APPROACHES TO ASSESSING THE BENEFITS, COSTS, AND IMPACTS OF THE RCRA SUBTITLE C PROGRAM

Draft Report

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INTRODUCTION AND OVERVIEW CHAPTER 1

The EPA Office of Solid Waste and Emergency Response (OSWER) is developing a framework for characterizing and analyzing the costs and benefits (including environmental, health, and other human welfare benefits) and other impacts of its various environmental programs. In the first step this effort, OSWER identified a comprehensive set of program attributes that describe a broad range of potential impacts that may result from OSWER programs.[1] This report represents the second step of this initiative, which is to develop potential methods OSWER could use to qualitatively or quantitatively characterize those attributes.

OSWER expects that the results of implementing the methods described in this report would be reviewed and used by both internal EPA managers as well as external stakeholders with an interest in the OSWER program performance. To this end, OSWER has identified among its attributes some benefit/cost categories that are still evolving and being actively debated in economic circles (e.g., sustainability), but are nevertheless important to those trying to gain an understanding of program impacts. In addition, OSWER believed it was important to go beyond the attributes typically considered in a traditional benefit/cost analysis to characterize and describe other program features and factors that influence the design, implementation, performance, and impacts of OSWER programs. The results of implementing the methods in this report, therefore, are intended to provide a broad-based program assessment, rather than just a traditional benefit/cost analysis.

OSWER selected two programs to serve as pilots to test the practical application of these attributes in characterizing and measuring program impacts: the Resource Conservation and Recovery Act (RCRA) Subtitle C prevention and waste minimization program, and the Underground Storage Tank (UST) cleanup program. As part of this pilot, Industrial Economics, Incorporated (IEc) is developing a range of potential methods (from relatively simple to more complex) for characterizing and/or quantifying the OSWER attributes that are relevant to each of these programs.

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[1] See Henry Roman, Thomas Walker, and Dr. Kimberly Thompson, *Risk, Cost, and Benefit Attributes for OSWER*, an unpublished memorandum prepared for EPA OSWER Comparative Risk Group, Office of Solid Waste and Emergency Response, December 31, 1998, and Exhibit 1-1 in this chapter.

The purpose of this report is to present the proposed methodologies we have developed for assessing the benefits, costs, distributional impacts, and other key features of the RCRA Subtitle C and waste minimization program. We also describe the advantages, disadvantages, and data requirements associated with the different methods.[2] Based on OSWER direction, we focused on development of methods for performing a retrospective analysis of the RCRA program.

1.1 BACKGROUND

The RCRA Subtitle C program governs practices related to the generation, management, and disposal of hazardous wastes. A series of RCRA regulations issued by EPA since 1980 have established a broad range of technical, tracking and reporting requirements for facilities that generate or manage hazardous waste. These requirements establish a far-reaching, "cradle-to-grave" system of regulations whose purpose is to assure that wastes, once generated, are properly treated, stored, transported, and disposed of in facilities that are protective of human health and the environment. All facilities generating or managing significant amounts of hazardous waste must obtain permits, meet technical specifications for waste management, comply with an extensive manifest system that tracks the transport and disposal of waste, and employ inspection and monitoring systems to prevent damage from accidental releases. In addition, the regulations prohibit land-based disposal for certain wastes, restrict facility siting in flood plains and other sensitive areas, and contain financial assurance provisions to guarantee that facilities will be able to properly address accidents and close down waste management units.

The RCRA waste minimization program also coordinates initiatives to induce industry to reduce the both the overall amount and toxicity (i.e., the quantity of persistent, bioaccumulative, and toxic constituents) of hazardous waste that is generated. These initiatives may produce benefits in the form of cost savings that accrue to industry for managing smaller quantities of waste; risk reductions because a smaller quantity of waste is managed; and potential reductions in cross-media transfer, non-compliance-related risk, and demand for landfill space.[3]

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[2] This memorandum is submitted under Task 3 of Work Assignment 2-37, EMRAD Contract 68-W6-0061. The Underground Storage Tank Cleanup Program methodologies are described in a separate memorandum under Task 2 of Work Assignment 2-37.

[3] Even when hazardous wastes are stringently regulated and managed, they may sometimes pose environmental concerns. Accidents during handling and transportation of hazardous wastes, for example, can result in releases to the environment or unexpected occupational exposures. In addition, waste minimization helps reduce risks from constituents that are difficult to manage using certain practices (e.g., metals, which are not destroyed by combustion and remain potentially available to the environment).

In 1996, OSWER initiated an effort aimed at improving its ability to characterize and communicate past and future program accomplishments and to improve decision making and strategic planning. This effort was prompted in part by recent calls for increased use of risk-based priority setting, benefit-cost analysis, and comparative risk analysis in EPA decision-making. OSWER has developed a comprehensive set of attributes that would represent the broad range of benefits, costs and distributional impacts that could apply to all OSWER programs and activities. Exhibit 1-1 lists these attributes.

Exhibit 1-1 presents OSWER's attributes in four general categories: Social Benefits, Social Costs, Distributional Impacts, and Program Context Attributes. The first two categories (i.e., Social Benefits and Social Costs) include those attributes that measure net economic benefits and costs associated with specific program results. Distributional impact attributes, in contrast, are not additive to the benefits and costs, but are instead metrics for identifying the allocation of costs and benefits of the regulation throughout society, and examining "who" in society is recipient of positive and negative impacts of the regulation. While distributional impacts do not represent net benefits or costs, they frequently identify results important to policy-makers.

The fourth category (Program Context Attributes) is a diverse set of attributes. This category includes some attributes that might represent net benefits (e.g., long-term behavioral change), but are difficult or impossible to measure, or difficult to isolate from other benefit and cost categories. Others are factors (e.g., stakeholder issues, legal constraints) or program initiatives (e.g., regulatory reinvention initiatives) that affect program performance and therefore might be important to policy-makers, but are not themselves measurable as benefits or costs.

This broad set of attributes is a "starting point" for OSWER programs to use in identifying potentially relevant attributes. The list serves as a menu from which program managers can select those attributes that most meaningfully contribute to characterizing the benefits, costs, and distributional impacts of their programs. Methods can then be developed for measuring those particular attributes.[4] It is hoped that at least some of the methods that are developed for one program could be useful in whole or in part to another OSWER program trying to measure that same attribute.

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[4] Exhibit 1-1 contains several attributes and examples that may potentially double-count certain benefits and costs, or may be addressed as real costs or benefits in a traditional benefit-cost analysis, and may also be addressed in a distributional analysis or a discussion of program context attributes. For example, transitional social costs such as job losses could represent real costs (or real gains, if a regulation resulted in new jobs). In addition, both job losses and job gains in different regions or industry sectors could be examined as distributional impacts of a regulatory program. In developing and implementing approaches to assessing specific programs policy-makers should carefully address issues of double-counting.

OSWER selected its RCRA Subtitle C and hazardous waste minimization program to serve as a pilot study for developing methods suitable for evaluating and communicating the performance of OSWER prevention-based programs. A parallel pilot study of the Underground Storage Tank cleanup program is addressing methods related to remediation of contaminant releases.

As a first step in the Subtitle C pilot, RCRA program staff selected from Exhibit 1-1 those attributes that, based on their experience, seemed most relevant to characterizing the benefits, costs, and distributional impacts of the prevention program. The purpose of this report is to identify and develop potential methods for characterizing and measuring those attributes; identify data and information requirements associated with those methods; determine data availability from federal, state, and local agencies and private sources; and discuss the advantages and disadvantages associated with the different methodological options. For benefits, costs, and distributional impacts, the report also considers an explicit long-term effects category. This category focuses on effects in future generations, an area of considerable importance to the Subtitle C program.

The methods are also expected to support OSWER's reporting under the Government Performance and Results Act (GPRA), which requires government agencies to develop methods for assessing the goals and performance of their programs. For the RCRA Subtitle C and hazardous waste minimization programs, the current long-term GPRA subobjectives are, respectively:

- By 2005, at least 85 percent of hazardous waste management facilities located in the United States, its territories, or on tribal lands will have permits or approved controls in place to prevent dangerous releases to air, soil, and groundwater.

- By 2005, reduce by 50 percent from 1991 levels the volume of priority persistent, bioaccumulative, and toxic (PBT) wastes in hazardous waste streams (to be listed by EPA in FY 2000) through voluntary partnerships and pollution prevention initiatives.

In Chapter 8 we discuss how the proposed methods can contribute to characterizing the impacts of the Subtitle C and hazardous waste minimization programs to support OSWER's GPRA performance reporting.

Exhibit 1-1 OSWER ATTRIBUTES MATRIX	
Attribute Category	**Attributes**
SOCIAL BENEFITS	
Human Health Benefits	
Individual Risk	1. Mortality Reduction - Examples: • Reduced risk of cancer fatality • Reduced risk of acute fatality 2. Morbidity Reduction - Examples: • Reduced risk of cancer • Reduced risk of asthma • Reduced risk of nausea • Reduced risk of acute health effects and injuries
Population Risk	
Ecological Benefits	
Market Ecological Values	Examples: 1. Commercial fisheries 2. Monetized recreational benefits 3. Food 4. Fuel 5. Fiber 6. Timber 7. Fur/leather
Non-Market Ecological Values and Amenities	Examples: 1. Recreational enjoyment 2. Non-use values: existence, bequest, and quasi-option values
Indirect Ecosystem and Resource Conservation Impacts	Examples: 1. Climate moderation 2. Flood moderation 3. Groundwater recharge 4. Sediment trapping 5. Soil retention 6. Nutrient cycling 7. Pollination by wild species 8. Biodiversity 9. Water filtration 10. Soil fertilization 11. Pest control 12. Reduced pressure on endangered species 13. Avoided habitat destruction
Avoided Costs	Examples: 1. Avoided costs of providing government mandated alternate drinking water supplies 2. Avoided costs associated with government mandated cleanups of chemical accidents or spills
Avoided Materials Damages, Improved Aesthetics and Historical Preservation	Examples: 1. Aesthetic pleasure 2. Improved taste, odor, visibility 3. Protection of resources with cultural and historic value 4. Protection of constructed resources (e.g., buildings, infrastructure)

Exhibit 1-1 OSWER ATTRIBUTES MATRIX	
Potential Long-Term Benefits (Sustainability)	Examples: 1. Avoided increases in damages related to changes in affected populations 2. Benefits associated with resource conservation 3. Benefits associated with the precautionary principle: protection from unforeseen issues 4. Benefits from long-term increases in the value of environmental quality
SOCIAL COSTS	
Compliance Costs	Examples: 1. Capital costs of new or retrofitted equipment 2. Operation and maintenance of new or retrofitted equipment 3. Waste capture and disposal 4. Changes in production processes or inputs 5. Maintenance changes in other equipment
Regulatory Costs (Government Sector)	Examples: 1. Training/administration 2. Monitoring/reporting 3. Enforcement/litigation 4. Permitting
Social Welfare Losses	Examples: 1. Higher consumer and producer prices 2. Legal/administrative costs
Transitional Social Costs	Examples: 1. Unemployment 2. Firm closings 3. Transaction costs 4. Disrupted production
Long-term Costs	Examples: 1. Potential failure to benefit from technology advances, decreases in cost 2. Potential failure to invest in more productive activities
DISTRIBUTIONAL IMPACTS	
Equity Effects	Examples: 1. Public/private distribution of costs 2. Enforcement of "polluter pays" principle 3. Environmental Justice and impacts on sensitive sub-populations 4. Inter-generational equity
Economic Impacts Positive	Examples: 1. Job creation/support 2. Increased tax revenue 3. Small business cost savings 4. Small government and non-profit cost savings
Negative	Examples: 1. Job losses 2. Plant closures 3. Small business closures 4. Negative impacts on small governments and non-profits

Exhibit 1-1 OSWER ATTRIBUTES MATRIX	
Risk Tradeoffs	Major risk increases or transfers: 1. Risk of worker exposures or accidents during response 2. Risk to neighbors during cleanup 3. Risks from transport & disposal of hazardous waste 4. Risks from substitutions of untested compounds for PB&T compounds as part of waste minimization effort
PROGRAM CONTEXT ATTRIBUTES	
Constraints	Legal/Statutory requirements: 1. Statutory mandates 2. Court orders 3. Budget riders 4. Threat of legal action
Stakeholder Issues	Examples: 1. Intensity of feeling (program addresses a problem for which there is high stakeholder interest; incorporates public's "dread") 2. Value of information systems, providing information to stakeholders 3. Empowers co-implementors (e.g., Tribes, states)
Other Program Context Attributes	Examples: 1. Technology forcing 2. Long-term behavioral change 3. "Streamlining:" increased efficiency and cost-effectiveness of site cleanup and redevelopment 4. Leveraged private/public investment 5. Supports EPA reinvention initiatives not otherwise listed in this matrix (e.g., paperwork reduction) 6. Other _____
Source: Industrial Economics, *Risk, Cost, and Benefit Attributes for OWSER*, an unpublished memorandum prepared for EPA's Office of Solid Waste and Emergency Response, December 31, 1998, as modified to reflect information in EPA's *Guidelines for Preparing Economic Analyses*, Environmental Protection Agency Science Advisory Board Review Draft, June 11, 1999.	

1.2 SCOPE OF THE RCRA SUBTITLE C ANALYSIS

This report identifies methodologies that address the effects of changes in hazardous waste generation and management under existing RCRA Subtitle C prevention programs. We define the scope of our analysis as follows:

RCRA Hazardous Waste: Our analysis focuses on Subtitle C prevention programs that establish and govern practices for the proper generation, management, and disposal of hazardous wastes. This includes all listed and characteristic wastes addressed under Subtitle C of RCRA in any of its rule-makings. However, we do not address regulations governing RCRA Subtitle D industrial or municipal wastes, or the use and disposal of toxic or hazardous materials that are not governed under RCRA. Toxic materials outside the scope of this analysis include non-waste materials regulated under separate statutes such as the Toxic Substances Control Act (TSCA), and certain

materials regulated as hazardous or toxic by other federal agencies such as the Department of Transportation.

Prevention Activities: Our proposed methods address activities related to the prevention of improper waste disposal, and do not address activities related to the cleanup or remediation of existing hazardous waste sites.[5] In other words, we do not address the costs and benefits of activities under RCRA's Subpart S Corrective Action program or under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Also, while we recognize that immediate response actions required as part of monitoring under RCRA can reasonably be considered prevention activities in that they can prevent releases from causing environmental damage, we have not yet isolated the costs of immediate response activities or determined their contribution to the program. We recommend that this issue be addressed before a complete analysis of RCRA is undertaken.

Retrospective Analysis: We present methodologies for developing a retrospective analysis of the RCRA program. That is, we examine only waste generation and disposal that has taken place prior to year 2000, and do not attempt to include benefits from future developments in waste management. We also remove from consideration impacts associated with management and disposal of waste prior to the implementation of RCRA regulations (i.e., before 1980). However, we do consider future releases and damage that may result from past and current "with-RCRA" waste generation and management practices (i.e., from 1980 to 2000) in calculating benefits, as well as the potential current and future damage that would have occurred in the absence of the regulation.

1.3 WITH-RCRA AND WITHOUT-RCRA SCENARIOS

To identify and evaluate the changes in practice that have resulted from the RCRA Subtitle C program, we define two scenarios: a baseline "without-RCRA" scenario and an actual "with-RCRA" scenario. The without-RCRA baseline estimates the effects of the hypothetical continuation of pre-RCRA waste management practices in the absence of the prevention program. Our without-RCRA scenario assumes that RCRA Subtitle C programs do not exist in any form; we remove both the prevention and the Corrective Action programs from consideration in this scenario. However, the "without-RCRA scenario" does assume the existence of the Superfund program under CERCLA; this program primarily implements hazardous waste remediation at "closed" or inactive facilities.

Note that while we assume that the Superfund program exists and addresses past contamination incidents, our without-RCRA scenario does not assume that remediation occurs at

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[5] We use the term "hazardous waste site" to describe a hypothetical site that would require cleanup under state or federal hazardous waste programs (e.g., Superfund). However, the term is not intended to describe a site of particular size, or to designate a site governed by a particular regulatory program.

active facilities or sites, or that remediation addresses post-1980 spills. Instead, we make the simplifying assumption that Superfund (and Subpart S Correction Action) addresses the remediation of contaminated sites existing in 1980 and RCRA Subtitle C, starting in 1980, addresses all post-1980 contamination associated with active facilities (i.e., through prevention and response requirements). We do not attempt to predict the application of the Superfund program to active sites in the absence of RCRA, or to identify prevention measures taken by facilities to avoid Superfund liability. In reality it is unlikely that either RCRA or Superfund (or state programs) could "take credit" for all prevention-related benefits, but we are unable to isolate the effects of specific programs.[6]

Our with-RCRA scenario reflects the generation and management of hazardous waste in the presence of all RCRA Subtitle C and state (RCRA-equivalent) hazardous waste prevention programs. This scenario includes existing and future environmental damage from hazardous waste management and disposal that took place before 1980 (i.e., damage that was not avoided by RCRA regulations). The "with-RCRA" facility population and waste management practices are represented by reporting data in the Biennial Reporting System (BRS) and by information in Resource Conservation and Recovery Information System (RCRIS), a database that combines several earlier EPA databases with information about facilities that generate and manage hazardous waste.

We make two simplifying assumptions at this stage of our methodology development. First, we assume that there is 100 percent compliance with all regulations included in the scenarios.[7] Second, we focus on facilities regulated under federal programs, and do not specifically address the contribution of state programs in either the baseline or the without-RCRA scenarios. However, a complete analysis of RCRA benefits and costs should consider both the effects non-compliance and the effects of activities under "RCRA-inspired" state hazardous waste programs. We address these issues in more detail in our discussion of further analysis in Chapter 8.

It is important to note, however, that because the purpose of this report is to present a preliminary range of methodologies for characterizing the RCRA Subtitle C program, we have focused on detailing those assumptions that are most critical for this early stage of option evaluation.

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[6] Note that it is possible to incorporate remediation into a without-RCRA scenario; doing so would require that both the avoided costs and benefits associated with remediation be incorporated into the benefits estimate.

[7] Section 5.3.2 of EPA's *Guidelines for Preparing Economic Analyses* suggests that it is reasonable in most cases for analysts to assume total compliance with regulatory scenarios. However we suggest a sensitivity analysis to address the potential effects of non-compliance with RCRA Subtitle C regulations, because the costs associated with hazardous waste management may provide considerable economic incentives for illegal waste disposal. See also *Guidelines for Preparing Economic Analyses,* Science Advisory Board Review Draft, US Environmental Protection Agency, June 11, 1999.

There are additional assumptions and design details that would need to be developed if a particular approach is selected for implementation, but we do not attempt to address all of the design and implementation issues at this time.

1.4 SUMMARY OF CHANGES IN WASTE GENERATION AND MANAGEMENT EXPECTED UNDER RCRA

The RCRA Subtitle C prevention program mandated large-scale changes in behavior that are, in turn, associated with improvements in the quality of human health and the environment. The general benefits of the program are associated with the following changes:

- **Closure/conversion of treatment, storage, and disposal (TSD) facilities with pre-RCRA hazardous waste management practices.** A reduction in the number of low quality TSD facilities results in fewer sites with the potential for spills, accidents, and environmental damage.

- **Improved waste management practices at TSDs.** The improvement of waste management practices at existing TSDs results in fewer releases that may cause environmental damage, and improved practices for addressing the handling of waste and waste releases.

- **Closure/conversion of facilities generating hazardous waste.** A reduction in the number of hazardous waste generators results in fewer sites with the potential for spills, accidents, and environmental damage.

- **Improved waste management practices at generator and transporter facilities.** Improved storage, container, and transport manifest practices at facilities that generate hazardous waste results in fewer accidental releases and fewer incidents of improper waste disposal.[8]

- **Reduction in waste quantities generated.** A reduction in the quantity of hazardous waste generated reduces the overall risk of environmental damage from the release of hazardous wastes.

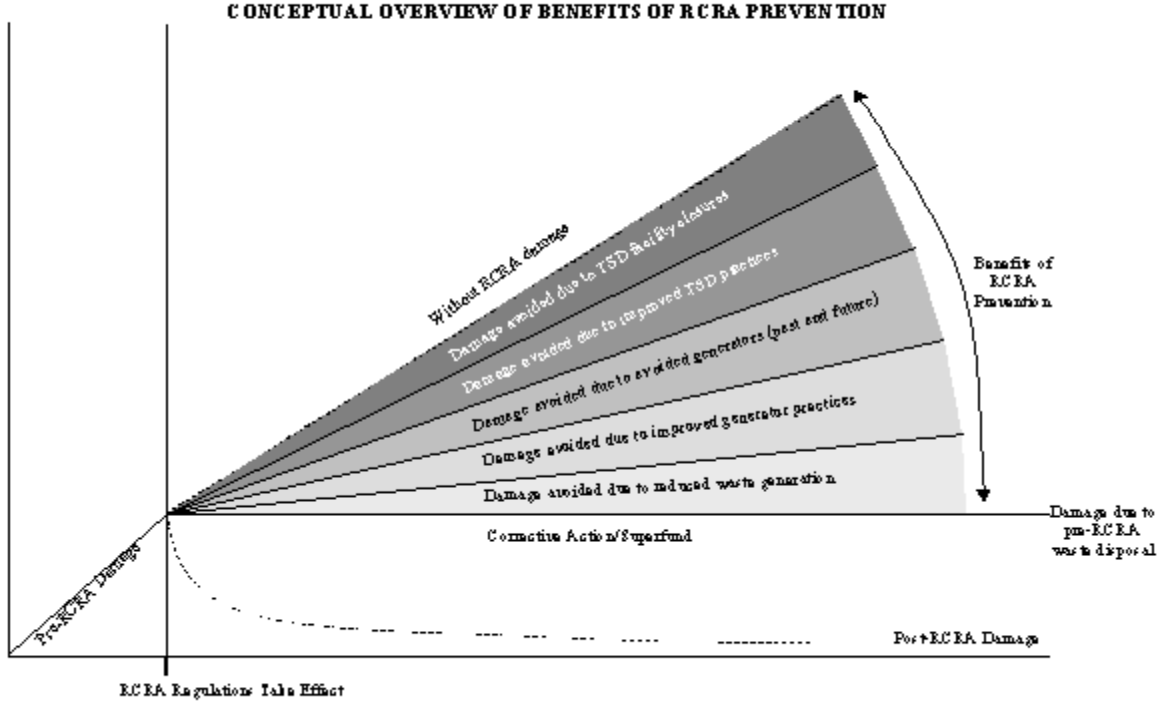
Each of these changes in behavior may have a wide range of associated impacts (or attributes) that describe its overall effects on the environment and economy. Benefits include reductions in human health and ecological risk, avoided costs associated with remediation and treatment of health effects, and long-term benefits such as the preservation of resources for future

[8] This category of benefits is the one most likely to be affected by rates of non-compliance.

generations. In addition, changes under RCRA increase compliance costs, and may have local and national economic impacts such as changes in employment opportunities and technological development, distributional shifts in environmental and economic equity, and possible additional risks associated with changes in transportation or waste handling. While it is not possible to establish the relative magnitude of the benefits associated with each of these changes in behavior, Exhibit 1-2 provides a conceptual overview of the potential benefits of the RCRA prevention program.

Exhibit 1-2

CONCEPTUAL OVERVIEW OF BENEFITS OF RCRA PREVENTION



1.5 APPROACHES TO MEASURING RCRA ATTRIBUTES

We present four general approaches to developing an estimate of the benefits of RCRA. The Property Value Estimate (Approach A, described in detail in Chapter 2) is a simplified approach that provides a single property value-based monetary estimate of the benefits associated with avoiding contaminated sites due to the closure of pre-RCRA TSDs. The estimate of avoided property value loss presents a combined "market value" for a number of benefits attributes, though no individual attribute is specifically measured. This approach is limited in both specificity and scope; it considers only the benefits and impacts of facility closures and avoided hazardous waste sites. However, it

is not particularly resource intensive relative to other proposed options; a limited number of available data sources are required to establish a program-wide estimate.

Chapter 3 presents three distinct approaches that aim to develop more specific descriptions of human health, ecological, and other benefits. All of these approaches incorporate the use of pathway modeling to describe human health and ecological impacts of RCRA regulations, though the approaches differ both in required data and in modeling approaches. Approach B is based on site-specific facility modeling, and uses facility and modeling data collected for the sample of facilities studied in the *Draft Regulatory Impact Analysis for the Final Rulemaking on Corrective Action for Solid Waste Management Units* (*Corrective Action RIA*), while Approach C describes a new sample selection and modeling effort tailored to a specific RCRA prevention analysis. Finally, Approach D estimates changes in waste management by key industries and uses pathway modeling to measure the effects of these changes at a hypothetical distribution of unregulated facilities. These approaches estimate the value of improved waste management and disposal practices at TSDs, including both the incremental benefits of improved management practices at operating TSDs and the value of avoided hazardous waste sites due to facility closures and conversions.

The remaining chapters of this report address benefits, costs, and impacts not captured in the general benefits approaches. Chapter 4 discusses potential long-term benefits that are not captured by the other approaches and are difficult to value economically. Chapter 5 presents two alternative approaches to assessing program costs. In Chapter 6 we address the distributional impacts of the RCRA program, attributes that are not adequately addressed in an analysis of net economic benefits. These attributes include inter-generational equity, economic equity, and environmental justice, as well as the impacts of RCRA on the economy and production and potential risk tradeoffs (increases in risk that result from the regulation). Chapter 7 identifies methods for addressing Program Context Attributes that describe the constraints and policy priorities that help determine program activities and effects. Finally, in Chapter 8 we summarize the approaches, identify the limitations associated with each, and note additional analyses that may contribute to a more comprehensive program analysis. We also discuss how the approaches might assist the RCRA program in its GPRA reporting. Appendix A is a review of property value literature. Appendix B contains a table summarizing all of the methods discussed in this report, along with their data requirements, advantages, and disadvantages. We strongly recommend that readers refer to and use Appendix B as they read through the chapters of this report because it provides a concise summary of the methods and facilitates comparing and contrasting the methods.

Exhibit 1-3 presents an outline of the approaches we present, and identifies the attributes selected by the RCRA program (from Exhibit 1-1) as the most relevant for characterizing the benefits, costs, and distributional impacts of the RCRA Subtitle C program. The exhibit briefly describes the alternative approaches to analyzing benefits, and then lists the relevant attributes that must be addressed separately under all approaches.

Exhibit 1-3

SUMMARY OF ATTRIBUTES ADDRESSED BY ANALYTIC APPROACHES

BENEFITS	
APPROACH A: Property Value Estimate	**APPROACHES B, C, and D: Modeling Approaches**
Estimate includes aggregate analysis of the following attributes as revealed in residential property value effects of proximity to hazardous waste sites. **Human Health Benefits** from reduction in the number of hazardous waste sites requiring cleanup. **Ecological Benefits** from avoided releases to air, land and water. **Avoided Costs** of government mandated site remediation, and other responses to hazardous waste exposure. **Improved Aesthetics and Historic Preservation Benefits** due to removal of "noxious" facilities and practices.	Estimates of specific benefits based on exposure modeling; includes separate analyses of the following four benefits attributes. * **Human Health Benefits** due to avoided releases of waste from improper disposal. Includes individual cancer, non-cancer risk reduction, population/monetized fatalities, injuries, disease case reduction, population threshold exceedance reduction. **Ecological Benefits** due to avoided releases of waste from improper disposal. Based on pathway modeling of areas near sample facilities. **Avoided Costs** of government mandated water treatment. **Improved Aesthetics and Historic Preservation Benefits** due to removal of "noxious" facilities and practices.
Potential Long-Term Benefits (Sustainability) including potential benefits associated with avoided long term damage, avoided increases in damage related to changes in exposed populations, avoided unforeseen damages, and future changes in the values society may place on avoiding risks or ensuring environmental quality.	
COSTS	
Costs, including compliance costs and government regulatory costs related to RCRA hazardous waste management.	
Potential Long-Term Costs, including incremental costs associated with technology changes and social costs associated with reductions in alternative investments.	
DISTRIBUTIONAL IMPACTS	
Intra-Generational Economic Equity Impacts due to better public/private cost distribution and improved emphasis on the "polluter pays" principle.	
Environmental Justice Impacts due to closure of pre-RCRA facilities and/or siting of new Subtitle C TSDs in areas with disadvantaged populations.	
Economic Impacts due to plant closures, new jobs related to changes in waste management practices.	
Risk Tradeoffs, including risks from management, transport, and disposal of hazardous waste, and risks from substitution of untested compounds for persistent, bioaccumulative, and toxic (PBT) compounds as part of waste minimization efforts.	
Long-Term Impacts: Inter-Generational Equity, addressing the occurrence of costs and benefits in different generations	
PROGRAM CONTEXT ATTRIBUTES	
EPA Reinvention Initiatives, including improved cost-effectiveness of regulatory programs	
Constraints on regulatory cost effectiveness, including statutory mandates, court orders, budget riders, threat of legal action.	
Technology Forcing characteristics (i.e., improvements in treatment technology as a result of new treatment standards).	
Stakeholder Issues that define program priorities, including intensity of feeling, value of information systems and providing information to stakeholders, and empowerment of co-implementers such as states.	
Long-Term Effects: Behavioral Change that is associated with waste management practices developed under the program.	

* The ability to extrapolate to national results in Approaches B, C, and D will depend on the representativeness of the sample and the level of available Agency resources. Depending on the level of resources available, the approach may range from a limited number of detailed case studies to a more extensive representative sample of facilities.

BENEFITS APPROACH A: SIMPLE PROPERTY VALUE ESTIMATE CHAPTER 2

Approach A addresses benefits related to one important result of the RCRA Subtitle C program: the avoided contamination associated with pre-RCRA facilities that ceased operations rather than upgrade their TSD facilities to meet RCRA standards. The RCRA Subtitle C program is widely believed to be responsible for the closure and/or change in operations of many TSD facilities from the late 1970s through the 1980s. Some of these facilities closed or ceased managing waste prior to the regulations taking effect in 1980, and did not apply for permits as TSDs under Subtitle C. Others operated as RCRA facilities after 1980 but have since closed. A portion of these closed facilities would likely have become hazardous waste sites that would have caused damage to human health and ecological resources in the absence of RCRA.

Approach A would provide a simplified method of estimating benefits of RCRA by projecting the "value" of hazardous waste sites that were avoided due to closures of TSD facilities under RCRA. In other words, the approach estimates the number of pre-RCRA TSDs that would likely have become contaminated (i.e., hazardous waste sites) in the future had they not closed under RCRA. The approach then estimates the "value of an avoided hazardous waste site" by identifying the residential property value loss associated with an "average" hazardous waste site and adjusting for the number of "avoided TSDs likely to have become contaminated." The range of property value losses associated with proximity to hazardous waste sites is estimated using values from the hedonic property value literature.[1]

In addition, the approach calculates an estimate of the value of avoided Superfund cleanup costs associated with the avoided sites. It is not clear from the hedonic literature whether home buyers near "Superfund" sites expect remediation, and incorporate that expectation into their purchase prices. We therefore present two scenarios for Approach A - a "with-remediation scenario" and a scenario net of remediation. Also, while we assume that hazardous waste sites absent RCRA

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[1] Hedonic studies identify the value of "quality of life" amenities such as clean water by examining differences in housing prices with regard to the presence or absence of the amenity. For a complete discussion of the hedonic property value literature relevant to hazardous waste sites and RCRA, see Appendix A.

would have had property value effects equivalent to "Superfund" sites, we would base cleanup cost estimates on average site remediation costs for both NPL and non-NPL sites (and, if possible, state hazardous waste sites).

2.1 ATTRIBUTES MEASURED

Property value effects (i.e., the loss in value that an average home suffers as a result of proximity to a waste site) provide a simple measure of the values that homeowners place on a bundle of economic goods that accompany a property. These values include the following RCRA attributes:

- **Human Health:** housing prices may include the value of perceived risks to human health (including both long-term and acute risks).

- **Ecological Services:** housing prices may reflect the values of local ecological services, including both recreational and commercial resources.

- **Avoided Costs:** possible costs associated with substitute drinking water sources, reduced water usage, and other activities associated with response to contamination may be incorporated into housing values.

- **Historic and Aesthetic Amenities:** house values include consideration of a number of local amenities that can be affected by both polluting facilities and cleanup activities. Values may reflect damage to historical structures from pollution and aesthetic disamenities such as noise from trucks and extensive cleanup activities.

- **Economic Impacts:** local economic opportunities, including those affected by RCRA (e.g., plant closures and job opportunities with environmental service firms) may be a component of property values.[2]

In addition, a key determinant of property value changes near Superfund sites appears to be the intensity of feeling about the site and the value of information available about the site and associated risks. These stakeholder concerns are implicitly reflected in bundled property values, but do not reflect separate "goods."

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[2] Local housing market responses to contaminated sites may incorporate local economic impacts and may reflect the extent of local stakeholder concerns; however, we also discuss these attributes again in later sections. In Chapter 7 (Distributional Impacts) we address national economic impacts associated with RCRA over the history of the program; in Chapter 8 (Program Context Attributes) we address Stakeholder Issues as they relate to policy development under RCRA.

Approach A measures the value of these attributes by estimating the avoided property value effects associated with hazardous waste sites "avoided" under RCRA. However, while the estimate incorporates or reflects the above attributes, it does not isolate the value of any particular attribute. In addition, there are two key areas of uncertainty in this approach: the number of sites avoided by RCRA that would have become contaminated in the absence of the Subtitle C regulations, and the magnitude of the property value effect (expressed as a percentage of the original property value). For these two values we present a range of estimates. Exhibit 2-1 illustrates the determinants of a range of results from this analysis, and the potential format that could be used to present the results of the analysis.

