilarities

Figure 2 illustrates the collective impact these methodological variations can have on the manner in which environmental problems are ranked. Consider, for example, how three different CRAs--EPA Region X [U.S. EPA, 1989, p. 41], the State of Vermont [Vermont Agency of Natural Resources, 1991, p. 2.], and the State of Arizona [Arizona Department of Environmental Management, 1995, pp. 9-26]--were designed to assess and rank the health risks presented by environmental problems. All of these CRAs elected to focus on human health as an endpoint and limited their analysis to residual risk. There was a difference, however, with respect to the people that conducted the ranking itself; rankings for Region X and Arizona were determined by a group of experts, whereas in the case of Vermont, the ranking was done by a public advisory committee.[12] Lastly, in terms of the ranking scheme utilized to compile the results, Vermont used a numerical system, whereas Region X and Arizona relied on different categorical systems.

Now consider how each of the three CRAs assessed and ranked a particular environmental problem--outdoor air pollution. In the case of Vermont, "outdoor air pollution" was defined broadly and was considered as a single environmental problem area. By contrast, Region X opted to consider outdoor air pollution in terms of specific pollutant categories--"air toxics plus PM10" and "criteria air pollutants." Arizona also elected to analyze outdoor air pollution in terms of specific pollutant categories, but chose slightly different categories--"fine particulate matter," "hazardous air pollutants," and "air pollutants other than lead." These differences in project design illustrate the types of complications that arise when trying to analyze risk ranking results in a comparative manner.

Despite the complexities, there is still utility in a comparative analysis of completed risk rankings. Certainly, since CRAs have used different lists of environmental problem areas, evaluative criteria, and ranking schemes, cross-project analysis is problematic. Yet, when thought of on the broad level of considering how different constituencies have ranked

[12] The public advisory committee was comprised of elected government officials, representatives of business and environmental groups, scientists, academics, and the public at-large.

Figure 2. Human Health Rankings from Selected Comparative Risk Projects

	US EPA Region X	***Vermont***	***Arizona***
Type of Risk	Human Health	Human Health	Human Health
Inherent or Residual Risk	Residual	Residual	Residual
Public or Expert	Expert	Public	Expert
Numerical or Categorical	Categorical (High (H), Medium/High (M/H), Medium (M), Medium/Low (M/L), Low (L))	Numerical (1-10)	Categorical (High (H), Medium (M), and Low (L))
Rankings	*Indoor Radon (H)*	*Indoor Air Pollution (*1)	Allergens and Valley Fever (H)
	Other Indoor Air (H)	Toxics in the Household (2)	Environmental Tobacco Smoke (H)
	Pesticides (H)	Toxics in the Workplace (2)	**Fine Particulate Matter (H)**
	Air Toxics Plus PM10 (H)	Depletion of the Ozone Layer (3)	Food Safety (H)
	Non-Public Drinking Water (M/H)	**Air Pollution (4)**	Ionizing Radiation (H)
	Public Drinking Water (M/H)	Drinking Water at the Tap (5)	Lead Poisoning (H)
	Other Groundwater (M/H)	Food Safety (6)	Radon (H)
	Criteria Air Pollutants (M)	Pollution of Lakes, Ponds, Rivers, and Streams (7)	Ultraviolet Radiation (H)
	Nonpoint Sources (M/L)	Hazardous and Radioactive Waste (8)	Drinking Water (M)
	POTWs (M/L)	Solid Waste (9)	**Hazardous Air Pollutants (M)**
	Accidental Releases (M/L)	Pests and Pest Management (10)	Medical Exposure to Ionizing Radiation (M)
	Hazardous Waste Sites, Abandoned (M/L)		Natural Hazards (M)
	Other Radiation (L)		Occupational Exposure to Toxic Materials (M)
	Releases from Storage Units (L)		Accidental Releases of Toxic Substances (L)
	Industrial Point Sources (L)		**Air Pollutants Other Than Lead and Fine Particulates (L)**
	Current Hazardous Waste Sites (L)		Animal Vectors of Human Diseases (L)
	Non-Hazardous Waste Sites (L)		Asbestos (L)
			CERCLA and WQARF (State Superfund) (L)
			Farmworker Exposure to Pesticides (L)
			Ionizing Radiation from Man-Made, Non-Medical Activities (L)
			Leaking Underground Storage Tanks (L)
			Noise (L)
			RCRA Sites (L)
			Surface Water Contact (L)

the risks posed to human health, the risk rankings are more similar than different. Referring again to Figure 2, for instance, though Region X and Vermont defined indoor air pollution differently ("indoor radon" and "other indoor air" vs. "indoor air pollution"), one can presume with a reasonable level of confidence that the participants conducting the ranking in the CRAs shared the view that indoor air pollution posed the most significant risk of the environmental problem areas considered. With this logic, it is useful to the extent possible to move beyond the limitations and to consider methods that facilitate cross-project analysis.

III. METHODOLOGY FOR COMPARING RISK RANKING RESULTS

The methodology described in this section provides a way to systematically modify individual risk-ranking results to make them more amenable to comparison. The standardization method has three important components: (1) aggregation of environmental problem areas into comparable categories; (2) normalization of ranking schemes; and (3) determination of an appropriate value of risk (High, Medium, or Low).

1. Aggregation of Environmental Problem Areas

As was discussed previously, not only have the lists of environmental problem areas used in CRAs varied significantly, so too have the definitions of particular environmental problem areas that comprise the lists. Without a standardization of the meaning of the environmental problem areas into commensurate categories, it is difficult to analyze risk ranking results in a comparative manner since, otherwise, the CRAs are ranking different things. The first step of standardization is the aggregation of the environmental problem areas into new environmental problem categories as a means to address their definitional inconsistencies. Though aggregation in some cases necessitates the creation of new environmental problem categories, the modified rankings can remain valid representations of the original rankings if the aggregation is completed in the manner suggested below.

The key issue with respect to this component of standardization is the identification of the correct level of aggregation, or, in other words, the determination of the appropriate scope of the new environmental problem categories. As a general rule, the aggregation of environmental problem areas should only be done to the level required to allow comparison. Adherence to this standard will best guarantee that the environmental problem categories will accurately reflect the original risk rankings. Precisely what this level will be depends on the specific CRAs that are being compared. The environmental problem areas comprising risk rankings of some CRAs will be sufficiently similar as to not require much aggregation, whereas others may be so disparate that substantial aggregation is necessary.

An example will illustrate the type of aggregation that may be required to complete this part of the standardization process. Suppose, for instance, that the state of Florida wanted to determine how its human health risk rankings for outdoor air pollution compared with that of its EPA regional office. The State of Florida's CRA, *Comparing Florida's Environmental Risks: Risks to Florida and Floridians*, opted to rank outdoor air pollution as a single environmental problem area, "ambient air quality" [Florida Center for Public Management, 1995, p. 15]. In contrast, the *EPA Region 4 Comparative Risk Project* analyzed and ranked outdoor air pollution in terms of numerous environmental problem areas, including "ozone/carbon monoxide," "toxic air pollutants," "airborne lead," and "particulate matter" [U.S. EPA Region 4, 1990]. For Florida to compare its results with those of EPA's, it is necessary to aggregate the environmental problem areas of the *EPA Region 4 Comparative Risk Project* into a new environmental problem category to provide a single measure of outdoor air pollution. As a result of the aggregation, the two CRAs can, in a simplified fashion, be compared in terms of how each assessed and ranked the risk associated with outdoor air pollution.

