Pollution Prevention Benefits Manual

Volume I: The Manual

Phase II

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TABLE OF CONTENTS

VOLUME I, THE MANUAL

TABLE OF CONTENTS (continued)

VOLUME I, THE MANUAL (continued)

TABLE OF CONTENTS (continued)

VOLUME II, APPENDICES

TABLE OF CONTENTS (continued)

VOLUME II, APPENDICES (continued)

LIST OF EXHIBITS

VOLUME I, THE MANUAL

VOLUME II, APPENDICES

LIST OF EXHIBITS (continued)

VOLUME II, APPENDICES (continued)

LIST OF COST TABLES

VOLUME I, THE MANUAL

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LIST OF WORKSHEETS

VOLUME I, THE MANUAL

VOLUME II, APPENDICES

PREFACE

It is the policy of EPA that the reduction or elimination of discharges and/or emissions to the environment through source reduction and environmentally-sound recycling is preferable to controlling such releases after they are generated or produced. Furthermore, source reduction, or elimination of releases at the source, is more desirable than recycling. It will be EPA's policy to aggressively implement pollution prevention (PP) through source reduction and environmentally-sound recycling as an integral part of its programs to protect all aspects of our nation's environment -- air, water, land, and ground water (policy proposed in Federal Register, January 26, 1989).

EPA has produced this manual to simultaneously achieve increased environmental protection and reduced environmental compliance costs. The purpose of the manual is to promote a complete and objective analysis of the economic benefits of PP projects. Since the passage of the RCRA Hazardous and Solid Waste Amendments (HSWA) in 1984, EPA has been developing a program to meet the statutory goal to reduce or eliminate the generation of hazardous waste as expeditiously as possible. EPA has extended the waste minimization (WM) concept to include releases to all environmental media. This manual refers to PP as the more meaningful concept.

EPA has met with corporate managers to discuss how PP can be achieved without recourse to additional regulations. A major theme has been that PP projects frequently do not get undertaken because the benefits of the project in terms of reduced raw materials, regulatory compliance, and environmental liability costs are poorly understood. EPA has unique experience in understanding the impacts and interrelationships of regulatory requirements, some of which can legitimately be avoided or mitigated through PP. The discussion of regulatory costs is intended to provide only an estimate of costs associated with regulatory compliance. The manual is not designed to provide regulatory guidance.

This manual enables you to calculate the true cost of the current materials and waste management practice and then evaluate the financial payback of the PP alternative. Until these true costs, often underestimated by managers by an order of magnitude, are correctly understood, more hazardous materials and waste will be managed/released than need be -- thus imposing additional costs on the generator, the environment, and society as a whole. EPA believes this manual to represent an extraordinary commonality of interests between economic self-interest and environmental protection.

CHAPTER 1
INTRODUCTION

This manual is intended to help you evaluate the economic feasibility of pollution prevention (PP) or waste minimization (WM) alternatives to your current practice. This introductory chapter is organized in five sections as follows:

(1.1) What is pollution prevention?
(1.2) Why should you undertake pollution prevention?
(1.3) What approach is used in this manual?
(1.4) What will you get out of this manual?
(1.5) How is this manual organized?

1.1 WHAT IS POLLUTION PREVENTION?

Pollution prevention is an extension of the concept of waste minimization. While pollution prevention includes waste minimization, it broadens the concept to include minimizing the generation and release of all hazardous materials and wastes to all environmental media.

1.1.1 What Does EPA Mean by Waste Minimization?

Waste minimization means the reduction, to the extent feasible, of any solid or hazardous waste that you generate or subsequently treat, store, or dispose of. Waste minimization techniques focus on *source reduction* or *recycling* activities that reduce either the volume or the toxicity of your waste.

Source reduction means the reduction or elimination of hazardous waste at the source; before it is generated. *Recycling*, on the other hand, means the *use*, *reuse*, or *reclamation* of a hazardous waste as an effective substitute for a commercial product or as an ingredient or feedstock in a process. Recycling by use or reuse involves returning a waste material either to the originating process or another process as a substitute for an input material. Reclamation is the recovery of a valuable material, or removal of impurities, from a waste. Because it is significantly more efficient and less expensive to prevent the generation of hazardous waste in the first place, you should consider source reduction to be the most preferable waste management option. Source reduction is followed, in order of decreasing preference, by recycling, treatment, and land disposal.

1.1.2 What Does EPA Mean by Pollution Prevention?

Recently, EPA launched a major new effort to reduce the threats posed by environmental pollution. The Agency proposed a policy statement that established pollution prevention as an official Agency policy:

> "EPA believes that developing and implementing a new multi-media prevention strategy, focused primarily on source reduction and secondarily on environmentally sound recycling, offers enormous promise for improvements in human health protection and environmental quality and significant economic benefits. (Federal Register, January 26, 1989, Page 3845)."

This new approach is profoundly simple and yet radically different from the Agency's past efforts to protect health and the environment. This approach recognizes that many of the benefits of controlling pollution have already been achieved. Further environmental gains must come from preventing the release of pollutants.

The Agency created the Pollution Prevention Office, which will be the Agency's focal point for an integrated, cross-media approach to pollution prevention, both inside and outside the Agency. EPA will

be actively promoting an environmental ethic stressing the prevention of pollution before it becomes a problem.