Exhibit 2-1

SAMPLE RESULTS OF APPROACH A: PROPERTY VALUE ESTIMATE

Scenario	High-End Property Effect	Average Property Effect	Low-End Property Effect
Assume all land disposal facilities avoided by RCRA would become hazardous waste sites	highest estimate		
Assume 75 percent of facilities avoided by RCRA would become hazardous waste sites			
Assume 50 percent of facilities avoided by RCRA would have become hazardous waste sites			
Assume 25 percent of facilities avoided by RCRA would have become hazardous waste sites			lowest estimate

Notes: The property value range is developed by considering average range of property effects at Superfund and other hazardous waste sites in the literature. Key assumptions that drive the extent of property value effects include the population density and the initial value of housing within a given site radius.

2.2 OUTLINE OF APPROACH A

Approach A would involve four basic analytic steps. Steps 1 and 2 would estimate the pre-RCRA population of facilities, and the number of facilities that closed or ceased managing hazardous waste as a result of RCRA regulations. Step 3 estimates the number of closed facilities that would have become hazardous waste sites requiring remediation in the absence of RCRA. Step 4 would estimate the avoided property value declines and cleanup costs associated with the avoided hazardous waste sites identified in Step 3. Below we describe these steps in more detail.

2.2.1 *Step 1. Identify Pre-RCRA population of TSDs*

Approach A focuses on the closure of land disposal facilities with pre-RCRA TSD practices. The pre-RCRA universe contained two basic types of land disposal facilities for hazardous waste: on-site waste disposal facilities at hazardous waste generators, and off-site facilities that receive waste from other entities (this includes both commercial hazardous waste facilities that were already in operation and non-specific solid waste landfills). We have identified two separate sources to estimate the pre-RCRA universe of each of these facility types:

- **On-Site Facilities:** EPA *Industry Assessments* for various industries (published throughout the 1970s) estimate the number of facilities managing hazardous waste in several key industrial sectors; each *Assessment* provides considerable detail about the waste quantities, constituents, and disposal practices that characterized the industry prior to the passage of RCRA.

- **Off-Site Facilities:** *1979 Waste Disposal Survey* Report to Congress. This document lists over 3000 landfill locations, along with disposal dates and types of waste, where the 53 largest chemical companies in the United States disposed of their wastes between 1950 and 1975.

Our proposed approach would estimate the universe of pre-RCRA TSDs in two parts. The number of pre-RCRA generating facilities with on-site TSD units would be equal to the number of facilities identified in the *Industry Assessments* as having on-site disposal, treatment, or long-term storage. We would estimate the universe of pre-RCRA off-site disposal facilities as the off-site facilities in the *1979 Waste Disposal Survey* that received hazardous waste after 1970.

Both of these universe estimates are incomplete. The *Industry Assessments* address only a subset of the industries (identified by Standard Industrial Classification (SIC) codes) that are regulated under RCRA, and the *1979 Waste Disposal Survey* omits any landfills that took waste only from companies other than those polled. However, while neither source provides a complete picture of hazardous waste practices prior to RCRA, they do provide a low-end estimate of the pre-RCRA TSD population in the important waste producing industries based on contemporaneous information.[3]

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[3] We are not able to quantify the portion of the RCRA universe that is omitted by these facilities, but other pre-RCRA studies and later BRS data consistently indicate that the industries targeted in the *Industry Assessments* do represent the majority of hazardous waste generated. Similarly, while it is very difficult to identify the quantity of pre-RCRA "hazardous waste" that was disposed off-site, pre-RCRA studies indicate that the majority of waste was disposed on-site.

In addition to the above studies, we explored a large number of contemporaneous information sources that described various aspects of the pre-RCRA universe. Useful sources of information on landfills included EPA's 1982 *Inventory of Open Dumps* and *Waste Age's* 1977 *Land Disposal Practices Survey* update. Detailed contemporaneous sources of information on generators and managers of hazardous waste include a 1979 report by the New York Department of Environmental Conservation titled *Industrial Hazardous Waste Generation in New York State,* EPA's 1982 *Surface Impoundment Assessment National Report,* and EPA's 1979 *Economic Impact Analysis of Hazardous Waste Management Regulations on Selected Industries.*

We could use these studies to supplement information about the facilities and practices of the pre-RCRA universe. However, we believe that the *Industry Assessments* provide the most consistent and detailed view of waste management practices in multiple industry sectors, and that the *1979 Waste Disposal Survey* Report to Congress provides the most extensive list of landfill sites with specific information about location, site ownership, type of waste disposed at the site, and specific time intervals during which disposal occurred.

2.2.2 *Step 2. Identify "Avoided TSD Facilities"*

Our proposed approach would identify "avoided TSD facilities" by performing a simple bounding analysis of the total change in the number of TSD facilities in SIC codes described in *Industry Assessments* and the *1979 Waste Disposal Survey*.[4]

- **Low-end estimate of avoided facilities**. For this estimate we subtract the 1981 *Generator Survey's* estimate of TSDs for specific SIC codes from the pre-RCRA universe of TSDs. This estimate assumes that all avoided facilities closed immediately, and that any closures or conversions after 1981 were not attributable to RCRA.

- **High-end estimate of avoided facilities**. For this estimate we identify the number of TSDs in the most recent Biennial Reporting System (BRS), and adjust populations to exclude facilities in SIC codes not addressed in industry studies on off-site management by 1980 regulations and those handling only wastes that were regulated after 1980. This would provide a consistent basis for comparison with facilities initially regulated under RCRA. We then subtract the adjusted BRS population from our pre-RCRA universe of TSDs. This estimate of avoided TSDs reflects actual economic growth and industry consolidation, and assumes all closures both before and after 1980 are due to

[4] We expect to use SIC code 4953 to identify commercial solid waste disposal operations and compare these with the off-site disposal facilities identified in the *1979 Land Disposal Survey.*

RCRA. The estimate will be high to the extent that it includes many facilities that closed for reasons other than RCRA.[5]

The result of this analysis is a high and low estimate of the total number of TSD facilities in relevant industries (i.e., SIC codes) that ceased operations due to RCRA regulations.

2.2.3 *Step 3. Estimate Number of "Avoided Hazardous Waste Sites"*

Our proposed approach assumes that a percentage of avoided TSDs would have experienced sufficient contamination in the absence of RCRA to require remediation under Superfund or other hazardous waste remediation programs. EPA's 1993 *Corrective Action RIA* estimates that 44 percent of RCRA facilities subject to Subpart S Corrective Action (that is, facilities with pre-RCRA solid waste management units on site) are expected to have past, current, or future releases that will require Corrective Action. Future failure rates are based on expert panel engineering estimates of structural failure at pre-RCRA facilities.[6] The RIA does not identify the percentage of facilities that were already contaminated in 1982.

While we believe the RIA's estimate of 44 percent failure represents a reasonable central tendency assumption for the likelihood of failure at a pre-RCRA facility, we cannot simply apply this percentage to the number of avoided TSDs to determine avoided hazardous waste sites. There are two key considerations in estimating hazardous waste sites avoided by RCRA:

- Some sites were likely to be contaminated prior to 1980 and have or will become hazardous waste sites despite the implementation of RCRA. These sites do not represent "avoided" damage due to RCRA and should not be included in the benefits of the program.[7] We must therefore adjust the

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[5] The estimate may also be low if the 1995 BRS includes as TSDs many facilities that "converted" from generation and disposal to generation only. However, it may be possible to account for these facilities using BRS estimates of quantity of waste disposed; for example, TSDs in BRS (i.e., WR, or waste received, facilities) that have not received waste in over two BRS reporting cycles could be considered "avoided TSDs."

[6] Environmental Protection Agency. *Regulatory Impact Analysis for the Final Rulemaking on Corrective Action for Solid Waste Management Units Proposed Methodology for Analysis.* Draft, (1993), p. 3-27. Because all Subpart S Corrective Action Facilities stopped receiving waste prior to July 1, 1982, the estimate addresses only pre-RCRA practices and wastes.

[7] This assumption underestimates the potential benefits of RCRA, which likely prevented even contaminated sites from becoming more contaminated and potentially more damaging. However, hedonic property value studies are not precise enough to identify the impacts of marginal

number of avoided TSDs to reflect only the number of avoided TSDs *without existing contamination*. We do not know the number of sites that were already contaminated when they ceased operations; we therefore propose a range of values for "number of sites already contaminated" and subtract these estimates from the total number of avoided hazardous waste sites estimated.[8]

- The sample of facilities in the *Corrective Action RIA* may not be representative of avoided TSDs that ceased operations under RCRA; therefore the actual percentage of facilities that would have become contaminated may be more or less than the 44 percent estimated in the RIA. For example, facilities that closed due to RCRA may have been poorly managed and more likely to leak than those that stayed open; this would increase the expected number of Superfund sites had those facilities continued to operate. It is also possible that avoided TSDs closed or reconfigured as preventative measures and are less likely to experience failure and contamination. Again, to address this uncertainty we propose to present a range of estimates for the likelihood of contamination.

For example, a worst case scenario under Step 3 would assume that a low percentage of avoided TSDs have prior contamination (i.e., the number of eligible avoided TSDs is likely close to the total number of avoided TSDs) and all would have become hazardous waste sites without RCRA (i.e., a 100 percent chance of future contamination). In contrast, a very conservative scenario would assume that a high percentage of avoided TSDs were contaminated at closure (and therefore do not represent benefits of the RCRA program) and that only 25 percent of the clean facilities would have become hazardous waste sites in the absence of RCRA. Note that the 1979 New York *Inventory of Industrial Hazardous Waste Generation* concluded that a significant percentage of wastes in that state were mismanaged. If this study is representative of national waste management practices, it is likely that both the number of facilities already contaminated in 1980, and the number likely to become contaminated had disposal practices continued, would be high.[9]

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changes in contamination at existing sites. We therefore eliminate these impacts from consideration.

[8] For example, if Step 2 estimated that 100 TSDs closed due to RCRA, and the *Corrective Action RIA* estimated that 44 of those sites would eventually become contaminated, we would adjust this number (i.e., 44) to reflect different assumptions about existing contamination. The resulting range of estimates may range from a fairly conservative estimate of 11 avoided sites (assuming that 75 percent of closed TSDs were already contaminated at closure) to a more aggressive estimate of 33 (assuming that only 25 percent of closed TSDs were already contaminated at closure).

[9] Prepared by Bureau of Hazardous Waste, Division of Solid Waste Management, New York State Department of Environmental Conservation, June 1979.

We emphasize that this step is associated with considerable uncertainty. It is impossible to "know" or estimate the probability of contamination without identifying and examining the specific facilities that closed. Because there are no complete records of closures that would otherwise have been regulated TSDs, we must address uncertainty by presenting a range of potential results. We also recommend that any implementation of this step include a review of new literature that might address some of the uncertainty associated with the probability of contamination.

2.2.4 *Step 4. Assign Values to Avoided Hazardous Waste Sites*

Approach A would estimate the value of an "avoided hazardous waste site" considering two scenarios that make different assumptions about the expectations of property owners. Scenario 1 would assume that property values incorporate no expectation of cleanup, and reflect the entire value placed on the risks and damage associated with perpetual site contamination. For Scenario 1 we would estimate avoided losses in property values proximate to the avoided hazardous waste sites. Scenario 2 would assume that housing values near Superfund sites reflect owners' expectation of site remediation, and therefore value only finite exposure and damage associated with the site. For this scenario we would add avoided site remediation costs to the property value changes identified in Scenario 1.[10] In both scenarios, the total benefits of the RCRA program identified in approach A represent the sum of the values of all avoided hazardous waste sites.[11] Below we present the calculations for both scenarios:

2.2.4.1 Estimate of Avoided Property Value Losses (Scenarios 1 and 2)

Our calculation of avoided property value losses is based on three parameters:

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[10] The hedonic property value literature highlights the importance of information as a determinant of housing value changes near hazardous waste sites. Several studies indicate that property values decline most rapidly as people first learn about contamination, and recover to some extent as information about cleanup becomes available. Based on these findings, we believe it is possible that property value declines may also reflect the expectation of cleanup; in other words, the declines reflect the present value of disamenities with a finite time length until cleanup is complete. We would therefore incorporate the costs associated with that cleanup into our scenario. We recognize that this is an assumption that has yet to be tested in the literature, and propose two separate analyses that would reveal the magnitude of the effects of this assumption.

[11] Approach A does not attempt to adjust benefits to reflect the timing of avoided hazardous waste contamination incidents (i.e., apply a discount rate to benefits) because it is impossible to predict the occurrence of avoided events. Approach A's undiscounted estimate effectively assumes that hazardous waste sites would have occurred consistently from 1980 through 2020.

- **Average percentage decrease in property value** expected within a certain radius of a hazardous waste site.[12] Our preliminary literature review indicates that most property value effects related to proximity to a hazardous waste site fall between two percent and eight percent of original house value. However, some studies indicate price effects of zero percent to twenty percent. For detailed discussion of the literature review, see Appendix A.[13]

- **Median population density** within a certain radius of a hazardous waste site. Population density is an essential variable in assigning values losses to Superfund sites, since value losses will be greater in areas where a greater number of houses are affected. Median density can be determined using a simple spatial analysis that identifies the number of CERCLIS and RCRA TSDs per county and uses U.S. Census data to determine county average density.[14] Spatial analysis of a sample of sites could identify uncertainty associated with the use of county average density estimates.

- **Median housing values** within a certain distance (e.g., one mile) of a Superfund site. This requires a simple spatial analysis of CERCLIS sites and RCRA TSDs, coupled with a weighted average of median housing values in the counties in which sites occur. Median house values can be found in

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[12] While several studies find property values effects up to seven miles from a hazardous waste site, we propose to limit our focus to a one mile radius (with three and five mile sensitivity analyses) and assume that the majority of property value effects will be captured within this range. This range is consistent across the literature, regardless of whether studies assess Superfund sites or other types of disamenities (e.g., landfills, incinerators). We found no clear pattern of values that distinguishes among types of disamenities.

[13] Again, information appears to be a key determinant of housing value changes near hazardous waste sites. Several studies conclude that property values decline most rapidly as people first learn about contamination, and start recover as information about cleanup becomes available. Our benefits estimate does not consider the timing of cleanups or the pattern of property value losses and recoveries while cleanup continues. We do note, however, that the literature is not conclusive with respect to the "rebounding prices" issue. While some studies indicate full recovery of prices upon site remediation, others find partial or even minimal rebound, which may be attributable to stigma. There is also some indication of the potential for RCRA *dis*benefits, resulting from the siting and/or "labeling" of operating facilities with RCRA permits.

[14] We assume that this range of pre- and post-RCRA sites (i.e., Superfund sites and TSDs) represent a wide range of industrial facilities and are similar in location requirements (e.g., resources, space) as the "missing" hazardous waste sites of interest. In other words, we examine CERCLIS and RCRA TSD sites as a representative distribution of "missing" industrial sites.

county Census data. Because we are applying an average percentage decrease in property values, sites surrounded by more expensive homes will induce greater monetary losses. Again, spatial analysis of a sample of sites could identify possible uncertainty associated with use of county averages.

In summary, the calculation of total property value losses avoided by RCRA in Approach A is:

(# of avoided sites) x (percentage value decrease) x (# houses within one miles) x (average house value)

We would assign a range of percentage decreases in property values to reflect the variation in property values literature. Thus, the result of the analysis will be a range in total property value losses avoided due to avoided hazardous waste sites. We emphasize that the property value approach distinguishes between the existence and non-existence of a disamenity, but is not useful for distinguishing subtle differences in management practices. Additionally, the resulting "value" of the avoided site characterizes a bundle of goods that cannot be isolated and valued separately. In other words, the property value approach is not useful for measuring individual attributes *per se* or describing "environmental outcomes" resulting from the RCRA program, but instead provides a "lump sum" value for all relevant attributes. See Appendix A for a more extensive discussions of the limitations of the hedonic approach.

2.2.4.2 Avoided Costs of Hazardous Waste Site Remediation (Scenario 2 only)

Our second scenario would produce a benefits estimate that includes both the avoided property value losses outlined above, and the avoided costs of site remediation (under Superfund or comparable programs). Avoided government-mandated remediation costs represent another potential benefit of avoided hazardous waste sites, because they are baseline (i.e., without RCRA) costs that are eliminated by the regulation. Scenario 2 would therefore add these costs to the property value effects associated with sites in order to calculate the total value of avoiding hazardous waste sites, using the following steps:

- A Congressional Budget Office Study (1994) provides one estimate of non-federal Superfund cleanup costs. The document presents a range of cost estimates (base case, high case, low case) for "mega-sites," "major sites," and "minor sites." They find an average present-worth cost for all NPL sites of $28.5 million to $31.2 million (1992 $). Approach A will adapt these cost estimates and derive an "average" site value.[15]

[15] While these estimates are useful, Approach A requires two adjustments. First, we do not assume that all avoided hazardous waste sites would have become NPL sites; therefore, it is

- These figures can be used to determine the median net present value (1999$) of a remediation under the Superfund program. Again, sampling of site-specific costs can characterize uncertainty with regard to use of this median.

Scenario 2 assumes that property value responses to hazardous waste sites *reflect the expectation of clean-up*. In other words, purchasers of property near hazardous waste sites assume that the site will be remediated and that human health and other disamenities are not permanent. If this is true, then avoided cleanup costs must be added to housing value declines to provide a complete estimate of benefits. We believe that this assumption is consistent with the findings of various studies that housing prices respond to information about risk and cleanup activities. However, more research on home purchasing decisions is necessary to test the validity of the assumption that homeowners anticipate cleanup. In the absence of additional research, analysts should consider alternate scenarios (i.e., both Scenarios 1 and 2) in which cleanup costs are included and excluded to determine the potential role of these avoided costs in the total benefits of RCRA.

While avoided government-mandated remediation costs can be considered in any analysis of RCRA, there is a potential double-counting of benefits because property value effects may reflect an unremediated hazardous waste site and thus address, in part, the value of cleaning the site (i.e., by identifying the negative value of allowing the site to remain). However, if homeowners purchase houses near hazardous waste sites with the expectation that remediation will take place, the housing values near Superfund sites may stay higher that they otherwise would have, reflecting the assumption that exposure to contamination is limited. If this is the case, then remediation costs can be added to property values and there is no overlap.

Note that there is an important distinction between the *cost* of site remediation and the *value* of site remediation. In Scenario 2 we do not attempt to identify the economic value (in terms of willingness-to-pay) to remediate a hazardous waste site; this value could be greater than or less than the cost of site remediation. In Scenario 1, however, we assume that the value associated with avoiding a hazardous waste site is included in the property value effect. Since we do not know the exact relationship between the *cost* of remediation and the economic *value* of remediation, we limit our Scenarios to explicit consideration of one or the other, but not both.

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important to determine a reasonable average of non-NPL Superfund sites. Second, since CBO (1994) assesses only non-federal (private sector) cleanups, it is necessary to account for cleanup costs of federal sites. State and/or EPA data can provide this information, but should be adjusted for uncharacteristically high-cost outliers such as large-scale Department of Defense facilities.

2.3 SUMMARY FOR APPROACH A: PROPERTY VALUE BENEFIT ESTIMATE

This simple approach identifies economic benefits and impacts as total residential property value losses avoided by RCRA due to avoided hazardous waste sites.[16] The approach potentially values the following attributes as a part of the property value perceived by nearby residents:

- Human health benefits;
- Ecological benefits;
- Avoided costs of alternate water supplies; and
- Aesthetics and historic preservation.

These values are bundled into a single property value increment that may also reflect certain stakeholder concerns and local economic impacts. Though these attributes are implicitly included in housing values, the value of each individual attribute cannot be isolated using Approach A. The sum of the values associated with avoided sites represents the benefits of RCRA.

In addition, Approach A requires the development of an alternative scenario (Scenario 2) that adds the average cost of remediation under the Superfund program to property value losses for a total estimate of the costs avoided under RCRA. This scenario assumes that property values near Superfund sites reflect the owners' expectations of site remediation. The sum of the avoided property value declines and avoided remediation costs (expressed as a range of values based on the percentage reduction in property values near avoided sites) gives total costs avoided as a result of avoiding hazardous waste sites under RCRA. Exhibit 2-2 summarizes the methodological steps in Approach A.

In addition, because of the significant uncertainties associated with estimates of facility closures and contamination levels, we recommend the following sensitivity analyses to determine the importance of several variables:

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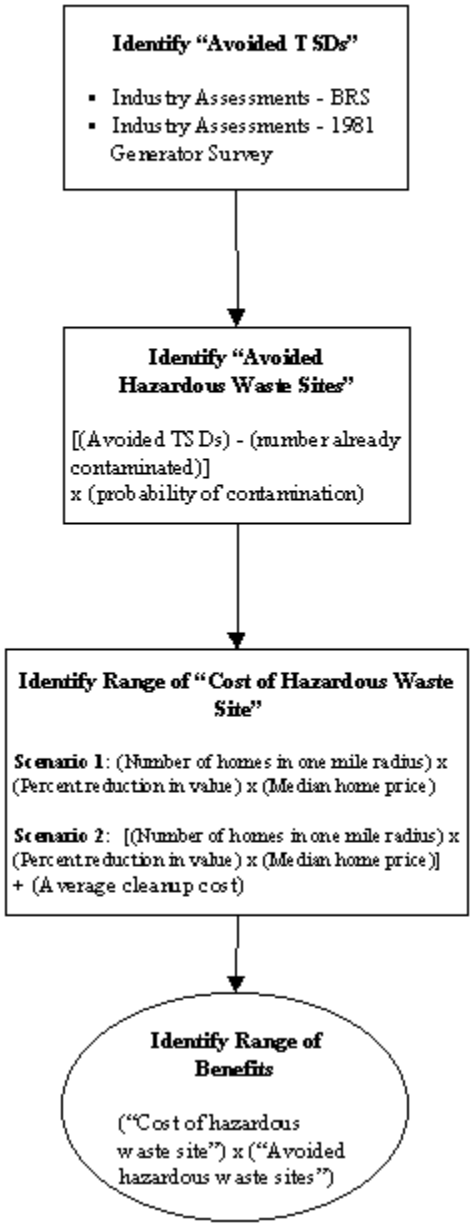
[16] Note that the property value assessment in Approach A considers only residential property. This approach could exclude considerable property value effects in commercial districts. While we assume that the cost of remediation captures the change in property value on the contaminated property itself, some studies indicate that property values of commercial properties proximate to, but not associated with, the contaminated property may suffer price effects in excess of those observed at residential properties. Implementation of Approach A should include an examination of recent literature to determine whether consideration of commercial properties is warranted. See Appendix A for additional detail.

- **Number of facilities avoided by RCRA:** A bounding analysis of facilities closed by 1981 and total facilities closed as reported in the most recent BRS;

- **Number of hazardous waste sites avoided by RCRA:** A sensitivity analysis reflecting a range of contamination scenarios.

Exhibit 2-2

SUMMARY OF APPROACH A



2.3.1 *Limitations of the Property Value Approach*

Approach A provides a general estimate of a key portion of RCRA benefits without demanding considerable resources. However, the approach does not examine several key aspects of the RCRA program. The major limitations of this approach are:

- The estimate of avoided TSD facilities considers only facilities in industries for which EPA performed pre-RCRA *Industry Assessments.* Newly regulated industries that have been addressed by RCRA more recently than 1980 are not included; nor are changes in the management of newly regulated wastes not included in the 1980 regulations (however, if new waste regulations are responsible for facility closures since 1980, then these closures are considered in the high-end estimate of avoided TSDs).

- The approach examines only TSD facilities - avoided hazardous waste sites associated with generating facilities are not included (i.e., avoided damage associated with poor storage and short-term management practices at facilities that were never identified as TSDs).

- The approach does not identify the benefits of improved waste management practices and reduced waste generation at existing TSDs and generators. RCRA regulations are likely to have reduced releases at operating facilities, and the benefits from the changes in practice may be a considerable portion of the benefits of the RCRA program.

Exhibit 2-3 illustrates the results of Approach A in the context of the total benefits of RCRA. In addition, separate analyses of long-term benefits, program costs, distributional impacts (e.g., equity and economic impact analyses), and program context attributes (e.g., program constraints) should be undertaken to complete the analysis.[17] Note that while this approach addresses only one aspect of the benefits of the RCRA Subtitle C program, it could potentially account for a large portion of RCRA benefits by itself and may therefore be useful information even if a full analysis of RCRA costs and benefits is not performed.

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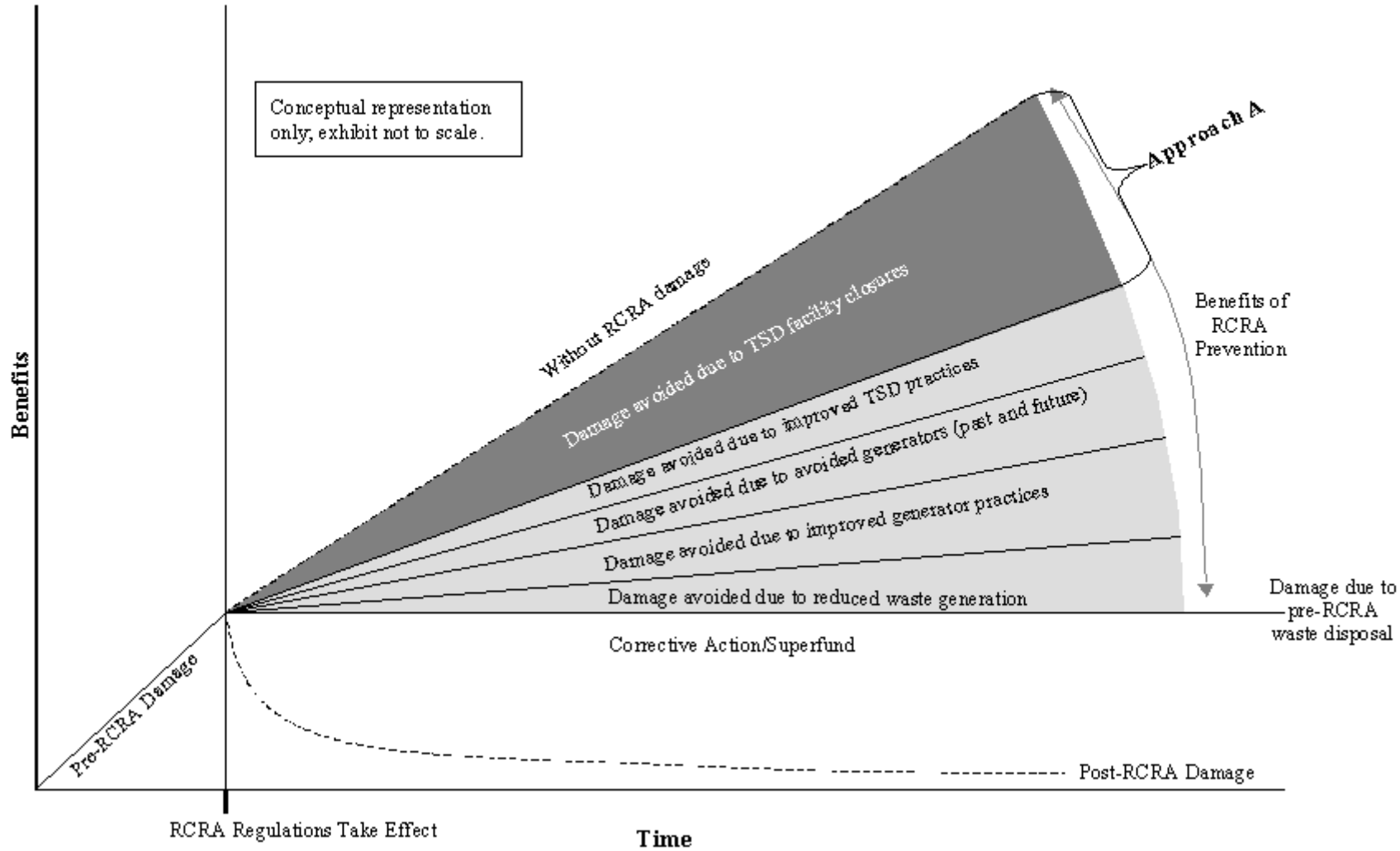
[17] Methodologies for addressing these additional attributes are described in Chapter 4 (Long-Term Benefits), Chapter 5 (Costs), Chapter 6 (Distributional Impacts), and Chapter 7 (Program Context Attributes).

Exhibit 2-3

CONCEPTUAL VIEW OF APPROACH A RESULTS



BENEFITS APPROACHES USING PATHWAY MODELING CHAPTER 3

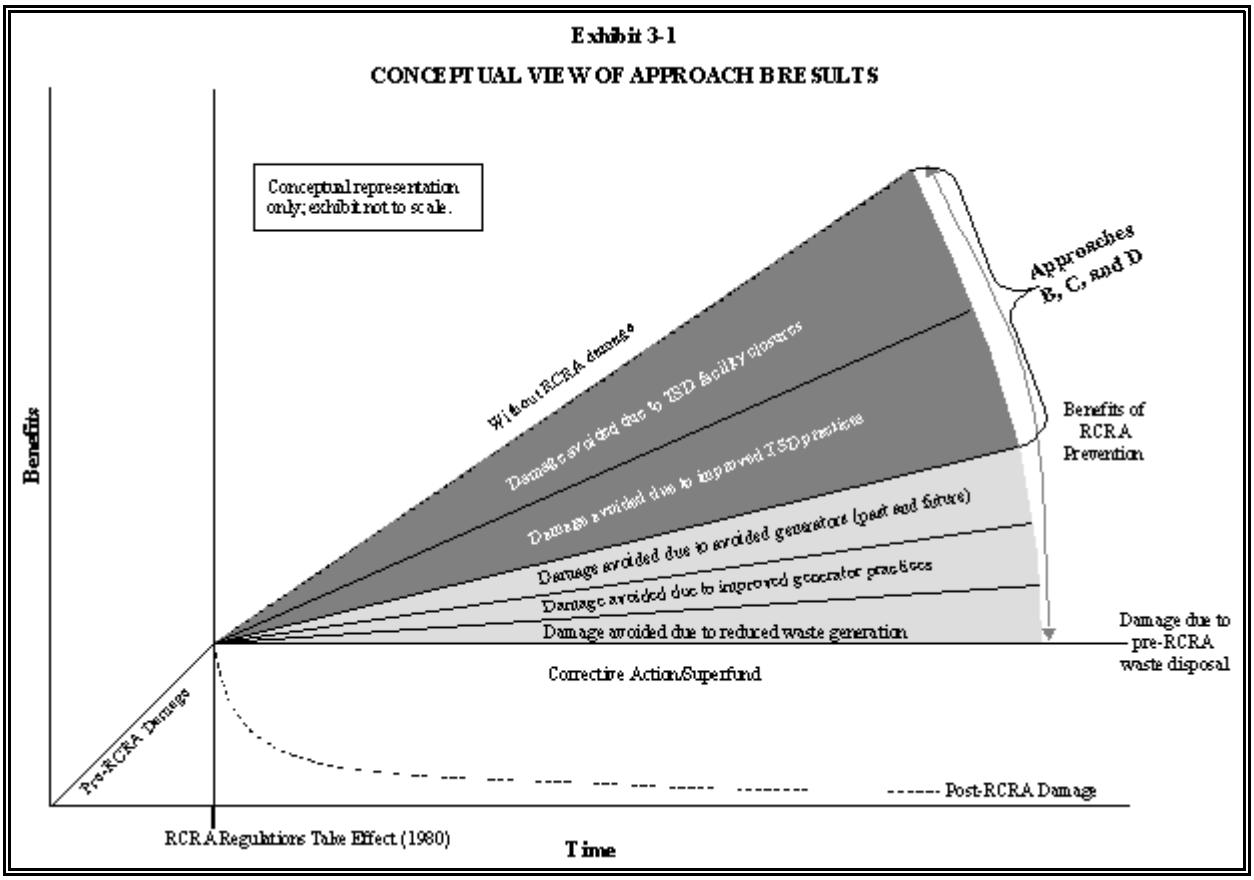
This chapter presents three approaches (Approaches B-D) for identifying the benefits of RCRA using pathway modeling of contamination at sample facilities. Relative to the property value method, these approaches would provide more detailed estimates of the range of exposure-related benefits of changes in waste generation, management and disposal practices under RCRA Subtitle C. While Approach A addresses benefits associated with facility closures, pathway modeling approaches identify the benefits associated with improved waste management at operating TSDs. The approaches provide:

- An estimate of incremental benefits of avoided contamination due to improved waste management practices at operating TSDs. Estimates reflect both changes in quantities of waste managed and changes in failure rates and releases from new waste management facilities. Pathway modeling can be used to identify the effects and probability of potential contamination in a "clean" site, and can also provide an estimate of incremental damages that would have resulted from continued waste disposal (in the absence of RCRA) at a site that was already contaminated in 1980.

- Specific information about the relative contribution of different benefits such as the value of avoided human health effects and the extent of ecological benefits. Pathway modeling methods allow separate evaluation of individual attributes and descriptions of the "environmental outcomes" resulting from the RCRA program; this can be useful in GPRA reporting, comparative risk analyses, or to address other Agency information needs, or in adjusting analyses to reflect new or updated approaches or information in the evaluation of specific attributes.

While pathway modeling focuses primarily on incremental benefits of changing waste management at on-going TSD operations, the approach may also be able to provide an alternative estimate of the benefits described in Approach A (i.e., the benefits associated with facility closures). The ability to extrapolate pathway modeling results to an estimate of avoided hazardous waste sites

will depend on the representativeness of the sample of facilities used in the modeling effort. Exhibit 3-1 illustrates the portion of RCRA benefits that may be addressed by Approaches B, C, or D.



We present three distinct pathway modeling approaches for identifying RCRA Subtitle C benefits. These approaches represent variations of a single approach in that they all model exposure scenarios using site-specific data from a sample of facilities. However, they differ from one another in two ways: they propose different methods identifying a sample of facilities representing RCRA (and without-RCRA) TSDs, and they employ different available pathway models. In consequence, the approaches differ in the certainty of their results and in their ability to extrapolate national benefits estimates from facility samples.

- **Approach B** would provide an assessment of the benefits of Subtitle C regulations based on site-specific information at a sample of RCRA TSD facilities from EPA's *Corrective Action RIA*.