An important benefit of this type of aggregation is that it allows for cross-project analysis of environmental problem areas at their broadest level. This type of approach is attractive in that generalizations can be drawn about large-scale environmental health concerns, but it also has important shortcomings. First, there is inescapably some loss of exactness as the generalized environmental problem categories do not maintain the detail of the original environmental problem areas. Additionally, when environmental problem areas are analyzed at this broad level, the most important components of the problem--those with the highest associated human health risks--are de-emphasized and, in fact, hidden within the larger, aggregated environmental problem categories. For example, consider indoor air pollution. Often in CRAs, indoor air pollution has been ranked in terms of a number of different pollutants (e.g., indoor radon, environmental tobacco smoke, asbestos) each with its own associated risk. If these individual pollutants are aggregated and assigned a composite risk value, it is not clear which of the pollutants was judged to present the most significant risk. In other words, the relative risk posed by the individual indoor air pollutants is lost through the aggregation into a single environmental problem category.

If this aggregation was done for all environmental problem areas, the results would be modified and reorganized risk rankings that consist of a common set of environmental problem categories for each CRA. Depending on the environmental problem areas considered in the original rankings, the modified rankings may contain new environmental problem categories that represent the aggregations. The aggregation process described above, however, represents only the first component of the standardization of dissimilar environmental problem areas. The second component is the normalization of ranking schemes.

2. Normalization of Ranking Schemes

The newly-established environmental problem categories must be assigned a value of risk that accurately reflects those of the aggregated environmental problem areas that comprise the category. A preliminary step in this determination is the creation of a uniform ranking scheme to normalize the disparate ways in which CRAs have arranged their rankings. Normalization is possible through the reorganization of the risk ranking data, both numerical and categorical, into three categories: High, Medium, and Low. A general rule that can be applied for numerical rankings is the following: the top third of the environmental problem areas ranked can be reassigned a value of "High," the middle third a value of "Medium," and the bottom third a value of "Low." For example, the *EPA Region III Comparative Risk Project* considered the human health risks of 18 environmental problem areas, giving each a numerical ranking [U.S. EPA, 1989, p. 40]. This ranking can be modified by re-assigning those environmental problem areas ranked 1-6 a value of High, those 7-12 a value of Medium, and those 13-18 a value of Low.

With respect to categorical rankings, the original rankings can be converted simply by assigning the top risk category a value of High, the middle risk categories a value of Medium, and the bottom risk category a value of Low. For instance, in the case of the *Arkansas Human Health & Environment Comparative Risk Project* [Arkansas Department of Health], environmental problem areas were originally assigned one of five categories of risk--High, Medium-High, Medium, Low-Medium, and Low. To consolidate these rankings into a High-Medium-Low format, those environmental problem areas originally placed in the top category of risk can be re-assigned a value of High, those in the middle three categories of risk can be re-assigned a value of Medium, and those in the bottom category of risk can be re-assigned a value of Low. This uniform ranking scheme may seem somewhat contrived, but it provides a reasonably accurate representation of the original rankings and is an essential step for cross-project analysis of risk ranking results.

A clear drawback of reducing the original risk rankings into only three categories is the inevitable loss of precision that results. Ideally, it would enhance comparative analysis if a ranking scheme could be devised that either incorporates more categories or creates an ordered list (e.g., 1-10). However, the uniform ranking scheme can only be as precise as the least precise original ranking system. Since many CRAs rely upon a categorized scheme with only three levels of risk, and do not rank environmental problems areas within each of the levels, a reasonable general rule is to convert risk rankings into this three-level framework. Depending on the characteristics of the two or more CRAs that are being compared, a different scheme could conceivably be used to normalize the rankings (e.g., 5-category format). The primary advantage of the High-Medium-Low format is that it is amenable to all completed CRAs.

3. Determination of Risk Value

The final component of the standardization process is the determination of the appropriate value of risk to assign the newly created environmental problem categories. To the extent possible, the value of risk should match that of the original environmental problem areas that comprise the category. There are two sensible ways of assigning a value of risk to the new environmental problem categories. First, the entire category can be given the risk value of the environmental problem area in the category with the single *highest* risk value. The logic underlying this "highest" rule is that no category should have a lower risk value than any single environmental problem area of the category. Alternatively, the new category could be given the *average* risk value of the individual environmental problem areas that comprise the new category.[13] The reasoning underpinning this "average" rule is that the most representative value of risk for the new category would be the average of the individual environmental problem areas that it encompasses. Both of these approaches have their advantages and shortcomings, but the methodology provides flexibility for the use of either.

As is illustrated for the case of indoor air pollution in the *Arizona Comparative Environmental Risk Project* in Figure 3, depending on which approach is employed, the resulting risk value may differ. Arizona originally ranked three separate environmental problems areas related to indoor air quality: "asbestos," "environmental tobacco smoke," and "radon," with the associated risks of Low, High, and High respectively. To determine how Arizona's ranking of indoor air pollution compares with that of another CRA which opted to rank indoor air pollution as a single environmental problem area, it is necessary to first aggregate three individual environmental problem areas into a single environmental problem category, which can be called "indoor air pollution." Depending on which decision rule is employed, this newly created environmental problem category may have either a risk value of High or Medium.

Figure 3. Arizona Comparative Environmental Risk Project--Indoor Air Pollution

Environmental Problem Area	***Original Ranking***	
Asbestos	Low	
Environmental Tobacco Smoke	High	
Radon	High	
Environmental Problem Category (After Aggregation)	***"Highest" Rule***	***"Average" Rule***
Indoor Air Pollution	High	Medium

In its entirety, this standardization method allows for the kind of direct comparisons of risk ranking results that is otherwise not possible due to project design dissimilarities. To illustrate the usefulness of the methodology for this purpose, recall the disparate nature of the original human health risk rankings of EPA Region X, the State of Vermont, and the State of Arizona from Figure 2. Now consider the modified rankings for these same CRAs exhibited in Figure 4, with the results shown for both the "highest" and "average" approach. The standardization process has converted the original risk rankings of each of the CRAs in a way that to the extent possible maintains their initial form, while enhancing their comparability with other two CRAs. Interestingly, of the three CRAs, only the risk value for indoor air pollution in Arizona was affected by whether the "highest" or "average" decision rule was employed.

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[13] The values used to calculate the average are High=3, Medium=2, and Low=1. Rounding rule applied is > or =.5 is rounded up.

