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

[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.