- **Approach C** would use primary data collection and modeling to identify benefits associated with a newly selected sample of facilities.

- **Approach D** would assess the benefits of RCRA by applying the Hazardous Waste Identification Rule (HWIR) 3MRA multi-pathway model, using the sample facilities in this model to represent pre-RCRA facilities.[1]

3.1 ATTRIBUTES MEASURED

Each of the pathway modeling approaches would provide estimates of benefits from avoided human health and ecological impacts. Each would use modeling to project contamination and damage in a without-RCRA scenario and then compare these results to "with-RCRA" damages. Modeling estimates of contaminant levels and duration can then be used to assess the avoided costs associated with contamination, including the government-mandated treatment and remediation costs and voluntary averting behavior and response costs (e.g., community time). In addition, for specific attributes and benefits that cannot be easily measured using pathway modeling (e.g., improved aesthetics and avoided health effects and costs related to acute events), the approaches include separate methodological options to augment the modeling results. The attributes addressed include:

- **Human Health Benefits** from reduced exposure to contaminated air, soil, and groundwater. Pathway modeling can provide estimates of chronic human health effects (e.g., population estimates of cancer and non-cancer effects and estimates of risk to maximum exposed individuals (MEI)). A separate method would address potential health effects related to avoided acute events (e.g., hazardous waste spills or explosions).

- **Ecological Benefits** from reduced surface water contamination and damage to biota and habitats. Pathway modeling can provide estimates of contamination at active facilities. A separate method would address the potential benefits of restrictions on building in flood plains (i.e., the potential reduction in ecological damage associated with flooding events).

- **Avoided Costs** associated with contamination incidents, including government-mandated treatment and remediation costs and costs related to voluntary averting behaviors.[2] Pathway modeling estimates of the extent of contamination provide the basis for estimated clean-up and averting behavior costs.

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[1] Glenn Farber in EPA's Office of Solid Waste has been developing this approach and has provided a general description of the approach in this chapter; the development of a more detailed description of this approach depends on the completion of the HWIR 3MRA model.

[2] While voluntary averting behavior costs typically function as a low-end proxy for willingness to pay to avoid health risks, we present avoided cost methods in one place for simplicity.

- **Improved Aesthetics and Historic Preservation** associated with improved waste management practices. These attributes describe benefits resulting from improved aesthetics (e.g., reduced noise and odors) attributable to improved waste management practices. Reduced impacts on historic landmarks are also considered.

These attributes identify the principal benefits of RCRA that can be estimated using pathway analysis. However, while pathway analysis can be used to provide quantitative estimates of health and ecological impacts over long time horizons, the approaches in this chapter do not specifically address a number of issues related to the long-term benefits associated with RCRA. We discuss the assessment of long-term benefits in more detail in Chapter 4.

The remainder of this chapter outlines the three pathway modeling approaches and the proposed methods for addressing the relevant attributes. We first provide a general outline of Approach B. We then describe potential methods for addressing the relevant attributes within the context of this approach. Finally, we provide general outlines for Approaches C and D. We do not, however, separately discuss methods for addressing attributes under Approaches C and D; these two approaches will likely use variants of the methods discussed in Approach B, but our information about specific models is currently limited and we cannot describe likely outcomes in detail.

3.2 APPROACH B: SITE SPECIFIC MODELING APPROACH USING CORRECTIVE ACTION RIA FACILITY DATA

Approach B directly examines a sample of facilities to identify and evaluate changes in practices. Approach B involves three basic analytic steps: identification and collection of a facility sample; modeling analysis of facility data and identification of avoided damage; and estimation or characterization of attributes related to avoided damage. At each of these stages there are methodological alternatives that vary in required resources and in the comprehensiveness and precision of results.

3.2.1 *STEP 1. Identification and Selection of Facility Sample*

Our proposed Approach B analysis would use the site specific data and models that were developed for the 79-facility sample of the *Corrective Action RIA*.[3] This data set has several distinct

[3] The *Corrective Action RIA* identified 79 sample facilities with pre-RCRA solid waste management units (SWMUs) that would require remediation under Corrective Action if they were (or became) contaminated. We believe that these facilities are likely to be generally representative of facilities with pre-RCRA practices. However, a close examination of facility data is necessary

advantages. First, the facility sample was selected to support a national estimate of the benefits and costs of the Subpart S Corrective Action program. The data set contains facility process information about a nationally-representative group of operating TSD facilities that also have pre-RCRA waste management units on site.[4] This data source, therefore, represents an alternative to a rigorous and extensive sample selection process.

Second, the sample of Corrective Action facilities was used to model the actual and expected contamination from closed (i.e., pre-RCRA) Solid Waste Management Units (SWMUs) on site at RCRA facilities. The baseline of this modeling effort effectively establishes the expected contamination levels for our proposed with-RCRA Subtitle C scenario.

One limitation of this sample is that it may contain several facilities with SWMUs that stopped receiving waste prior to the development of RCRA, and are therefore not relevant to RCRA prevention programs. If this is the case, then the effective sample size for an analysis of the RCRA prevention program may be smaller, affecting the ability to extrapolate results nationally. However, because the 79 sites were active RCRA facilities in 1992, and because many had multiple SWMUs on site, it is likely that there is a sufficient sample of SWMUs and facilities that were affected by RCRA to be able to estimate some national level benefits of the program.

3.2.1.1 Supplemental Data Sources

While Approach B would be based primarily on the *Corrective Action RIA* facility sample and modeling results, we also examined a number of other national data sets that may be useful in supplementing the analysis either by providing additional facility data or by identifying additional facilities if the *Corrective Action RIA* sample is limited. Moreover, these sources may provide useful data about RCRA facilities and contaminated sites that could help inform the development of national estimates of certain benefits:

- **CERCLA Facilities:** The CERCLIS database contains facility information on the extent of existing contamination and environmental damage for NPL and non-NPL sites. For many sites, the Agency has prepared site narratives describing historical operations and waste disposal patterns. Although these sites represent only a subsection of relevant facilities (that is, contaminated

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to verify the extent to which sample facilities are representative of the pre-RCRA universe. The actual number of representative facilities (i.e., the effective sample) may be smaller than 79.

[4] The *Corrective Action RIA* used a stratified random sampling approach that emphasized the selection of facilities with extensive available data. It is therefore possible that the sample may not be representative of all pre-RCRA facilities. A careful evaluation of the sampling protocol and the facilities in the sample is necessary to identify potential bias would affect an analysis of RCRA.

facilities that closed prior to 1980), the site-specific information and range of industries, locations, and contamination levels may be considerable. Sample selection requires identifying facilities with sufficient data that are likely to represent RCRA-related closures (i.e., facilities that were disposing of hazardous waste after 1970 but closed by 1980).[5]

- **RCRIS Facilities:** RCRA programs store facility information in the extensive RCRIS database, which is a collection of previous databases. One drawback of RCRIS is inconsistency in the type and quantity of data. However, the database has permit information on key parts of the population of facilities affected by RCRA, including "converters" (i.e., facilities that obtained Interim Status as TSDs and then ceased managing hazardous waste) and "protective filers" (i.e., facilities that entered the RCRA system but never completed the permit process). Use of RCRIS demands initial research into the availability and quality of specific types of data.

- **BRS Facilities:** BRS tracks only active RCRA facilities, but examination of different BRS reports over time may reveal patterns in closure and changes in the number of industries and facilities regulated under RCRA as new initiatives and regulations have been added. In addition, BRS contains information on quantities and types of waste generated, and may be useful in assessing the benefits of waste minimization efforts under RCRA.

- **State Programs:** Certain state hazardous waste programs maintain comprehensive information about prevention and cleanup activities at all sites. States may provide a broader range of facility sizes and damage incidents than Federal sources because they frequently address "smaller" releases than those addressed by CERCLA or Corrective Action. However, information quality varies by state, along with dominant industries and ecological features; the principal challenge of using these data would be extrapolating them to national results. In addition, if state information is not in a form readily available to the public, then collection of data from more than nine states may require an ICR.

The specific objectives and resources available for an analysis of RCRA will dictate which of these sources is most appropriate for different portions of the analysis, or for supplementing the *Corrective Action RIA* facility sample, if this should prove necessary. We recommend a number of methods based on data from several of these sources in our proposed approaches to various individual attributes throughout the remainder of this report.

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[5] Some CERCLA and RCRIS data may be restricted as enforcement sensitive but we do not believe that this will prevent collection of basic information about facility practices and damage.

3.2.2 *STEP 2. Model Baseline and Without-RCRA Subtitle C Releases*

Our proposed Approach B would develop an estimate of the incremental benefits of improved waste management practices at active RCRA facilities, using all or a portion of the *Corrective Action RIA* facility sample to represent the universe of these facilities. Based on this sample, the approach would next model the expected environmental damage at these facilities in both the with-RCRA Subtitle C and without-RCRA Subtitle C scenarios.

3.2.2.1 Identify Level of Contamination in the Presence of RCRA Subtitle C

The *Corrective Action RIA* analysis modeled the number and size of releases from existing SWMUs on site at sample facilities. The results of this analysis were used to depict a baseline contamination level assuming that Corrective Action cleanup programs existed. The benefits of Corrective Action were then measured by modeling the reduction in damage as a result of expected cleanup activities under the program.

All of the releases modeled in the Correction Action RIA result from waste that was disposed prior to 1982, and has therefore not been reduced or controlled by the RCRA prevention program. As a result, releases modeled in the *Corrective Action RIA* baseline do not directly address RCRA prevention benefits. Instead, they represent the expected contamination level in the with-RCRA Subtitle C scenario because we assume that these SWMUs closed due to RCRA Subtitle C. This approach assumes that the risk of damage from new Subtitle C units at the sample facilities is negligible, due to monitoring and response requirements under RCRA prevention regulations.[6]

3.2.2.2 Model Contamination Levels in the Absence of RCRA Subtitle C

While they did not prevent contamination from existing waste, RCRA Subtitle C disposal standards were responsible for the diversion of waste streams from pre-RCRA SWMUs after 1982. Therefore, the RCRA Subtitle C prevention program is responsible for any incremental benefits of discontinued waste disposal in these units (i.e., for any releases or damage avoided by discontinuing disposal in the units in 1982).

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[6] This assumption may be aggressive, because even stringently regulated and managed wastes may sometimes pose environmental concerns (e.g., due to accidents during handling and transportation of hazardous wastes, or potential risks from constituents such as metals that are difficult to manage using certain practices). The strength of the assumption can be tested using the RCRIS database to identify the actual rate of occurrence of non-compliance and damage incidents at sample facilities. If damage caused by releases from Subtitle C-regulated facilities is significant, then the expected level of contamination in the with-RCRA scenario can be adjusted to reflect this; and the specific contribution of waste minimization efforts should be addressed.

By adjusting the *Corrective Action RIA* modeling to reflect continued disposal of waste in sample pre-RCRA units, we can estimate the total damage that would have resulted if pre-RCRA waste disposal practices had continued at these sites.[7] The benefit attributable to the Subtitle C prevention program is the difference between this "continued disposal" damage and the *Corrective Action RIA*'s baseline estimate of contamination from the sample facilities. This captures the benefits of discontinued waste disposal practices at current facilities.

3.2.3 *STEP 3: Estimate or Characterize Benefit Attributes*

The modeling results in Stage 2 provide estimates of the number and extent of releases and environmental damage that have been avoided by the implementation of RCRA prevention programs. The third stage of Approach B involves estimating benefits associated with avoiding this damage. It is necessary in this approach to address benefit attribute categories separately. There is no aggregate measure of benefits such as the property value estimate in Approach A. However, while separate analysis of individual attributes requires additional effort, it provides the following flexibility that is not available in Approach A:

- The ability to focus on a specific attribute or category of benefits and provide more information on specific environmental outcomes resulting from the RCRA Subtitle C program;

- The ability to revisit and update specific attribute analyses as information improves or as the literature in the field develops.

We present potential methodologies for estimating benefits in the next section of this chapter.

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[7] We expect that the facility information that was collected during the development of the *Corrective Action RIA* will be sufficient to support an estimate of facility production, waste generation, and disposal rates. To address continued waste disposal practices we propose to identify a range of scenarios, including a scenario that predicts continued disposal at a constant rate, and scenarios that suggest declines in waste generation (e.g., due to technology improvements) and increases in waste generation (e.g., due to facility growth). For cases in which facility-specific data are not sufficient to develop a scenario of continued disposal, we propose to supplement facility-specific information with industry-level data in EPA's *Industry Assessments* to develop a reasonable disposal scenario for a representative facility.

3.2.4 *STEP 4: Apply Modeling Results to "Avoided TSDs"*

The modeling scenarios in Step 2 identify incremental damages that would have occurred if waste continued to be managed in certain SWMUs. These results should be representative of TSD facilities in the Corrective Action universe (i.e., operating facilities that changed practices under RCRA).[8] In addition, these results can also provide an alternate estimate of the benefits associated with facility closures (i.e., an alternative to the property value-based result of Approach A). This alternative would apply the average avoided contamination level identified in Step 2 to the number of "avoided TSDs" (subject to the same uncertainties) identified in Approach A. The result would be an estimate of total avoided contamination associated with TSDs that closed under RCRA. This step would require the following calculations:

- Identify the range of avoided damages at RCRA facilities (based on modeling results from Step 2) and adjust this avoided damage estimate to reflect the total universe of facilities estimated in the *Corrective Action RIA*; this would provide a national estimate of avoided damages due to improved practices at ongoing facilities;

- Apply the range of avoided (without-RCRA) average per site damage estimates calculated for the sample facilities to the "avoided TSDs" identified in Approach A.[9] This would provide an estimate of the avoided damage due to facility closures; and

- Add the results of these two analyses to provide a total estimate of the damage avoided by RCRA regulations at TSDs.

The avoided damage from closures under Approach B can be measured simply by applying the range of damages identified at existing facilities to the number of avoided facilities, including both "clean" facilities and those with existing damage that were eliminated from consideration in

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[8] The extent to which these results can be applied nationally will depend on the extent to which facilities and SWMUs in the *Corrective Action RIA* facility sample are representative of units that were affected by RCRA.

[9] Note that a simple extrapolation of the range of damages from the *Corrective Action RIA* to theoretical "avoided facilities" assumes that the avoided facilities would look like the facilities in the *Corrective Action RIA* sample. This extrapolation can be adjusted if available information suggests that *Corrective Action RIA* facilities are not representative of avoided TSDs. Remaining uncertainty can be addressed with a sensitivity analysis.

Approach A.[10] As in Approach A, however, it is necessary to develop a range of estimates to reflect possible differences in the profile of existing contamination at facilities in the *Corrective Action RIA,* and the profile of existing contamination at facilities that closed under RCRA. Exhibit 3-2 shows a flow chart illustrating the calculations in Approach B.

3.3 PROPOSED METHODOLOGIES FOR BENEFITS ATTRIBUTES

The Approach B modeling effort provides data that define the extent of avoided contamination associated with improvements in waste management under the RCRA Subtitle C program. These data, in turn, inform a set of analyses that would estimate the benefits associated with avoiding this contamination. Below we propose methodologies for assessing human health benefits, ecological benefits, avoided costs, and aesthetic and historical benefits associated with RCRA Subtitle C program. These methods rely primarily on the data and modeling results available under Approach B. In addition, while the *Corrective Action RIA* data are sufficient for some of the methods we propose, we also recommend additional data collection or additional analyses to address aspects of attributes that Approach B modeling data do not adequately address.

3.3.1 *Human Health Benefits Related to Chronic Exposure*

An important potential benefit of RCRA is the avoided human health effects associated with exposure to hazardous waste. Because of the large number of different chemical constituents and waste types addressed by the law, avoided health effects include a range of individual and population cancer and non-cancer risks. Although these effects are usually the result of chronic exposure over a long period of time, improved waste management under RCRA may also prevent acute health effects related to exposure from accidents; we address acute events separately below.

Furthermore, exposure to the variety of wastes regulated by RCRA can occur through one or more of several pathways, including ingestion or dermal exposure (e.g., through showering) to contaminated water, inhalation of airborne contaminants, or exposure to soil contaminants through agricultural products or dermal contact. Actual exposure levels are dictated by the site specific variables of geography, hydrology, and the level and type of resource use in the vicinity of a facility. A large release at a facility in a remote area with impermeable soil may not create a measurable human health risk, while a smaller leak in a densely populated area or near an aquifer used for drinking water can have considerable effects.

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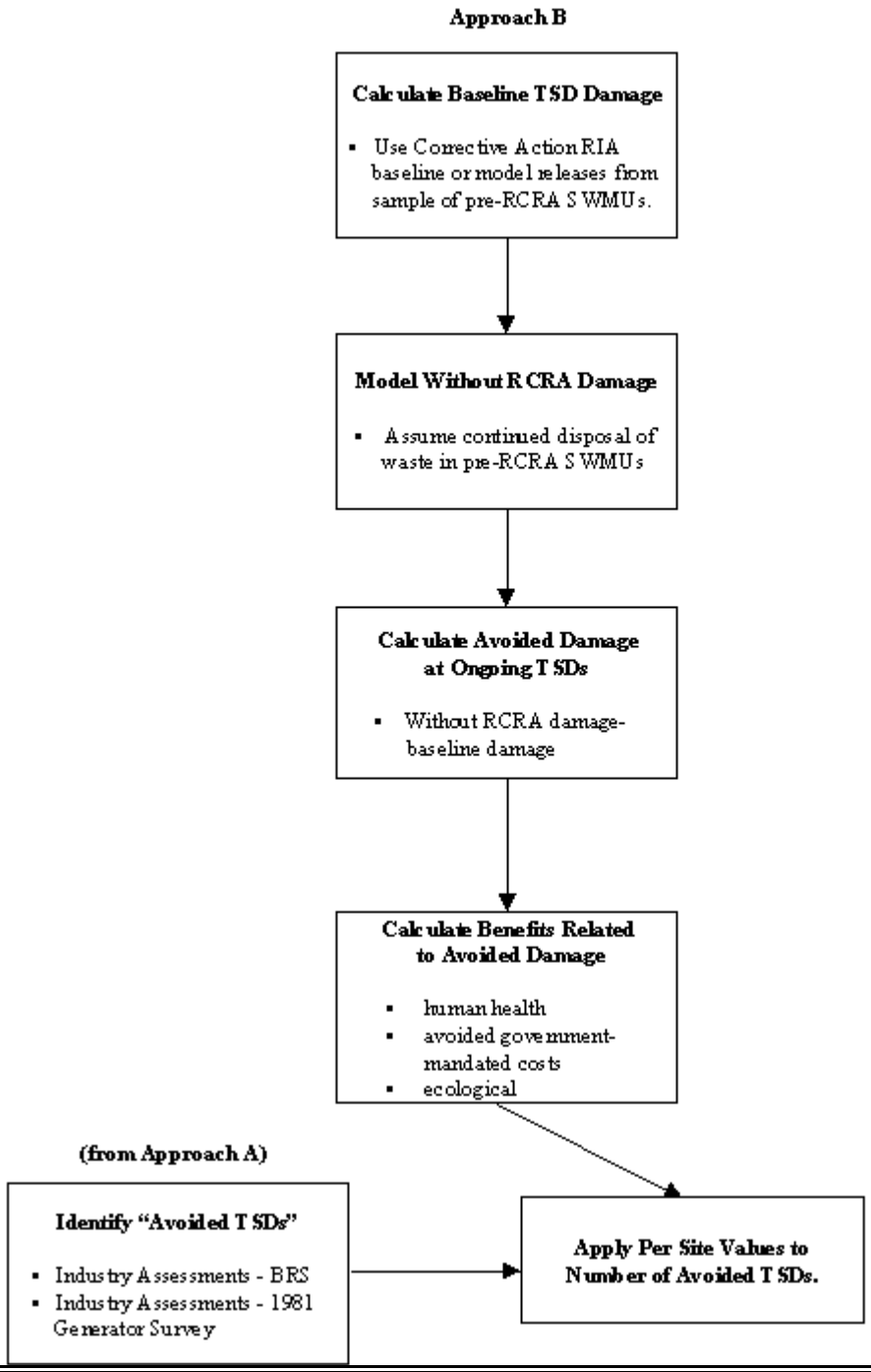
[10] Refer to Exhibit 3-1 for a representation of the portion of benefits and impacts captured under Approach B.

Exhibit 3-2

SUMMARY OF APPROACH B TO ESTIMATING RCRA BENEFITS



Multiple pathway exposure modeling is the most appropriate method for effectively addressing and estimating human health risks in the wide variety of scenarios that occur under RCRA. The standard approach for benefits analysis using multiple pathway exposure modeling involves the following steps:

- Estimating the environmental transport of contaminants through soil, air, and other pathways under a range of with-RCRA and without-RCRA release scenarios;

- Identifying the human "exposure points" in the vicinity of the facilities (e.g., nearby homes, drinking water wells and agricultural land); and

- Applying estimates of the value of avoiding the expected health effects that result from these exposures.[11]

The site-specific data required for characterizing avoided releases under Approach B should be sufficient, if carefully collected, for developing a modeled estimate of the range of human health risks associated with exposure. The sample of 79 facilities in the *Corrective Action RIA* forms the basis for a national estimate of the human health benefits of the Corrective Action program. The RIA uses MMSOILS to model the baseline and Corrective Action exposure scenarios and derives cancer and non-cancer benefits estimates based on exposure scenarios from the model. In addition to their potential use in developing an estimate of total environmental damage avoided by RCRA, these data can provide a baseline estimate of human health risks at ongoing TSDs.

Method:

- Use the *Corrective Action RIA* baseline to identify human health risks from old waste disposal in the presence of RCRA (i.e., units that closed due to Subtitle C);

- Re-run the Corrective Action models to determine exposure to continued waste disposal in the absence of RCRA;

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[11] The statistical value of a human life is frequently used to monetize the population-level benefits of cancer risk reduction and has been applied in other scenarios. This value, and its application in different types of analysis, is itself the subject of ongoing discussion among economists, but its application is an established practice. The selection of a value would be done in accordance with EPA's *Guidelines for Performing Economic Analyses* as part of the design and implementation phase of this project.

- Estimate the economic value of the differences in human health risks under the two scenarios; and

- Apply the range of results from this methodology to the Approach A estimate of avoided TSD facilities.

The *Corrective Action RIA* provides an estimate of both population risks and "MEI" risk; MEI risk in this case would addresses those individuals who represent the top ten percent of exposures associated with waste in closed pre-RCRA SWMUs. The RIA modeling effort attempted to address all damage associated with closed SWMUs (including future human health risks from past releases) and developed a present value estimate of the monetized avoided risks. A revised model would likewise predict future damages associated with "past" waste disposal by modeling continuation of disposal from 1982 until the present time. Potential adjustments to the original modeling assumptions may include updates in estimates of future population density, potential changes in assumptions about the calculation of a present value of human health risks, and revisions to model inputs to reflect new research in health effects or exposure analysis. In addition, the methods for valuing avoided health effects should be carefully reviewed.

Advantages: This approach uses published data and a reliable methodology, and does not require significant additional collection of site-specific data for the development of a modeled estimate of the benefits of changes in management practices at operating TSDs. Assuming that the *Corrective Action RIA* sample facilities are representative of RCRA TSDs, the method would provide a national estimate of avoided population and MEI risks associated with improvements in waste management under RCRA.[12] The approach identifies the benefits of "original" RCRA program regulations.

Disadvantages: The results of this approach are limited to practices at TSD facilities, and does not address generators under RCRA. In addition, the approach does not address newer RCRA regulations because it looks only at SWMUs that ceased operations by 1982. Finally, the effort required to re-examine facility data and re-program the MMSOILS model is likely to be considerable.[13] Note that while the original modeling protocols have been well documented, the effort required to recreate the original modeling results and adjust the model for the without-RCRA scenario would be significant. For example, the *Corrective Action RIA* was concerned with the risks associated with pre-RCRA SWMUs. As a result, the modeling did not emphasize air releases because most volatilization had already occurred. In contrast, the modeling effort required to predict

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[12] Reduction in the number of MEIs, however, would not represent a separate, additive health benefit to reduction in population cancer risk.

[13] In addition, EPA's Science Advisory Board (SAB) identified the limitations of MMSOILS in its peer review of the *Corrective Action RIA*; to the extent that newer versions of MMSOILS have not addressed these limitations, Approach B would require addressing the SAB concerns.

without-RCRA exposures would need to include potential air releases associated with continued waste disposal. Exhibit B-1 in Appendix B contains a summary description of this methodology, along with methods for estimating human health benefits recommended in other approaches.

3.3.2 *Acute Events*

In addition to reducing the risk of health effects from chronic exposure, the RCRA Subtitle C program may provide significant benefits by reducing the frequency and severity of acute events. While these benefits are difficult to identify and monetize, they may include human health effects, ecological damage, and costs associated with emergency response and cleanup.

We briefly examined two aspects of potential benefits of RCRA associated with acute events: reduction in the overall frequency of events, and reduction in the probability of infrequent but catastrophic events. The results of our screening analyses were inconclusive, but suggest that further examination of these issues may be useful. We therefore provide a brief summary of our analyses and propose methods for further examining this issue.

3.3.2.1 Frequency of Acute Events

The number of acute waste-related events appears to have declined since adoption of RCRA. ICF (1996) reports 370 hazardous waste acute events in a three year, post-RCRA period (1993-1995).[14] In contrast, review of the *EPA Hazardous Materials Incidents Reported to U.S. EPA Regional Offices* document (1980) suggests a conservative estimate of 620 hazardous waste acute events in a comparable pre-RCRA time frame.[15] Thus, the frequency of acute events has been as much as halved (i.e., from over 200 per year to roughly 120 per year) since the adoption of RCRA.[16]

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[14] ICF. "Memorandum: Results of Analysis on Releases from Waste Facilities." (1996).

[15] EPA. *Hazardous Materials Incidents Reported to U.S. Environmental Protection Agency Regional Offices from October, 1977 through September, 1979.* Washington, D.C.: EPA. (1980).

[16] The EPA *Hazardous Materials Incidents* report does not distinguish hazardous waste incidents from hazardous materials incidents. However, the document does divide reported incidents into thirteen categories of events. We assume that three of these categories (storage, waste disposal, and treatment) provide a conservative estimate of hazardous *waste* events. This estimate is conservative as it excludes categories that most likely include some hazardous waste incidents, such as rail, truck, fire and miscellaneous. Since the EPA report covers a two year period, we scale these results to a three year period (by assuming a constant number of annual events) to make the EPA results comparable to the ICF results.

Despite the significant decline in the occurrence of acute events, the total number of events both before and after adoption of RCRA appears to be relatively small, and available data do not provide estimates of typical costs or health effects associated with acute events. While some events may require considerable response costs (e.g., evacuations) and may impose significant health risks, others may involve little more than stabilization and removal of spilled waste. As a result, it is not clear whether the overall reduction in acute events under RCRA is associated with significant benefits. Because of the small number of events both before and after RCRA's passage, average costs per event would have to be quite high to be significant relative to other costs and benefits of the RCRA Subtitle C program.[17] While we anticipate that avoided costs associated with acute events would not be significant given the relatively low occurrence of events, willingness to pay to avoid health effects related to acute events could be considerable. However, we are not aware of reliable empirical data identifying willingness to pay to avoid acute events.

Method: To better determine the benefits associated with a reduction in the frequency of acute events, we propose a detailed examination of a sample of the events reported in both the ICF study and the 1980 EPA report, to determine the extent of costs and health effects associated with emergency responses. In addition, we suggest a review of the risk communication and valuation literature to identify any new research that presents an estimate of the value associated with avoiding acute events similar to those prevented by RCRA.

3.3.2.2 Reduced Risk of Catastrophic Events

Though the frequency and anticipated average cost of acute events may be relatively low, RCRA regulations may reduce the risk of infrequent but catastrophic events, such as the Bhopal event in India in 1984. In this case it is worth characterizing and monetizing the benefits of avoiding such disasters. EPA (1996) developed an approach for estimating the costs associated with catastrophic events based on the probability of occurrence.[18] The study characterizes the probability of an event equivalent to the Bhopal disaster, and the probability that such an event would occur in the U.S. This probability is then applied to estimates of the total costs (human health, environmental, economic) of such a disaster. Based on that benchmark, the study extrapolates annual costs of catastrophic events.

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[17] For example, if the average "value" of avoiding an event were one million dollars (reflecting both avoided response costs and willingness-to-pay to avoided health effects), then the total annual benefit associated with acute events avoided under RCRA would be roughly $100 million (based on the above data sources). In comparison, total 1994 *private sector* RCRA expenditures were roughly $2,500 million, excluding costs to government or society at large.

[18] EPA. *Economic Analysis in Support of Final Rule on Risk Management Program Regulations for Chemical Accident Release Prevention, as Required by Section 112(r) of the Clean Air Act.* (1996).

A similar method could be applied to the potential for catastrophic events involving pre- and post-RCRA hazardous wastes. However, catastrophic waste-related events appear to be rare. Our preliminary examination of the Acute Hazardous Events Database (1985) and two EPA studies did not identify any hazardous waste-related events of "catastrophic" magnitude as defined by impacts on human health.[19] The infrequency of events and the limitations of available data make it difficult to identify a baseline of catastrophic events against which to measure RCRA. As a result, while the costs savings and willingness to pay to avoid catastrophic events could be considerable, it is difficult to determine the change in probability of such an event under RCRA.

Method: One possible approach is to conduct case studies of catastrophic events. This might require going back in history to examine past U.S. events or looking outside the U.S.. One example would be a case study review of the damage and cost estimates associated with the recent mining waste releases in Romania. While these incidents took place outside the United States and likely involve "Bevill Amendment" waste that is exempt under RCRA, they may provide a useful "worst case" benchmark for hazardous waste-related accidents. If the accidents did involve RCRA wastes and/or waste management practices discontinued under RCRA (e.g., the use of surface impoundments for hazardous waste), then it might be possible to estimate the extent to which RCRA has reduced the probability of such events. Exhibit B-1 in Appendix B contains a summary description of our proposed methods for addressing acute events.

Note that RCRA may also reduce the frequency of waste-related damage during catastrophic events such as floods. While releases during floods are clearly acute events, the magnitude of flood damages makes it difficult to isolate health benefits or clean-up costs associated with hazardous waste releases. We therefore address the potential reduction of flood damages in our discussion of ecological benefits below.

3.3.3 *Ecological Benefits*

RCRA prevention primarily addresses land disposal practices. As a result, releases to land are the type of polluting event most often avoided by regulation. The effects of land releases can include contamination of soil and groundwater, surface water, and some types of pollution by air. The potential for ecological damage varies with geography and constituent. For example, some constituents when released into the air can be carried and deposited at a relatively great distance from

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[19] IEc. *Acute Hazardous Events Data Base.* (1985); EPA. *Estimating Potential Casualties from Acute Events at Emergency Response Sites*. (date unpublished); EPA. *Hazardous Materials Incidents Reported to U.S. Environmental Protection Agency Regional Offices from October, 1977 through September, 1979.* Washington, D.C.: EPA. (1980). One recent event that may be classified as catastrophic is the large releases of waste from gold mines in Romania in early 2000. However, the ecological and human health damage from this event and the costs associated with its cleanup are still unclear.

the point of release. Others may have health and ecological impacts only at short distances from the release point, due to their instability.

Measurable damage to ecological resources from land releases generally occurs when groundwater or overland flow of water carry contaminants to a nearby surface water body. Flood events and other acute incidents can cause releases of waste that have an immediate and significant effect on ecological resources (e.g., a surface impoundment dike fails and releases contaminants into a river, killing fish and other biota). More common are gradual increases in contaminant levels due to long-term releases to groundwater. These may have a broad array of impacts on both resources used by humans (such as fish populations) and on "non-use values" such as the value of preserving habitat and species diversity.[20] In addition, biota can be affected by uptake of contaminants from soil, particularly in wetlands or areas where the water table is high. Relevant ecological impacts and benefits will vary with specific sites.

RCRA may have other ecological benefits related to the location and operation of newer TSDs. Approach B incorporates an initial assumption that there is *de minimis* risk from Subtitle C facilities so consideration of new TSDs is not necessary. However, this assumption may underestimate risk from these facilities, particularly from catastrophic events such as major floods. If the analysis is adjusted to incorporate potential risks from Subtitle C units, then the various construction and siting requirements related to these units should be considered in an evaluation of program-wide improvements.

We propose two approaches for addressing different aspects of ecological benefits. First, we present an approach for addressing ecological effects related to changes in practice at TSDs: this approach is based on, but also expands on, *Corrective Action RIA* modeling and data. Second, we propose a single approach for identifying the effects of RCRA siting requirements that are protective of flood plains and other ecologically sensitive areas.[21]

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[20] The value of preserving habitat and species diversity can include use values as well as non-use values. We use the terminology here to emphasize that analysis should recognize both use value and non-use value when assessing ecological benefits.

[21] Note that we do not specifically address ecological benefits associated with the preservation of groundwater because there is no established method for addressing the non-use value of groundwater, and it is unclear whether groundwater is, in fact, understood by most people to be an ecological resource. However, we address the use value of groundwater in our discussion of avoided costs below in Chapter 3, and we discuss the long-term issues related to the preservation of groundwater (e.g, "assurance" and bequest values) in our discussion of Long Term Benefits in Chapter 4.

3.3.3.1 Model Ecological Benefits Using Multi-Pathway Analysis

The *Corrective Action RIA* modeled baseline ecological damage to surface waters at 52 facilities with SWMUs. While this sample was not specifically selected to emphasize geographic distribution or proximity to ecological resources, adjustment of the model to identify the ecological impact of continued pre-RCRA waste disposal at these facilities can reveal information about the potential importance of prevention. While results of this modeling should not be applied on a national level without adjustment, a supplementary sampling effort or a careful benefits transfer analysis may provide the basis for a reasonable national estimate. Without a close examination of facility data from the *Corrective Action RIA*, it is not possible to identify specific approaches to national extrapolation. However, we do provide a description of a general modeling approach using *Corrective Action RIA* data.