1.2 WHY SHOULD YOU UNDERTAKE POLLUTION PREVENTION?

Your firm should investigate and implement PP alternatives to your current practice for several reasons. Pollution prevention can help you achieve the following:

(1) Improve your firm's "bottom line;"

(2) Make compliance with environmental regulations easier; and

(3) Demonstrate a proactive commitment to genuinely pursuing a PP program.

EPA has developed a system of federal regulations to protect human health and the environment from dangerous wastes and materials. Although EPA has tried to avoid imposing unnecessary costs upon private industry as a result of these regulations, EPA understands that private industry may still face significant compliance costs. *Pollution prevention can improve your firm's bottom line* as a result of:

- Reduced process costs;
- Reduced regulatory costs;
- Reduced liability costs; and
- Less tangible benefits resulting from improved customer satisfaction and enhanced corporate image.

If you are like most owners or operators of businesses regulated by the U.S. EPA and/or a state environmental agency, you have complied with the new regulations by adding equipment to deal with wastes after they are generated. For example, you may have added wastewater and process-water treatment equipment or air pollution control equipment like stack scrubbers or electrostatic precipitators and filters. Also, you may have contracted with vendors who have permits to dispose of your hazardous wastes. However, many manufacturers have found that the most cost-effective approach to complying with environmental regulations is to minimize or avoid generating or releasing hazardous materials or wastes in the first place; i.e., to prevent the pollution before it occurs. Many firms have found that by "coupling" pollution prevention with other corporate goals (e.g., efficiency, R&D, health and safety) not only have costs been cut, products been improved, or processes been enhanced, but also *compliance with regulations has become easier!* For example, a search for a less expensive, more effective cleaning solvent may lead to use of an aqueous cleaner that also generates less hazardous waste. Attempting to reduce the down-time due to cleaning and rinsing of equipment associated with batch-processing may result in rearranging the process sequence so that the wastes from the previous batch are compatible with the inputs for the next batch, which may also reduce the amount of wastewater generated.

Furthermore, you must certify on your hazardous waste manifests that you have a program in place to reduce the volume and toxicity of the waste you generate and you must describe this program in your biennial reports. Any waste minimization or pollution prevention efforts you take now will not only result in immediate economic benefits to your firm, but will also serve to demonstrate a proactive commitment to *genuinely pursuing a pollution prevention program.*

1.3 WHAT APPROACH IS USED IN THIS MANUAL?

Your decision to select a PP alternative to current practice, however, is often an economic one. To make a particular selection you may need to know how much a PP alternative will cost relative to your current practice. *The purpose of this manual is to help you make this comparison on the basis of the "true" costs and benefits of preventing pollution.*

Exhibit 1-1 illustrates the general approach taken by this manual. As you can see, the economic evaluation of a PP alternative can be performed at four levels or tiers. At each tier, the economic evaluation is a two-step process:

Step 1: Account for all costs associated with current practices and with the alternative PP project: This manual describes four tiers or levels of costs associated with hazardous wastes and materials management: usual costs, hidden regulatory costs, liability costs, and less tangible costs.

Step 2: Estimate key financial indicators of the economic viability of the PP project on the basis of Step 1 costs: This manual describes the financial calculations for estimating net present value, internal rate of return, and annualized cost savings of a PP project.

In Exhibit 1-1 the four peripheral boxes represent the four tiers of the cost calculations (i.e., Step 1). The central box represents the financial calculations (i.e., Step 2). Note that the same financial calculations are performed in each tier of the economic evaluation.

The manual describes procedures or protocols for performing the cost and financial calculations. After performing the cost protocol associated with a tier, you should use the financial protocol to evaluate the economic merits of the PP alternative. Each tier is evaluated using the same basic techniques. Only you can determine the appropriate level of analysis to employ; not everyone will need or choose to employ all four tiers of the analysis.