Figure 4. Human Health Rankings from Selected Comparative Risk Projects, After Standardization

	"Highest" Rule			"Average" Rule		
Environmental Problem Category	***EPA Region X***	***Vermont***	***Arizona***	***EPA Region X***	***Vermont***	***Arizona***
Accidental Releases	M		L	M		L
Acid Deposition						
Allergens and Valley Fever			H			H
Animal Vectors of Human Disease			L			L
Drinking Water Quality	M	M	M	M	M	M
Food Quality		M	H		M	H
Groundwater Quality	M			M		
Hazardous Waste	M	L	L	M	L	L
Indoor Air Pollution	H	H	*H*	H	H	*M*
Lead			H			H
Natural Hazards			M			M
Noise Pollution			L			L
Outdoor Air Pollution	H	M	M	H	M	M
Pests and Pest Management		L			L	
Pesticides	H		L	H		L
Radiation Exposure (Other Than Indoor Radon)	L		M	L		M
Radioactive Waste Issues		L			L	
Solid/Non-hazardous Waste	L	L		L	L	
Storage Tanks (Releases/Leaks)	L		L	L		L
Stratospheric Ozone Depletion		H			H	
Surface Water Quality	M	M	L	M	M	L
Toxics		H	M		H	M

IV. CONSOLIDATED RANKING OF ENVIRONMENTAL HEALTH RISKS

The primary use of the methodology described in section III is for the comparison of the risk ranking results of one CRA with another. An ancillary benefit of the methodology is that it provides for the standardization of completed human health CRAs, which then can be quantitatively analyzed to determine a consolidated list of the most significant environmental health risks. This consolidated list can be determined through a two-part process. The first part is the application of the methodology described in the last section to all of the existing comparative risk projects that have considered human health as an endpoint. The use of this methodology organizes the risk rankings in a way that allows for the next step, a calculation of the frequency in which each environmental problem category was identified as posing a risk to human health. From this two-part process, the most often cited environmental health risks can be determined. Though this type of analysis is problematic due the methodological variations explained previously in this paper, the purpose of such a list is to provide a benchmark that can be thought of as an approximate synthesis of the environmental problems most frequently judged by those conducting CRAs as posing the severest risks to human health.

Prior to explaining the process, however, it is first necessary to describe the data used in the analysis. The data comes from the results of completed comparative risk projects that have ranked environmental problems based on their risks to human health.[14] Thirty-nine human health CRAs were included in the analysis--2 national, 10 regional, 20 state, 2 territorial, and 5 local.[15] (See Appendix A for a list of the comparative risk projects included.) The analysis described below also could be used to compare risk ranking results of other endpoints considered in CRAs (e.g., ecosystem health, quality of life), but, since this paper is focused on environmental health risks, it is appropriate to include only data from existing human health risk rankings.

1. Standardization of Risk Ranking Results

Before the human health risk ranking results can be quantitatively analyzed in any meaningful manner, it is necessary to standardize them so that they are more uniform. This is possible using the same techniques described in the previous section. The first step of the standardization process is to aggregate the environmental problem areas considered in each CRA to create new environmental problem categories. (See Appendix B for the list of aggregations.) In this analysis, determining the most appropriate level of aggregation was relatively simple in that the environmental problem categories could only be as specific as the CRA with the single most general set of environmental problem areas. In other words, since many of the CRAs defined their environmental problem areas broadly (e.g., hazardous waste, surface water pollution, outdoor air pollution), the environmental problem categories also could be defined broadly.

Following aggregation, the ranking systems of the original CRAs were converted to the uniform ranking scheme of High, Medium, and Low. (The specific decision rule used for converting the rankings to the uniform ranking scheme are indicated for each CRA in Appendix C.) Subsequently, each new environmental problem category was assigned new risk values, one based on the "highest" rule and the other based on the "average" rule. After

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[14] When all endpoints are considered, the total number of comparative risk projects completed is 142 (1 national, 10 regional, 23 state and territorial, and 108 local (including 84 Mississippi counties) [Environmental Defense Fund, 1999].

[15] *Unfinished Business*, the *Wisconsin Tribes Comparative Risk Project*, and the *Guam Comparative Risk Analysis* were each counted as two separate cases since each conducted human health rankings for both cancer risk and non-cancer risk. CRAs that covered multiple jurisdictions were counted as single CRAs since only one ranking was done for the greater area (e.g., the Northeast Ohio Regional Environmental Priorities Project was counted as one CRA though it covered the counties of Cuyahoga, Lake, Lorain, Summit, Geauga, Medina and Portage). The Mississippi CRA, *Comparative Environmental Risks in Mississippi*, did include individual human health rankings for 84 counties, but these were excluded from the data set used in the analysis. Additionally, the comparative risk project conducted by the State of Kentucky, *Kentucky Outlook 2000: A Strategy for Kentucky's Third Century*, was not included in the analysis due to its unique, issue-based approach, an approach that was difficult to reconcile with all the other comparative risk projects that considered human health.

this standardization process, each CRA is reorganized in a such a fashion that it has a common set of environmental problem categories, each of which is assigned a risk value of High, Medium, or Low. Figure 4 above illustrated the results of this process for three of the thirty-nine cases.

2. Quantitative Analysis

Once the human health rankings have been reorganized so they are commensurate, it is possible to quantitatively analyze how often each environmental problem category was identified as posing a risk to human health. This was accomplished through the determination of the frequency in which each environmental problem category was ranked. Each environmental problem category was tabulated in terms of the number of total times and percentage it was ranked in all the human health rankings, and the number of times and percentage each environmental problem category was ranked in a particular risk category--High, Medium, or Low.

As an additional measure, an index scoring system was devised to further characterize the data. Assigning High a value of 3, Medium a value of 2, Low a value of 1, and not ranked a value of 0, a raw score was calculated for each environmental problem category. Using this raw score, a weighted score was calculated (raw score/total number of times ranked). The primary reason for computing the weighted score was to account for a potential outcome, for instance, in which two environmental problem categories both had a raw score of 6, but one was ranked high twice and the other was ranked low six times. (See Appendices D and E for the results.)

3. Summary of Results

Through the quantitative analysis of the human health risk rankings, it is possible to determine a consolidated ranking of the ten most significant environmental problem categories ranked in terms of the risks they pose to human health. This consolidated ranking could be formulated in several different ways: total times ranked, total times ranked high, raw score, or weighted score. The results of all the tabulations are presented in Figure 5 and Figure 6. It is necessary to exhibit the results in two sets to illustrate the slight differences that emerge due to the choice of the decision rule, "highest" or "average," used to assign risk values to the environmental problem categories.

Among these options, two are seemingly the best proxies for determining which environmental problem categories were most often associated with high risks to human health--the number of times ranked high and the weighted score. The number of times each environmental problem category was ranked high represents the frequency in which each problem was placed in the highest risk category of a CRA, whereas the weighted score takes not only this factor into account but also the frequency in which each environmental problem category was ranked.