Modeling is the most effective approach to identifying the ecological benefits of RCRA at a variety of facilities with varying wastes, varying quantities, and varying proximity to fragile and valuable ecosystems. Although modeling of ecological resources has intensive data requirements, many of the most important types of environmental data are readily available in spatial form. The facility-specific data and MMSOILS baseline analysis associated with the *Corrective Action RIA* provide a reasonable starting point for an analysis of incremental effects.

Method:

- Use the baseline MMSOILS model results from the *Corrective Action RIA* to identify with-RCRA Subtitle C damage.

- If data are available, expand modeling to additional pathways such as air and soil (the original analysis examined only surface water) and identify any additional effects.

- To identify avoided damage, revise the model to predict expected releases and damage from SWMUs assuming continued waste disposal in the absence of RCRA Subtitle C.

- Characterize damage avoided by RCRA, and establish values for impacts based on literature or benefits transfer methodologies. Note while some benefits such as the value for commercial and recreational fishing can be assigned monetary values, other ecological benefits such as preserved habitat may be difficult or impossible to monetize.

- If specific risk drivers are identified (e.g., proximity to a specific type of resource, geology, or industry type) a scoping analysis of the potential risk driver can identify possible national level benefits (e.g., a spatial analysis of the number of facilities located in riparian zones).

Advantages: This approach provides detailed modeling results that can contribute to analysis of a variety of different ecological benefits. It also allows construction of state-of-the-art geographic information system that can be updated as methodologies advance.

Disadvantages: The approach may require significant effort if modeling extends to facilities beyond the *Corrective Action RIA* sample. Also, the ability to extrapolate results to national level may be limited by previous sampling priorities. Finally, most available models are not able to measure acute events such as floods.

3.3.3.2 Assess Effects of Subtitle C Facility Siting Requirements

One potential benefit of RCRA is improved siting of new TSD facilities due to regulations that require facilities to be located away from flood plains and other sensitive ecological areas. While site requirements have a limited effect on existing facilities, a simple analysis comparing the locations of new and "older" RCRA TSDs may identify significant ecological protection benefits not captured in the approaches outlined above.

Method: Our proposed method for examining this potential benefit is a spatial analysis using a geographic information system (GIS) to identify the proximity of flood plains and other sensitive locations to RCRA facilities. Data in RCRIS and BRS can be used to identify pre-RCRA siting decisions (i.e., TSDs that applied for interim status in 1980) and more recently regulated facilities. Using geographic data from the United States Geological Survey, National Oceanographic and Atmospheric Administration, and other public sources to identify ecological features, a simple analysis of the percentage of facilities in close proximity to fragile systems can identify the extent of change in siting decisions under RCRA.[22] In addition, a supplemental analysis of high water data for recent large flood events (e.g., the 1993 Mississippi River floods) and multiple years of BRS data may allow identification of specific facilities that ceased managing waste prior to flood events.

The results of this analysis are not additive with the results of the multi-pathway ecological analysis because it is impossible to predict what facilities "would have been sited" absent RCRA. However, an identifiable trend toward siting decisions that are protective of ecological resources is a clear benefit of the program that can be presented in conjunction with the above approach.[23]

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[22] This analysis assumes that, absent RCRA, spatial distribution of RCRA facilities would be similar to the distribution of pre-RCRA facilities that still exist.

[23] Flood-related hazardous waste releases would also likely include materials damage and human health effects, but these effects would be difficult to isolate from general flood damage, and may also be included in an analysis of acute events. Our discussion of the benefits of RCRA siting requirements therefore focuses only on ecological impacts.

Exhibit B-2 in Appendix B contains a summary description of these two methodologies, including a brief description of data requirements for each.

3.3.3.3 Note on Resource Conservation Benefits

Our proposed methods for characterizing the ecological benefits of RCRA do not address "resource conservation benefits" associated with reductions in the quantity of hazardous waste generated under RCRA. Reduced waste generation may be associated with reduction in the extraction and use of raw materials. Avoided ecological damage associated with the extraction of raw materials should be considered a benefit of RCRA.[24] However, at this time we have not examined available data sources or considered potential methods for addressing these benefits. We recommend that this potential source of benefits be revisited as part of implementation.

3.3.4 *Avoided Costs*

The "avoided costs" attribute is often difficult to define and measure, particularly in the context of a prevention-related program. A central purpose of the RCRA Subtitle C prevention programs is to avert environmental damage and its associated costs. Therefore, many benefits of RCRA may be expressed as "avoided costs" and some avoided costs are captured in other attributes. However, here we specifically address the costs associated with government mandated and voluntary treatment or "averting behaviors" to avoid the effects of contamination. Government mandated treatment costs avoided by RCRA Subtitle C are not captured by other attributes and may have a significant impact on the overall value of the program. Voluntary averting behavior costs may also be considerable and may be useful in estimating the full value of avoiding health impacts. Our proposed methods address the avoided costs associated with obtaining alternative water supplies.

Because most releases of waste from hazardous waste facilities are releases to land, contamination of groundwater is a primary exposure pathway. The costs related to this damage include the incremental costs of switching to a new water supply. This can mean purchase of bottled water, connection of homes to a municipal water supply, or installation of water treatment for an existing supply. In any situation where contamination requires installation of a more expensive water supply mechanism, the avoided costs of averting health effects include the switching costs and any incremental water costs. Note that while other types of exposure (e.g., ingestion of food grown

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[24] Note that conservation of finite resources represents a transfer of goods across time and may or may not be associated with an economic benefit. Actual economic benefits would be determined by the extent to which the future value of the resource is affected by scarcity, demand, and availability of substitutes. However, resource conservation is often a stated goal of a particular policy or regulatory program and it may also be important to identify the extent of resource conservation as part of a comprehensive assessment of a program.

in contaminated soil or water) may require changes in behavior, in most cases we believe that switching costs are negligible (e.g., since most populations are not exclusively dependent upon local food sources).[25] Finally, this definition of avoided costs is conservative in that it does not consider behavior changes with no obvious replacement cost, such as the need to reduce showers or outdoor activities in order to limit dermal exposure to or inhalation of VOCs and other contaminants.

One issue in estimating avoided water supply benefits is the potential overlap with human health risks, since averting behavior should reduce risks to health, even before site remediation is complete. A simple approach assumes that all exposure-related human health risks are fully mitigated by averting behavior at the point in time when public notification of risk occurs (for simplicity we also assume that notification is simultaneous with the beginning of site remediation). Therefore, the duration of human health risks is defined as the interval between initial exposure and the public notification of risk.[26] The value of avoided costs is then added to human health risk estimates.[27] Exhibit 3-3 illustrates this view of a hypothetical damage incident and its associated impacts; additive costs represent the sum of other costs in the figure. Note that any implementation of these methods should carefully define exposure duration and averting behavior costs to assure that there is no double-counting of these impacts.

Our proposed Approach B would address both the avoided costs associated with improved practices at active TSDs and the benefits associated with avoiding hazardous waste sites. Therefore, each avoided cost estimate would incorporate two calculations: an assessment of benefits associated with operating TSDs (removing from consideration remediation and response activities in the with-RCRA scenario), and a separate estimate of avoided costs associated with avoided hazardous waste sites. Below we present two alternative approaches to calculating avoided water costs. Within each of these methodologies we address both existing and avoided TSD facilities.

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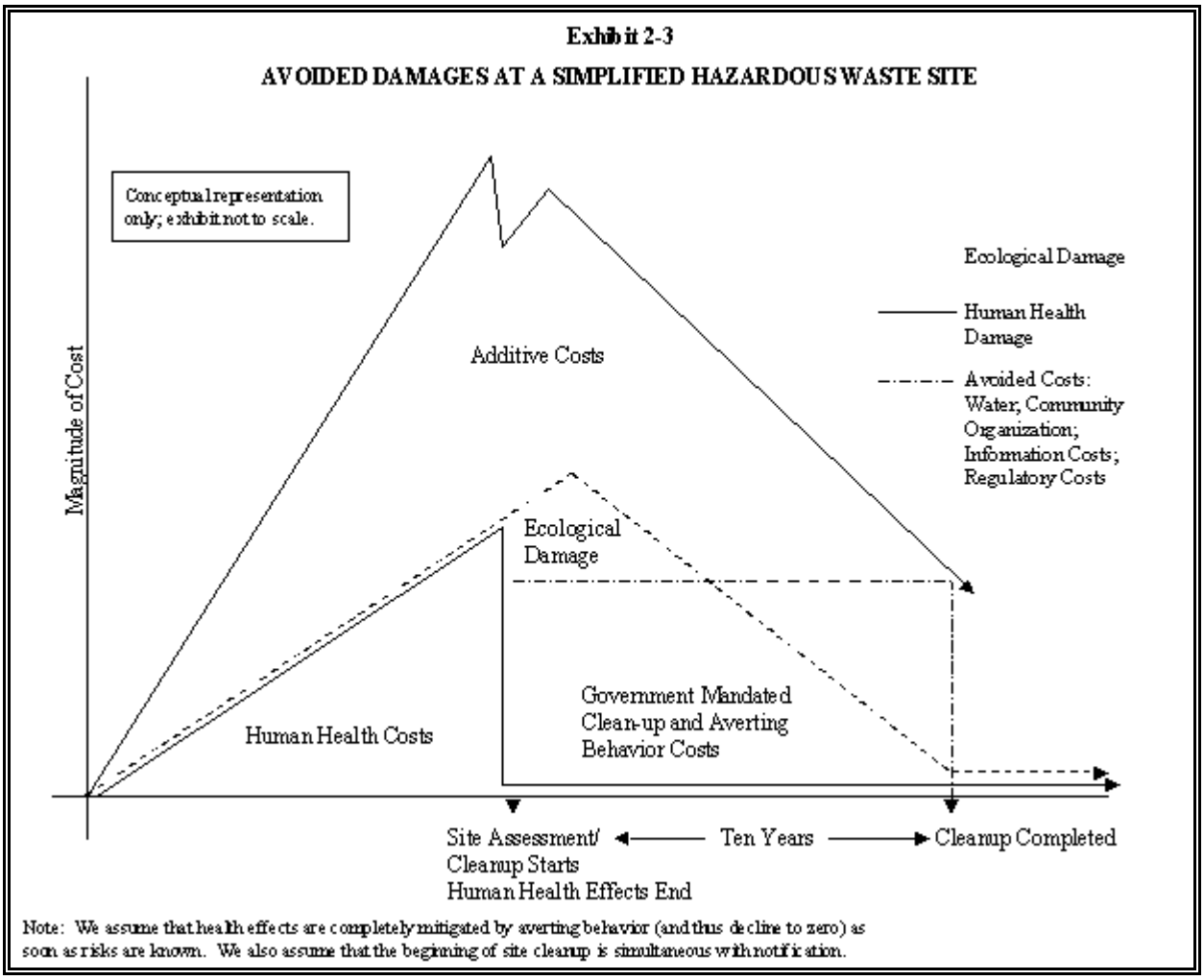
[25] In some cases where certain populations are dependant on a specific food source this assumption may not be valid. The environmental equity attribute addresses the distributional effects of contamination on sensitive populations and can be used to identify cases where this issue arises.

[26] This simplifying assumption does not address circumstances in which persons continue to be exposed to risk (e.g., through refusal to take averting actions, lack of notification, or exposure to "unavoidable" risks such as air transport of pollutants from a site). In these cases averting behavior-related costs may serve as a rough substitute for the continuation of human health risks.

[27] Implementation of any modeling approach must address the issue of assessing total impacts; one approach could be to model perpetual human health impacts to estimate extent of environmental damage. Alternatively , it may be preferable to model more limited health impacts and consider clean-up and averting behaviors. The actual extent of health risks and averting behaviors vary with site specific characteristics. The modeling approaches suggested for human health effects will require identification of expected duration and timing of contamination and health effects, or consideration of avoided costs on a site-specific basis.



3.3.4.1 Option 1. Simple Extrapolation of Existing Estimate

The *Corrective Action RIA* modeled baseline avoided costs of providing alternative water supplies. One very quick estimate of costs can be generated by assuming that water supply damage (and replacement costs) have a linear relationship with the spatial extent of contamination. This estimate uses modeling data generated for the human health benefits evaluation above to compare the spatial extent of affected groundwater resources under the without-RCRA scenario with that identified in the baseline. Then the RIA's total estimate of $230,000,000 (in 1992 dollars) can be adjusted by the same percentage.[28] The RIA's total estimate can also be adjusted to provide an

[28] Note that we use groundwater volume as a metric because we assume that well access is determined by property ownership patterns and not by aquifer volume. However, we suggest a bounding analysis using change in percentage volume affected to reflect an assumption that the well access is determined by the extent of the resources and does not conform to property lines.

estimate of the avoided costs associated with the total number of avoided facilities identified in Approach A. This assumes a simple linear relationship between cost and number of affected facilities, and assumes that the Corrective Action universe is representative of the avoided facilities. The simple calculations for this approach are:

Avoided Water Costs at operating TSDs =

area affected groundwater (without RCRA)/area affected groundwater (baseline)× baseline total avoided costs

Avoided Water Costs at avoided TSDs =

(average replacement costs per site (RIA baseline)) × # avoided TSD's (Approach A)

Total RCRA avoided water supply benefits =
Avoided Costs at operating TSDs +Avoided Costs at avoided TSDs

Advantages: This option provides a simple characterization of the extent of water replacement costs avoided under RCRA without requiring significant data collection.

Disadvantages: The result of this option is based on the assumption that relationships between the extent of damage (either spatial extent of pollution or number of facilities with releases) and avoided costs are linear. This assumption obscures the fact that avoided water costs are "project-defined." For example, the two long-term options for alternative water supply (treatment and extension of municipal systems) require significant capital investments, but the marginal cost of "adding another house" to an extended system may be insignificant. Also, the approach requires the designation of an "average time span" for contamination in order to designate plume sizes; this estimate will contribute uncertainty to the analysis. As a result, the estimates identified in this methodology are most useful for scoping purposes only.

3.3.4.2 Option 2: Calculate Benefits Using Modeling and Site-Specific Data

Option 2 addresses the issue of cost variability by using *Corrective Action RIA* sample facility data to model the extent of additional without-RCRA disposal effects in real settings. The *Corrective Action RIA* outlines an approach that incorporates actual well use data and existing water supply options into its baseline avoided cost estimate. An approach that reproduces or updates this methodology will provide a more specific and reliable estimate of avoided costs.

Method:

- Define with-RCRA scenario using *Corrective Action RIA* data to determine the following: affected population of well users for each sample facility; likely alternative water sources for each site (e.g., municipal water sources or wells not in the path of contamination); and costs associated with the most

reasonable option for each facility, based on engineering estimates borrowed from the literature or generated for the project.[29]

- Modify model to determine extent of groundwater contamination in a without-RCRA scenario.

- Using *Corrective Action RIA* engineering cost and site specific data, estimate the total costs of without-RCRA alternative water supplies, and calculate the benefit by subtracting the with-RCRA estimate.

- Extrapolate results to existing TSD facilities with on-site pre-RCRA SWMUs.

- Estimate costs associated with avoided facilities by applying the ratio of without-RCRA to with-RCRA costs to the number of avoided TSDs identified in Approach A. Like Option 1, this approach assumes a linear relationship between value of the benefit and number of affected facilities.

Advantages: This option would provide a more defensible estimate of avoided costs by using actual site information and project cost estimates. The approach addresses the possibility that marginal avoided costs at a site already contaminated might be very different than total project costs.

Disadvantages: The approach may require significant effort if additional or updated facility data collection becomes necessary. If the effort requires consistent data collection from more than nine individual facilities, then an ICR may be necessary. Exhibit B-3 in Appendix B contains a summary description of our proposed methods for addressing avoided costs.

3.3.5 *Improved Aesthetics and Historic Preservation*[30]

Although RCRA Subtitle C regulations do not directly address the preservation of historic districts or improved aesthetics, better waste management practices may have incidental benefits,

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[29] The likely population of well users must reflect expected population growth and land use transitions in predicting future exposure incidents related to pre-RCRA wastes. The *Corrective Action RIA* presents a method for addressing this issue over the time frame identified in that analysis, but this issue should be addressed again carefully in developing an analysis of RCRA Subtitle C.

[30] This attribute is for consideration in Approaches B, C and D. The value of aesthetics and historic preservation are already reflected in the property values that form the basis of Approach A, though these values do not include non-residential benefits such as improved revenue from tourism.

including reduction in noise and odor and improved visibility in the immediate vicinity of TSD facilities. In addition, TSD facilities near historic districts or open spaces such as parks might affect the quality of experience in these places; regulations mandating appropriate waste treatment might therefore improve the quality of the resources. Alternatively, RCRA regulations that result in a facility owner/operator having to transport their waste for off-site storage, treatment, or disposal to ensure effective management may increase truck traffic and noise, and may actually reduce aesthetic quality. It is even possible that total benefits under this attribute could be negative if new RCRA facilities are larger and more disruptive than older facilities.

There are three difficulties in addressing aesthetics and historic preservation in the RCRA context. First, because impacts on these attributes are indirect results of RCRA, there is no national effort to collect information to identify these effects. Second, the attributes and their values are very localized and require site-specific evaluation.[31] Finally, it is difficult to attribute benefits to RCRA because other environmental laws (e.g., the Clean Air Act) also affect aesthetics and the preservation of historic landmarks. For these reasons we limit our range of approaches to those that will characterize the possible importance of these attributes without demanding considerable resources. We recommend four methodological options. The first two options address aesthetic improvements; the third addresses historical preservation, and the fourth is an integrated approach that addresses both improvements in aesthetics and historic districts in the vicinity of RCRA facilities.

3.3.5.1 Potential Benefits to Aesthetics Under RCRA

Option 1. Identify Correlation, Trends Between RCRA Sites and Reported Disamenities. The American Housing Survey from the U.S. Census asks residents in various metropolitan regions to report on the features of their housing, including environmental disamenities such as noise, smoke, and traffic. Based on data from various years of this survey and corresponding BRS data, this approach would identify spatial correlations (using a GIS) between RCRA TSD facilities and reports of disamenities. Changes in these patterns over time (e.g., a reduction in reports of disamenties within a given distance from RCRA facilities) could be extrapolated to show trends in the vicinity of RCRA facilities.

Option 2. Qualitatively Discuss Changes in "Noxious Facilities." Using Industry Assessment data and specific engineering knowledge, this method would identify

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[31] One direct approach to valuing aesthetic quality or historic importance is a contingent valuation (CV) survey. CV studies identify the willingness of people to pay for a particular resource or asset by asking them their preferences in multiple different scenarios and options. However, CV studies are resource intensive and their results are often difficult to interpret, because they rely on hypothetical responses and not on exhibited behavior. We therefore limit our methods to simpler approaches to the evaluation of these attributes.

pre-RCRA practices and waste facilities in key industries that would likely have been "noxious." Using Arthur D. Little, Inc. (1991) and BRS data, the method would estimate changes in the number of facilities and use of waste management practices since RCRA, and would then identify qualitatively the extent and type of effects of these changes on aesthetics.

3.3.5.2 Potential Impact of RCRA on Historical Sites

Option 3. Identify Proximity of RCRA sites to Historical Sites. This methodology would identify potential impacts of RCRA practices on historical areas. Using BRS data and a GIS, the approach would map large RCRA facilities (TSDs and large quantity generators) from several different years of BRS data. For all or a random sample of the sites, we would then develop a GIS layer of historical areas and overlay this layer on the RCRA sites (note that this analysis can also be expanded to include natural and cultural resources such as national parks).[32] Finally, we would identify changes over time in the number of RCRA sites close to historical districts.

3.3.5.3 Impact of RCRA on both Aesthetics and Historical Sites

Option 4. Perform Detailed Case Study of a Sample of Facilities. This method would use the Approach B sample or a separately collected sample and perform case studies. The case studies would identify patterns of land use, population density, and facility practice both before and after RCRA, and would estimate the potential impact of changes in waste management practices.[33]

While none of these approaches defines a value for the effects of RCRA on aesthetics and historic sites, all four address the range and magnitude of the possible effects. By performing case studies to address both historic and aesthetic effects or by using a combination of two of the other methods, it is possible to determine whether impacts on aesthetics and historical areas were likely to be considerable. If the scope of these benefits appears to be extensive, then additional resources can be allocated to analyzing a sample of facilities using either GIS technology or site-specific research.

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[32] The ability to map all historical areas will be limited by data availability. While some historical districts are mapped by the US Geological Survey and are available in national coverages for use in a GIS, other sites are determined by locality and may not be available from national sources. In addition, the data management requirements of a national GIS can be considerable.

[33] This method may be most appropriate in the context of Approach C (see discussion below), which requires collection of detailed site specific data as part of its modeling effort.

Exhibit B-4 in Appendix B contains a summary description of the methods for addressing improved aesthetics and historic preservation, including a brief description of data requirements for each.

3.3.6 *Approach B Summary*

Approach B provides a method for the detailed assessment of individual benefits attributes related to both improvements in TSD operations at active RCRA facilities, and to avoided hazardous waste sites due to closure of pre-RCRA TSDs. The approach outlines a method for identifying an appropriate facility sample and for modeling two scenarios: a baseline with-RCRA Subtitle C scenario that reflects damage from previous waste disposal and a without-RCRA Subtitle C scenario that estimates environmental damage from projected waste disposal in the absence of RCRA.

Based on these modeling results and other available information, Approach B presents methods for addressing four key exposure-related attributes.[34]

- Human health benefits
- Ecological benefits
- Avoided costs of alternate water supplies and site remediation
- Improved aesthetics and historic preservation

These attributes must be addressed separately, and benefits estimates will be additive or suitable for national extrapolation only to the extent allowed by the size and representativeness of the facility sample. However, to avoid the expense associated with sample selection and data collection Approach B proposes the use of the existing facility and modeling data for the sample of facilities studied in the *Corrective Action RIA*. In addition, the approach would examine the relative importance of each attribute, allowing the use of state-of-the art literature and methodologies for evaluation.

Our proposed Approach B is significantly more resource intensive than Approach A, and though it effectively analyzes the entire range of activities associated with TSDs, it still does not address the benefits of changes in waste management practices at RCRA-regulated facilities such as generators and transporters. In addition, though approaches to certain attributes address newly regulated RCRA facilities, the central focus of Approach B is on the wastes and facilities initially

[34] Some data collected for Approach B may also be useful in examining Environmental Justice impacts related to RCRA; we discuss these impacts in Chapter 6.

regulated under RCRA. A thorough analysis of newly regulated wastes and industries would require an additional effort.

Approach B is also limited in its analytic options by the sample selection and data collection performed for the *Corrective Action RIA*. If it is determined that additional information or sample facilities are necessary to supplement the scope of an analysis, then a separate data collection effort would be required (note that an organized data collection effort from more than nine facilities would likely require an ICR). Even if the *Corrective Action RIA* is representative of the pre-RCRA universe, updating and adapting the RIAs model and analyses will demand considerable resources.

Finally, Approach B would address several important attributes and could provide a estimate for a substantial portion of the benefits of RCRA regulations affecting TSD facilities. However, as in Approach A, a complete examination of the benefits and costs of RCRA under this approach would require analysis of long-term benefits (Chapter 4), costs (Chapter 5), distributional impacts (Chapter 6) and program context attributes (Chapter 7).

3.4 APPROACH C: SITE SPECIFIC MODELING USING ORIGINAL DATA COLLECTION AND MODELING

Our proposed Approach C is similar to the site-specific modeling approach described in Approach B, but it would use different source data. While Approach B is based on the sample selection and available data of the *Corrective Action RIA,* Approach C outlines a methodology based on an original sampling and modeling effort. This approach allows more flexibility in study design to respond to issues such as resource limitations or analysis of a specific aspect of the RCRA Subtitle C program.

Our proposed Approach C would follow the same analytic outline as Approach B and involves several stages, including identification of sample facilities and collection of data; modeling analysis of facility data and identification of avoided damage; and estimation/characterization of attributes related to avoided damage. At each of these steps we present methodological alternatives that vary in required resources and in the comprehensiveness and precision of results. However, it is important to note that in an actual analysis, initial decisions about sample size and data collection may limit or expand later options for evaluation of some attributes.

3.4.1 *STEP 1. Identification and Selection of Facility Sample*

In Approach C, there is no pre-selected sample data. The most appropriate sample size and type is determined by specific analytic objectives. For instance, a limited number of detailed case studies may be most appropriate if the analytic objective is to characterize the range of possible benefits and costs of the RCRA or to develop a "worst case" damage scenario. Alternatively, if the objective is to reach a defensible national estimate of RCRA benefits and costs, then a larger,

representative sample of facilities is necessary, providing a range of industries, geographic locations, and pre-RCRA waste management and disposal practices.

In selecting an appropriate sample under Approach C, it is important to identify the aspects of facilities that will allow the most accurate measurement of a variety of attributes. To address this, it is important to identify a range of:

- **Waste constituents.** These should reflect a variety of fate and transport behaviors and a range of effects on human health and ecological resources.

- **Facility sizes and management technologies.** Some pre-RCRA waste management units are likely to be riskier than others.

- **Proximate ecological resources**. This may include a range of land use, surface water resources, notable resources such as national parks and wilderness areas, and climates.

- **Human receptors.** This should include a range of population densities in various geographic areas of the country, to identify the likely range of health effects from different types of facilities.

- **Geology.** Because groundwater is an important pathway for human exposure, it is important to look at the effect of geology on the extent of damage from a facility.

Without knowing specific objectives in advance, we have identified a variety of data sets that may be useful in the development of sample frames and facility universe estimates. These include *Corrective Action RIA* data, as well as data from CERCLIS, RCRIS, BRS (for more recent facility information) and various state sources.[35] For a more detailed discussion of these sources see our description of Approach B above.

3.4.2 *STEP 2. Model Baseline and Without-RCRA Releases*

Approach C can be used in developing an estimate of the incremental benefits of improved waste management practices at active RCRA facilities, as well as benefits associated with avoided

[35] Several states maintain publicly available facility and site information; however, if data are not readily available and the approach requires data from more than nine states, then an ICR may be necessary.

hazardous waste sites and TSDs. Furthermore, depending on sample selection, this approach could incorporate more recently regulated TSDs and wastes.

As in Approach B, it is necessary to identify pre-RCRA facilities that ceased or changed management of waste with the implementation of RCRA regulations. Using any of a number of sources, including *Corrective Action RIA,* RCRIS, state information sources, and CERCLIS, sample selection can be tailored to address specific analytic objectives.

In addition, Approach C would require the selection of a multi-media model that can be used to simulate a range of future release and damage scenarios. There are several multi-media models that are capable of providing reasonable scenarios for a variety of sites. To the extent that a model can be "customized" with site specific data in the place of default parameters, these models can provide reliable estimates of transport and exposure at individual facilities; however, if the preferred methodology is a set of case studies, then a site specific analysis based on actual field data may be preferable. We mention two of the available models with multi-pathway capability:[36]

- The MMSOILS model was used in the *Corrective Action RIA* in the analysis of human health risks. MMSOILS is a multi-pathway model that can calculate releases and exposure to contaminants through air, groundwater, overland flow and surface water, as well as ingestion of contaminants in soil.

- The MEPAS model is similar in function to MMSOILS; it is also capable of calculating the movement of releases through soil, groundwater, air, surface water, and overland runoff. Also like MMSOILS, it is capable of estimating human health risks from exposure through the various pathways.[37]

When the appropriate sample and model have been selected, Approach C analysis follows the same general steps as Approach B in developing an estimate of damages avoided under RCRA. A more detailed discussion of these steps is outlined above in our discussion of Approach B.

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[36] The HWIR 3MRA model is also under development and may be available for use in an analysis of RCRA human health and ecological benefits. Approach D (below) describes a methodology that uses this model.

[37] While a number of sources of information are readily available (e.g., RCRIS, CERCLIS data) Approach C data collection from facilities or states could require an ICR if the number of sample facilities (or states) exceeds nine.

3.4.2.1 Identify Level of Contamination in the Presence and Absence of RCRA

Our proposed Approach C requires site specific modeling of sample facilities to establish a level of contamination that has or would occur as a result of releases that took place before RCRA took effect. This effort may include collection of facility data from public records and databases, direct measurement of site conditions, and/or modeling of facilities based on engineering estimates and theoretical release scenarios. As in the *Corrective Action RIA,* it is necessary to identify a sample of facilities with pre-RCRA waste management units, though this sample can include facilities whose units were not regulated by RCRA until more recently. As in Approach B, this approach assumes that the risk of damage from new Subtitle C units at the sample facilities is negligible, due to monitoring and Subpart F Corrective Action requirements under RCRA prevention.

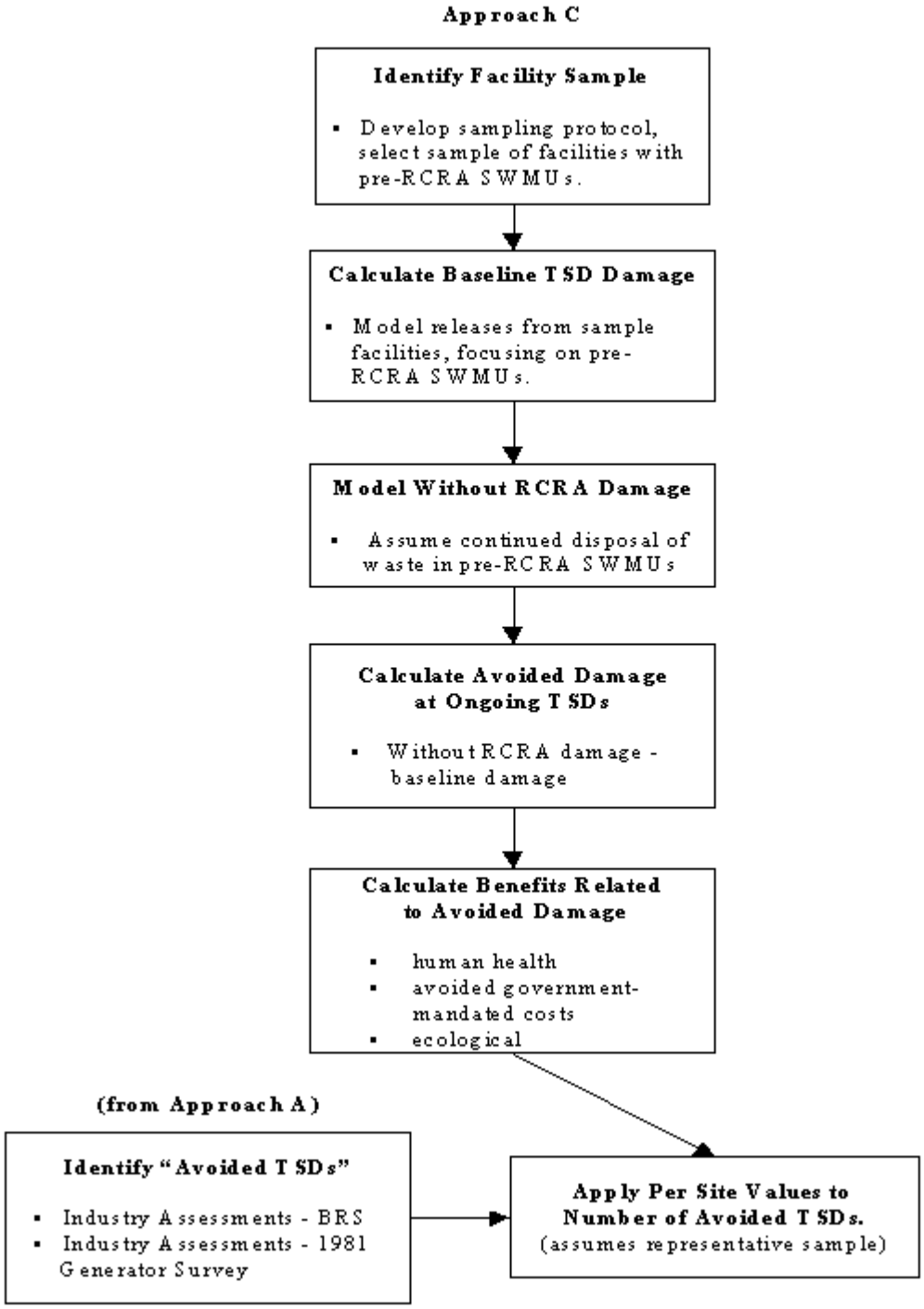
Approach C also requires modeling of the without-RCRA scenario assuming the continuation of waste disposal practices that were in place prior to RCRA. This requires facility information about past practices and wastes. As in Approach B, the extent of avoided damage attributable to the Subtitle C prevention program is the difference between this "continued disposal" damage and the actual with-RCRA estimate of contamination from the sample facilities.

3.4.2.2 Apply Modeling Results to "Avoided TSDs"

If Approach C involves a representative sample of facilities with pre-RCRA TSDs, then the avoided damage from closures can be measured by applying the range of damages identified at existing facilities to the number of avoided facilities identified in Approach A. As in Approach A, however, it is necessary to develop a range of estimates to reflect possible differences between the profile of existing contamination between sample facilities and the profile of existing contamination at facilities that closed under RCRA. In addition, this extrapolation is not possible if Approach C is implemented as a case study approach. Exhibit 3-4 provides a flow chart summary of Approach C.

Exhibit 3-4

SUMMARY OF APPROACH C TO ESTIMATING RCRA BENEFITS



3.4.3 *STEP 3: Estimate/Characterize Benefit/Cost Attributes*

Approach C modeling would provide an estimate of the number and extent of releases and environmental damage that have been avoided by the implementation of RCRA prevention programs at TSD facilities. The final stage of the approach addresses the four localized benefits that are addressed by Approach B: human health and ecological benefits, avoided costs, and aesthetics. The potential methods for estimating these attributes in Approach C are essentially the same as the methods identified in Approach B. For this reason we do not present detailed descriptions of the methodologies here. However, the development of an original modeling effort for each of these attributes requires attention to particular parameters. We list a few additional considerations below:

- **Human Health Effects:** It is important to determine the specific human health affects to be addressed by the model, as well as an average exposure time length, and to identify any high-end risk populations and scenarios (such as small children ingesting contaminated soil). Model selection will affect the extent to which specific human health risk parameters (e.g., individual, population, and MEI risks) can be estimated.