1.3.1 Four-Tier Cost Protocol

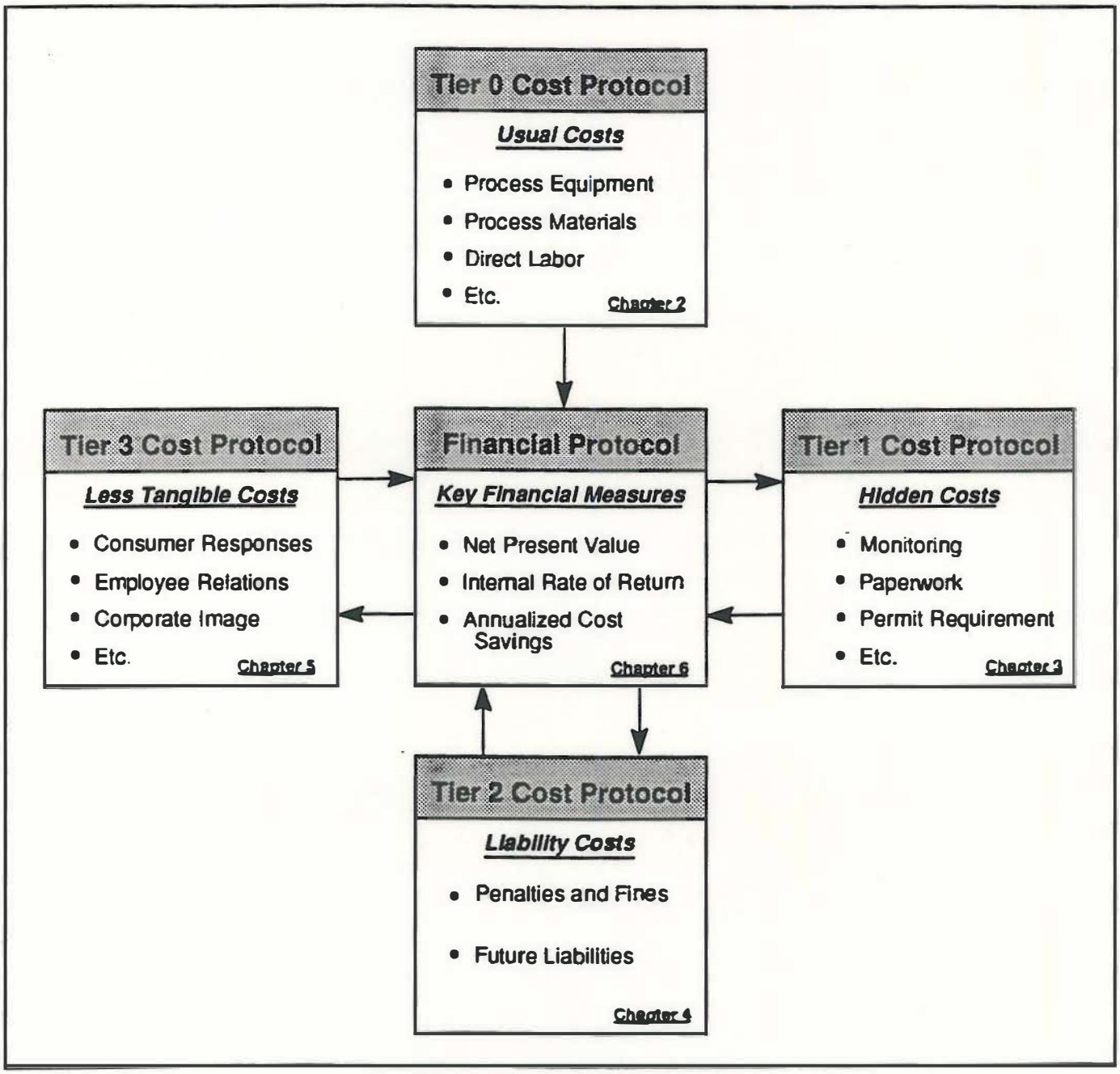
The manual describes four "tiers" or levels of costs associated with hazardous materials and waste management. You may go through as many tiers as necessary to demonstrate the economic viability of your PP project. The four cost tiers are summarized next. Note that Tiers 2 and 3 are judgmental in nature. You are encouraged to be conservative in your cost estimates thus reflecting your emphasis on PP as a goal and not profit maximization. If you get to Tiers 2 and 3, your estimates of liability costs and less tangible benefits will reflect subjective corporate policy and not precise, scientific calculations.

Tier 0 addresses the "usual" capital and O&M costs associated with new technology and operating practices -- labor costs, equipment costs, raw materials costs, etc. In this manual, EPA has assumed that you have conducted or will conduct an evaluation of usual costs by using other EPA guidance, internal corporate experience, or outside consultants. To use this manual, you will need to provide the Tier 0 cost estimate.

Tier 1 includes "hidden" costs associated with pollution practices -- permitting costs, monitoring/testing costs, training costs, inspection costs, and other regulatory costs. In some cases, these costs can be significant and pollution prevention can lower them. These costs are "hidden" because often they are not allocated to the corporate unit(s) actually responsible for incurring them. Instead, hidden costs often are charged to indirect or overhead accounts. Frequently, the individual(s) most able to control hidden costs are either uninformed about them or lack the incentive to reduce them. Tier 1 costs should be relatively easy to obtain or estimate, because they generally relate to the regulatory status of your

EXHIBIT 1-1

APPROACH AND ORGANIZATION OF MANUAL:
FOUR-TIER COST PROTOCOL AND FINANCIAL PROTOCOL



current operations. Using your current accounting records and the procedure in this manual, you should be able to estimate Tier 1 costs fairly accurately.

Tier 2 considers potential liability costs. As you are probably aware, environmental liability claims are becoming more common, and more expensive. By avoiding pollution, you may be able to avoid liability costs. This manual presents a protocol to estimate two types of liability costs: penalties and fines associated with non-compliance, and other liabilities referred to as future liabilities.

Tier 3 includes "less tangible" benefits that your company may achieve as a result of reducing or eliminating pollution. Less tangible benefits include increased revenues or decreased expenses due to improved consumer acceptance, employee relations, and corporate image. Although it is difficult to predict the extent of these benefits with certainty, it is reasonable to assume that these benefits may be significant. For example, several States are currently offering "excellence" awards to businesses for outstanding PP efforts (e.g., CA, MN, NC, TN). Winning such an award may result in favorable publicity (i.e., free advertising), which may promote consumer acceptance and interest in a firm's products or services. Likewise, by drawing attention to efforts to reduce the amount of hazardous materials or hazardous wastes handled at a facility, thereby making the facility a safer workplace and a safer neighbor, employee productivity and product acceptance by consumers may be enhanced. This manual discusses some of the benefits that may be realized by reducing or eliminating pollution. Only you, however, can estimate the value of these benefits.