Figure 5. Consolidated Top Ten Lists of Environmental Health Risks - "Highest" Rule

Total Times Ranked				*Total Times Ranked High*			
Rank	*Environmental Problem Category*	*# (max.=39)*	*%*	*Rank*	*Environmental Problem Category*	*# (max.=39)*	*%*
1	Outdoor Air Pollution	37	95	1	Indoor Air Pollution	29	74
2	Indoor Air Pollution	36	92	2	Outdoor Air Pollution	20	51
3	Surface Water Pollution	35	90	3	Lead	9	23
4	Hazardous Waste	32	82	4	Pesticides	8	21
5	Drinking Water Pollution	30	77	5	Food Quality	7	18
6	Solid/Non-hazardous Waste	27	69	5	Stratospheric Ozone Depletion	7	18
6	Storage Tanks (Releases/Leaks)	27	69	5	Toxics	7	18
8	Groundwater Pollution	25	64	8	Drinking Water Pollution	6	15
8	Radiation Exposure (Other Than Indoor Radon)	25	64	9	Accidental Releases	4	10
10	Accidental Releases	23	59	10	Hazardous Waste	3	8
				10	Radiation Exposure (Other Than Indoor Radon)	3	8
				10	Surface Water Pollution	3	8

Raw Score				*Weighted Score*			
Rank	*Environmental Problem Category*	*Score*	*Times (max. = 39)*	*Rank*	*Environmental Problem Category*	*Score (max. = 3.0)*	*Times (max. = 39)**
1	Indoor Air Pollution	101	36	1	Indoor Air Pollution	2.81	36
2	Outdoor Air Pollution	94	37	2	Outdoor Air Pollution	2.54	37
3	Surface Water Pollution	66	35	3	Lead	2.41	17
4	Drinking Water Pollution	63	30	4	Food Quality	2.39	18
5	Hazardous Waste	62	32	5	Pesticides	2.30	23
6	Pesticides	53	23	6	Stratospheric Ozone Depletion	2.28	18
7	Groundwater Pollution	49	25	7	Toxics	2.11	19
8	Solid/Non-hazardous Waste	46	27	8	Drinking Water Pollution	2.10	30
9	Accidental Releases	44	23	9	Groundwater Pollution	1.96	25
10	Radiation Exposure (Other Than Indoor Radon)	43	25	10	Hazardous Waste	1.94	32
10	Food Quality	43	18				

*Only those environmental problems ranked at least ten times were included.

Figure 6. Consolidated Top Ten Lists of Environmental Health Risks - "Average" Rule

Total Times Ranked				***Total Times Ranked High***			
Rank	*Environmental Problem Category*	*# (max.=39)*	*%*	*Rank*	*Environmental Problem Category*	*# (max.=39)*	*%*
1	Outdoor Air Pollution	37	95	1	Indoor Air Pollution	27	69
2	Indoor Air Pollution	36	92	2	Outdoor Air Pollution	13	33
3	Surface Water Pollution	35	90	3	Lead	9	23
4	Hazardous Waste	32	82	4	Pesticides	8	21
5	Drinking Water Pollution	30	77	5	Food Quality	7	18
6	Solid/Non-hazardous Waste	27	69	5	Stratospheric Ozone Depletion	7	18
6	Storage Tanks (Releases/Leaks)	27	69	5	Toxics	7	18
8	Groundwater Pollution	25	64	8	Drinking Water Pollution	6	15
8	Radiation Exposure (Other Than Indoor Radon)	25	64	9	Accidental Releases	4	10
10	Accidental Releases	23	59	10	Hazardous Waste	3	8

Raw Score				***Weighted Score***			
Rank	*Environmental Problem Category*	*Score*	*Times (max. = 39)*	*Rank*	*Environmental Problem Category*	*Score (max. = 3.0)*	*Times (max. = 39)**
1	Indoor Air Pollution	99	36	1	Indoor Air Pollution	2.75	36
2	Outdoor Air Pollution	86	37	2	Lead	2.41	17
3	Drinking Water Pollution	63	30	3	Food Quality	2.39	18
4	Surface Water Pollution	62	35	4	Outdoor Air Pollution	2.32	37
4	Hazardous Waste	62	32	5	Pesticides	2.30	23
6	Pesticides	53	23	6	Stratospheric Ozone Depletion	2.28	18
7	Groundwater Pollution	49	25	7	Toxics	2.11	19
8	Solid/Non-hazardous Waste	45	27	8	Drinking Water Pollution	2.10	30
9	Accidental Releases	44	23	9	Groundwater Pollution	1.96	25
10	Food Quality	43	18	10	Hazardous Waste	1.94	32

*Only those environmental problems ranked at least ten times were included.

An examination of the results suggests that, regardless of whether the total times ranked high or the weighted score was used, in large measure, the same set of environmental problem categories comprise the consolidated top ten lists. More specifically, indoor air pollution and outdoor air pollution repeatedly emerge as the environmental problem categories most frequently cited as presenting the most significant risks to human health. The second group of environmental problem categories is more dependent on the tabulation method, but generally includes lead, food quality, pesticides, and stratospheric ozone depletion. Interestingly, the results are quite similar to those of the cancer risk rankings of Unfinished Business in which the environmental problem areas placed in the highest risk category--worker exposure to chemicals, indoor air radon, pesticide residues on food, indoor air pollutants other than radon, consumer exposure to chemicals, and hazardous/toxic air pollutants--are all components of the aggregated environmental problem categories determined in this analysis to be most frequently judged as presenting serious human health risks [*Unfinished Business*, pp. 28-29].

The most significant discrepancy in the order of the environmental problem categories occurs with respect to outdoor air pollution. In Figure 5, which depicts the results based on the "highest" rule, outdoor air pollution emerged as the second most frequently ranked environmental health risk both when measured in terms of its total times ranked high and its weighted score. In contrast, when the "average" rule was employed, as shown in Figure 6, outdoor air pollution dropped down to the fourth position when measured in terms of its weighted score. The explanation for this divergent outcome is that more often than any other type of environmental problem category, outdoor air was separated into distinct components for risk ranking purposes. While typically, at least one of these individual components was judged as posing a high risk to human health, overall there was a wide range of risk values associated with outdoor air pollutants, not a surprising result considering the location-specific nature of outdoor air pollution. Thus, when aggregating and assigning a risk value based on the "highest" rule, outdoor air pollution frequently was ranked as posing a higher risk than when the risk value was assigned using the "average" rule.

Overall, however, the consolidated top ten lists of environmental health risks are quite similar, irrespective of the tabulated data used and the decision rule employed for assigning risk values. These results should not be interpreted, however, as representing the definitive list of environmental problems presenting the greatest risks to human health. Clearly, as is the case with respect to all environmental problems, there are considerable local variations in the extent of the risk, which is a main reason state and municipal governments choose to conduct their own CRAs. These consolidated risk rankings, however, do provide a benchmark and a credible representation of the environmental problem areas repeatedly determined in CRAs as posing significant risks to human health. As noted below, however, there are some important shortcomings of these synthesized risk rankings.

4. Shortcomings of Consolidated Ranking

An important factor that complicates the interpretation of the consolidated rankings is the determination of the best level of aggregation for the environmental problem categories.