- **Ecological Effects:** It is important to determine the general ecology of the areas proximate to facilities and potential human uses (such as fishing), as well as the existing non-RCRA pollutants and damage in the area.

- **Avoided Costs:** It is important to consider the actual and future expected uses of groundwater, in addition to the availability of alternative supplies, and the possibility of economic incentives or regulatory requirements to install treatment or become part of a municipal system. It is also important to establish the model parameters to avoid double-counting avoided costs and human health benefits.

3.4.4 *Approach C Summary: Site Specific Approach Using Original Data Collection and Modeling*

Like Approach B, Approach C allows a site-specific analysis of a portion of the benefits related to both changes in practice at operating TSDs and to avoided hazardous waste sites due to closure of pre-RCRA TSDs. Also like Approach B, Approach C would use modeling to identify differences between with-RCRA and without-RCRA scenarios addressing the four key site specific attributes:[38]

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[38] Some data collected for Approach B may also be useful in examining Environmental Justice impacts related to RCRA; we discuss these impacts in Chapter 6.

- Human health benefits
- Ecological benefits
- Avoided costs of alternate water supplies and site remediation
- Improved aesthetics and historic preservation

In addition, Approach C provides considerable flexibility in determining the scope and focus of an analysis. For example, because it is based on original sampling and data collection, this approach may be used to target "newer" industries and wastes that were not originally regulated by RCRA, in addition to the universe of facilities whose SWMUs were regulated by 1982.

Approach C also provides a methodology for performing a detailed examination of a limited number of case studies to identify "worst case" facilities or to focus on specific industries or SWMU types. However, the benefits estimates will be additive or suitable for national extrapolation only to the extent allowed by the size and representativeness of the facility sample.

The chief limitation of the proposed Approach C is the resources that would be required to achieve a national estimate of benefits. In addition, the approach does not address RCRA generators and transporters, though site-specific modeling approaches could be used to address release scenarios at these facilities as well as TSDs.

Finally, as in Approach B, Approach C would address several important attributes and could provide an estimate for a substantial portion of the benefits of RCRA regulations affecting TSD facilities. However, a complete examination of the benefits and costs of RCRA under this approach would require analysis of long-term benefits (Chapter 4), costs (Chapter 5), distributional impacts (Chapter 6) and program context attributes (Chapter 7).

3.5 APPROACH D: PATHWAY MODELING APPROACH USING THE HWIR 3MRA MODEL

This methodology is similar to the other pathway modeling approaches in that it addresses benefits from reducing chronic risks to human health and to ecological resources. The approach hinges on the initial development of a without-RCRA scenario, describing how wastes would be generated and managed today if the waste management standards of RCRA were not applied. Using risk assessment damage functions, the approach compares the impacts of management in the without-RCRA scenario with the impacts of waste management in the with-RCRA scenario, where wastes are managed in compliance with the requirements of Subtitle C.

The approach is similar to the site-specific modeling approaches described in Approaches B and C, but uses different sources for data on the properties of the wastes and the locations and characteristics of projected waste management sites. The steps in this approach include:

- Identification of industries for modeling;
- Creation of a pre-RCRA scenario of waste generation and management (approximately 1978);
- Creation of a without-RCRA scenario of waste generation and management in a current year (approximately 2000);
- Modeling of waste disposal in sample facilities, and
- Modeling of environmental releases and resultant risks to human health and environmental resources.

Approach D and Approach B are similar in that they both employ a specific model to provide estimates of damage associated with waste management at a sample of "pre-RCRA" facilities. The following are principle differences between Approach D and Approach B:[39]

- **Source of waste data:** Approach B uses waste data based on individual sites (i.e., the specific facilities in the *Corrective Action RIA*), while waste data for Approach D are based on industry sectors;
- **Waste management facilities:** Approach B uses the sample of facilities at the *Corrective Action RIA* sites, while Approach D uses the sample of Subtitle D (i.e., non-hazardous) waste management facilities that are incorporated into the HWIR model; and
- **Methods for assessing risks:** Approach B uses Corrective Action data and the MMSOILS model, while Approach D uses the HWIR 3MRA (multimedia, multi-exposure pathway, multi-receptor risk assessment) model.

Approach D involves three basic steps in its development of modeling results.

[39] Approach C also presents a similar methodology based on pathway modeling at a sample of facilities, but does not specify a sample selection or modeling protocol that can be meaningfully compared to those described in Approaches B and D.

3.5.1 *STEP 1. Identification of Industries for Modeling*

Approach D portrays waste generation and management in various industries, beginning in the period before RCRA. The first step in this approach, therefore, is identifying which specific industries to model. This approach will only be feasible if data for a sufficient number of industries is available to create an overall picture of waste generation and management for the entire U.S. This effort is not expected to create a comprehensive picture of *all* industries, yet it is expected to produce a portrait that will represent benefits of good waste management for a significant proportion of wastes generated.

Candidates for modeling include the industries identified in the Office of Solid Waste *Industry Assessments* in the late 1970's. These reports profiled generation and management of hazardous waste in a number of industrial sectors. Other industries which were not included in those profiles may also be good candidates, if data are available.

3.5.2 *STEP 2. Creating Scenarios of Waste Generation and Management*

An initial set of industries will be assembled as candidates to model waste generation and management in both a "true" pre-RCRA scenario and a counterfactual, without-RCRA scenario. These are defined and explained below.

3.5.2.1 Pre-RCRA Scenario

For each industry selected, the next step would be to create a scenario describing waste generation and management in a pre-RCRA year (prior to promulgation of RCRA regulations). For each industry, the pre-RCRA scenario will note what wastes are generated, in what volumes, in what forms, what constituents are in the waste, and how they are managed. Existing data sources should be sufficient to provide information about waste generation and management. Much of the data in the *Industry Assessments* was collected to learn how waste was managed; the resulting reports provided information about the threats posed by mismanaged hazardous waste.

This information would need to be updated by including data on wastes which were *generated* in the pre-RCRA year, but were not yet *tracked* (or identified as hazardous) by the RCRA program. By bringing together data from a variety of sources, it should be possible to create a reliable and reasonably accurate scenario describing hazardous waste management before RCRA management practices were employed.

3.5.2.2 Without-RCRA Scenario

Working from the pre-RCRA scenario (waste management before RCRA standards), the next step would be to create the without-RCRA scenario. This would require extrapolating waste generation data for each industry from the pre-RCRA scenario (approximately 1978) up to today. This extrapolation would require careful estimation, examining actual generation in each year as well as industry trends, other regulatory initiatives, and economic factors that influenced industrial production and waste generation in each year.

The end product of this task would be a scenario describing generation and management of hazardous waste *as it would be today,* if RCRA management standards were not in place. Specifically, the scenario would include information on:

- Waste streams generated
- Quantities generated/managed
- Types of management units used (landfills, surface impoundments, waste piles, open dumping, etc.), and
- Waste constituents and concentrations.

3.5.2.3 Location of Management Units

To describe the effects of continued waste management under pre-RCRA practices, we would need to determine how wastes would be managed in the absence of RCRA standards. The pre-RCRA scenario would include information on the types of management units used. In order to understand the impacts of substandard waste management practices, waste disposal at particular locations would be modeled. The approach assumes that wastes would be disposed at typical non-hazardous waste management facilities (this approach understates the risks from non-RCRA waste management, since wastes could simply be dumped).

The 1985 *Screening Survey of Industrial Subtitle D Establishments* described data on locations of facilities and waste management units, representing over 150,000 establishments managing non-hazardous wastes. A representative sample of these facilities was assembled by the OSWER office of Solid Waste (OSW) to create the Site Survey Database for the 3MRA model.

This approach would use this sample database to represent disposal of wastes at typical non-hazardous waste units around the country. Quantities of waste generated each year can be modeled as being disposed at these typical facilities, in the types of units that were used historically to manage these wastes, as indicated by the industry data.

There are several advantages to use of this database. These include:

- **Representative data on locations and types of facilities**: The sites are representative of the types, sizes, and geographic locations of non-hazardous waste management units at which waste might be disposed for the universe of these units known in 1986. Assuming some advances in regulation since the initial RCRA regulations were promulgated in 1980, these sites most likely represent waste disposal alternatives that are at least as protective as those which might be used in the absence of RCRA; in fact, they are likely to be more protective.

- **Characterization of the sites, include attributes affecting fate and transport of contaminants:** OSW has conducted extensive site-specific characterization of the sample sites, including human receptors, water bodies and watersheds, soils, and other ecological receptors. EPA has supplemented this site-specific data with regional data on meteorological conditions and water quality and aquifer data.

- **Representative data to characterize management units:** This database also includes data on the various types of management units used for non-hazardous waste management, and characteristics (size, location, etc.) of these units. The sampling method and the Monte Carlo methods in the 3MRA model would provide statistically valid representations of waste management at the universe of non-hazardous waste management sites around the country.

3.5.3 *STEP 3. Modeling Environmental Impacts*

This approach would use the 3MRA model which has been developed to provide risk assessment supporting the Hazardous Waste Identification Rule. The 3MRA model is the result of years of effort from both OSWER and Office of Research and Development (ORD), and has been extensively reviewed and tested.

The model is designed to estimate human health and ecological risks from management of wastes in waste management units that are not compliant with RCRA Subtitle C standards. Inputs to the modeling would include:

- Waste quantities and characteristics from the without-RCRA scenario;

- Data on waste management units from the Site Survey database;

- Site-specific data on watersheds, water bodies, soil characteristics, and human and ecological receptors;

- Region-specific data on meteorological properties, groundwater and surface water, and other ecological receptors; and

- Supplementary national-level data.

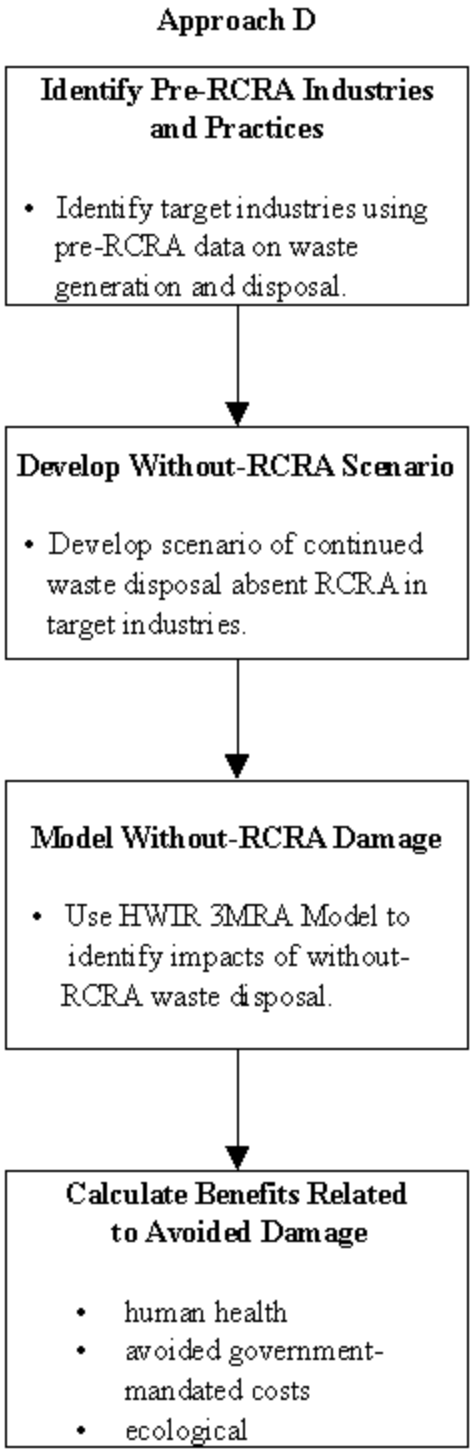
The result of the modeling effort would produce estimates of human health (both individual and population) risks and ecological risks that would be present *today* if RCRA standards were not followed. These risks would be compared to those present in the baseline condition (waste management in these industries today, as regulated by RCRA management standards). The difference in chronic human health and ecological risks would address two of the major benefits attributes associated with RCRA Subtitle C standards. Exhibit 3-5 provides a flow chart summary of Approach D.

As with Approaches B and C, Approach D modeling data might also be used to support estimates of avoided costs; additional methodologies presented as part of Approach B would also be relevant to this approach.[40] Finally, as with the other benefits approaches, a complete examination of the benefits and costs of RCRA under Approach D would require analysis of long-term benefits (Chapter 4), costs (Chapter 5), distributional impacts (Chapter 6) and program context attributes (Chapter 7).

[40] Note that engineering cost estimates of alternative water supplies are not likely available as part of the 3MRA model; however, it may be possible to use cost data from *The Corrective Action RIA* or other sources to provide general estimates of avoided costs.

Exhibit 3-5

SUMMARY OF APPROACH D TO ESTIMATING RCRA BENEFITS



The RCRA Subtitle C prevention program addresses many environmental and human health effects that involve long time horizons due to factors such as the slow movement of groundwater or the persistence of contaminants associated with health effects. As a result, an assessment of the benefits of RCRA must consider the avoided damages that would have continued indefinitely into the future, creating health effects or requiring averting behaviors many years from the present time.[1] For example, avoided groundwater contamination is likely to be a key outcome of RCRA's land disposal restrictions. While many potable aquifers are not currently used for drinking water and therefore have no "use value" today, it is difficult to predict the long-term demand for these resources or the long-term value associated with protecting them from contamination. Despite the uncertainty involved in assessing long-term effects, it is important to identify and discuss these potential benefits in any comprehensive program evaluation of RCRA. This chapter addresses long-term benefits that are not captured in the benefits approaches outlined in Chapters 2 and 3.

Some aspects of long-term benefits (e.g., the number of cancer cases avoided) can be estimated through modeling. However, there is little consensus in the economics literature on assigning monetary values to the health effects and costs assumed (or avoided) by future generations.[2] Moreover, some benefits may occur far in the future, or may increase over long time horizons due to factors such as increased population density (which could increase exposure to

[1] Long-term benefits are related to the concept of sustainability, which measures the extent to which present actions preserve for future generations the level of environmental resources and quality that are available today. Sustainability incorporates long-term benefits and a broader "polluter pays" principle that requires those using resources or causing environmental damage to be responsible for assuring that damages will be repaired and resources replenished. Other aspects of sustainability and the polluter pays principle are addressed in our Chapter 6 discussions of inter-generational equity.

[2] EPA's *Guidelines for Economic Analysis* (Chapter 6) discusses the difficulties related to social discounting for inter-generational policies.

health risks). This chapter discusses four distinct aspects of potential long-term benefits. The first three methods address potential long-term impacts of RCRA Subtitle C regulation:

- **Avoided long-term damages,** reflecting the continuation of health and ecological benefits into future generations.

- **Avoided increases in damages** due to changes in affected populations (e.g., future population growth that results in a higher number of people affected) and/or increases in costs of clean water and land.[3]

- **Avoided damage from unforeseen events or issues** such as environmental damages caused by substances whose risks are poorly understood today.

While these three types of long-term benefits represent regulatory impacts that are theoretically quantifiable (though perhaps not with currently available information), it is difficult to estimate their value because economic theory cannot predict the value that future generations will place on environmental goods. Increases (or decreases) in the value of environmental quality and resources would affect the value of all long-term benefits. We therefore address this fourth issue separately, and provide a separate method for characterizing potential changes in future generations' value of environmental quality.[4] All of our methods focus on qualitative discussions, but we also identify quantitative analyses that may help illustrate the potential magnitude of benefits.

In addition to long-term benefits directly associated with avoiding contamination, the RCRA Subtitle C program may also contribute to two other long-term impacts: long-term changes in behavior related to management of waste, and long term impacts related to waste minimization programs. Long-term behavior changes include behaviors directly mandated by regulation (e.g., improved technical specifications) and behaviors that appear to be indirectly related to specific programs (e.g., an increased demand on the part of property purchasers and banks for "clean" properties as a condition of sale).[5] Waste minimization benefits, in contrast, are related to improved production efficiency and would be reflected in future reductions in waste management and disposal

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[3] In addition to population growth, increases in costs of clean resources may also be associated with other factors such as decreased availability of potable water due to water scarcity.

[4] Recent literature suggests that the willingness to pay for environmental quality has increased and changed in focus in recent decades. One discussion of the transformation in resource values is *Forest Dreams, Forest Nightmares: The Paradox of Old Growth in the Inland West*, by Nancy Langston and William Cronon (University of Washington Press: October 1995).

[5] The increased demand for clean properties is likely attributable (at least in part) to the combination of regulations and liabilities established under both RCRA and CERCLA.

costs. Although these changes in behavior or cost reductions may ultimately be associated with benefits, we discuss these attributes in Chapter 7 as Program Context Attributes because it is often impossible to determine either the net "value" or the causality associated with changes in behavior, and to predict long-term changes in cost attributable to the Waste Minization program.

4.1 AVOIDED DAMAGES OVER LONG TIME PERIODS

RCRA regulations prevent the release of constituents that could persist in soil or groundwater and cause human health and ecological impacts for several generations. In Chapter 3 we identified the methods for estimating the value to the current generation of preventing those effects. Our proposed methods for estimating the potential continuation of (avoided) damages over long time horizons include two separate analyses; a general discussion of the continuation and accumulation of (avoided) damages over time, and a specific analysis of the avoided contamination of groundwater resources, measured as the volume of groundwater contamination avoided.

4.1.1 *General Qualitative Discussion of Long-Term Damages*

We propose a qualitative discussion of the potential accumulation of benefits associated with long-term damages (e.g., avoided costs, property value benefits) and factors potentially influencing benefits such as natural attenuation of contamination and changes in property values over time. This method is consistent with Approach A and also with any of the modeling approaches. Note that the pathway modeling approaches would provide a range of quantified benefits that would reflect different modeling scenarios and time horizons; the qualitative discussion of long-term damages would provide context for the interpretation of these modeling results.[6]

4.1.2 *Method for Identifying Groundwater Conservation Benefits*

The RCRA program prevents long-term damage to groundwater resources by establishing rigorous standards for waste disposal, including such requirements as the Land Disposal Restrictions (LDRs) which restrict certain waste streams to specific, low-risk disposal methods or establish constituent concentrations that must be met before waste can be disposed. The program aims to prevent damaging releases to the environment, including groundwater. Groundwater damage from a single release may increase over decades or even centuries. As a result, groundwater protection

[6] Consistent with EPA's *Guidelines for Economic Analysis,* we suggest a range of scenarios that would provide both discounted and undiscounted estimates for avoided costs, and a quantification of health effects that does not apply values or discount rates.

is an important part of the potential long-term benefits of the program.[7] To identify the total extent of groundwater preserved under RCRA, we provide the following approach:

- **Step 1.** Identify the number of groundwater contamination incidents avoided by RCRA. In Approach A this is possible by using Superfund, Corrective Action, and state data to calculate the percentage of hazardous waste sites that require groundwater remediation, and then multiplying that percentage by the number of avoided hazardous waste sites identified in Approach A. In Approaches B, C, and D, incremental contamination can be identified using modeling results and the same extrapolation to avoided hazardous waste sites.

- **Step 2.** Identify average extent of groundwater contamination in cubic feet or gallons and apply to the avoided sites. Again, in Approach A this value can be an average based on typical Superfund, Corrective Action, and state sites. For Approaches B, C, or D, this extent can be modeled directly.

This calculation provides an initial estimate of the quantity of groundwater spared from contamination by RCRA. However, this estimate may be high if considerable contamination of groundwater already exists from non-RCRA sources, and additional "without-RCRA" contamination would not increase the cost of remediation. Therefore, we would also provide a second, lower estimate that includes a simple correction for existing contamination. The lower estimate would adjust the total quantity of groundwater by subtracting the percentage of groundwater resources believed to be contaminated by other sources.[8]

These approaches would provide a first cut on characterizing long-term benefits due to the inter-generational duration of damages. It would, however, be associated with significant uncertainty because it would require assumptions about future waste generation and management practices, the duration of contamination events, and the likelihood that remediation would occur.[9]

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[7] Our Chapter 3 benefits methods address the avoided costs of obtaining alternative water supplies. Avoided costs of alternative water supplies reflect a portion of the use value of groundwater, but do not address "non-use value" (i.e., the value to the current generation of preserving clean groundwater that is not used for drinking). While these values may be important, there is no currently accepted method for identifying non-use values associated with groundwater.

[8] We have not yet identified a single data source that identifies the current extent of groundwater contamination. However, a number of studies have been performed estimating the extent of groundwater contamination due to petroleum leaks from underground storage tanks (USTs). Estimates from this literature could be used as a proxy for total contamination.

[9] One issue in characterizing potential long-term benefits is the degree to which natural processes such as biodegradation may reduce the prevalence of some contaminants over time, since

4.2 AVOIDED INCREASES IN DAMAGES RELATED TO CHANGES IN AFFECTED POPULATIONS

In addition to continuing over long periods of time, future damages in the absence of RCRA might also increase due to changes in the density of affected populations. To characterize long-term benefits associated with avoiding increases in future damages, we would provide a qualitative discussion of factors that might drive these increases (e.g., population growth, scarcity of resources due to contamination, changes in the legal framework guiding resource utilization). In conjunction with any of the three modeling approaches, we would also conduct sensitivity analyses to identify the human health impacts related to higher population densities near pre-RCRA facilities.[10] In addition, we would conduct a sensitivity analysis to characterize the potential increases in water prices (i.e., as a result of scarcity and contamination).

These analyses would provide a rough estimate of the magnitude of benefits that might be associated with potential increases in exposure in a without-RCRA scenario. In addition to factors of uncertainty discussed above, projections of future population densities and use of drinking water would be uncertain.

4.3 THE PRECAUTIONARY PRINCIPLE: PROTECTION AGAINST UNFORESEEN ISSUES OR EVENTS

The RCRA Subtitle C program may yield benefits associated with the reduction of currently unknown or underestimated risks. In other words, RCRA's engineering standards for disposal units may prevent not only known hazards, but also the release of constituents that are identified as hazardous in the future. In this way the program may provide "insurance" against future damages.[11]

The "precautionary principle," which describes a preference of implementing protective policies or regulations in advance of conclusive scientific evidence that connects activities (or

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natural attenuation might potentially off-set long-term damages. Various natural processes may either "remove" contamination or may limit the spatial extent of environmental damage. Because RCRA addresses a wide variety of contaminants and exposure pathways, it would be extremely difficult to estimate the effects of natural attentuation, but it is likely that damages would not increase in a simple linear pattern over long periods of time.

[10] This would be done by applying a reasonable range of future population densities to the model and assessing increases in the number of people potentially affected.

[11] RCRA can also create an analogous risk tradeoff by encouraging use of untried chemicals as replacements for regulated ones; this substitution risk tradeoff can be identified in using the methodology outlined in Option 2.

chemicals) to risk, has recently emerged as a principle in international environmental policy.[12] While both the definition and practical implementation of a precautionary principle is still a matter of considerable debate, the essential wisdom of precaution is reflected in the notion that "an ounce of prevention is worth a pound of cure." While we do not attempt to resolve the issues surrounding the development and use of precautionary policies, this principle is consistent with the preventative objectives of the RCRA Subtitle C program. Subtitle C regulations have designated as hazardous some wastes that contain constituents with unknown potential risks. Some of these constituents have later been found to be hazardous; prior to their designation, however, RCRA's protective disposal requirements (e.g., liners) have prevented releases.[13] It is possible that the strict disposal regulations of RCRA will reduce or prevent exposure to hazards that have not yet been identified or verified; the avoided exposure would ultimately be a measurable benefit of the program.

It is clearly impossible to identify "unknown effects" *a priori*, but an examination of "hindsight" might be an appropriate way to characterize these benefits. In addition, RCRA may already have provided an identifiable short-term "precautionary benefit" among its own waste regulations and listings. We suggest two possible approaches to characterising the potential benefits related to the precautionary aspects of RCRA:

- **Option 1: Examine the extent of existing compliance with new RCRA listings.** Using data from RIAs for RCRA wastes listed since 1980, identify in each new listing RIA the number of affected facilities that were already in compliance with the new rules as a result of earlier waste treatment investments under RCRA. Where previous RCRA regulations result in management practices that were properly addressing "new wastes," these regulations provide "insurance." One immediate benefit of this insurance is the avoided costs of incremental compliance enjoyed by the facilities that were already protective under earlier regulations.[14] However, this estimate

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[12] There is a large body of theoretical literature discussing the development and implementation of versions of the precautionary principle. Treaties articulating the precautionary approach include the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer, the 1992 Convention on Biological Diversity, the 1992 Treaty on European Union, and the 1992 Rio Declaration on Environment and Development, which states "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

[13] RCRA's delisting process also supports the notion of precaution in recognizing that emerging research may determine that certain wastes and constituents do *not* pose significant risks.

[14] An issue with this estimate is the extent to which a facility "over-complied" with initial regulations in anticipation of additional regulations, or in response to state standards. While these

does not address total "insurance" benefits and should be considered only as an indicator in a qualitative discussion.

- **Option 2: Identify historical examples of underestimated risks.** Identify one or more examples of a hazardous waste (e.g., lead) that was widely considered to be less toxic than it is today. Identify the extent to which RCRA addresses this waste as part of otherwise regulated waste streams. For example, include the quantities of lead disposed of as part of industrial waste streams, but do not include lead used in gasoline or paint. Identify potential damage or risk associated with the avoided quantities; this illustrates potential damages avoided by RCRA. However, like Option 1, it is not a comprehensive measure of avoided damage and should be used for illustration only in a qualitative discussion.

Neither of these approaches provides a comprehensive estimate of future damage avoided by RCRA; both instead provide an estimate of the extent to which existing regulations did or could address newly identified problems. If these methodologies indicate a considerable benefit, then additional efforts to refine these estimates may be a reasonable next step.

Exhibit B-5 in Appendix B contains a summary description of our proposed methods for addressing long-term benefits, including a brief description of data requirements for each.

4.4 BENEFITS FROM LONG-TERM INCREASES IN THE VALUE OF ENVIRONMENTAL QUALITY

Long-term benefits present a theoretical "problem" in economics. Traditional economics discounts future benefits and costs to account for market growth and the expected return on an investment in today's market. However, the economic preferences of future generations (and therefore the economic value of resources in future generations) are essentially unknowable. Economic measures may therefore be unable to predict **increases** in resource value as a result of scarcity (see above) or of changes in social norms. One example of dramatic change in the social value of a resource is the change over the past century in the American view of forests, which have evolved from a resource for timber with relatively little value to a resource for recreation and non-use habitat that can far exceed the value of the fiber source.[15] This evolution in value could not have been predicted by traditional economics, which can only reflect the value that current generations

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issues may be addressed by examining contemporary literature on patterns of environmental investment and on the extent and anticipation of environmental regulations; we suggest that these issues be addressed only if the initial benefits estimate is substantial enough to warrant the effort.

[15] See Langston and Cronon (1995).

place on resources. Furthermore, the value placed on environmental protection (i.e., avoiding risk) may itself grow if future generations become more risk averse.

Conversely, a resource that is highly valued today may not maintain its value in the future if substitutes emerge or preferences change. There is a fundamental difficulty in predicting how, if at all, a future flow of resources will be valued. New research in this area may be revealing, and may propose additional methodologies for adjusting discussions of future benefits to reflect a range of economic growth and scarcity scenarios as well as potential shifts in social value.

Our proposed method for characterizing the effects of changes in risk aversion and valuation of environmental quality by future generations would involve two steps:

- **Qualitative discussion of past trends** of risk aversion and valuation of environmental goods. Our discussion would include an assessment of historic decreases in acceptable risk over time and concurrent increases in the valuation of environmental goods. We would then provide a discussion of how these trends might change in the future, and identify the potential implications for values associated with clean resources. In addition, we would provide a discussion of potential changes in willingness to pay for resource utilization (i.e., use values) that could, for example, be associated with changes in recreational behavior (e.g., increases in the amount of time for recreational activities available to individuals).

- **Discussion of potential effects on value of groundwater.** Using recent literature and the estimates of avoided groundwater contamination developed in the modeling approaches, we would discuss the potential impacts of changes in value on the avoided groundwater contamination benefits of RCRA. While some portion of the value of groundwater is reflected in the cost of obtaining alternative water supplies (captured in the avoided costs attribute in Chapter 3), changes in the way people regard groundwater (i.e., as an important ecological resource or as an option for future use) may have an important impact on the value of the RCRA program.

This analysis would provide an overview of the potential magnitude of the impacts that future generations' changes in value might have on all of the long-term benefits associated with RCRA. We recognize that this discussion would be qualitative and would not capture the possibility of future changes in trends related to risk aversion and the valuation of environmental quality. However, the perspective of future generations forms a central issue in the discussion of long-term benefits, and it is essential to, at a minimum, discuss the potential implications of evolution in values.

This chapter presents potential methods for assessing the costs of the RCRA Subtitle C program, including compliance expenditures and government sector regulatory costs related to RCRA prevention programs. Prevention-related costs do not include remediation costs at SWMUs that remediated under the Subpart S Corrective Action program. However, prevention program costs should reflect monitoring and cleanup of "new spills" (i.e., spills at RCRA-permitted facilities) required under Subpart F Corrective Action programs. This chapter first addresses available EPA estimates of RCRA Subtitle C government and compliance costs, then provides an alternative method of identifying compliance and regulatory costs, and finally addresses the issue of potential long-term costs.

These approaches do not address the economic costs that can result from changes in compliance and government-sector costs (i.e., transitional social costs and general equilibrium effects such as changes in markets indirectly affected by RCRA). While RCRA regulations may have resulted in welfare losses, the calculation of these costs is still a focus of debate among economists, with recent discussions suggesting that earlier analyses may have overstated impacts.[1] Moreover, evaluation of transitional social costs would require extensive economic analysis for all industrial sectors affected by RCRA. However, impacts such as plant closures and development of new industries are important to consider in assessing RCRA. We therefore discuss the distributional aspects of these costs (and possible benefits) in a discussion of Economic Impacts in Chapter 6. In addition, EPA's forthcoming *Environmental Investments: The Cost of a Clean Environment* (*Cost of Clean*) will contain a discussion of economic costs that may provide additional information about the impacts of RCRA Subtitle C.

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[1] Jorgenson and Wilcoxen (1990), for example, calculate the total costs of pollution abatement to include the impact of regulations on economic growth and interactions between industries, and find that the total social costs of environmental regulations exceed expenditures for compliance. However, recent literature challenges this position. For example, Porter and Van der Linde (1995) assert that spending to comply with environmental regulations can have positive spinoff effects that counterbalance some financial expenditures (see also unpublished Morgenstern, et al., 1997).

5.1 COST ESTIMATES AVAILABLE IN EPA'S *COST OF CLEAN*

EPA is currently developing a new version of its 1990 comprehensive assessment of both compliance and government-sector costs related to environmental regulations of all kinds: *Environmental Investments: The Cost of a Clean Environment* (*Cost of Clean*). When complete, this document will provide useful estimates of both the monetary expenditures and total economic costs associated with RCRA Subtitle C programs. The 1990 *Cost of Clean* also provides total cost estimates and projections for RCRA Subtitle C programs, but the document overestimates projected costs significantly because of the limited number of years of cost data (1983-1986) available at the time of publication.[2] The forthcoming *Cost of Clean* will correct these estimates to reflect additional years of industry cost data, and will provide estimates of government sector regulatory costs associated with RCRA.[3] In the interim, we suggest an alternative method of estimating costs based on 1983-1994 Pollution Abatement Costs and Expenditure (PACE) Surveys.

5.2 METHOD FOR ESTIMATING COMPLIANCE COSTS USING PACE DATA

We propose a method that would project compliance cost estimates from 1983 to 2000 using U.S. Census Bureau Pollution Abatement Costs and Expenditures (PACE) Reports. Although EPA's *Cost of Clean* uses a similar methodology, we propose this separate method for two reasons. First, it would provide an alternative approach until the revised *Cost of Clean* is available. Second, it would allow EPA to identify costs related to specific industries (i.e., reflecting the scope of potential analysis under Approaches C or D).

This method would first identify with-RCRA waste management costs using PACE data. We would then adjust these data (if necessary) to correspond to the universe of facilities identified in the selected benefits approach. Finally, we would estimate without-RCRA hazardous waste management costs to identify the incremental costs associated with RCRA Subtitle C regulations.[4]

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[2] *Cost of Clean* uses cost data from 1983-1986 Pollution Abatement Costs and Expenditures (PACE) Reports.

[3] The forthcoming *Cost of Clean* will still need to be adjusted for this project if EPA addresses only a subset of industries or facilities in the report.

[4] Note that PACE Reports include only compliance costs. To determine total costs of RCRA, we would also need to identify federal and state government regulatory expenditures on hazardous waste disposal both before and since the adoption of RCRA.

5.2.1 *STEP 1. Identify With-RCRA Hazardous Waste Compliance Costs*

PACE reports published by the Census Bureau provide the most complete record of national pollution-related expenditures by media type (air, water, hazardous waste, etc.).[5] Our method would use PACE data from the years 1983 to 1994, because PACE did not distinguish hazardous waste from solid waste before 1983 and was discontinued after 1994. No PACE report was published in 1987.

The relatively small number of PACE data points is the most serious limitation of this source. Available data do not span the full with-RCRA time period, and do not isolate hazardous waste-related expenditures prior to the implementation of RCRA. PACE data also has several other limitations. First, PACE data are based on a survey of hazardous waste generators with twenty or more employees, and therefore may exclude many small generators.