1.3.2 Common Financial Protocol

The results from each tier are evaluated using the financial protocol. The financial protocol assumes that a PP project is economically viable if its implementation will result in overall net savings for the plant or company. The financial protocol will guide you through the calculation of three key financial indicators of the economic feasibility of your PP alternative:

- Annualized Savings -- the equal amounts of dollar savings (or losses) expected every year over the lifetime of the project (e.g., $2,000 per year over 20 years);
- Internal Rate of Return (IRR) -- the expected long-term return on investment in the PP project (e.g., 12 percent); and
- Net Present Value (NPV) -- the present value of cash inflows minus the present value of cash outflows (e.g., $5,000).

Each of these financial measures recognizes that one dollar earned or spent today is worth more than one dollar earned or spent tomorrow, even in the absence of inflation. Financial experts acknowledge this time value of money by discounting future cash flows in order to compare them to present cash flows. The financial measures presented above are commonly used by firms; they are all based on discounting of future cash flows. Using discounted cash flows, you will be able to compare costs or cost savings expected to be incurred at different times in the future.

1.4 WHAT WILL YOU GET OUT OF THIS MANUAL?

Using this manual, you will be able to summarize the expected savings from choosing a PP alternative to your current practice. To illustrate this, Appendix D of this manual presents the economic benefits to a hypothetical firm of switching from current practice to a PP alternative. The hypothetical firm is an electroplater of gold jewelry. Currently, the firm uses 1,1,1-tricholoroethane (TCA) in a pre-cleaning step which generates spent solvents. The firm ships the spent solvents off-site for recycling. After distillation for the spent solvents, the off-site recycler incinerates the still bottoms and disposes of the ash

in a landfill. Under the PP project, the hypothetical firm would replace the TCA precleaner with a mechanized aqueous based cleaner. The firm would not generate any spent solvents under the PP project.

Exhibit 1-2 summarizes the cost savings or benefits to the hypothetical firm at each of the four 'tiers' or levels of analysis. For the hypothetical firm, the cost savings from raw materials are not large enough to compensate for increased costs such as the capital expenditure for purchase and installation of the mechanized aqueous-based cleaner.[1] At the Tier 0 level, the PP project costs an additional $3,500 a year compared to the current practice and has an Internal Rate of Return (IRR) of 12 percent, which is less than the 15 percent minimum rate of return acceptable to the hypothetical firm. Therefore, the PP project is not justified using usual costs only.

The PP project continues to be not cost-justified when considering hidden regulatory costs (Tier 1) in addition to usual costs. Despite the additional cost savings associated with reduced regulatory requirements (e.g., less inspections), the PP project continues to cost $1,500 more than the current practice each year with an IRR of 13.7 percent (still less than the 15 percent minimum acceptable rate of return).

The PP project becomes cost-justified when liability costs (Tier 2) are added to usual costs and hidden regulatory costs. Compared to the current practice, the PP project is estimated to save $45,600 a year in the form of reduced future liabilities associated with the management (especially solvent storage in tanks and ash disposal in landfill) of hazardous waste and materials. The PP project has an estimated IRR of 33 percent, which far exceeds the 15 percent minimum acceptable rate of return.

The PP project looks even better when less tangible benefits (Tier 3), such as increased sales resulting from improved corporate image, are also taken into account. At the Tier 3 level, the PP project is estimated to save $48,000 a year compared to the current practice. Because the IRR estimate (34 percent) is greater than 15 percent, the PP project is cost-justified.

1.5 HOW IS THIS MANUAL ORGANIZED?

The remainder of this manual is arranged in five chapters and five appendices. Each chapter first summarizes the steps to be covered in the chapter and the approach taken, and then provides more detailed information on how to perform the steps.

Chapter 2 discusses the Tier 0 cost protocol for usual costs.

Chapter 3 discusses the Tier 1 cost protocol for hidden regulatory costs.

Chapter 4 discusses the Tier 2 cost protocol for liability costs.

Chapter 5 discusses the Tier 3 cost protocol for less tangible costs.

Chapter 6 describes the steps needed to perform the financial calculations for each tier.

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[1] Note that the purchase and installation of PP equipment will cost an additional $24,800 a year over the entire lifetime of the equipment. As demonstrated in Appendix D, this annualized cost corresponds to a capital investment of $155,000 in equipment with a 20-year lifetime, and assumes a 4 percent annual inflation rate.