Aggregation of the environmental problem areas to different levels would produce markedly different consolidated top ten lists. The judgment made in this paper is that concentration on the broadest level of aggregation provides the clearest picture of what environmental problem areas participants in CRAs most oftentimes identified as posing the severest risks to human health. Additionally, it was the most expedient approach considering the breadth of human health CRAs considered in the analysis. In choosing to include such a large number of CRAs, a certain level of precision was inevitably sacrificed.

A clear weakness of this approach is that aggregation to this broad level obscures the individual components of the environmental problem categories that are presenting the severest risk. For example, although indoor air pollution was most often cited as posing the most significant risk to human health, focusing on indoor air pollution as a single environmental problem category conceals which indoor air pollutants should be given the most attention (e.g., indoor radon, environmental tobacco smoke, etc.). The alternative would be to base the consolidated top ten list on a different level of aggregation. However, since many CRAs elected to define environmental problem areas broadly, it would be necessary to dis-aggregate to properly account for the significance of individual pollutants (e.g., carbon monoxide) or pollutant categories (e.g., criteria air pollutants). Unfortunately, while the outcome may be preferable, disaggregation is clearly not an option. The conclusion reached in this paper is that, while aggregation may be problematic, it represents a feasible and useful approach. Moreover, concentration on the most expansive level of aggregation allows for a simple and generalized view of the environmental problems that have been judged in CRAs as presenting the most significant risks to human health.

These aggregation issues point to a locus of active debate among CRA practitioners and methodologists who are continually working on ways to best categorize environmental problems for ranking in CRAs [for instance, see Morgan, Florig, DeKay, and Fischbeck, 1999]. As Graham and Hammitt indicate, there is no right answer to the question of how risks should be aggregated and listed for ranking purposes [Graham and Hammitt, 1996, p. 98]. Unfortunately, the lack of consistency that results, requires the type of aggregation employed in this analysis, and the corresponding over-simplifications that must be made.

Another important shortcoming of this type of cross-project analysis is the inevitable blurring of human health endpoints. Of the thirty-nine CRAs included in this analysis, most (thirty-three) of the final risk rankings reflect human health impacts as a single endpoint. In the other six final risk rankings included in the analysis, three are based on cancer-risk as the human health endpoint and three are based on non-cancer risk as the human health endpoint. For the purposes of this paper, and to allow for comparability and aggregation, cancer-risk and non-cancer risk were weighted equally and commensurate with the general human health endpoint. Though the nature of the endpoint considered is a critical component of CRAs, this type of obfuscation is an unavoidable drawback of cross-project analysis.

V. CONCLUSION

This paper illustrates a methodology that can be used to facilitate comparisons of the risk ranking results of one CRA with another, and an application of the methodology that provides a consolidated ranking of the environmental problem areas most often cited as posing the severest risks to human health. Despite the substantial methodological variations that impede both cross-project analysis and the synthesis of completed risk rankings, the method provides a convenient tool for those interested in either comparing the results of one CRA to another or discerning which environmental problems have most frequently been judged as human health threats.

The project design differences, particularly those related to the definition and categorization of environmental problem areas, raise some questions that merit further investigation. Specifically, what is the best level of aggregation for ranking environmental problems and how can these environmental problem areas be most clearly defined to prevent double counting issues? Moreover, is the determination to rank environmental problems the best approach, or would it be more useful to conduct CRAs on a programmatic basis or in terms of alternative risk reduction options? This latter question is particularly important in light of the limited impact *Unfinished Business* and many of the state and local comparative risk projects have had in altering risk perceptions or influencing budgetary and human resource allocations in government agencies. Perhaps, if CRAs change their focus from environmental problems to risk management options, government agencies will better be able to incorporate the results into planning and decision-making.

Until these issues are resolved or an agreed upon CRA method emerges, CRAs will continue to concentrate their rankings on the risks posed by environmental problems. Consequently, it will be helpful to use the methodology suggested in this paper and others like it both to enhance cross-project analysis and to better understand which environmental problems are most often identified in CRAs as presenting high risks to human health.

Appendix A. List of Comparative Risk Projects Included in Analysis

Level of Government	***Project***
National	U.S. EPA, *Unfinished Business*.*
Regional	EPA Regions 1-10.
State	Alabama; Arizona; Arkansas; California; Colorado; Florida; Hawaii; Iowa; Louisiana; Maryland; Minnesota; Mississippi; North Dakota; Ohio; Texas; Utah; Vermont; Washington; Wisconsin.*
Territory	Guam.*
Local	Northeast Ohio; Clinton County (OH); Columbus (OH); Denver (CO); Washington, DC.

* Counted as two separate cases since each conducted human health CRA for both cancer risk and non-cancer risk.

Appendix B. List of Aggregations*

Environmental Problem Category	*Environmental Problem Areas*†
Accidental Releases	Accidental Releases-Oil Spills; Accidental Releases-Toxics/Hazardous Materials
Acid Deposition	Acid Deposition; Acid rain
Deep Well Injection	Deep Well Injection-Traditional Underground Injection Wells; Deep Well Injection-Other Underground Injection Wells
Drinking Water Pollution	Drinking Water (General); Drinking Water (Public); Drinking Water (Non-Public); Total Suspended Solids, BOD, or Nutrients in Water; Nitrates; Naturally Occurring Contaminants in Drinking Water
Food Quality	Food Contamination (Seafood); Food Contamination/Food Quality/Food Safety; Pesticide Residues on Food; Food Safety-Natural Toxins
Groundwater Pollution	Groundwater (Anthropogenic Source Releases); Groundwater (Natural Source Releases); Other Ground-Water Contamination; Groundwater Contamination/Groundwater Quality
Habitat Modification/Ecosystem Alteration	Aquatic Habitat Modification; Terrestrial Habitat Modification; Habitat/Ecosystem Modification or Quality of Natural Areas
Hazardous Waste	Hazardous Waste Sites-Active (RCRA); Hazardous Waste Sites-Inactive/Superfund; Hazardous Waste General; Hazardous Waste Facilities, Regulated; Hazardous Waste Facilities, Abandoned and Unregulated; Radioactive and Hazardous
Indoor Air Pollution	Environmental Tobacco Smoke; Indoor Air General; Indoor Air Pollutants Other Than Radon; Asbestos; Indoor Radon
Outdoor Air Pollution	Criteria Pollutants; Hazardous/Toxic Pollutants; Commercial and Stationary Sources; Toxics Plus PM10; Other Air Pollutants; Outdoor Air Other Than Lead and Fine Particulates; Industrial Emissions; Mobile Sources; Benzene; Outdoor Air; Airborne Lead; Carbon Monoxide; Sox; SOx, NOx, and Acid Deposition; NOx; Ozone; Particulate Matter; VOCs; Commercial and Stationary Sources; Toxics Plus PM10; Dust: cars/industry; Areas Sources/Non-point Sources; Smog; Combustion By-Products
Pesticides	Agricultural Use of Pesticides; Pesticides; Application of/Farm Worker Exposure to Pesticides; Pesticides Non-Agricultural Use of Pesticides; Pesticides, Others Risks (Runoff/Air Deposition); Spraying of Pesticides; Agricultural Practices/Pesticide Pollution Pesticides (Surface Runoff)
Pests and Pest Management	Pest Management; Pests (Exotic Species)