In addition, the PACE survey addresses generators but does not include TSD facilities that do not generate waste. However, while we are interested in disposal and TSD facilities, we believe that the PACE surveys are reasonable proxies for costs of compliance, including disposal.[6] We would assume that generators include disposal costs in waste management costs, and that costs at commercial TSDs would be offset by receipts from generators. However, a more complex source of uncertainty is generators with on-site waste disposal facilities that accept waste from other generators. It is unclear whether waste-accepting generators adjust their disposal costs to account for income received from off-site generators. If not, their total costs may be over-reported in PACE data. This issue could be addressed by examining waste-accepting generators more closely.

We would then convert available PACE data to constant year-dollars, adjusting for known and expected inflation.[7]

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[5] The Bureau of Economic Analysis also published an annual cost survey called Pollution Abatement and Control Expenditures. The BEA PACE reports use the Census PACE reports with some data adjustments. A key difference between these sources is that PACE data reports non-cash costs (i.e., depreciation) that do not represent expenditures; Pollution Abatement and Control Expenditure data include only expenditures, but addresses money spent on control costs that are not included in the PACE survey. We chose not to use the BEA reports primarily because we only found highly aggregated data from this source. If more detailed BEA data are available, we would consider this source as a means to providing an alternative estimate.

[6] Note that PACE reports compliance expenditures on a pre-tax basis. Implementation of a method using PACE data should consider calculation of post-tax costs. For simplicity, however, we base our current discussion on original PACE data and do not attempt to make this adjustment.

[7] Several other adjustments to this data source would be necessary as part of implementation, such as adjustments for depreciation and cost offsets. For simplicity, however, we base our current

5.2.2 *STEP 2. Project Known Data Points to the Year 2000*

Since the PACE reports end in 1994, we would project post-1994 cost estimates based on the year 2000 value conversions of available data. In Exhibit 5-1 below, we present several possible projections in comparison to the *Cost of Clean* (1990) projection. In addition to the *Cost of Clean* (1990) projection, we estimate linear projections to the year 2000 based on four sets of years:

- The 1983-1994 set includes all available years of PACE data. While this set includes the greatest number of data points, it may not be the most accurate projection for reasons discussed below.

- In 1991, the PACE survey of manufacturers (on which the reports are based) began to distinguish cleanup costs from other hazardous waste costs. In other words, PACE data prior to 1991 may include some remediation costs (e.g., Superfund cleanups). The projection based on 1983 to 1990 data is based on data collection before the distinction was made explicit. The projection based on 1991 to 1994 data is based on data that definitively exclude cleanup costs.

- Prior to 1987, costs of Superfund and Corrective Action were nonexistent or minimal. Between 1988 and 1991, remediation costs were significant but not explicitly excluded from PACE expenditure estimates. Thus, we believe that data between 1988 and 1991 may overestimate expenditures on RCRA prevention. Since we cannot determine the magnitude of this overestimate, we include a fourth projection based on data from 1983 to 1986, and data from 1992 to 1994. This projection predicts slightly lower expenditures than the projection that incorporates all available data.

Of the four projections, we believe that the full data set (1983-1994) and the data set incorporating the years 1983 to 1986 and the years 1992-1994 are the most accurate estimates of RCRA Subtitle C expenditures. However, these are likely upper-bounds of expenditure estimates, since they do not incorporate the eventual downward trend observed since 1991. As such, we believe that a non-linear (perhaps asymptotic) function may be a more appropriate means of predicting hazardous waste expenditures.[8]

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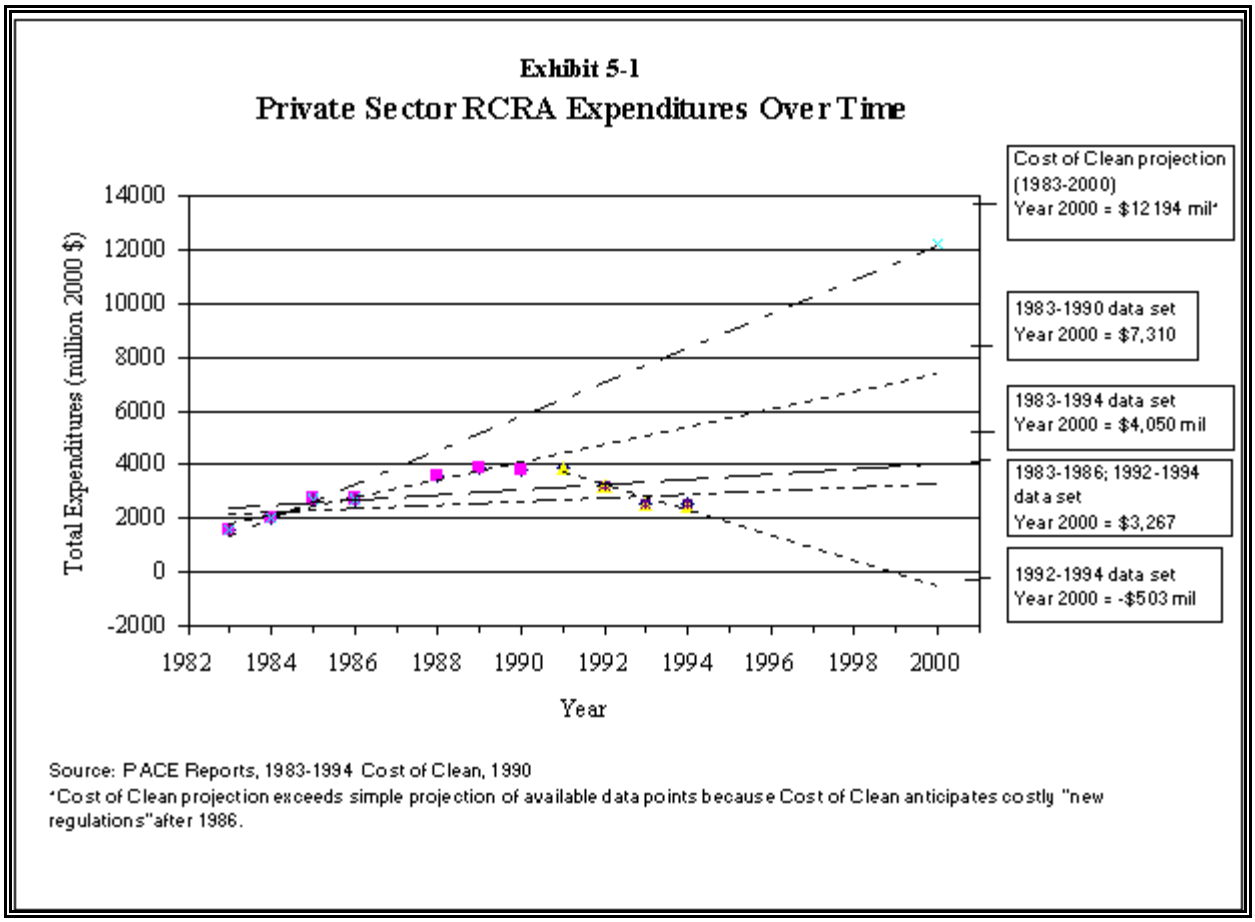
discussion on unadjusted PACE data and do not attempt to make these adjustments at this time.

[8] Because RCRA has so many overlapping regulations, identifying a "true" curve would be very difficult. At the plant level it is reasonable to assume that initial capital investment is followed by lower annual operating expenditures. However, it is difficult to determine how this pattern would manifest itself across industries and facilities.



5.2.3 *STEP 3. Adjust Projections to Focus on Industry Groups Of Interest*

One advantage of PACE is that it identifies industry groups by the first two digits of SIC codes. We may choose to isolate cost data by industry group to maintain consistency with the economic impacts approach, and with the potential "Approach C" which may be designed to target specific facility types. In addition, isolated analysis of industry groups is one possible method for addressing uncertainty related to data quality related to PACE and other data sources (e.g., *Industry Assessments).*

5.2.4 *STEP 4. Adjust PACE Projections to Isolate Without-RCRA Costs*

Whether costs are estimated using the forthcoming *Cost of Clean* or using our alternative method also based on PACE reports, data would need to be adjusted to correspond to the scope of a RCRA analysis. PACE data reports total hazardous waste expenditures each year. These data do not isolate incremental hazardous waste costs since the adoption of RCRA. Thus, to determine the true costs of RCRA, total expenditures would need to be adjusted for spending on hazardous waste disposal prior to the RCRA legislation. Exhibit 5-3 summarizes two approaches for adjusting PACE

data. For each approach, we discuss possible methods, expected results, and the advantages, limitations and data sources of the approach:

Exhibit 5-2

METHODS FOR ADJUSTING TOTAL EXPENDITURES TO REFLECT INCREMENTAL COSTS OF RCRA SUBTITLE C

	SIMPLE APPROACH	INDUSTRY-SPECIFIC APPROACH
Method	• Assume that, without Subtitle C, all hazardous waste would have been disposed of under Subtitle D.[a] • Estimate the total cost of Subtitle D, and the volume of waste handled by Subtitle D. • Apply this cost per volume unit of Subtitle D to the total volume of Subtitle C waste. • Extrapolate "without-Subtitle C" costs to the year 2000.	• Collect pre-1983 industry-specific cost estimates for hazardous waste disposal as available; assume that all other hazardous waste (unless otherwise indicated by industries) was disposed of as a solid waste. • Extrapolate "without-Subtitle C" costs to the year 2000.
Expected Results	• Highly generalized "without-Subtitle C" cost estimates based on Subtitle D costs.	• Gives more precise estimate of pre-RCRA costs. • Estimate of pre-RCRA costs can be subtracted from total expenditures under RCRA to give incremental cost of RCRA.
Advantages/ Limitations	• Simple; few data requirements.	• More extensive data requirements.
Sources	• PACE reports, 1975-1982 • EPA *Cost of Clean* (1990)	• PACE reports, 1975-1982 • Arthur D. Little (1981)[**] • State Industry Assessments

[**]Arthur D. Little, Inc. "Economic Impact Analysis of RCRA Interim Status Standards." Prepared for EPA Office of Solid Waste, 1981.
[a] This method of course relies on the assumption that RCRA Subtitle D would have existed in the absence of RCRA Subtitle C.

5.2.5 *STEP 5. Establish Quantity of Hazardous Waste Generated Without-RCRA*

Costs are a function of the quantity of hazardous waste that requires disposal. To estimate "without-RCRA Subtitle C" costs, it would be necessary to project pre-RCRA hazardous waste quantities to the year 2000. There are three possible methods for projecting without Subtitle C costs:

- **Index hazardous waste quantities to solid waste quantities.** This method would assume that waste managed under RCRA would have been affected by the same recycling and/or pollution prevention changes as any other solid waste, and projects hazardous waste quantities as a constant function of solid waste quantities.

- **Project hazardous waste quantities according to a Gross Domestic Product (GDP) inflator or similar growth indicator.** This method would assume that hazardous waste generation has grown at a similar rate as overall economic growth (i.e., the growth in industry and economic activity that accompanies economic growth inevitably generates consistent growth in hazardous waste). The primary limitation of this method is that it relies on

post-RCRA growth figures. In other words, rates of economic growth to some degree reflect the conditions of the "with RCRA" universe.

- **Project hazardous waste quantities according to industry-specific growth indicators.** This method is similar to the second method, but is more precise in that it reflects industry-specific trends. For example, certain key industries which generate large quantities of hazardous waste may have grown at faster or slower rates than the GDP as a whole. However, this method also relies on post-RCRA growth figures, which may be even more limiting in industries that generate large quantities of hazardous waste.

5.2.6 *Conclusions of Compliance Cost Estimate Using PACE Data*

The methodology we propose for estimating the costs of RCRA regulation rely on post-1983 Pollution Abatement Costs and Expenditures (PACE) data. While this data source does have limitations that should be taken into account in future analyses, we believe that it is the most complete source available at this time. In addition, a more complete estimate of the costs or RCRA Subtitle C would include administrative costs from EPA and state governments. We emphasize, however, that the forthcoming *Cost of Clean* may make more elaborate cost analyses unnecessary.

5.3 LONG-TERM COSTS

Similar to potential long-term benefits discussed in Chapter 4, the RCRA Subtitle C program may also be associated with long-term costs that would not be captured in the core analysis. We have identified the following two major types of potential long-term costs:

- **Failure to benefit from future improvements in remediation.** To the extent that new and innovative technologies will reduce costs and/or improve the efficiency of remediation, prevention regulations that require immediate and expensive process changes might increase overall long-term costs of the program compared with an efficient cleanup program. This would be especially relevant in cases in which the occurrence of environmental damage (i.e., to groundwater or soil) is delayed or is very gradual.

- **Failure to invest in other more productive economic activities** because available resources are spent on prevention activities. This cost would emerge in cases where forgone investments make future generations worse off than they would otherwise be. While it is possible that these costs could be "negative" (i.e., could actually represent benefits), this attribute may also represent a real long-term cost, and we therefore suggest a method here that

may characterize it in isolation.[9] Note that short-term (i.e., retrospective) and long-term economic impacts of RCRA are included in our discussions of Economic Impacts and Inter-Generational Equity in Chapter 6, respectively. Note also that this cost could be "negative" (i.e. a benefit) if the value of investing in prevention exceeds the value of other investments.

Method: Our proposed method for characterizing potential long-term costs associated with future decreases in cleanup costs would focus on a description of the innovation cycles for treatment and prevention technologies.[10] This would include a literature review to assess trends in remediation technologies and costs in recent years and describing potential future trends.[11] In addition, we would compare retrospective cleanup costs with those that would have accrued if present cleanup technologies had been available.

Our proposed method for characterizing potential long-term costs associated with a failure to invest in more productive economic activities would focus on a review of the developing literature that addresses the comparative benefits of environmental expenditures.[12] We would then discuss implications for the RCRA Subtitle C program and provide examples of how foregone investments might affect future generations.

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[9] Consideration of this long-term cost is balanced by consideration of long-term benefits (see Chapter 4 discussion of long-term benefits from long-term increases in value of environmental quality and benefits associated with the precautionary principle). It is possible that long-term effects could eventually include both measurable costs and benefits; there, our methods address both possibilities.

[10] We note that we also discuss changes in technologies and potential data sources in our discussion of Technology Forcing in Chapter 7.

[11] The actual rate and pattern of innovation is difficult to predict and is likely to vary among industries. However, one approach to identifying "location" on the innovation cycle would be to examine past changes in remediation costs. In one simplified approach, we could assume that if costs have been dropping rapidly in the past, then the innovation cycle for technology development may be nearing a "diminishing returns" phase, suggesting little future change. If, however, technologies and costs have changed little in the past, there may be opportunity for relevant future decreases in cleanup costs. Alternatively, we could consider "straight-line" innovation trends (i.e., an industry's past rate of innovation is indicative of its future rate). The appropriate approach should be determined in part by an examination of emerging literature on innovation in relevant industries.

[12] The literature addressing comparative costs and benefits of environmental investments is still developing and includes a variety of disciplines and authors (e.g., economist Dale Jorgenson and corporate strategist Michael Porter).

Advantages and Disadvantages: This method would provide a rough indication of future relative changes in cleanup and compliance costs, and may provide an indication of whether prevention is and will continue to be cost-effective. It would also illustrate the extent to which alternative economic investments may make future generations better off relative to their situation in the presence of RCRA. The results would be qualitative and would contain significant uncertainty associated with estimating future technology development and the importance of alternative investments for future generations. In addition, the analysis would to some extent address economic impacts and inter-generational equity; these attributes are also addressed separately in Chapter 6.

Distributional impacts of environmental regulations often represent some the most far-reaching program effects, but these impacts often cannot be monetized, and do not represent overall ("net") program benefits or costs. The prevention activities required under RCRA have particularly important distributional impacts because a key purpose of these regulations is to redistribute the costs of environmental protection. RCRA regulations require specific waste management practices that increase current costs in order to prevent future damage, as well as financial practices that ensure that polluters assume financial responsibility for wastes rather than externalizing these costs. In addition, RCRA's regulations can have positive and negative economic and risk impacts that result from increases in waste management costs and requirements. These impacts may result in unequally distributed benefits across different sub-populations or regions, and should therefore be examined as distributional issues. Attributes that address distributional impacts include:

- **Intra-generational economic equity:** This attribute refers to two aspects of the "polluter pays" philosophy. First, regulations that require companies to upgrade systems or pay high waste management costs may increase the competitive advantage of innovative companies that produce less waste. Second, the requirement that polluters manage waste from cradle to grave shifts the emphasis on costs away from public sector-managed remediation.

- **Environmental justice:** This attribute addresses the impacts of a regulation on environmental quality among disadvantaged populations and sensitive sub-populations.

- **Economic impacts:** This attribute addresses the positive and negative impacts of environmental regulation on economic activity. While the net effect of economic impacts may be positive or negative (i.e., may represent an actual cost or benefit) and could be included in a benefits analysis, it is also important to address the distribution of effects among different population segments.

- **Risk tradeoffs:** This attribute addresses potential increases in risk that may result from environmental regulations (e.g., increased risks of hazardous waste exposure during remediation activities). Again, while the net effects of risk tradeoffs may represent an actual cost or benefit and should be included in an analysis of benefits, it is also important to consider the distribution of risks among different segments of the population.

In addition to the more immediate distributional impacts of RCRA, we provide a separate discussion of the long-term distributional impacts (i.e., inter-generational equity impacts) of the program. Inter-generational equity describes the exchange of costs and benefits across generations. For example, RCRA prevention programs incur costs in the near term to prevent pollution events, including human health and environmental damage, that would have occurred many years in the future. These impacts, particularly those related to prevention of groundwater pollution and associated health and ecological impacts, may represent some of the most significant effects of the program.

While the net effects of some distributional impacts may represent benefits or costs, a net benefits analysis does not capture the extent of some of the changes that result from RCRA. Therefore, while not "additive" to an assessment of net benefits or costs, distributional analyses provide information that is very important in an effective program assessment. This chapter provides a general description of one or more potential methodologies for each of the distributional attributes identified above. Appendix B provides summary tables of methodological options for inter-generational equity, environmental justice, and economic equity attributes.

6.1 INTRA-GENERATIONAL ECONOMIC EQUITY

The economic equity attribute addresses the *intra*-generational distributional effects of RCRA. Like the inter-generational equity attribute, the economic equity attribute does not identify a net gain or loss to society as a result of RCRA. Instead, the attribute addresses two short-term impacts of the "polluter pays" principle in RCRA. The first is market efficiency improvements, or the extent to which RCRA eliminates situations in which a company can remain competitive by using cheap and environmentally damaging waste practices. The second is public-private equity, or the extent to which RCRA (through financial assurance provisions) assures that the polluter will pay for environmental remediation and removes this burden from the public sector. In both of these cases, this attribute addresses the improved market efficiency of resource allocation that can also be described as "internalizing environmental externalities." Below we propose one method for addressing market efficiency improvements, and two alternative methods for addressing public-private equity. Note that this attribute should be considered in conjunction with the Economic Impacts attribute, which describes the industry-level distributional impacts (i.e., the industrial "gainers and losers") under RCRA Subtitle C.

6.1.1 *Changes in Market Efficiency*

- **Method:** Develop a qualitative discussion of the redistribution of profits and costs among companies and technologies as a result of RCRA regulations. Use theoretical literature and data from the recent RIA for the Hazardous Waste Combustion MACT Standards to discuss the extent and effects of the redistribution of disposal between cement kilns and incinerators. The changes in use of these units can provide an example of economic equity benefits due to RCRA.[1]

6.1.2 *Changes in Public-Private Equity*

- **Option 1:** Using Cost of Clean and the *Corrective Action RIA,* develop and compare profiles of the public and private cost distributions for RCRA Corrective Action programs, RCRA Prevention programs, and the Superfund program.[2] Identify the public-private "leverage" (if any) that is achieved in prevention programs as opposed to cleanup programs.

- **Option 2:** Using *Cost of Clean*, estimate the percentage of the GDP that has been spent on public clean-ups of pre-RCRA wastes (through the Superfund and RCRA Corrective Action programs). Compare this with government sector RCRA funding.

6.2 ENVIRONMENTAL JUSTICE

Environmental justice addresses the distribution of environmental quality among different demographic groups and sub-populations. This attribute incorporates the Agency position that while there is measurable value in reducing overall levels of pollution and environmental damage, this reduction is imperfectly achieved when there is an inequitable distribution of environmental quality and benefits among different ethnic groups and socioeconomic classes. Research in the field of environmental justice indicates that there may be correlations between disamenities such as

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[1] The theoretical literature in this field is part of the literature on the economic costs of regulation (addressed below in our discussion of Economic Impacts). However, because this attribute aims to identify the extent of redistribution among competitors, rather than total or net economic effects of regulation, the results do not overlap with our discussion of Economic Effects.

[2] The Superfund is collected primarily from a tax on certain industries; however, payers are not necessarily the companies or facilities that have created the pollution. We assume that money collected by taxation and spent at the discretion of the government is effectively public money.

hazardous waste sites and proximate populations with a high number of poor or minority members. In addition, in some areas specific damages such as contamination of fish stocks may have a disproportionate affect on "sensitive subgroups" such as subsistence farmers or traditional communities, whose dependence on specific resources may be higher than average.

RCRA regulations have the potential to have both positive and negative environmental equity implications. For example, if pre-RCRA facilities have traditionally been concentrated in areas with disadvantaged populations, then improvements in practices at these facilities (or closure of non-compliant facilities) have positive implications for environmental justice because disadvantaged populations would enjoy a relatively large portion of the benefits related to environmental improvements. It is also possible, however, that after the passage of RCRA new Subtitle C facilities continue to be sited disproportionately in areas with disadvantaged populations (perhaps because awareness of hazardous waste issues has increased resistance to siting facilities in more affluent or politically powerful communities); in this case these communities would enjoy the reductions in risk associated with improved practices, but may still face a disproportionate share of the disamenities (including any remaining risk) associated with Subtitle C waste management.[3]

The approaches outlined below aim to identify the extent to which RCRA regulations have (or have not) been associated with an improvement in environmental justice, as indicated by the proximity of hazardous waste facilities to disadvantaged populations. The methodologies for analysis of environmental equity issues are developing, and there is considerable and growing literature on the issue of proximity to waste sites in particular. We propose two alternative methods for addressing this issue: Option 1 is a targeted approach based on existing literature that addresses potential "negative" environmental justice issues that have persisted in the presence of RCRA; Option 2 is a broader methodology addressing both positive and negative environmental justice impacts based on original research.

6.2.1 *Option 1: Use Existing Literature to Identify Possible Negative Environmental Justice Impacts Associated with RCRA*

The environmental justice literature is still rapidly developing, and does not yet address the long-term changes in facility practice and location that may indicate positive environmental equity

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[3] While it is possible to identify correlations between facility locations and disadvantaged populations, it is often impossible to attribute causality to RCRA (or to any source) in cases where inequities persist or even grow in the face of regulation. Contributing factors may include existing disparities in the economic and political power of different communities, compounded by heightened awareness of hazardous waste issues. Awareness of hazardous waste issues itself could result from any of several sources (e.g., Superfund, RCRA, or well-publicized local cases). Finally, demographic trends may be unrelated to RCRA facilities sites - it is conceivable that neighborhoods have undergone negative (or positive) demographic transitions after facilities were sited.

effects associated with RCRA. However, the literature does examine more recent siting decisions of RCRA Subtitle C facilities, particularly those operated as commercial waste treatment and disposal facilities.[4] These studies suggest that poorer areas are still disproportionately selected to site hazardous waste facilities, due in part to the well-organized resistence of wealthier communities. Additionally, the literature review from Approach A may shed some light on this issue. While these effects may not be *caused* by RCRA, and while the overall environmental justice effects of RCRA may be positive, it is important to consider this issue carefully in assessing the program.

Method: Perform a review of the environmental justice literature and using the measures identified in the literature (e.g., percentage of facilities sited in predominantly minority areas) determine the extent to which it indicates a consistent pattern of impacts under RCRA.

Advantages: This approach requires only available data and identifies a potentially significant impact of the RCRA program that is not captured elsewhere.

Disadvantages: This approach is reliable only for establishing post-RCRA impacts; any immediate or early changes due to RCRA are not likely to be captured. As a result, this approach is likely to understate the positive effects of the RCRA program.

Note that we recommend this non-site-specific approach to address environmental equity issues in the context of our proposed Approach A.

6.2.2 *Option 2: Perform a temporal and spatial analysis of sample facilities to determine changes in population distribution*

This approach addresses changes in population demographics near RCRA facilities over at least one decade, and also looks at differences in the locations of new and pre-RCRA facilities (i.e., facilities that existed prior to RCRA). These changes may include heightened awareness of potential disamenities, changes in demographics surrounding existing facilities, or changes in siting patterns of new facilities. The approach assembles available U.S. Census data and sample facility locations in a GIS and identifies patterns in demographics near the sites. Comparison to two types of facilities (TSDs with pre-RCRA SWMUs and "new" TSDs) and two decades of Census data (1980 and 1990 are available in digital form) allows an examination of changes over time. This may allow some insights into the issue of causality — whether RCRA facilities are sited in poor areas, or whether the siting of a RCRA facility makes an area less desirable.

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[4] For example, see Boerner and Lambert, "Environmental Justice in the City of St. Louis: The Economics of Siting Industrial and Waste Facilities," (1995); Been, "Unpopular Neighborhoods: Are Dumps and Landfills Sited Equitably?" (1994); Glickman, Measuring Environmental Equity with Geographical Information Systems," (1994).

Method:

- Map the locations of sample facilities from benefits methodologies (e.g., *Corrective Action RIA* sample facilities or HWIR model facilities) to represent facility locations before RCRA and map demographic patterns (including ethnicity, income, age, and housing density) around each facility in 1980 and 1990 (and 2000, if available) using US Census block level data.

- Compare these local demographic patterns to national and county averages and determine changes in demographics over time.

- Collect a sample of "new" TSDs from recent BRS data (i.e., limit the selection to facilities first reporting in 1993 or 1995) and analyze the demographics around these facilities.

- Compare the two analyses to determine whether new facilities are more or less likely than old facilities to be located in areas near disadvantaged or sensitive sub-populations.

Advantages: This approach allows an examination of changes in demographics, as well as facility siting. This may reveal improvements in RCRA siting and will also reveal how demographic patterns have changed over a decade near existing facilities.

Disadvantages: This approach does not identify net environmental equity effects due to RCRA because it does not identify how much "worse" or "better" RCRA facilities are than other commercial facilities, including facilities that ceased operations as a result of RCRA.[5]

Exhibit B-4 in Appendix B contains a summary description of the options for addressing environmental equity, including a brief description of data requirements for each.

6.3 POSITIVE AND NEGATIVE ECONOMIC IMPACTS

The economic impacts attribute is one that addresses both the positive and negative impacts related to employment opportunities, industry productivity, and industrial development. This attribute addresses a number of the same issues that economists identify when attempting to determine the "true economic costs" of a regulation. However, as we have illustrated, we attempt

[5] This uncertainty might be addressed with a supplemental analysis that evaluates the demographics around a sample of appropriate Superfund sites (i.e., manufacturing facilities that operated after 1970 and closed by 1980) and compares these to the other two samples.

to separate our analysis of these attributes, addressing only program expenditures in our cost attribute (see Chapter 5) and discussing the additional economic impacts of the program here.[6]

The RCRA Subtitle C program significantly increased the cost of hazardous waste management. Many TSD and generator facilities were required to undertake both capital expenditures to upgrade facilities, and new operations and management expenditures to comply with an extensive permitting and reporting process and the waste manifest tracking system. The potential negative effects of these changes include facility closures (both before and after the implementation of RCRA regulations), job losses, reduced productivity, and diminished profits in regulated industries, as well as "ripple effects" in local economies due to facility closures and unemployment. In the meantime, RCRA requirements have spawned entire new industries in waste handling technologies and services, providing new jobs and improving the profitability of some existing firms.

Positive economic impacts of environmental regulations can also include "ripple effects" of improved environmental conditions such as increased worker productivity due to reduced health effects, or the economic development that often "follows" a site remediation. However, in the case of RCRA prevention regulations the avoided health effects are generally localized and are often delayed for a number of years, making it difficult to identify specific related productivity changes. We therefore limit our discussion of RCRA economic impacts to industry productivity and employment effects related to changes in the cost of waste management.

There are several confounding factors in attempting to measure changes in industry productivity and employment that have resulted from 20 years of RCRA regulations. For example:

- RCRA affects a broad array of industrial sectors with different waste generation and management approaches; addressing national level economic impacts would require multiple sector-level analyses to identify exact effects.

- The domestic economy has undergone considerable shifts since the 1970s, many of which are unrelated to RCRA. These include global changes in raw materials supply and end-use markets, technology advances, labor force shifts such as the number of women in the work force, and changes in domestic monetary policy such as interest rates. While these shifts occur at the national level, their effects on specific sectors may vary considerably and complicate an attempt to isolate the effects of RCRA.

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[6] Negative and positive impacts can represent real costs and benefits on a local and regional level, and may represent real costs and benefits on a national level as well. However, given the breadth and complexity of the RCRA Subtitle C program, coupled with the limited information about the baseline (i.e., pre-RCRA) universe, a national analysis of net economic impacts would be both complex and speculative. We therefore propose methods that address the distributional aspects of this attribute by characterizing the key positive and negative impacts of the program.

- A number of other federal regulations, including additional environmental regulations, worker safety regulations and minimum wage requirements, have had significant impacts on the domestic economy. Again, isolating the effects of RCRA in the context of other regulatory requirements is difficult.

While these realities complicate the evaluation of RCRA's economic impacts, the potential impacts related to this attribute are considerable and may have an important effect on an overall program assessment. We propose two methods for estimating at least a portion of the economic impacts related to the RCRA Subtitle C program. Note that each method we propose below can be performed independently, or both may be performed as a single approach.

6.3.1 *Qualitative Assessment Based on Existing Literature*

The theoretical and empirical literature related to economic impacts of regulation includes analysis of several industrial sectors and environmental regulations, including industry assessments and RIAs specific to RCRA. While existing studies may differ with regard to scope or underlying assumptions about the relationship between environmental regulation and economic growth, a thorough investigation of this material may provide the basis for a general qualitative discussion of the impacts of RCRA. A review of methods may also reveal new approaches to defining and measuring economic impacts.

This analysis would require a thorough examination of the theoretical and empirical literature addressing the economics of regulation to identify the studies most relevant to RCRA. This would include an examination of sector level data for sectors likely to be affected by RCRA, and could also include literature on issues such as regional variation in the economic impacts of the regulations. This method may provide information for additional analysis or for framing this topic to reflect recent developments in the field. While it may stand as a separate approach, the method is exploratory in nature and may not provide compelling results for a program-wide analysis of RCRA.

6.3.2 *Case Study of Economic Effects at Sample Facilities*

This method would provide facility-specific estimates of the types of economic impacts associated with RCRA. The method requires initial identification of industries most likely affected by RCRA; we propose using a subset of the sample of facilities associated with a specific benefits approach to identify industries and processes most likely to be affected by RCRA. We then recommend the following analysis:

- **Step 1:** Select a sample of facilities for close examination. This sample can include facilities from the Approach B *Corrective Action RIA* sample or a

separately selected sample. Alternative facilities to examine are facilities known to have closed at the time RCRA regulations took effect.[7]

- **Step 2:** Identify facility-specific changes in practice and cost as a result of RCRA, including required capital investments and increases or decreases in operations and management costs. If data are available, identify the effect of these changes on facility operations (e.g, layoffs, additional hires, temporary or permanent facility closures, relocation, and/or changes in production).

- **Step 3:** Examine the local economic effects of any facility changes, such as changes in unemployment rates, housing values, median household income, and related facility closures (such as a dedicated repair business or supplier).

Results: This analysis would provide a case-study-based illustration of the local economic effects of RCRA based on practices at specific facilities. Local economic impacts identified would include, if data were available, the impact on total facility production, local employment levels, and "ripple effects" to the general local economy.

Advantages: This analysis would provide a method for directly measuring actual economic impacts related specifically to RCRA regulations. The facility level of detail also provides the ability to separately identify the extent of different types of economic effects, such as changes in employment and changes in total household income or housing value.

Disadvantages: This analysis may require considerable data collection for some facilities, including investigation into historical local economic conditions (although we assume this method would involve fewer than nine case studies and would not require an ICR). In some cases data availability issues may prevent a complete analysis. In addition, this analysis is limited to the level of illustration only, and would not provide sufficient information to extrapolate the impacts of RCRA to a feasible national result.

6.3.3 *Note on Economic Modeling*

The most comprehensive approach to addressing the economic impacts caused by national environmental regulation would be an approach that models changes in the sector or the economy

[7] We believe that these facilities can be most easily identified using the RCRIS database, which contains information about a sample of "protective filers" who for a variety of reasons, including in some cases facility closure, were never regulated under RCRA though they applied for an initial Part A TSD permit.

that result from these regulations (such as increases in capital and operating costs).[8] However, to implement a modeling option would require the collection of sufficient data to construct a defensible baseline and with-RCRA scenario. While a range of models are available to identify the distributional effects resulting from a policy change, we do not believe that the baseline data for the RCRA program are sufficient to justify the considerable expense involved with any of these efforts. In addition, the complexity of the Subtitle C regulations and the wide range of affected industries and markets precludes any simplified modeling approach to measuring economic impacts.

6.4 POTENTIAL RISK TRADEOFFS UNDER RCRA

Risk tradeoffs identify potential increases in risk that may result from environmental regulations (e.g., increased exposure to hazardous waste workers during removal actions). While the value associated with these risk increases should be incorporated into an analysis of the net benefits of a regulation, a separate analysis of risk tradeoffs can reveal potential patterns in risk increases that are important in assessment of a regulatory program.

We attempt to characterize both the positive and negative ways that workers involved with hazardous waste management may be affected by RCRA Subtitle C. RCRA regulations may benefit remediation workers by reducing the number or severity of sites requiring remediation. However, risk tradeoffs under RCRA include two possible categories: health risks to workers from increased exposure to hazardous wastes as a result of various RCRA waste management requirements, and risks and costs associated with an increased number of waste transportation accidents due to potential higher mileage required to deliver waste to the relatively small number of commercial Subtitle C waste management facilities. We briefly summarize these risk tradeoffs and present our conclusions about their contribution to the costs and benefits of the RCRA program.