EXHIBIT 1-2

BENEFITS TO THE HYPOTHETICAL FIRM OF SWITCHING FROM CURRENT PRACTICE TO PP ALTERNATIVE

Level of Analysis/ Project Justification	Cost Item	Net Savings or Benefits (in $ per year) a/
Tier 0: Usual Capital Costs and O&M Costs		
PP alternative not cost-justified. Fails to meet the firm's 15% minimum rate of return on investment.	Equipment and installation	-$24,800
	Raw Materials	$57,900
	Energy	-$14,500
	Disposal	-$2,900
	Maintenance	-$11,600
	Revenues	-$3,200
	Tier 0 Taxes	**-$4,500**
	After-Tax Savings Through Tier 0	**-$3,500**
	IRR Through Tier 0	**12%**
Tier 1: Hidden Regulatory Costs		
PP alternative not cost-justified. Fails to meet the firm's 15% minimum rate of return on investment.	Reporting	$930
	Inspections	$1,800
	Other	$870
	Tier 1 Taxes	**-$1,600**
	After-Tax Savings Through Tier 1	**-$1,500**
	IRR Through Tier 1	**13.7%**
Tier 2: Liabilities		
PP alternative is cost-justified. Has an IRR of 33%, which is greater than 15% minimum rate of return on investment.	Treatment or Storage in Tank	$47,500
	Transportation	$1,300
	Disposal in Landfill	$35,300
	Tier 2 Taxes	**-$37,000**
	After-Tax Savings Through Tier 2	**$45,600**
	IRR Through Tier 2	**33%**
Tier 3: Less Tangible Benefits		
PP alternative is cost-justified. Meets the firm's hurdle for investments (34% > 15%)	Net Increase in Operating Revenues	$ 4,300
	Tier 3 Taxes	**-$1,900**
	After-Tax Savings Through Tier 3	**$48,000**
	IRR Through Tier 3	**34%**

a/ All savings are before tax except when in bold. A discount rate of 15 percent is assumed. Negative estimates represent a cost increase or net loss. Positive estimates represent a cost decrease or net benefit. All numbers may not add up due to rounding.

Appendix A contains blank worksheets to be used in completing each tier of the analysis.

Appendix B provides information on the regulations that are discussed under Tier 1.

Appendix C provides additional information on the future liability costs discussed under Tier 2.

Appendix D illustrates the manual's approach with a hypothetical firm example.

Appendix E introduces the treatment standards promulgated under the land disposal restrictions and provides reference for additional guidance on the subject.

CHAPTER 2

TIER 0 COST PROTOCOL: USUAL COSTS

This chapter discusses the steps needed to perform the Tier 0 analysis of usual costs. As discussed in Chapter 1, the Tier 0 analysis includes analyzing facility operations, developing options, and estimating the direct expenses of the options. For purposes of this manual, it is assumed that you have conducted or will conduct the Tier 0 analysis by following other EPA guidance, by using your internal corporate experience, or by using outside consultants. This chapter lists the types of costs that EPA anticipates will result from the Tier 0 analysis of pollution prevention (PP) alternatives, but does not describe the process of obtaining the cost estimates.

STEPS	APPROACH
1. Identify one or more PP alternatives; i.e., alternatives to the current practice expected to result in less hazardous waste generated or less hazardous materials disposed or released.	1. Conduct a PP audit, or consult the EPA Manual for Waste Minimization Opportunity Assessments for further guidance.
2. Estimate the "usual" costs (capital equipment, direct operating and maintenance, and other direct costs) associated with current and alternative practices.[1]	2. Consult the EPA Manual for Waste Minimization Opportunity Assessments, engineering handbooks, trade associations, or outside consultants.
3. Report estimates on the Tier 0 cost worksheet for the current practice and for each PP alternative separately.	3. Use the blank Tier 0 cost worksheet (Worksheet 0) provided at the end of this chapter and in Appendix A of this manual.

[1] It is important to emphasize that you must estimate capital and operating costs for both the current and alternative practices. Frequently the capital costs associated with the current practice will not be zero. This is because existing equipment either may still have depreciation charges against it or may be made obsolete by new regulations on pollution control within a few years.

INTRODUCTION

The first step in reducing the costs associated with pollution and waste management is to conduct a facility assessment to determine where waste is generated and which processes lead to the regulated discharge of pollutants. Frequently, waste-generating processes will be found to date from a time when waste disposal and pollution control was less costly, so that changes in the process, which may be simple "housekeeping" changes or those requiring more significant time and planning, can result in immediately identifiable cost reductions through decreased energy, materials, labor, and disposal costs. Assessment of these costs is considered to be "Tier 0," because the review of these "usual" costs is assumed to be a necessary part of doing business.

As discussed in Chapter 1, however, waste reduction need not begin as a separate, full-blown program nor even as an attempt to minimize pollution. Instead, the initial steps can come about through simple awareness that waste and pollution are costly, and that minimizing waste and pollution can save money. Pollution prevention also can result from attempts to optimize certain plant processes, e.g., installation of a floating roof tank to control evaporative loss of volatile liquids during storage. Although PP audits would provide the most comprehensive information through a detailed, full-facility review, simply reviewing plant operations as part of periodic inspections can also provide valuable information on waste stream generation. Similarly, it is not necessary to redesign an entire plant, but if process modifications are being examined, then the potential impact of the modifications on waste generation and pollutant discharge should be considered.

This manual does not provide detailed guidance on how to perform the Tier 0 facility analysis and cost development. Instead, it provides a brief review of the steps that are often entailed and describes the cost elements that are generally estimated as a result of the review. EPA has prepared a separate manual, the Waste Minimization Opportunity Assessment Manual, that covers the subject in detail.[2] Engineering handbooks and manuals may also provide information on estimating equipment needs and costs. Also, many trade associations can provide guidance, and several commercial firms offer professional auditing and facility review services.