Appendix B. List of Aggregations (cont'd)

Environmental Problem Category	***Environmental Problem Areas***†
Radiation Exposure (Other Than Indoor Radon)	Anthropogenic Sources of Radiation Radiation; Ionizing Radiation from Man-Made, Non-Medical; Ionizing Radiation; Medical Exposure to Ionizing Radiation; Natural Sources of Radiation; Non-Ionizing Radiation; Ultraviolet Radiation; Radiation Other Than Radon
Radioactive Waste Issues	Disposal of Radioactive Waste; Radioactive Waste Sites-Active; Radioactive Waste Sites-Inactive; Radioactive and Hazardous Waste
Solid/Non-Hazardous Waste	Non-hazardous Waste Sites-Industrial; Non-hazardous Waste Sites-Municipal; Waste Sites/Non-Superfund (Uncontrolled); Non-hazardous Waste Sites; Solid Waste Disposal; Municipal Solid Waste; Solid Waste Reduction Facility/Dioxin; Solid Waste; Solid Waste Disposal Capacity; Solid Waste Industrial; Solid Waste Municipal Incinerators; Solid Waste Municipal Storage Landfills
Surface Water Pollution	Discharges of Estuaries, Coastal Waters and Oceans; Discharges to Wetlands; Discharges/Pollution of Rivers and Streams; Surface Water Contact; Surface Water Quality General; Surface Water Direct Point Source; Discharges/Wastewater-Industrial; Discharges/Wastewater-Municipal; Surface Water Point Source Discharges; Surface Water Point Source Discharges-POTWs; Wastewater Discharges; Nonpoint Sources Pollution/Discharges to Surface Water; Surface Water Contact; Surface Water Quality-Potomac; Surface Water Quality-Anacostia; Combined Sewer Overflow/Inadequate Infrastructure; Surface Water; Direct Point Source Discharges/Wastewater-Industrial; Direct Point Source Discharges/Wastewater-Municipal
Toxics	Worker Exposure to Toxics/Chemicals; Consumer/Household/ School Exposure to Toxics/Chemicals/Hazardous; Substances; Persistent Organochlorines; Inorganics; Toxic Chemicals; New Toxic Chemicals; Hazardous Substances
Waste Issues	Waste; Industrial Disposal of Waste; Transportation of Waste

* Some environmental problem areas were unique and were not aggregated into environmental problem categories (e.g., stratospheric ozone depletion).

† As titled in original CRAs.

Appendix C. Rule Used to Convert Risk Rankings to Uniform Ranking Scheme

Comparative Risk Project	***High***	***Medium***	***Low***
Unfinished Business (cancer)	Category 1 (1-6)	Categories 2, 3 (7-22)	Category 4 (23-27)
Unfinished Business (non-cancer)	Category 1 (1-6)	Categories 2, 3 (7-22)	Category 4 (23-27)
EPA Region 1	Highest	High, Medium, Low	Lowest
EPA Region 2	Very High	High, Medium	Low
EPA Region 3	1-6	7-12	13-18
EPA Region 4	High	Medium-High, Medium, Medium-Low	Low
EPA Region 5	High	Medium-High, Medium-Low	Low
EPA Region 6	Category 1	Categories 2, 3	Category 4
EPA Region 7	High	Medium	Low
EPA Region 8	Category 1	Categories 2, 3, 4	Category 5
EPA Region 9	High	Medium-High, Medium, Medium-Low	Low
EPA Region 10	Category 1	Categories 2, 3, 4	Category 5
Alabama	1-8	9-17	18-25
Arizona	High	Medium	Low
Arkansas	High	Medium-High, Medium, Low-Medium	Low
California	High	Medium	Low
Colorado	Category 1	Categories 2, 3	Category 4
Florida	High	Medium	Low
Hawaii	High	High-Medium, Medium	Low
Louisiana	Very High	High, Medium-High, Medium	Low
Maryland	High	High-Medium, Medium, Low-Medium	Low
Minnesota	1-4	5-8	9-12
Mississippi	High	Medium	Low
North Dakota	1-3	4-8	9-11
Ohio	Group A	Group B	Group C
Texas	1-4	5-10	11-14
Utah	High	Medium-High, Medium, Medium-Low	Low
Vermont	1-3	4-7	8-10
Wisconsin Tribes (cancer)	Very High	High, Medium	Low
Wisconsin Tribes (non-cancer)	Very High	High, Medium	Low
Guam (cancer)	1	2, 3, 4	5
Guam (non-cancer)	1	2, 3, 4	5
Northeast Ohio	High	Medium-High, Medium, Medium-Low	Low
Clinton County, Ohio	1	2-4	5
Columbus, Ohio	High	Medium-High, Medium, Medium-Low	Low
Denver, Colorado	I	II	III
Washington, DC	High	Medium	Low

Appendix D. Results of Quantitative Analysis - "Highest" Rule

	Total		High		Medium		Low		Index Scoring System	
	Times	*%*	*Times*	*%*	*Times*	*%*	*Times*	*%*	*Raw*	*Weighted*
ENVIRONMENTAL PROBLEM AREA										
Abandoned Industrial Sites	1	3%	1	3%	0	0%	0	0%	3	3.00
Abandoned Water Wells	1	3%	0	0%	1	3%	0	0%	2	2.00
Accidental Releases	23	59%	4	10%	13	33%	6	15%	44	1.91
Acid Deposition	9	23%	0	0%	5	13%	4	10%	14	1.56
Air Quality General	1	3%	0	0%	0	0%	1	3%	1	1.00
Allergens and Valley Fever	1	3%	1	3%	0	0%	0	0%	3	3.00
Alteration of pH, Salinity, or Hardness of Water	1	3%	0	0%	0	0%	1	3%	1	1.00
Animal Vectors of Human Diseases	2	5%	0	0%	1	3%	1	3%	3	1.50
Animal-Human Health	1	3%	0	0%	1	3%	0	0%	2	2.00
Biological Diversity	2	5%	0	0%	1	3%	1	3%	3	1.50
Biotechnology	1	3%	0	0%	0	0%	1	3%	1	1.00
Channelization of Streams and Rivers	1	3%	0	0%	0	0%	1	3%	1	1.00
Chemical Management (Consumer and Agricultural)	3	8%	0	0%	1	3%	2	5%	4	1.33
Construction of Dams	1	3%	0	0%	0	0%	1	3%	1	1.00
Contaminated Sludge	4	10%	0	0%	1	3%	3	8%	5	1.25
Deep Well Injection	2	5%	0	0%	2	5%	0	0%	4	2.00
Dredging	2	5%	0	0%	0	0%	2	5%	2	1.00
Drinking Water Pollution	30	77%	6	15%	21	54%	3	8%	63	2.10
Ecological Balance	1	3%	0	0%	0	0%	1	3%	1	1.00
Electromagnetic Fields	2	5%	0	0%	0	0%	2	5%	2	1.00
Environmental Stewardship	1	3%	1	3%	0	0%	0	0%	3	3.00
Feedlots	1	3%	0	0%	1	3%	0	0%	2	2.00
Flooding	2	5%	0	0%	0	0%	2	5%	2	1.00
Food Quality	18	46%	7	18%	11	28%	0	0%	43	2.39
Global Climate Change	9	23%	1	3%	3	8%	5	13%	14	1.56
Green Space (Loss, Lack of)	1	3%	0	0%	0	0%	1	3%	1	1.00
Groundwater Pollution	25	64%	2	5%	20	51%	3	8%	49	1.96