6.4.1 *Risk to Workers*

Risk to workers may constitute both a benefit and a risk tradeoff of RCRA. Worker exposure to hazardous waste may be changed in three ways as a result of RCRA regulations. Exhibit 6-1 summarizes these worker scenarios and the change in risk since the adoption of RCRA:

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[8] Computable general equilibrium (CGE) models are the most comprehensive of the modeling options; these models address general measures of economic performance (i.e., employment) across multiple economic sectors. Additional, more limited options include partial equilibrium models and input-output models addressing specific markets and parameters. However, application of an approach involving any of these models requires extensive data collection and the careful development of a baseline estimate of economic activity prior to the policy. This includes information about other government policies, as well as detailed producer and consumer profiles for affected markets.

Exhibit 6-1 APPROACHES TO CALCULATING RISK TO WORKERS		
WORKER CATEGORY	**NET CHANGE SINCE RCRA**	**CHARACTERIZATION OF BENEFIT**
Workers required for remediation	Risk to remediation workers is **reduced** as a result of RCRA for two reasons: 1. RCRA reduced the number of sites that may eventually have required remediation. 2. Though RCRA Corrective Action sites also require remediation, we assume that these cases are less severe than Superfund remediations, and thus require fewer man-hours to complete (this assumption could be verified by examining cost estimates for cleanups in EPA's forthcoming *Cost of Clean*).	Health benefit to workers.
Workers required for storage/ disposal as mandated by RCRA	Risk is **created** as a result of RCRA since new workers required by RCRA incur new risks.	Risk trade-off due to RCRA.
Workers required for transport to remediation or disposal sites	Risk is **increased** as a result of RCRA. We assume that risk per mile driven remains constant for transport workers before and after RCRA. However, after RCRA more miles are driven to compliant, off-site waste disposal sites.	Risk trade-off due to RCRA (addressed as part of transportation risk).

We have examined the available literature to determine the possible magnitude of these changes. However, based on our findings we believe that the benefits or risk tradeoffs incurred under RCRA may be insignificant.

Remediation Worker Risk: If remediation workers experience incremental risks associated with exposure during remediation work, then RCRA may be associated with reduced risk to workers due to a decline in the total number and severity of sites requiring remediation. However, it is unclear whether either Superfund or Corrective Action workers face unique exposure-related risks during remediation work. Hoskin, et al. (1994) provide estimates of risk to remediation workers by occupational title (e.g. carpenter, foreman, etc.). These risk estimates, however, are applicable to any construction worker regardless of whether or not the construction job involves hazardous materials. We assume that remediation workers would be employed in comparable construction jobs had the remediation project not employed them. Thus, if there are additional risks associated with remediation work specifically, this relative risk is not reflected in Hoskin's risk estimates. We have been unable to identify any literature specifically addressing exposure risk to remediation workers.[9] Therefore, at this time we offer no method for addressing this issue.

[9] If there are unique risks associated with remediation work, it would be important to identify and compare construction worker wages to identify whether or not this incremental risk is compensated. If 1) risks of various types of construction work are equal (or if uneven risk is fully compensated), and 2) construction workers would find construction jobs regardless of the existence of remediation projects, then there may be no distributional impact associated with RCRA.

Waste Management Worker Risk: If workers are required to perform additional storage or disposal handling tasks under RCRA, a potential risk may be created. However, it is difficult to determine a baseline level of risk due to non-hazardous materials handling requirements already in place. RCRA requires handling procedures in accordance with OSHA guidelines. Since OSHA guidelines are designed to protect worker safety, we would assume that these guidelines reduce worker risk and offset potential increases in risk due to increased handling under RCRA.

6.4.2 *Transportation Risk*

Under RCRA Subtitle C, strict technical standards for TSDs have likely resulted in fewer facilities accepting hazardous waste. In addition, limitations on storage at generating facilities have likely resulted in more generators disposing of hazardous waste off-site. In a without-RCRA universe, these generators may have disposed of hazardous waste on-site, or at nearby sites that would not meet RCRA regulations. In this case, it is likely that facilities disposing of hazardous waste must transport waste for greater distances than they might have in the absence of RCRA regulations. Assuming a constant risk per mile traveled, additional miles of waste transport would contribute to a greater risk of a transport incident.

Transportation risks include two separate elements; human health risks to transport workers that include both accident related injuries and possible exposure to hazardous wastes, and the additional costs and risks associated with emergency response (including both public safety activities and immediate cleanup) and liability. We first address the risk to transport workers, and then discuss remaining public safety risks and costs associated with accidents.

Transport Worker Risk: Our examination of the literature involving risk to transport workers suggests that these risks are likely to be insignificant. Hoskin, et al. (1994) made progress in calculation of risks incurred by hazardous waste remediation workers. They provide average death rates by occupational title (e.g., carpenter, mechanic) for the top three methods of site remediation, and find that truck drivers face the highest risks. However, several sources indicate that, since 1981, only one hazardous waste transport worker has been killed on the job. Furthermore, injuries to hazardous waste transport workers have never exceeded fifty in one year, and average eleven per year. There has been no discernable upward or downward trend in the frequency of hazardous waste transporter injuries since the adoption of RCRA. These statistics indicate that the incremental risk to transport workers as a result of RCRA is likely to be insignificant.

Risk of Accidents: Though we conclude that the risk of injury or death to transport workers has not increased under RCRA, the number of accidents involving hazardous waste, and the associated costs of these accidents, may have gone up as a result of the regulations. Transport incidents can still incur monetary costs in the absence of worker injuries or fatalities, such as damage costs, emergency response, cleanup costs, and liability costs.

Though risk to transport workers is insignificant, the total number of transport incidents has increased considerably since 1991. It is unclear whether this increase is due to an increase in miles driven to RCRA sites, or whether the trend simply mirrors a general increase in the frequency of all highway incidents. The increase in hazardous waste transport incidents is a risk tradeoff of RCRA if and only if the overall rate of highway incidents has remained constant over time. Because records of all highway incidents have only been found for 1990 to 1995, it is difficult to discern a clear trend.

However, it appears that the overall rate of highway incidents has increased. This change would be reflected in the "risk per mile driven" variable. If this is the case, the increase in hazardous waste transport incidents cannot be fully attributed to RCRA. It is possible that the "miles driven to disposal site" have also increased since adoption of RCRA, since the new regulations require generators to transport waste to approved off-site disposal facilities. If risk has increased due to an increase in the miles driven to disposal sites, this is a risk tradeoff due to RCRA. The extent to which each of these variables contributes to the observed increase in hazardous waste transport incidents has not yet been determined. Arthur D. Little, Inc. and BRS data can provide information on the quantities of waste disposed on and off site before and since RCRA. Spatial analysis of generators and disposal facilities could provide information on the distances traveled to dispose of hazardous waste.

In summary, to estimate transportation risks, we propose to assume that the total risk of hazardous waste transport is equal to the total miles driven times the per mile risk of an accident:

Probability of transport accident =
(Miles driven to disposal site) x (Probability of transport accident per mile driven)

6.5 LONG-TERM DISTRIBUTIONAL IMPACTS (INTER-GENERATIONAL EQUITY)[10]

Inter-generational transactions may be among the most important contributions of the RCRA prevention program; they are also among of the most difficult to identify and measure because inter-generational equity focuses on distribution of goods across very long time periods. Environmental programs such as RCRA affect inter-generational equity by encouraging conservation of resources

[10] Inter-generational equity is related to the concept of sustainability, which measures the extent to which present actions preserve for future generations the level of environmental resources and quality that are available today. Sustainability incorporates both long-term benefits (discussed in Chapter 4) and a broader "polluter pays" principle that requires those using resources or causing environmental damage to be responsible for assuring that damages will be repaired and resources replenished. Because the theoretical literature on sustainability is rapidly developing, we believe that the first step in addressing any aspect of sustainability, including both long-term benefits and inter-generational equity, should be a thorough review of recent and emerging literature.

(e.g., groundwater and raw materials) and by supporting the "polluter pays" principle. The objectives of these changes are not production of additional goods or services in the immediate time frame; their aim is rather to protect the quality of the environment for current and future generations, and ensure that the costs associated with protecting the environment are borne by those who are using resources.

Traditional economic approaches do not effectively address inter-generational equity because they have difficulty predicting the values that future generations will place on goods. Economic valuation of benefits traditionally "discounts" future events and resource flows to reflect the present value of future events. In Chapter 4 we discussed the long-term implications for benefits, and identified potential resource conservation (i.e., groundwater) and health impacts that can be quantified using current methods and may represent measurable benefits at some time in the future. In this chapter we address the overall scope of transfers of costs and benefits across generations, without reference to their effects on net benefits or costs.

One measure of inter-generational equity is the extent to which later generations must repair damage caused by earlier generations. Many existing hazardous waste sites reflect a failure to achieve inter-generational equity; often these sites are decades old and place a disproportionate cost burden on the current generation rather than the generations who generated the waste and enjoyed the associated products.

The RCRA Subtitle C program requires proper management of hazardous waste in order to prevent damages that may not be observable for several decades. In essence, the program aims to eliminate the future need for remediation. We propose methods for addressing two prevention program aspects that directly affect inter-generational equity: shifts in treatment away from land-disposal units to treatment strategies with fewer long-term consequences, and the monitoring and financial assurance provisions that require permit holders to maintain the financial capability to perform immediate response actions and closures.[11] We propose two methods for quantifying or characterizing these program elements.

6.5.1 *Reduction in Land Disposal*

Land disposal practices are the most likely to affect inter-generational equity; a reduction in the quantity and percentage of waste disposed by these methods indicates a shift to disposal technologies likely to have fewer inter-generational effects. Using BRS data and pre-RCRA

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[11] Financial assurance provisions contribute to inter-generational equity in the same way that other response and disposal requirements do; they help assure that later generations do not have to address "current" pollution. Financial assurance requirements also shift financial burden away from taxpayers and toward polluters, but this is an issue of intra-generational economic equity (as opposed to inter-generational equity) and is addressed separately.

estimates of disposal practices, it is possible to identify trends in treatment and disposal technologies for waste. We recommend the following:

Method:

- **Step 1.** Collect pre-RCRA land disposal data (e.g., Arthur D. Little, Inc. *Economic Impact Analysis of RCRA Interim Status Standards*, 1981) and several years of BRS data for consistent industries (identified by SIC Code).[12]

- **Step 2.** Identify changes in quantity and percentage of waste disposed according to management code or associated treatment type, and number and percentage of facilities reporting different management codes.[13]

- **Step 3.** Identify total and percentage reductions in the quantity of waste land disposed and the number and percentage of facilities using land-disposal technologies.

6.5.2 *Avoided Future Cleanups Due to Monitoring and Response Requirements (includes financial assurance provisions)*

To identify the inter-generational effects of RCRA monitoring and response requirements, it is necessary to develop both a with-RCRA and a without-RCRA scenario of the number of waste sites and the average lapse in time between a hazardous waste release and clean-up. Our initial, simplifying assumption is that the with-RCRA scenario has a negligible time lapse in site-clean-ups due to the monitoring and response requirements.[14] As a result, no waste sites are created in this scenario. However, we propose a method for estimating the without-RCRA scenario and calculating the extent of inter-generational equity gains:

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[12] Pre-RCRA data sources are generally limited in scope to the industries first regulated under RCRA. Therefore, to determine the magnitude of changes over time, we would initially limit the scope of BRS data to be consistent with earlier data and with benefits Approaches outlined in Chapters 2 and 3.

[13] Note that information about the number of facilities reporting different management types may be limited to BRS and other post-RCRA sources. However, some industry-level waste quantity and management information is available for pre-RCRA facilities. Also, it will be important to identify changes in BRS reporting requirements that could alter reported quantities of waste.

[14] We assume full compliance and full protection from risk under the regulations.

Method:

- **Step 1.** Using results from selected benefits approach, identify the number of hazardous waste sites avoided under RCRA. (An alternative approach to this estimate is to identify the number of response actions at Subtitle C facilities, but this alternative is conservative because it reflects the engineering improvements under RCRA.)

- **Step 2.** Select a sample of CERCLIS and state hazardous waste sites, removing illegal disposal sites and sites that closed before 1970. This removes facilities that would not have been regulated under RCRA and accounts for the fact that Superfund would address long-closed sites in the absence of RCRA. In other words, the Superfund program has its own inter-generational equity benefits, and we do not consider these.

- **Step 3.** For the remaining sites in the sample, use site narrative data to identify the average length of time between a polluting incident and the discovery of contamination.

- **Step 4.** Apply this average to the avoided sites to determine the inter-generational equity impact, measured in number of sites removed from future concern and in the number of years delay associated with those sites.

6.5.3 *Inter-generational Effects Summary*

The methods outlined above address two important components of inter-generational equity:

- Reductions in land disposal practices (changes in the number of land disposal facilities, quantity of waste sent to land disposal); and

- Time delays avoided by immediate response requirements: (number of avoided facilities) x (average years delay before cleanup).

In addition, a complete assessment of inter-generational equity should include a qualitative discussion of the equity impacts of resource conservation such as preservation of groundwater. An estimate of the quantity of groundwater potentially affected by RCRA is outlined in the discussion of long-term benefits (Chapter 4). While these results address some of the same issues that are raised in our discussion of long-range benefits, the equity analysis provides additional information on the magnitude of transfers across generations, rather than focusing on net benefits and costs.

6.6 CONCLUSIONS

The distributional effects of RCRA Subtitle C regulations may represent some of the program's most important results. The methods we have outlined above identify the extent to which RCRA effects important changes in the distribution of the impacts of improved hazardous waste management. While these attributes are not additive with benefit and cost attributes, they may provide important information in assessing the extent to which the program has met certain objectives, such as supporting the "polluter pays" principle.

PROGRAM CONTEXT ATTRIBUTES CHAPTER 7

In this chapter, we address our proposed methods for characterizing additional attributes of the RCRA Subtitle C program not covered in the previous sections, which we call "program context attributes." As explained in Chapter 1, OSWER is developing a process for evaluating a broad set of program impacts and features, beyond those evaluated in traditional benefit-cost analyses. The results of implementing the methods described in this report are expected to be reviewed and used by both internal EPA managers as well as external stakeholders with an interest in the performance of the RCRA Subtitle C program. To this end, OSWER believed it was important to go beyond the attributes typically considered in a traditional cost/benefit analysis, to also characterize and describe other program features and factors that influence the design, implementation, performance, and impacts of OSWER programs. OSWER believed these "program context attributes" could be relevant to those internal and external reviewers trying to gain a better understanding of the impacts and drivers behind OSWER programs.

Some of these attributes may, in fact, be associated with real benefits or costs, but it is not possible to identify the net effects of these attributes using available data. Others simply represent factors that can influence the performance of the RCRA program. Program context attributes associated with the RCRA Subtitle C program include:

- **EPA regulatory reinvention initiative impacts.** Recent efforts to refine the implementation of the RCRA program may have effects on future costs and benefits of the regulations;

- **Regulatory constraints under RCRA** include several statutory and legal requirements that can affect program priorities, costs, and benefits;

- **Stakeholder issues** identify the extent to which program priorities are defined by, and responsive to, stakeholder interests and needs.

- **Technology forcing impacts.** RCRA regulations may have provided incentives for the rapid development and adoption of technologies that reduce the generation or disposal of hazardous waste;

- **Long-term effects: behavioral change** related to RCRA Subtitle C regulations may have implications for program implementation, and may be related to changes in the long-term social value of environmental quality.

Below we suggest approaches for characterizing these attributes.

7.1 BENEFITS, COSTS AND IMPACTS OF EPA REGULATORY REINVENTION INITIATIVES

In recent years EPA has undertaken a number of initiatives designed to revise and clarify RCRA Subtitle C program priorities. Key among these initiatives are voluntary efforts such as the waste minimization program, which increases program emphasis on source reduction and recycling. In particular, waste minimization targets persistent, bioaccumulative, and toxic (PBT) wastes, and encourages generators to reduce, eliminate, or recycle these wastes. In this way the program aims to improve the cost-effective reduction of risk through pollution prevention.

More recent EPA regulatory reinvention efforts have focused on reducing the regulatory burden of RCRA. The Agency introduced three new rules in 1998 that have implications for future costs of complying with RCRA Subtitle C regulations:[1]

- April 1998 *Land Disposal Restrictions Phase IV, Final Rule: Promulgating Treatment Standards for Metal Wastes and Mineral Processing Wastes* encourages recycling for mineral processing wastes and introduces new soil standards that allow land disposal rather than incineration of some contaminated soils.

- October 1998 *Standards Applicable to Owners and Operators of Closed and Closing Hazardous Waste Management Facilities: Post-Closure Permit Requirement and Closure Process: Final Rule* streamlines closure of hazardous waste disposal facilities by providing an enforceable document alternative to the post-closure permitting process, and allows site specific post-closure permitting to reconcile conflicting requirements for hazardous and solid wastes.

- November 1998 *Hazardous Waste Identification Rule for Contaminated Media (HWIR-Media), Hazardous Remediation Waste Management Requirements* were released. The new requirements allow storage of

[1] Environmental Protection Agency Office of the Administrator 1998 annual report *Reinventing Environmental Protection*, March 1999 (EPA100-R-99-002) pp.64-66.

contaminated soils during clean-up and simplify approval of state hazardous waste management programs as they incorporate new federal requirements.[2]

All of these activities may have a measurable effect on the production and management of hazardous waste and on the costs associated with these activities. However, the benefits of these initiatives are difficult to incorporate into a retrospective analysis for two reasons:

1. Most reinvention activities are too recent to be reflected in a retrospective analysis. The most recent data available about waste generation quantities and costs pre-date EPA's recent reinvention activities.

2. The effects of these programs are difficult to isolate within the broader data available from the Biennial Reporting System. While general reporting data may show decreases in waste generation or in the cost of waste disposal, it is difficult to attribute these changes directly to a specific EPA initiative.

While the benefits of these initiatives are not relevant to a retrospective analysis and we do not provide a method for addressing them here, the potential benefits of reinvention initiatives should be incorporated into the future cost estimates in any prospective analysis of the RCRA program. The methodologies for measuring these costs are relatively simple. For example, to calculate projected savings due to reduced permit requirements, EPA estimates reduced "burden hours," or hours saved by streamlined requirements. The benefit is calculated as the number of hours saved multiplied by the average cost per hour of personnel responsible for the "old" permitting requirements.

Similarly, the success of the Waste Minimization effort may be difficult to isolate and measure due to its relatively recent development in 1993. However, the results of the program should be reflected in the general trends revealed in BRS and cost data; reduction in waste quantities and in the number of facilities generating and/or managing hazardous waste (and associated reductions in costs) may be attributable to a combination of waste minimization programs and more general prevention efforts. Also, if recent (and future) BRS data show a significant reduction in the generation of PBT wastes relative to total wastes, then some or all of the reduction in risk associated with this shift may be attributable to waste minimization activities.[3] Estimating the risk reduction related to reduced PBT waste would require a facility-level examination of process changes at

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[2] Final Rule November 30, 1998 *Federal Register* pp. 65873-947 and December 30, 1998 *Federal Register* pp. 66101- 2.

[3] To estimate risk reduction associated specifically with decreases in both total hazardous wastes and PBT wastes it is necessary to determine the level of risk associated with Subtitle C waste management. Our proposed methods make the initial assumption that this risk is insignificant, but we recommend that this assumption be examined closely during implementation.

facilities reporting decreases in PBT waste, in order to determine the net effect of waste minimization efforts. For example, if a facility prevents generation of a small amount of PBT waste by producing a large amount of non-PBT hazardous waste, then the net benefit might be very small.

7.2 REGULATORY CONSTRAINTS UNDER RCRA

Several statutory and congressional mandates and court actions have influenced the scope of the RCRA regulations and policy options for its implementation. These constraints on RCRA activities may have an important influence on what can be done under the RCRA program. For example, certain constraints may limit the scope of RCRA or may require EPA to implement specific initiatives. Bureaucratic or legal incidents can play a positive role in refining RCRA specifications, but can also be costly and time consuming. In many cases legal and congressional restrictions force EPA to prioritize certain regulatory activities over others. In the context of conducting an evaluation of the costs, benefits, and other impacts of the RCRA Subtitle C program, it could be important to understand the source of the drivers behind those impacts. In a complete assessment of the RCRA program, we recommend citing examples of important statutory requirement and court decisions that influence the design and implementation of the RCRA Subtitle C program. Examples include the following.

7.2.1 *Congressional Actions*

- **Section 3001 (b)(3)(A), Bevill Amendment:** The Bevill amendment is an example of a congressional mandate that defines parameters of the RCRA Subtitle C Program. The Bevill Amendment exempts several sectors of hazardous waste generators, including those that generate mining wastes, mineral processing wastes and cement kiln dust. As a result, RCRA does not apply to key waste streams in major sectors. It is important to note that more recent RCRA actions have reduced the reach of the original Bevill Amendment. In other words, RCRA now regulates some facilities that were once exempt. However, continued existence of the Amendment may limit the potential benefits of the program.

- **Hazardous and Solid Waste Amendments (HSWA):** HSWA is an example of a statutory congressional requirement issued to EPA. HSWA restricted land disposal of hazardous wastes beyond specified dates unless waste was treated to meet certain RCRA-equivalent standards. EPA was required to enact land disposal restrictions and treatment standards by May 8, 1990 for all wastes that were either listed or identified as hazardous by the 1984 amendments. A later deadline was issued for wastes listed after 1984. In this case, EPA's implementation of RCRA requirements was influenced

by a congressional statute which guided the Agency's priorities and changed the scope of RCRA regulations.

7.2.2 *Court Decisions*

Several major court decisions had considerable influence on the interpretation and implementation of RCRA. For example:

- **Chemical Waste Management v. EPA:**[4] A series of Chemical Waste Management, Inc. v. EPA decisions in 1989 and 1992 had the following general effects: 1) Broadened the scope of RCRA by upholding the "derived from" rule that any soil or water that contains hazardous waste is itself hazardous waste; 2) Upheld EPA's right to authorize placement of decharacterized hazardous wastes into Subtitle D impoundments if dilution meets RCRA treatment definitions (limiting the scope of RCRA); and 3) Broadened the scope of RCRA by upholding the "Third Thirds" rule which requires treatment of characteristic hazardous wastes to levels where they are decharacterized.

7.2.3 *Congressional/Court Actions*

The Land Disposal Program Flexibility Act (1996) is a case of EPA having to reconcile multiple and conflicting demands on how RCRA is implemented. A lawsuit filed with the District Court in 1992 (*EDF vs. Reilly*, Civ. No. 89-0598, D.D.C.) finalized more rigorous treatment standards under the land disposal restrictions program for hazardous wastes listed after 1984, and for wastes with hazardous waste components. In response to this court decision, however, Congress demanded additional research before adoption of the standards. The Land Disposal Program Flexibility Act amended Section 3004(g) of RCRA by requiring a risk characterization study of hazardous waste managed in units regulated under the Clean Water Act's National Pollutant Discharge Elimination System (NPDES) program, pretreatment program, or in a zero discharge system. As a result, standards have not become stricter since the court ruling pending the risk characterization study.

7.2.4 *Characterizing Constraints Affecting RCRA Subtitle C Programs*

We suggest an examination of RCRA legislative mandates and court decisions in an effort to qualitatively describe their effects on RCRA policies and regulations. Some, such as the Bevill

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[4] Chemical Waste Management, Inc. v. EPA, 869 F.2d 1526, 1536-37 (D.C. Cir. 1989) and Chemical Waste Management v. EPA, 976 F. 2d 2, 25 (D.C.Cir. 1992).

Amendment, may have far-reaching impacts on the scope and prioritization of program activities. Other constraints may have effects that are more difficult to characterize. For all key constraints the method would provide a qualitative discussion of the potential impacts on program priorities and activities.

7.3 STAKEHOLDER ISSUES

The final attribute in a complete analysis of RCRA is stakeholder issues; this attribute addresses the needs and demands of stakeholders. The purpose of this attribute is to inform decision-makers who may use a RCRA program evaluation about the role and intensity of stakeholder concerns.[5] Two aspects of stakeholder concerns are particularly relevant to RCRA: 1) the role and value of information collected under the regulations and available to the public (and to regulators), and 2) the level of stakeholder intensity of feeling about RCRA Subtitle C and about hazardous waste in general. Below we suggest a qualitative discussion of each of these issues based on available literature and information:

7.3.1 *Method for Characterizing Value of Information*

RCRA Subtitle C regulations include the development and reporting of various tracking information related to the generation and disposal of hazardous waste. This includes: individual manifest and tracking information verifying that individual waste shipments have been properly disposed; summary information on constituent facility waste generation and management provided by RCRA facilities in the *Biennial Reporting System* (BRS); and facility permit and enforcement information maintained in the RCRIS database. Various stakeholders use these systems, including:

- **Investigators and Enforcement Personnel**, including federal, state, and private personnel (e.g., insurance investigators) who use the manifest system and permit information to verify proper disposal and to support investigations of improper disposal;

- **Industries** who use historical tracking information showing reduced hazardous waste generation as a valuable marketing strategy; and

- **Members of the Public** who can obtain information about facilities and waste generation and management practices in specific areas, or over specific time periods.

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[5] Stakeholder issues, such as intensity of feeling, are implicitly reflected (though not measured) by the Approach A methodology. It may be worthwhile to consider these impacts in isolation under all approaches, but particularly under Approaches B and C.

It is possible that these data could be associated with specific benefits linked to reductions in the cost of investigations and in the availability of high-quality data to support independent research efforts. However, it is impossible to isolate any quantitative benefits (or costs) associated with these efforts from other benefit and cost attributes that address reduced waste disposal and related outcomes. We therefore recommend a qualitative discussion summarizing the extent of the available information associated with RCRA and providing a summary of recent research on the value that the public places on available environmental information.[6] This qualitative analysis could be supported by quantitative estimates from the Agency about how many non-EPA stakeholders have requested data under the Freedom of Information Act (FOIA) or have accessed the data through EPA's Envirofacts website. This analysis would provide a qualitative discussion of the

7.3.2 *Method for Characterizing Intensity of Feeling*

Intensity of feeling describes the level of importance that stakeholders place on implementing (or repealing) environmental regulations. The extent to which the regulatory program is changed by stakeholder involvement frequently reflects intensity of feeling, particularly when the changes are counter to typical measures of economic value or efficiency. Examples of other programs that have been affected by intensity of feeling are the Superfund program, which was in part a result of public outrage over incidents such as Love Canal, and the safety standards and building codes for nuclear power plants, which are often much more protective than standards at other facilities with practices that also pose significant risks to the public (though risks of a different type).

To address intensity of feeling, we recommend a review of the history of RCRA, particularly the public and congressional activities leading up to the passage of the 1984 Hazardous and Solid Waste Amendments (HSWA). Though RCRA prevention has, in general, received much less public attention than the Superfund clean-up program, the extensive revisions to the law under HSWA may be illustrative of the intensity of feeling exhibited by the public about the mission and purpose of the regulation.

7.4 TECHNOLOGY FORCING CHARACTERISTICS

The treatment and disposal standards of the RCRA Subtitle C prevention program may have contributed to rapid technological advancement by creating economic incentives to avoid generation of hazardous waste or improve its treatment and disposal. In fact, RCRA Subtitle C regulations have

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[6] The Toxics Release Inventory (TRI) database was developed under the Community Right-to-Know provisions of the Toxic Subtances Control Act (ToSCA). There is a well-established body of literature addressing the potential value of this source, and this information may assist in identifying the potential value associated with the similar BRS system.

explicitly mandated the elimination of certain types of waste treatment and disposal. The result of these advances could be highly efficient manufacturing systems that "over-comply" and produce less hazardous waste. In addition, technology advances could reduce costs, and provide competitive advantages for innovative companies.

Technology forcing could potentially result in true economic benefits. The benefits that would be attributable to RCRA are the improved consumer or producer surplus from process advances that would not have been implemented in the absence of regulation (though it is important to note that some "benefits" could be solely due to new costs imposed by the altered regulatory setting and would therefore not be net gains). However, it is very difficult to attribute technological advances to any specific regulatory or market force. For example, it is not possible to determine the "normal" pace of technological advancement in the absence of RCRA, in part because Superfund liability under CERCLA may have provided similar incentives to minimize waste disposal. Therefore we focus only on identifying indicators that technology forcing may have taken place, and do not attempt to quantify specific benefits or identify causality.

We propose two methodologies for addressing this attribute. The first is an "indicator approach." By examining a number of indicators it may be possible to provide support for the presence (or absence) of rapid technological advancement. The second is a primary research effort that collects data on technology development directly from suppliers; this approach is most appropriate in conjunction with a case-study based assessment of benefits (e.g., Approach C). Due to data limitations and the likely pace of technological development, both of these methodologies focus on technology development primarily since 1980 and in the presence of RCRA.

7.4.1 *Identify Likelihood of Technology Forcing through Indicators*

This approach incorporates three indicators that address the relationship between compliance costs, production, and profitability in industries regulated by RCRA. The approach is based on the assumption that in the absence of technological advance, costs under RCRA would increase and productivity and profitability would decrease, due the diversion of capital to address waste management. We therefore suggest a set of measurements that identify trends in the relationships between these data. Taken together, these indicators may help verify the existence and characterize the extent of technological advancement in the field of hazardous waste generation and management.

- **Compare pre-regulation industry Subtitle C compliance cost estimates with actual reported costs.** If pre-regulation estimates are significantly higher than reported costs, technological advances may be responsible for all or part of the difference (sources for this approach include PACE data and

pre-RCRA estimates from Arthur D. Little, Inc. *Economic Impact Analysis of RCRA Interim Status Standards*, 1981).[7]

- **Compare inflation-adjusted product price and production trends with waste trends for the top hazardous waste producing industries.** If prices are flat or decreasing as waste decreases, this may indicate that waste reduction technologies are not negatively affecting cost structure (sources for this measure include price trends from the *Statistical Abstract of the U.S.* or industry trade journals, and waste generation data from BRS).

- **Identify trends in waste generation per dollar value added (an indication of profitability) over time and compare industry-specific profitability with national, cross-industry profitability.** This measure identifies correlations between profitability and waste production for various industries (sources for this measure include quantity data from BRS or the *Statistical Abstract of the U.S.*, and dollar value added from *Census of Manufacturers*).

These indicators will not provide a single estimate of the economic value of technology forcing in the RCRA program. They will, however, assist in determining the extent to which technological advancement has occurred and has contributed to (or detracted from) profitability. While these indicators do not identify the relative pace of technology adoption in the with- and without-RCRA scenarios, and while some advances are likely due to market forces other than RCRA, these indicators may help address the contention that inflexible RCRA regulations prevent technological advancement.

7.4.2 *Identify Drivers of Technology Development Through Interviews*

An alternative method of evaluating technology forcing benefits is to conduct interviews with technology suppliers; the extent to which regulation drives the R&D and marketing efforts of these companies may indicate the extent to which technology adoption has been speeded (or the extent to which technologies have become economical) as a result of regulation.[8] In this context, incremental

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[7] Note that technological advances are not the only explanation for higher "expected" than "actual" costs. Firms and industries have an economic incentive to provide high cost predictions during the regulatory development period.

[8] There is also considerable literature addressing the pace of technology development and its relationship to regulation, though no national studies have assigned a value to the effects of regulation on the pace of development. One publication with a number of analyses is *Competitive Implications of Environmental Regulations: A Study of Six Industries.* Management Institute for the Environment and Business, (Washington D.C., 1994).

profits from sales of technology that are driven by regulation may be a reasonable estimate of technology forcing benefits. The extent to which this approach can identify national estimates of the incremental profits due to RCRA will depend on the survey effort, including sample size and extent of information collected (note that if the sample size is larger than nine, an ICR would likely be required). If the effort is voluntary, competition concerns may limit the level of cooperation on the part of the technology industries. Exhibit B-9 in Appendix B provides a summary table of methodological options for addressing technology forcing in the RCRA context.

7.5 LONG-TERM EFFECTS: BEHAVIORAL CHANGE UNDER RCRA

Long-term behavioral change is frequently a stated or implied goal of environmental regulations, particularly those that (like RCRA Subtitle C) aim to eliminate externalities from the market by mandating that those who generate and manage hazardous waste assume the costs of proper treatment and disposal. The RCRA program requires immediate changes in treatment and disposal practice, but its broad aim is to affect the decisions and priorities of those who generate and manage hazardous waste. While the effects of many of these immediate changes are reflected in other attributes, the extent of change itself can often be a measure of the impact of a program.

"Long-term" behavioral change also implies a level of permanence such that repeal of regulatory incentives would not result in an immediate change back to pre-regulation behavior patterns. In the context of RCRA this type of change might result from alterations to production and waste treatment systems at generators and TSDs, respectively. An example of a permanent shift in behavior would be conversion to a newer production system that does not generate hazardous waste. In contrast, the shipment of waste to a recycling facility rather than a disposal facility may be a temporary behavior if regulatory reform provides a lower-cost disposal option. Note that this attribute likely addresses a subset of the technological developments identified in the discussion of technology forcing and could"double-count" some short-term benefits associated with these developments. Because we propose qualitative methods for addressing both of these attributes, we suggest that the issue of double-counting also be discussed qualitatively.

Our proposed method for characterizing this attribute is a study of the pollution prevention literature to identify the extent to which capital investment in new processes has reduced or eliminated the production of hazardous waste. Indicators of behavioral changes might include the number of capital pollution prevention projects completed, the total production capacity altered by pollution prevention capital investments, and the total quantity of hazardous waste eliminated as a result of these projects.[9] This approach may use any of the following sources:

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[9] Note that the total quantity of waste reduced by pollution prevention projects does not double-count resource conservation benefits, because it is used only as an indicator of the extent of "permanent" changes in production. While some hazardous waste reduction may be the result of immediate changes in feedstock that do not represent process changes, the reductions in quantities

- Industry, state, and program-level assessments and progress reports generated by Waste Minimization programs, the Common Sense Initiative, Project XL, and other pollution prevention initiatives;
- Theoretical literature on the economic effects of environmental technology adoption patterns in key industries; and
- Specific project case studies that illustrate the potential changes in production and manufacturing systems under RCRA.[10]

In identifying relevant case studies and industry activities, it is important to focus on capital investment projects that specifically reduce or prevent the production of hazardous wastes. Where data are available, it may be possible to identify the net monetary benefits such as increased productivity and/or reduced waste production of specific environmental investments.[11]

The advantage of this approach is its flexibility. The number and type of studies collected can vary according to the scope and focus of the RCRA analysis. In addition, this approach is not resource intensive in that it does not require a primary data collection effort.