STEP 1: IDENTIFY PP ALTERNATIVES

Concept and Purpose

Before you can reduce the costs associated with pollution, you must know what processes contribute to pollution and waste generation and the nature and extent of pollution and waste generation. After identifying polluting processes or procedures, you can identify ideas for reducing or eliminating the pollution. Finally, the costs of the alternative processes or procedures can by estimated.

Actions

(1) Develop a Procedure for Reviewing Pollution Generation

The first step is to develop a procedure for reviewing pollution generation. Frequently, any changes to processes or procedures will require prior approval by management; most successful pollution reduction and waste minimization programs have strong encouragement from the upper management before they begin. In general, a team should be developed with experience in the facility operations and knowledge of potential alternatives. Plant managers and engineers, foremen, and operators can all provide valuable insight into

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[2] U.S. EPA, Hazardous Waste Engineering Research Laboratory, "Waste Minimization Opportunity Assessment Manual (EPA/625/7-88/003)," Prepared by Jacobs Engineering Group, July 1988.

the nature of the practices. Trade associations, state officials, outside consultants, and vendors can often provide suggestions based on prior experience in reducing pollution.

(2) Collect Data

The second step in the process is to collect data on the facility operations to identify the waste generating steps. "Material balances" showing the amount of raw materials going into and the amount of finished product and waste coming out of a process will often help to pinpoint the largest contributors. Records from waste disposal operations (air and water treatment plants and solid and hazardous waste disposal costs) will suggest the largest volumes of waste. In many cases, you can find examples of unnecessary pollution or waste generation by simply walking through the plant to find leaking valves, open drains, evidence of excessive dragoff from chemical baths and cleaning operations, and uncovered containers. A useful source of data for this purpose may be your SARA §313 data submissions.

(3) Develop PP Alternatives

The next step is to develop PP alternatives. For example, your records may show extensive use of organic solvents that are not matched by equivalent records of disposal or recycling. Alternatives to reduce the fugitive losses of solvent include enclosing the process or switching to a different cleaning mechanism (e.g., aqueous solvents or mechanical abrasion). A review of water flows may show that most water is used only once, but that all water is mixed before discharge. In many cases, non-contact cooling water (water routed through jackets to cool equipment) can be used for washing purposes. Many plants have found that highly toxic waters (e.g., rinse waters from cyanide baths) are drained to the floor, where they can mix with less hazardous water used for cleaning purposes. Some facilities have found that "counter-current" rinsing, where the effluent rinse water from one step is used as the source to a preceding step, conserves water usage and decreases chemical usage and operating costs.

(4) Determine the Feasibility of the Alternatives

The final step in the audit process is to determine if the alternatives are feasible -- will they work at your plant. In some cases, the alternatives merely require good housekeeping practices or minor alterations (e.g., using a drain board to drain solutions back into baths, rather than letting the fluid drip to the ground or contaminate the next step in the process). In other cases, additional research will be necessary to determine whether the change will have an adverse effect on quality (e.g., recycling wastes back into a process).

STEP 2: ESTIMATE THE USUAL COSTS OF CURRENT AND ALTERNATIVE PRACTICES

Concept and Purpose

Once alternative practices have been identified, you can estimate the "usual" costs associated with them. As discussed in Chapter 1, "usual" costs include those that are directly associated with the polluting or alternative practice, and typically include equipment costs, material and energy costs, and direct labor costs. As shown in Worksheet 0, costs can be put into two major categories: capital expenses that must be depreciated for tax purposes, and other expenses that can be deducted from taxes in a single year. Some of the other expenses shown in Worksheet 0 (e.g., start-up costs) are commonly calculated as "capital" costs because they are one-time costs that are needed before the process can be used. Because they are treated as expense for tax purposes, however, Worksheet 0 includes them under "expenses." Worksheet 0 also provides room for recording any changes in revenues expected as a result of using an alternative practice, and provides room to record the estimated annualized cash flows to be developed following the financial protocol discussed in Chapter 6.

Actions

(1) Estimate Capital Cost Items

Worksheet 0 shows the 6 elements of depreciable capital costs commonly associated with process changes.

Equipment. This cost item represents the investment in new equipment needed to implement the PP alternative. The cost element should include the price (f.o.b. factory), taxes, freight, and insurance needed for delivery, and the cost for the initial spare parts inventory. You should include any additional equipment needed to support the PP alternative, such as additional storage and material handling equipment or additional laboratory and analytical equipment.

Materials. Materials costs include piping, electrical equipment, new instrumentation, and changes in the structure. These costs are those incurred in purchasing the materials needed to connect the new process equipment (or to revise the use of existing equipment) to implement a waste minimization alternative.

Utility Connections. This item includes costs for connecting the new equipment (or for making new connections to existing equipment) as part of implementing the waste minimization option. Typical utilities include electricity, steam, cooling water, process water, refrigeration, fuel (gas or oil), plant air (e.g., for process control), and inert gas.

Site Preparation. This item includes the costs for any necessary site preparation -- demolition, site clearing, paving.

Installation. This item includes the costs incurred during the installation of the process equipment or process change. Be sure to include charges by the vendor as well as by in-house staff.

Engineering and Procurement. This item includes the costs incurred to design the process equipment or process change and to purchase any new equipment. Charges for consultants used in designing and procuring equipment would be included here.