Appendix D. Results of Quantitative Analysis - "Highest" Rule (cont'd)

	Total		**High**		**Medium**		**Low**		**Index Scoring System**	
	Times	*%*	*Times*	*%*	*Times*	*%*	*Times*	*%*	*Raw*	*Weighted*
ENVIRONMENTAL PROBLEM AREA										
Habitat Modification/Ecosystem Alteration	10	26%	0	0%	2	5%	8	21%	12	1.20
Hazardous Waste	32	82%	3	8%	24	62%	5	13%	62	1.94
Healthcare Facilities	1	3%	0	0%	0	0%	1	3%	1	1.00
Illegal Dumping	1	3%	0	0%	0	0%	1	3%	1	1.00
Indoor Air Pollution	36	92%	29	74%	7	18%	0	0%	101	2.81
Land Use and Preservation	1	3%	0	0%	1	3%	0	0%	2	2.00
Landfill Sites	3	8%	1	3%	1	3%	1	3%	6	2.00
Lead	17	44%	9	23%	6	15%	2	5%	41	2.41
Lighting	1	3%	0	0%	0	0%	1	3%	1	1.00
Litter	2	5%	0	0%	0	0%	2	5%	2	1.00
Medical Waste	3	8%	0	0%	1	3%	2	5%	4	1.33
Microbiological Contaminants	1	3%	0	0%	1	3%	0	0%	2	2.00
Mining Waste/Milling Waste	5	13%	0	0%	4	10%	1	3%	9	1.80
Mining, Roads, Trash	1	3%	0	0%	0	0%	1	3%	1	1.00
Natural Resources-Harvesting	1	3%	0	0%	0	0%	1	3%	1	1.00
Natural/Geologic Hazards	3	8%	0	0%	1	3%	2	5%	4	1.33
Noise Pollution	8	21%	0	0%	2	5%	6	15%	10	1.25
Odor Pollution	1	3%	0	0%	1	3%	0	0%	2	2.00
Oil and Gas Exploration	1	3%	0	0%	1	3%	0	0%	2	2.00
Outdoor Air Pollution	37	100%	20	51%	17	46%	0	0%	94	2.54
Parks	1	3%	0	0%	0	0%	1	3%	1	1.00
Pesticides	23	59%	8	21%	14	36%	1	3%	53	2.30
Pests and Pest Management	4	10%	1	3%	1	3%	2	5%	7	1.75
Population Change	1	3%	0	0%	1	3%	0	0%	2	2.00
Radiation Exposure (Other Than Indoor Radon)	25	64%	3	8%	12	31%	10	26%	43	1.72
Radioactive Waste Issues	3	8%	0	0%	2	5%	1	3%	5	1.67

Appendix D. Results of Quantitative Analysis - "Highest" Rule (cont'd)

	Total		**High**		**Medium**		**Low**		**Index Scoring System**	
	Times	*%*	*Times*	*%*	*Times*	*%*	*Times*	*%*	*Raw*	*Weighted*
ENVIRONMENTAL PROBLEM AREA										
Recreation	1	3%	0	0%	0	0%	1	3%	1	1.00
Recreation Areas (Loss of)	1	3%	0	0%	1	3%	0	0%	2	2.00
Recycling	1	3%	0	0%	1	3%	0	0%	2	2.00
Resource Extraction	1	3%	0	0%	0	0%	1	3%	1	1.00
Road Salt	1	3%	0	0%	0	0%	1	3%	1	1.00
Septic Tanks	3	8%	0	0%	1	3%	2	5%	4	1.33
Sewage Treatment	1	3%	0	0%	0	0%	1	3%	1	1.00
Soil Quality	1	3%	0	0%	1	3%	0	0%	2	2.00
Solid/Non-Hazardous Waste	27	69%	1	3%	17	44%	9	23%	46	1.70
Storage Tanks (Releases/Leaks)	27	69%	0	0%	14	36%	13	33%	41	1.52
Stratospheric Ozone Depletion	18	46%	7	18%	9	23%	2	5%	41	2.28
Surface Water Pollution	35	90%	3	8%	25	64%	7	18%	66	1.89
Tire Management	1	3%	0	0%	1	3%	0	0%	2	2.00
Toxics	19	49%	7	18%	7	18%	5	13%	40	2.11
Transportation Pollution	1	3%	0	0%	1	3%	0	0%	2	2.00
Uncontrolled Grass and Weeds	1	3%	0	0%	0	0%	1	3%	1	1.00
Urban Environment (Quality of)	1	3%	0	0%	0	0%	1	3%	1	1.00
Urban Sprawl	3	8%	0	0%	1	3%	2	5%	4	1.33
Visual and Cultural Degradation	1	3%	0	0%	1	3%	0	0%	2	2.00
Waste Issues	4	10%	0	0%	1	3%	3	8%	5	1.25
Wastewood Disposal or Treatment	1	3%	0	0%	0	0%	1	3%	1	1.00
Water Quality (General)	3	8%	1	3%	2	5%	0	0%	7	2.33
Water Supply/Water Quantity	4	10%	1	3%	1	3%	2	5%	7	1.75
Wetlands	1	3%	0	0%	0	0%	1	3%	1	1.00
Yard Waste	1	3%	0	0%	0	0%	1	3%	1	1.00