This approach has two limitations. First, it does not address causality, though in some cases reductions in hazardous waste may be specifically identified. However, many programs encourage pollution prevention, and it will be difficult to attribute activities and benefits to the RCRA program. Second, while it may be possible to identify benefits in specific cases, it may be difficult to generate a national estimate of the extent of capital investment due to company concerns about proprietary technologies and to a varying definition of "environmental" investments.

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due to capital projects represent future waste production trends that are likely to remain stable.

[10] There are multiple examples of these studies in the literature, including some compilations such as: Springer, Johnny Jr. *Pollution Prevention Case Studies Compendium*. Risk Reduction Engineering Laboratory, U.S. EPA, 1992; Goldberg, Terri. *Pollution Prevention Successes: A Compendium of Case Studies From the Northeast States*. Northeast Waste Management Officials' Association, 1993; Badgett, Lona, et al. *Analysis of Pollution Prevention and Waste Minimization Opportunities Using Total Cost Assessment: A Case Study of the Electronics Industry*. Pacific Northwest Pollution Prevention Research Center, 1995.

[11] The pollution prevention literature uses Toxics Release Inventory information to measure success in terms of reduced outputs. However, TRI data are not specific to waste production or to constituents regulated under RCRA; for these reasons our methodology does not rely on this data source alone. Moreover, TRI does not identify capital investments; we believe that capital projects are a better indicator of long-term behavioral changes under RCRA.

Other changes in behavior under RCRA may be considerable and should be at least qualitatively described in a RCRA program evaluation, but are even less measurable. For example, as a result of RCRA and other environmental laws, including CERCLA, it has become common practice to examine property for unremediated pollution prior to a purchase. The expectation of proper waste management and remediation by property owners likely represents a permanent change in the perception of liability and responsibility. However, identifying the value of this change in the benefits due to RCRA (as opposed to CERCLA, for example) may be impossible.

SUMMARY OF PROPOSED APPROACHES AND NEXT STEPS — CHAPTER 8

We have proposed a range of analytic approaches for assessing each of the attributes of the RCRA Subtitle C prevention program; these approaches differ in analytic scope, level of resources required, and in the level of certainty of results. Below we first discuss these key characteristics of each of the three major approaches we have outlined. We then provide brief discussion of potential additional steps in methodology development for RCRA Subtitle C.

8.1 OVERVIEW OF THE PROPOSED APPROACHES

We provide four alternative approaches to estimating the benefits of the RCRA program associated with regulations that govern the operation of TSD facilities and the disposal of hazardous waste. While all of the approaches would provide quantitative estimates of selected benefits associated with the program, they differ in the level of resources they require, the universe of facilities they address (e.g., "avoided" TSDs), and the certainty of their results. In addition, because the approaches focus only on a subset of attributes, a comprehensive assessment of the benefits, impacts and costs of RCRA based on any of these approaches would also require separate analyses of long-term benefits, short- and long-term costs, distributional impacts of the program, and program context attributes identified in the OSWER framework. Exhibit 8-1 provides a summary of the scope of the benefits approaches (i.e., Approaches A, B, and C, and D) and also summarizes the scope of the separate analytic approaches recommended for the national-level attributes.

Exhibit 8-1

SUMMARY OUTLINE OF RESULTS OF PROPOSED METHODOLOGIES

Attributes	Approach A	Pathway Modeling Approaches (B, C, and D)
BENEFITS		
Scope of Analysis	"Avoided Hazardous Waste Sites" in industries described in *Industry Assessments*, landfills	Improved practices at operating TSDs with pre-RCRA Solid Waste Management Units, and benefits of avoided TSDs
Human Health Benefits	‣ Single estimate of value of "Avoided Hazardous Waste Sites" based on avoided property value losses and avoided costs of government-mandated cleanup	‣ Modeled estimate of cancer, non-cancer risk reduction, disease case reduction, population threshold exceedance reduction; ‣ Modeled estimate of MEI risk reduction ‣ Estimate of number of avoided acute events
Ecological Benefits		‣ Modeled estimate of avoided surface water, soil contamination incidents, lost use values
Avoided Costs		‣ Monetized estimate of avoided government-mandated replacement costs for contaminated groundwater
Aesthetics and Historical Preservation		‣ Aesthetics: Proximity, trend analysis of homes reporting "smoke, odor" and RCRA sites ‣ Historic Preservation: Proximity, trend analysis of historic areas, RCRA facilities
Long-Term Benefits (Sustainability)	‣ Avoided damages over long time horizons and increases in damages due to changes in affected populations: quantitative modeling estimates of avoided damages *(not possible using Approach A information)* ‣ Benefits associated with the precautionary principle: protection from unforeseen issues: Qualitative analysis of past costs of unrecognized hazards, effectiveness of original RCRA rules at addressing "new" wastes ‣ Benefits from potential long-term increases in the value of environmental quality: quantitative estimate of volume of groundwater contamination avoided under RCRA; qualitative discussion of issues involved with valuing long-term benefits	
COSTS		
Compliance Costs	‣ Monetized estimates of total compliance costs based on *Cost of Clean,* PACE data	
Government Costs	‣ Monetized estimates of total program costs based on *Cost of Clean* data	
Long-Term Costs	‣ Qualitative discussion of potential long-term costs	
DISTRIBUTIONAL IMPACTS		
Intra-generational Economic Equity	‣ Public/Private Equity: Comparison of distribution of public/private funds expended under Superfund, RCRA Corrective Action, and RCRA prevention programs ‣ Improved Competition: Qualitative discussion of value of improved competition; assessment of number of facilities meeting compliance standards pre-RCRA	
Environmental Equity	‣ Literature review identifying negative siting effects of RCRA	‣ Geographic analysis of changes in demographics near RCRA sites over time
Economic Impacts	‣ Estimate based on trend analysis and sample facility analysis to identify changed practices	
Risk Tradeoffs	‣ Estimated number of additional accidents due to increased vehicle miles traveled for accident related costs associated with transportation (other risk tradeoffs negligible)	
Long-Term Impacts: Inter-generational Equity	‣ Total and percentage reduction in land disposal quantities and facilities ‣ "Cleanup delays avoided" by RCRA monitoring requirements	
PROGRAM CONTEXT ATTRIBUTES		
Technology Forcing	‣ Qualitative analysis based on indicator analysis and survey of hazardous waste technology suppliers to identify drivers, customers of rapidly developing technologies	
Reinvention Initiatives	‣ Programs too recent to have measurable effect for a retrospective analysis; qualitative discussion of potential impacts	
Constraints	‣ Qualitative analysis of the effects and limitation of various court, legislative acts	
Stakeholder Issues	‣ Qualitative analysis of intensity of feeling and value of information collected and available under RCRA	
Long-Term Effects: Behavioral Change	‣ Qualitative discussion of extent of capital investment in pollution control	

8.2 KEY CHARACTERISTICS AND LIMITATIONS OF THE APPROACHES

Our proposed benefits approaches provide an estimate of selected benefits and impacts of RCRA that are associated with avoided hazardous waste releases from TSD facilities. The four benefits approaches use different methodologies to develop estimates that consider human health benefits, ecological benefits, and avoided government-mandated costs associated hazardous waste sites. Below we summarize key characteristics of these approaches, including resource and data requirements, flexibility, and limitations. In addition, we summarize the approaches we have outlined for addressing the potential long-term benefits, social costs, distributional impacts, and program context attributes for the RCRA Subtitle C program.

8.2.1 *Approach A: The Simple Property Value Estimate*

Approach A would provide a low-end estimate of RCRA benefits and impacts based on a relatively limited level of data and resources. The approach would be limited to an assessment of: 1) the attributes reflected in property value effects; and 2) the averted government-mandated cleanup costs that would be associated with hazardous waste sites avoided due to the closure of pre-RCRA TSDs. Property value changes related to proximity to a hazardous waste site may reflect property owners' evaluations of multiple characteristics, including human health risk (from contaminated wells as well as acute incidents), ecological damage, cost of alternative water supplies, and economic effects such as changes in employment opportunities. However, the extent to which property values accurately capture these attributes (and therefore the extent of overlap) is uncertain. For example, property value benefits may not entirely account for human health risk in cases where property buyers are not fully informed about contamination or risk associated with a site. Alternatively, property value effects may exceed the total value of other benefits if perceived contamination and risk exceeds actual levels. Because of both the potential overlap and the uncertainty associated with property value benefits, we suggest using this attribute as a general alternative method for calculating a set of benefits, and do not recommend "adding it" to other attributes.

The analysis would provide only a lower bound of benefits because it does not consider the benefits of changes in practice at TSDs that continued in operation. An additional limitation of the approach is the inability to identify the contribution of specific benefits or impacts to the total property value. However, this approach may provide a relatively inexpensive initial indication of the potential extent of total RCRA benefits, and may suggest that the potential benefits of RCRA are significant enough to merit a full-scale analysis.

8.2.2 *Approach B: Pathway Modeling Approach Using Corrective Action RIA Facility Data*

Approach B is a more sophisticated approach to identifying the benefits associated with changes in practice at TSDs under RCRA. Approach B would extend the scope of Approach A to

address the incremental benefits of improved waste management practices at operating TSDs, as well as the benefits associated with TSD closure. Approach B would use accepted multi-pathway modeling methods and facility data developed and peer reviewed for the *Corrective Action RIA;* by basing the analysis on this previous effort, Approach B could provide some national-level estimates without undertaking the expense and effort associated with sample selection and full model development and calibration. However, even with previously collected data, this approach would be considerably more resource intensive than Approach A because it would require verification and updating of previous modeling protocols and development of new modeling scenarios.

While the analytic scope of Approach B is broader than that of Approach A, it is limited to examination of TSDs and wastes that were originally addressed under RCRA Subtitle C because the *Corrective Action RIA* sample identifies only facilities with SWMUs that ceased operation by 1982. In addition, the extent of nation-level analysis describing the benefits of RCRA prevention would be limited by the characteristics of *Corrective Action RIA* sample facilities, and the extent to which the actual facilities in this sample are truly representative of the broader RCRA universe.

8.2.3 *Approach C: Pathway Modeling Approach Using Original Data Collection and Modeling*

Approach C would use modeling approaches like those described in Approach B to estimate the same benefits attributes, but based on an original data collection and modeling effort. This would provide additional flexibility in establishing the scope of the program analysis to virtually any type of facility affected by RCRA. However, it would require considerable additional resources, particularly if implementation required selection of a nationally representative sample of facilities. Depending on the size of the sample collected for this approach an ICR may be necessary.

8.2.4 *Approach D: Pathway Modeling Approach Using HWIR 3MRA Modeling*

Approach D would construct an industry level "without-RCRA" scenario of waste generation in the absence of RCRA. The approach would then use the HWIR 3MRA model to provide national estimates of human health and ecological benefits associated with disposal of without-RCRA wastes in the sample facilities incorporated into the HWIR model. This approach would eliminate the need for selecting a representative sample of facilities, but it might require considerable resources to undertake an original modeling effort, and would demand careful attention to the representativeness of the facilities in the HWIR model. The HWIR model reflects information from 200 representative Subtitle D (i.e., nonhazardous) industrial disposal facilities; this model is undergoing peer-review but has not been used in a program-level assessment comparable to the approach outlined here.

Like Approach B, Approach D would not automatically address new wastes and industries regulated after 1980 (i.e., because the without-RCRA scenario is based primarily on industry

information related to the earliest Subtitle C listings), but the model could be adjusted to reflect new wastes using the same sample disposal facilities and more recent industry information. Exhibit 8-2 summarizes the key differences among the modeling approaches.

Exhibit 8-2

COMPARISON OF MODELING APPROACHES TO ESTIMATING BENEFITS OF RCRA SUBTITLE C*

Feature of Approach	Approach B	Approach D
Industries Addressed	1970s industry studies and 79 Corrective Action sample facilities	1970s industry studies and 3MRA industrial database (17 industries)
Waste Management Units Addressed	Landfills, Land Treatment Units Waste Piles Surface Impoundments Tanks Incinerators Injection Wells Waste Transfer Stations Waste Recycling Spill Areas Accumulation Areas Process Sewers	Landfills Land Application Units Waste Piles Surface Impoundments Aerated Tanks
Disposal Locations Addressed	Locations where hazardous waste actually disposed	Industrial Subtitle D locations, linked to specific industry
Representativeness of Disposal Locations	On site - small number of sites represents industry	Off site - sites represent all waste disposal locations for industry
Methods for Damage Functions	Pathway modeling using MMSOILS; Separate risk assessment required	Risk assessment modeling using 3MRA
Peer Review Status	Corrective Action Approach (including use of MMSOILS) peer reviewed; reservations noted	3MRA undergoing peer review; no comparable project using 3MRA
Resources Required	Update of MMSOILS, without-RCRA scenario of continued disposal required	Model calibration, scenario development required for both scenarios

* Approach C, as a original modeling effort, may address a range of industries, waste management units, and disposal locations, and may involve one or more of several different pathway and risk assessment models with damage function methods. Therefore, we do not attempt to compare it with the more specific approaches outlined in Approaches B and D.

8.2.5 *Approaches to Addressing Remaining Attributes*

In addition to the approaches outlined above for assessing exposure-related benefits, a complete assessment of the RCRA Subtitle C Prevention and Waste Minimization programs requires separate analyses that address long-term benefits, social costs, distributional impacts, and program context attributes. Below we briefly summarize the methods we have proposed for assessing these additional benefits, costs, and other program impacts. The approaches we have outlined for these attributes are generally less resource intensive (even in total) than the modeling approaches outlined above; however, certain optional approaches we have suggested may require an ICR. Detailed descriptions of data requirements are available in Chapters 4 through 7.

- **Long-Term Benefits:** We propose four separate analyses to address potential long-term benefits of RCRA prevention programs. These include discussions of three potentially measurable program outcomes (i.e., avoided exposure over long time periods, avoided increased exposure resulting from changes in affected populations, and avoided damages from unforeseen events or issues), and a separate discussion addressing recent and potential changes in consumers' willingness-to-pay for environmental quality (this issue will ultimately affect the value of all potential long-term benefits). Our methods primarily involve qualitative discussions of attributes, supported when possible by quantitative estimates illustrating the potential magnitude of long-term impacts (e.g., quantity of groundwater protected).

- **Social Costs:** We propose to estimate the monetary value of compliance and government-sector program costs using EPA's forthcoming *Cost of Clean*; however, we provide an alternative approach to estimating compliance costs to address a supplemental or industry-specific examination that requires more detailed sector data than provided in *Cost of Clean*. We also propose a qualitative assessment of the potential long-term costs related to RCRA, including costs related to missed opportunities to take advantage of technological change or to invest in more productive long-term activities.[1]

- **Distributional Impacts:** We propose methods for addressing five key distributional impacts of RCRA: intra-generational economic equity; environmental justice, economic impacts, risk tradeoffs, and long-term (inter-generational) distributional impacts. For each of these attributes we suggest approaches that would provide a qualitative discussion accompanied by quantitative estimates of the magnitude of the potential impact.

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[1] Due to the lack of baseline information about pre-RCRA hazardous waste management, we do not attempt to identify net social welfare losses and transitional social costs related to RCRA; we discuss the distributional aspects of these attributes in our discussion of intra-generational equity.

- **Program Context Impacts:** We propose qualitative discussions (again, where possible supported by quantitative indications of magnitude) for five program context attributes, including impacts related to regulatory reinvention, regulatory constraints, stakeholder issues, technology forcing activities, and impacts related to long-term behavioral changes. While the regulatory reinvention and technology forcing attributes may ultimately be associated with measurable benefits, existing information is insufficient to isolate and measure these impacts. The remaining three attributes address program issues and characteristics that provide insight into the prioritization of RCRA activities.

8.2.6 *Use of Approaches to Describe Performance Under GPRA*

Certain of the methods we have proposed may be useful in evaluating OSWER's success in meeting long-term GPRA subobjectives for the RCRA Subtitle C and hazardous waste minimization programs. Below we summarize the key analyses that would be most supportive of the stated goals:

RCRA Subtitle C: OSWER's 2005 subobjective is to have permits or approved controls in place to prevent dangerous releases to air, soil, and groundwater at 85 percent of hazardous waste management facilities located in the United States, its territories, or on tribal lands.[2] To the extent that the modeling approaches outlined above can provide average "per-facility" estimates of the benefits related to implementation of RCRA Subtitle C regulations, these approaches can likely be used to evaluate the benefits of achieving this goal (though Approach C would only be appropriate if it involved a nationally representative sample of facilities). Approach A provides only a summary estimate of benefits; this approach would not provide specific release estimates or benefits assessments needed to properly support the specific objective. In addition to benefits analyses, the quantitative evaluation of environmental justice and intra-generational economic equity and the qualitative discussion of potential long-term benefits may provide additional information about the impacts of achieving this goal.

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[2] The baseline used to develop this estimate includes facilities that manage hazardous waste (in addition to Subtitle D facilities managing non-hazardous waste) and addresses facilities that are currently in compliance with permits (i.e, are currently in BRS but require updates to permits or systems) as well as facilities that do not have RCRA permits in place (i.e., are not in BRS but are in RCRIS or other available data sources. Using the information sources and categories that EPA used to develop the baseline, it should be possible to assess the potential benefits associated with the Subtitle C facilities (but not the Subtitle D facilities); the bulk of potential benefits will likely be associated with changes at those facilities who do not have final RCRA permits in place.

Waste Minimization: OSWER's 2005 subobjective is to reduce the priority PBT waste volumes in hazardous waste streams by 50 percent from 1991 levels. Several of the proposed approaches would reflect the current achievements under waste minimization programs as part of the overall benefits of Subtitle C, but it is difficult to isolate and quantify the specific health and ecological benefits related to this program, due in part to its relatively recent development. However, our proposed methods for addressing program context attributes identify a qualitative assessment of the potential benefits associated with the program; these include reduced costs associated with disposal and maintenance of disposal facilities; reduced demand for the creation of waste disposal sites (which are widely regarded as "disamenities" by local communities), and reduced possibility for acute events and cross-media transfer of waste.

The value associated with waste minimization depends critically on the level of risk that is associated with Subtitle C waste management. Therefore, to estimate risk reduction associated specifically with decreases in both total hazardous wastes and PBT wastes, it is necessary to identify Subtitle C-related risk. Our modeling approaches make the initial assumption that this risk is insignificant, but we recommend that this assumption be examined closely during implementation. To the extent that we can define risk associated with management of waste under RCRA Subtitle C, we can estimate the benefits associated with decreasing this risk. Note, however, that it may be difficult to attribute waste reduction specifically to waste minimization programs.

8.3 POTENTIAL DOUBLE COUNTING OF BENEFITS, COSTS AND DISTRIBUTIONAL IMPACTS

One step in aggregating the results of analyses for different attributes would be to address potential double counting of benefits, costs, or distributional impacts that could occur through implementation of the full suite of approaches. This document presents a variety of potential approaches to assessing various attributes; the extent to which actual analyses overlap will depend on the selection and implementation of specific approaches. In most cases we have attempted to clearly define attributes and analyses in order to minimize potential overlap. However, below we identify three areas of analysis which require careful attention to assure that overlap is avoided.

8.3.1 *Human Health, Avoided Costs of Alternative Water Supplies, and Avoided Government-Mandated Remediation Costs*

The human health and avoided cost attributes both address (in different ways) the value that is associated with avoiding health effects (i.e., since averting actions should reduce risk of exposure to contaminants). Therefore, when estimating potential exposure or avoided costs it is important to identify when averting behavior would begin and adjust the exposure levels accordingly, and it is also important not to "double count" these impacts by adding them together.

There is one case in which avoided costs can be added to health impacts; that is the specific case in which other existing regulations would have required a response (e.g., a mandatory requirement for a water treatment system or for cleanup). If a clear response would have been mandated, then both the health effects (reflecting exposure until government actions are taken) and the costs of the mandatory response are avoided under the regulation, and these avoided effects should be reflected in the benefits of the program.

8.3.2 *Technology Forcing, Behavioral Change, and Regulatory Reinvention Programs*

Technology forcing effects address the extent to which a program supports or encourages the development and adoption of improved technologies; the adoption of these technologies could, in fact, be associated with real benefits (i.e., through cost reductions or risk reductions). Similarly, behavioral change can include permanent shifts in technology, and regulatory reinvention programs can include cost reduction measures such as technology development. Any attempt to quantify or value the outcomes associated with these attributes could potentially result in double counting. To eliminate the potential for double-counting in our proposed approaches, we present qualitative methods for discussing these three attributes as program context attributes, and do not attempt to quantify or evaluate impacts. Also, because regulatory reinvention is relatively recent and because identification of "permanent" behavioral change requires a long time-horizon, there is little information specifically addressing these attributes at this time. However, as new information about these areas becomes available, it may be necessary to revisit the issue of double-counting.

8.3.3 *Stakeholder Issues and Long-Term Benefits*

"Intensity of feeling" is one of the key attributes describing stakeholder issues. This attribute can reflect both short-term and long-term concerns among stakeholders, but stakeholder involvement in hazardous waste policy making often reflects considerable concern for long-term (often inter-generational) risks associated with waste management. As a result, intensity of feeling can provide an indicator of the emphasis (and potential value) that the public places on long-term risks and benefits. Our proposed method for addressing intensity of feeling does not attempt to value or quantify the extent of stakeholder concerns about hazardous waste, so there is no specific issue related to double-counting of these outcomes with long-term benefits. However, to avoid the potential for over-emphasis of this issue, it is important to maintain the distinction between the program context attributes (which help describe program priorities and limitations) and attributes that measure actual benefits.

8.4 CONCLUSIONS AND NEXT STEPS

The benefits approaches we have outlined provide a starting point for an assessment of the entire RCRA Subtitle C prevention program. These approaches would each provide an assessment of the benefits associated with TSD facilities, which we believe to be a major portion of the benefits and impacts of the program. Moreover, these approaches present a range of analytic options that are responsive to the range of program and analytic priorities that may be involved in a national analysis of the benefits, impacts and costs of the RCRA Subtitle C program.

However, while we believe that these methods can provide plausible results for a national assessment of RCRA Subtitle C, we suggest the following potential adjustments to the scope of the analysis to address issues that are not incorporated into our current approaches:

- **Adjust Scope of Analysis to Address Changes in Generator Practices** While the impacts of some changes in generator practices (such as waste minimization) are reflected in the development of the "without-RCRA" scenarios in various attributes, other generator practices (i.e., improved storage practices that result in fewer releases and reduced damages) are not addressed directly by the proposed methodologies.

- **Adjust Scope to Include Additional Industries and Wastes:** Although Approach C provides the flexibility for addressing facilities subject to regulation after 1980, Approaches A, B, and D, as described, are limited to the original wastes regulated under RCRA.

- **Adjust Benefits, Impacts and Costs to Reflect State Program Activities:** The proposed approaches do not specifically address the contribution of state hazardous waste prevention programs, including those that were "RCRA-inspired," (and should be included in the benefits and costs of the RCRA program) and those that pre-dated RCRA (and should not be included in an assessment of the RCRA program).

- **Address (and Refine, if Necessary) Baseline Assumption that Subtitle C Waste Management is Risk-Free:** Our modeling approaches make the initial assumption that this risk is insignificant, but we recommend that this assumption be examined closely during implementation. To estimate risk reduction associated specifically with decreases in both total hazardous wastes and PBT wastes, it is necessary to identify Subtitle C-related risk.

The adjustments above may have varying impacts on the total estimate of the benefits, impacts and costs of the RCRA program, and would require varying levels of effort to address in the context of the different proposed approaches. Therefore, we recommend that the importance of each of these potential adjustment be considered if methodology development progresses.

Addendum to:

Approaches to Assessing the Benefits, Costs, and Impacts of the RCRA Subtitle C Program

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Introduction

The following pages contain excerpts from a draft August 2001 project plan prepared by the OSWER Office of Solid Waste (OSW), which describes a potential strategy for assessing the benefits of RCRA Subtitle C hazardous waste standards. This plan was the basis for modeling approach "D" that is described in section 3.5 of the "Approaches to Assessing the Benefits, Costs, and Impacts of the RCRA Subtitle C Program" and provides a more detailed explanation of the methodology for developing "with and without RCRA" scenarios.

Project Description

The project will provide a descriptive account of the benefits of RCRA waste management practices. The report will quantitatively describe the changes in waste generation and management that are attributable to adoption of these practices.

This assessment of changes in waste management can then be used to develop more precise economic estimates of the benefits of RCRA waste management standards.

Objectives

The objective of the project is to describe the benefits of RCRA waste management standards. The assessment of benefits will be based on a comparison of two scenarios:

- A baseline scenario, describing waste generation and management practices under existing RCRA standards today.

- A counterfactual scenario, describing waste generation and management practices as they *would be* today *in the absence of* existing RCRA standards.

RCRA benefits are assessed based on an evaluation of the differences between these two scenarios: differences in risk to human health and the environment, difference in esthetic impacts, differences in damages to ecological resources and recreational and commercial activities.

These scenarios will be developed for a series of industries that generate hazardous waste. The improvements in waste management will be described for each industry individually, and then in aggregate.

Methods

<u>Step One</u>: Determine Relevant Industries and Available Data

The aim of this step is not to obtain a representative sample of industries, but rather to select a number of industries that would, in the aggregate, compose a significant proportion of hazardous waste generation. A complete assessment of benefits would entail evaluating all industries that generate hazardous waste. This project, owing to limitations on data and other resources, will instead seek to assess a large (but not total) proportion of benefits; the results are therefore, by design, *underestimates* of the benefits of hazardous waste management standards.

Among the criteria for selection of industries:

> *Availability of data*: In order to understand waste management practices in the absence of RCRA, OSW needs to characterize waste management before RCRA (see step 2). Availability of pre-RCRA waste management information is an important limiting factor in selection of industries; an initial set of industries with data is noted under Step 2.
>
> *Significant waste generation*: Industries which do not produce large amounts of waste are less likely to affect the overall picture of waste management.

<u>Step Two:</u> Characterize Waste Generation and Management in the Pre-RCRA Scenario

For each industry selected, OSW will create a characterization of waste generation and management techniques, *as practiced before the advent of RCRA regulations*[1]. The data will be presented with the same data elements as in the baseline scenario.

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[1] The exact year of the pre-RCRA scenario will be determined by the availability of data. It will most likely be approximately 1975, just before the passage of the RCRA statute.

An important source of data for the pre-RCRA scenario will be industry profiles created for the Office of Solid Waste Management Programs in the late 1970's. These reports profiled generation and management of hazardous waste in a selection of industries:

<	Organic Chemicals	<	Non-Ferrous Smelters
<	Inorganic Chemicals	<	Electroplating
<	Pharmaceuticals	<	Special Machinery
<	Pesticides	<	Electronic Components
<	Explosives	<	Batteries
<	Petroleum Refining	<	Rubber and Plastics
<	Petroleum Re-refining	<	Leather Tanning
<	Iron & Steel	<	Textiles

Other industries which were not included in those profiles may also be good candidates, if data is available.

For each industry selected, the next step in the project is to create a scenario describing waste generation and management in a pre-RCRA year (prior to promulgation of RCRA regulations); this year will probably be approximately 1975-1976. For each industry, the pre-RCRA scenario will note what wastes are generated, in what volumes, in what forms, what are the constituents, and how are they managed. Much waste management in these scenarios is likely to consist of environmentally risky methods such as unlined landfills, lagoons, and simple surface dumping.

Existing data sources should be sufficient to provide information about waste generation and management. Much of the data (for the 1970s studies) was collected to learn how waste was managed; the resulting reports provided information about the threats posed by mismanaged hazardous waste.

This data will need to be updated by including data on wastes which were *generated* in the pre-RCRA year, but were not yet *tracked* (or identified as hazardous) by the RCRA program. By bringing together data from a variety of sources, it should be possible to create a reliable and reasonably accurate scenario describing hazardous waste management before RCRA management

practices were employed.

<u>Step Three</u>: Characterize Waste Generation and Management in the Baseline Scenario

With each selected industry, OSW will create a characterization of current waste generation and management techniques. The characterization will include:

< Waste streams generated
< Quantities generated of each waste stream
< Chemical constituents of each waste stream, and constituent concentrations
< Waste codes
< Management practices, including treatment and disposal units.

Waste management in the baseline scenario is expected to consist largely of safe and preventive practices, such as advanced treatment to destroy or immobilize constituents, followed by disposal of residuals in approved management units such as lined, covered landfills.

<u>Step Four</u> Characterize Waste Generation and Management in the Counterfactual Scenario

Working from both the pre-RCRA scenario and the baseline scenario, the next task is to create the <u>counterfactual</u> scenario , which represents waste management today *as it would be* in the absence of RCRA standards. This is obviously a more difficult task than the pre-RCRA or baseline scenarios.

Waste management: The premise of the counterfactual scenario is that waste management today would be similar to waste management pre-RCRA, in the absence of waste management standards.[2] To the extent that there are differences in waste management from the pre-RCRA scenario to the baseline scenario, therefore, OSW will assume continuation of the pre-RCRA

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[2]This does not mean that OSW is assuming that there would be no safe waste management in the absence of RCRA legislation or regulations. See the discussion under "Scope and Assumptions."

management, unless some event or requirement exogenous to RCRA standards had caused that change in management technique.

Waste generation: Estimating what wastes would be generated today, and the characteristics of those wastes, requires an extrapolation based on the pre-RCRA scenario and the baseline scenario. To the extent that there are differences in the wastes generated in those scenarios, OSW will need to determine whether those differences are caused by changes in waste management standards. Changes in waste generation (from the pre-RCRA scenario to the baseline scenario) that are caused by other environmental statutes (e.g., restrictions on pesticides from the Federal Insecticide, Fungicide, and Rodenticide Act) or changes in technology or changes in the economy will be represented in the counterfactual scenario; although RCRA standards are not assumed to exist in the counterfactual, all other environmental programs are assumed to exist. Changes in waste generation that are caused by RCRA waste management standards (e.g., reduced toxicity from treatment requirements) will not be represented in the counterfactual scenario.

Determining waste generation and characteristics will require a careful estimation, examining actual generation in each year as well as industry trends, other regulatory initiatives, and economic factors that influenced industrial production and waste generation in each year.

The end product of this task will be a scenario describing generation and management of hazardous waste *as it would be today,* if RCRA management standards were not in place. The same data elements (e.g., quantities, constituents, management techniques) will be determined for the counterfactual scenario as are used for the other two scenarios.

Step Five **Assessment of RCRA Benefits**

In this final step, the benefits of RCRA waste management standards are qualitatively described, based on analysis of the differences in waste generation and management between the baseline and counterfactual scenarios.

Scope and Assumptions

This report is *not* predicated on an assumption that the federal RCRA program is the sole cause of the benefits identified. Certainly, some hazardous wastes were being managed in an environmentally responsible manner even before the proposal
of RCRA regulations in 1978, and even before the federal RCRA legislation in 1976.

It is also clear that industrial waste managers follow safe waste management protocols for a variety of reasons, regardless of the existence of federal regulations or enforcement:

- Many states and localities have regulations on waste management that are independent of RCRA.
- Facilities may seek to avoid liability under CERCLA or similar statutes.
- They may seek to comply with requirements of their insurers (or lower their insurance premiums).
- Most facilities are inclined to take actions that will gain them goodwill with nearby communities, who may have concerns about the effects of poor waste management practices.

OSW is not prepared to determine the degree to which federal regulations drive waste management practices, in comparison with these other motivations. Therefore, this project will not assess the benefits of the federal RCRA program, *per se*. Rather, this project is intended to assess the benefits of implementing safe waste management practices, as represented by the management standards of the RCRA program.

Without attributing causality, though, the study methodology does exclude waste management improvements which cannot plausibly be connected to RCRA at all. The study therefore specifically excludes consideration of industries that manage waste safely before RCRA, as well as industries that have not come under RCRA authority. This latter category includes industries which have not had significant wastes listed as hazardous (for example, pulp and paper, or paint manufacturing).

Exclusion of these industries will not bias the results. The report will provide a snapshot of waste management based on aggregated industries, not based on a representative sample. Therefore, the benefits of RCRA are *at least* as great as those described in this report. If those other industries were included, they would not *decrease* the benefit estimate.

Future Efforts

Once baseline and counterfactual scenarios exist for all the industries, the next phase of the project can begin. In that phase, OSW will assess the implications of the differences between the two scenarios.

Chronic Human Health Damages Avoided or Reduced: Using existing EPA models, assess the cancer and non-cancer risks associated with the counterfactual scenario.
For example, the Multimedia, Multipathway, MultiReceptor Risk Assessment (3MRA) model could be used to project damages resulting from management of wastes in the counterfactual scenario.

Acute Events Avoided or Reduced: The inferior management standards in the counterfactual scenario are anticipated to lead to more frequent acute events such as explosions, fires, and toxic gas clouds. OSW can assess reductions in injuries, deaths, and resource damages resulting from such events. Such events occur in the baseline scenario as well, so the assessment of benefits stems from the reduced number of events compared to the counterfactual.

Resource Damages Avoided or Reduced: The waste management practices in the counterfactual would be expected to result in greater releases of hazardous chemicals than under the baseline. These releases would result in damages to recreational and commercial activities, negative esthetic impacts to residential areas, damages to ecological services, and to non-use values for resources.

Response Costs Avoided or Reduced: Smaller and/or less frequent releases in the baseline should translate to savings in averting expenditures and in remediation costs.