(2) Estimate Expenses

Worksheet 0 shows the 14 operating cost elements commonly associated with process and procedural changes. The costs in this category include both one-time costs and on-going costs that are deductible for income-tax purposes. For consistency with the approach used in the Tier 1, 2, and 3 analyses, the costs are presented as total current costs and total costs after the change; the evaluation of economic feasibility presented in Chapter 6 will show how to perform the comparative analysis.

Start-up Costs. Start-up costs include labor and material costs incurred during the start-up of the equipment.

Permitting Costs. These costs include both fees and the costs incurred by in-house staff in documenting the process change to meet permit requirements.

Salvage Value. Estimate the net amount (in today's dollars) that the used equipment will be worth at the end of its useful lifetime. *Include the value of working capital and catalysts and chemicals that will remain at the completion of the equipment's life.*

Training Costs. Training costs include the costs for on-site and off-site training related to the use of the new equipment or for making sure the process change achieves its goal.

Initial Chemicals. The initial charges for chemicals and catalysts can be considered a capital item.

Working Capital. This category includes all elements of working capital (required inventories of raw materials, in-process inventories, materials and supplies) not already included as charges for chemicals and catalysts or for spare parts.

Disposal Cost. The disposal cost includes all of the direct costs associated with waste disposal, including solid waste disposal, hazardous waste disposal, and off-site recycling. Exhibit 2-1 presents typical treatment and disposal costs (in 1985) by type of waste and technology.

Raw Materials Costs. You should include both the raw materials directly affected (e.g., chemicals for which more effective or less toxic substitutes are being found) and other raw materials affected by the change in the process (e.g., if a change in cleaning agent changes the rejection rate of metal parts, then there may be a change in the total materials costs for raw metal).

Utilities Cost. Utilities costs include electricity, any process steam, water, compressed air, and heating oil or natural gas. It is important to consider whether a process change causes downstream effects as well as direct process effects. For example, if a process is modified to recycle aqueous streams, then there may be utilities costs for the process (different costs to adjust the temperature of the stream to match the process requirements) and different costs associated with the downstream water treatment process.

Catalysts and Chemicals. In this category, you should include any chemicals or catalysts necessary to the process that are not raw materials. For example, cyanide makeup for metal plating, pH adjusters for water treatment, and catalysts used to speed chemical reactions all are necessary to the process, but do not become an integral part of the final product.

Operating and Materials (O&M) Labor Costs. This cost elements includes the labor needed to run the affected processes.

Operating and Materials Supplies Costs. This cost element includes supplies needed on a regular basis, such as glassware, buckets, cleaning agents, uniforms, air and dust filters, protective equipment.

Insurance and Liability Costs. In some cases, your insurer will review your insurance and make adjustments based on changes in the risk associated with you plant. For example, if you replace a process with a high history of accidents or health problems, your rates should go down.

Other Operating Costs. This cost element includes other operating costs that have not been specifically included above.

(3) Estimate Operating Revenues

In some cases, adopting a PP alternative will lead to changes in the revenue from operations. Worksheet 0 provides room for two categories: revenues from primary products, and revenues from marketable by-products.

Primary Products. If the process or procedural change will change the production rate of the process, then the revenues before and after the change should be calculated.

Marketable By-Products. One outcome of many PP projects is an increase in the amount of marketable by-products. For example, precious metal platers in Massachusetts have found that concentrating the plating baths and sludge has allowed them to sell the sludge to recycling facilities for the precious metal content.

EXHIBIT 2-1

TYPICAL TREATMENT AND DISPOSAL COSTS

Waste Management Technology	Type/Form of Waste	Price a/ (1985 $ Per Gallon)	Price b/ (1987 $ Per Gallon)
Landfill	• 55-gallon drum	50-137/drum	64-186/drum
	• Bulk	69-140/ton	97-166/ton
Land Treatment/ Solar Evaporation	• All	0.33-0.83	
Incineration	• Clean liquids, high BTU value	0.10-1.93	1.35-2.95
	• Clean liquid, low BTU value	1.33-4.17	1.33-3.38
	• Sludges and solids	2.75-4.75	5.40-8.56
	• Highly toxic liquids	2.10-8.30	2.36-5.02
	• PCB liquids	2.50-3.50	2.36-4.34
	• PCB solids	4.50-12.50	3.84-8.17
Chemical Treatment	• Acids/alkalies	0.12-2.00	N/A
	• Cyanides	0.50-0.90	N/A
	• Highly toxic wastes	0.80-6.00	N/A
	• Heavy metals	0.20-1.00	N/A
Resource Recovery	• Organics	(0.25)-3.00	N/A
	• Mixed Halogenated	2.20-4.20	N/A
	• Oil	0.00-0.42	0.20-1.13
Deep Well Injection	• Oily wastewaters	0.08-0.50	0.09-0.50
	• Toxic rinsewaters	0.50-1.20	0.15-0.63
Transportation		0.18-0.22/ton-mile 2.70-4.5/loaded mile (20 tons per load)	0.23/ton-mile 3.35-3.51/loaded mile (20 tons per load)

NA = Type of waste not included in 1987 survey.

a/ U.S. EPA, "1985 Survey of Selected Firms in the Commercial Hazardous Waste Management Industry," Final Report, November 6, 1986.

b/ U.S. EPA, "1986-1987 Survey of Selected Firms in the Commercial Hazardous Waste Management Industry," Final Report, March 31, 1988.