Appendix E. Results of Quantitative Analysis - "Average" Rule

	Total		**High**		**Medium**		**Low**		**Index Scoring System**	
	Times	*%*	*Times*	*%*	*Times*	*%*	*Times*	*%*	*Raw*	*Weighted*
ENVIRONMENTAL PROBLEM AREA										
Abandoned Industrial Sites	1	3%	1	3%	0	0%	0	0%	3	3.00
Abandoned Water Wells	1	3%	0	0%	1	3%	0	0%	2	2.00
Accidental Releases	23	59%	4	10%	13	33%	6	15%	44	1.91
Acid Deposition	9	23%	0	0%	5	13%	4	10%	14	1.56
Air Quality General	1	3%	0	0%	0	0%	1	3%	1	1.00
Allergens and Valley Fever	1	3%	1	3%	0	0%	0	0%	3	3.00
Alteration of pH, Salinity, or Hardness of Water	1	3%	0	0%	0	0%	1	3%	1	1.00
Animal Vectors of Human Diseases	2	5%	0	0%	1	3%	1	3%	3	1.50
Animal-Human Health	1	3%	0	0%	1	3%	0	0%	2	2.00
Biological Diversity	2	5%	0	0%	1	3%	1	3%	3	1.50
Biotechnology	1	3%	0	0%	0	0%	1	3%	1	1.00
Channelization of Streams and Rivers	1	3%	0	0%	0	0%	1	3%	1	1.00
Chemical Management (Consumer and Agricultural)	3	8%	0	0%	1	3%	2	5%	4	1.33
Construction of Dams	1	3%	0	0%	0	0%	1	3%	1	1.00
Contaminated Sludge	4	10%	0	0%	1	3%	3	8%	5	1.25
Deep Well Injection	2	5%	0	0%	2	5%	0	0%	4	2.00
Dredging	2	5%	0	0%	0	0%	2	5%	2	1.00
Drinking Water Pollution	30	77%	6	15%	21	54%	3	8%	63	2.10
Ecological Balance	1	3%	0	0%	0	0%	1	3%	1	1.00
Electromagnetic Fields	2	5%	0	0%	0	0%	2	5%	2	1.00
Environmental Stewardship	1	3%	1	3%	0	0%	0	0%	3	3.00
Feedlots	1	3%	0	0%	1	3%	0	0%	2	2.00
Flooding	2	5%	0	0%	0	0%	2	5%	2	1.00
Food Quality	18	46%	7	18%	11	28%	0	0%	43	2.39
Global Climate Change	9	23%	1	3%	3	8%	5	13%	14	1.56
Green Space (Loss, Lack of)	1	3%	0	0%	0	0%	1	3%	1	1.00
Groundwater Pollution	25	64%	2	5%	20	51%	3	8%	49	1.96

Appendix E. Results of Quantitative Analysis - "Average" Rule (cont'd)

	Total		High		Medium		Low		Index Scoring System	
	Times	*%*	*Times*	*%*	*Times*	*%*	*Times*	*%*	*Raw*	*Weighted*
ENVIRONMENTAL PROBLEM AREA										
Habitat Modification/Ecosystem Alteration	10	26%	0	0%	2	5%	8	21%	12	1.20
Hazardous Waste	32	82%	3	8%	24	62%	5	13%	62	1.94
Healthcare Facilities	1	3%	0	0%	0	0%	1	3%	1	1.00
Illegal Dumping	1	3%	0	0%	0	0%	1	3%	1	1.00
Indoor Air Pollution	36	92%	27	69%	9	23%	0	0%	99	2.75
Land Use and Preservation	1	3%	0	0%	1	3%	0	0%	2	2.00
Landfill Sites	3	8%	1	3%	1	3%	1	3%	6	2.00
Lead	17	44%	9	23%	6	15%	2	5%	41	2.41
Lighting	1	3%	0	0%	0	0%	1	3%	1	1.00
Litter	2	5%	0	0%	1	3%	1	3%	3	1.50
Medical Waste	3	8%	0	0%	1	3%	2	5%	4	1.33
Microbiological Contaminants	1	3%	0	0%	1	3%	0	0%	2	2.00
Mining Waste/Milling Waste	5	13%	0	0%	4	10%	1	3%	9	1.80
Mining, Roads, Trash	1	3%	0	0%	1	3%	0	0%	2	2.00
Natural Resources-Harvesting	1	3%	0	0%	0	0%	1	3%	1	1.00
Natural/Geologic Hazards	3	8%	0	0%	1	3%	2	5%	4	1.33
Noise Pollution	8	21%	0	0%	2	5%	6	15%	10	1.25
Odor Pollution	1	3%	0	0%	1	3%	0	0%	2	2.00
Oil and Gas Exploration	1	3%	0	0%	1	3%	0	0%	2	2.00
Outdoor Air Pollution	37	95%	13	33%	23	59%	1	3%	86	2.32
Parks	1	3%	0	0%	0	0%	1	3%	1	1.00
Pesticides	23	59%	8	21%	14	36%	1	3%	53	2.30
Pests and Pest Management	4	10%	1	3%	1	3%	2	5%	7	1.75
Population Change	1	3%	0	0%	1	3%	0	0%	2	2.00
Radiation Exposure (Other Than Indoor Radon)	25	64%	1	3%	14	36%	10	26%	41	1.64
Radioactive Waste Issues	3	8%	0	0%	2	5%	1	3%	5	1.67

Appendix E. Results of Quantitative Analysis - "Average" Rule (cont'd)

	Total		High		Medium		Low		Index Scoring System	
	Times	*%*	*Times*	*%*	*Times*	*%*	*Times*	*%*	*Raw*	*Weighted*
ENVIRONMENTAL PROBLEM AREA										
Recreation	1	3%	0	0%	0	0%	1	3%	1	1.00
Recreation Areas (Loss of)	1	3%	0	0%	1	3%	0	0%	2	2.00
Recycling	1	3%	0	0%	1	3%	0	0%	2	2.00
Resource Extraction	1	3%	0	0%	0	0%	1	3%	1	1.00
Road Salt	1	3%	0	0%	0	0%	1	3%	1	1.00
Septic Tanks	3	8%	0	0%	1	3%	2	5%	4	1.33
Sewage Treatment	1	3%	0	0%	0	0%	1	3%	1	1.00
Soil Quality	1	3%	0	0%	1	3%	0	0%	2	2.00
Solid /Non-Hazardous Waste	27	69%	0	0%	18	46%	9	23%	45	1.67
Storage Tanks (Releases/Leaks)	27	69%	0	0%	14	36%	13	33%	41	1.52
Stratospheric Ozone Depletion	18	46%	7	18%	9	23%	2	5%	41	2.28
Surface Water Pollution	35	90%	0	0%	27	69%	8	21%	62	1.77
Tire Management	1	3%	0	0%	1	3%	0	0%	2	2.00
Toxics	19	49%	7	18%	7	18%	5	13%	40	2.11
Transportation Pollution	1	3%	0	0%	1	3%	0	0%	2	2.00
Uncontrolled Grass and Weeds	1	3%	0	0%	0	0%	1	3%	1	1.00
Urban Environment (Quality of)	1	3%	0	0%	0	0%	1	3%	1	1.00
Urban Sprawl	3	8%	0	0%	1	3%	2	5%	4	1.33
Visual and Cultural Degradation	1	3%	0	0%	1	3%	0	0%	2	2.00
Waste Issues	4	10%	0	0%	1	3%	3	8%	5	1.25
Wastewood Disposal or Treatment	1	3%	0	0%	0	0%	1	3%	1	1.00
Water Quality (General)	3	8%	1	3%	2	5%	0	0%	7	2.33
Water Supply/Water Quantity	4	10%	1	3%	1	3%	2	5%	7	1.75
Wetlands	1	3%	0	0%	0	0%	1	3%	1	1.00
Yard Waste	1	3%	0	0%	0	0%	1	3%	1	1.00

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