STEP 3: COMPLETE THE TIER 0 COST WORKSHEET

The final step is to complete the Tier 0 cost worksheet, i.e., Worksheet 0. The worksheet has three major blocks. The left-hand block has summary descriptions of each cost item. These descriptions, which correspond to the cost elements used in EPA's Waste Minimization Opportunity Assessment Manual, have been defined in Step 2. The middle block provides room to enter values for the elements of the cash flow. The right-hand block will be discussed in Chapter 6. The following discussion pertains to the elements in the middle block.

Concept and Purpose

Worksheet 0 provides a way to summarize the costs obtained in Step 2 using a standard format that allows comparison between the current and alternative practices. In filling out a cost worksheet (Worksheets 0 through III as introduced in this and subsequent chapters), **costs or cash outflows should be entered as negative values, and revenues or cash inflows should be entered as positive values.**

For each tier, you may perform the cost calculations either (1) once; i.e., for your PP alternative relative to current practice or (2) twice, i.e., once for your current practice and once for your PP alternative. In the first case, you will check the "incremental" box in Worksheet 0 and complete it only once. If, for example, you estimate that costs will decrease by a certain amount as a result of the PP alternative, you will enter the decrease in costs on the worksheet as a positive cash flow. In the second case, you will complete Worksheet 0 once for the current practice and once for the PP alternative and check the current and alternative practice boxes accordingly. However, you need only estimate and enter those cash flows that are affected by the PP alternative. For example, if you do not believe that revenues will change as a result of your PP alternative, then you need not enter the amount of revenues at all.

Actions

(1) Record the Cash Flow Amount

For each cash flow item, report your cash flow estimate in current dollars, as obtained in Step 2.

(2) Estimate and Record the Escalation Rate

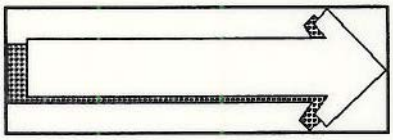
The escalation rate, or inflation rate is the average increase in unit costs or revenues from year to year, expressed as a decimal. For example, if your costs are rising at a rate of 5 percent per year (that is, for every $20 dollars spent today, you expect to spend $21 next year for the same quantity of goods or services), then you should enter the escalation rate as 0.05. If you expect some costs to go up faster than others, you should enter different rates. Otherwise, you should enter the same rate. For example, treatment, storage, and disposal (TSD) costs for solid and hazardous wastes have increased rapidly in the last few years, and may continue to rise sharply as a result of further restrictions on the types of wastes that may be land disposed. In particular, the costs of TSD services have increased by 10 percent to 150 percent per year between 1983 and 1985. High increases in rates were observed for such services as incineration. More recently, the costs of TSD services have continued to rise at a rate of 10 percent to 20 percent per year.

(3) Record the First Year of Cash Flow

The second element is the year when the cash flow is expected to first occur. For example, salvage value would be recorded as a positive cash flow starting in the first year after the expected useful life. Thus, if you expect to install new equipment within the next year, and you expect it to last 10 years, you should record a value of 10. In most cases, the first year of cash flow, however, will be year 0 (today).

(4) Estimate and Record the Lifetime

The third element is the lifetime associated with the cash flow. For equipment costs (A1 through A6) you should use the expected equipment lifetime. For other costs, you should use the estimated *project* lifetime. As a general rule, a good value to use for lifetime is the estimated lifetime of the longest-lived equipment item.



After completing Worksheet 0, you should proceed to Chapter 6. Chapter 6 provides the financial protocol, which will give you instructions to (1) complete the right-hand block of the Tier 0 Cost Worksheet (i.e., annualized cash flows), and (2) calculate the annualized cost savings, net present value, and internal rate of return of each alternative PP practice relative to current practice. These values will allow you to assess the economic feasibility of your PP alternative(s).

Worksheet 0
Tier 0 • *Usual Costs*

☐ Current Practice
☐ Alternative Practice
☐ Incremental

ITEM DESCRIPTION	CASH FLOW INFORMATION				ANNUALIZED CASH FLOW [a]			
	Escalation Rate (r_e, %)	First Year of Cash Flow (t_1, years)	Lifetime (n, years)	Cash Flow Estimate (C, [a])	r_d = 5%	r_d = 10%	r_d = 15%	r_d =
A. DEPRECIABLE CAPITAL EXPENDITURES								
A1 Equipment								
A2 Materials								
A3 Utility Connections								
A4 Site Preparation								
A5 Installation								
A6 Engineering & Procurement								
B. EXPENSES								
B1 Start-up								
B2 Permitting								
B3 Salvage Value								
B4 Training								
B5 Initial Catalysts								
B6 Working Capital								
B7 Disposal								
B8 Raw Materials								
B9 Utilities								
B10 Catalysts & Chemicals								
B11 Labor								
B12 Supplies								
B13 Insurance								
B14 Other								
C. OPERATING REVENUES								
C1 Revenues								
C2 By-product Revenues								

[a] *In thousands of year-0 dollars*

CHAPTER 3

TIER 1 COST PROTOCOL: HIDDEN REGULATORY COSTS

This chapter presents the protocol for estimating the hidden regulatory costs associated with your current and alternative practices. You may perform the cost calculations described in this chapter either (1) once; i.e., for your alternative practice relative to current practice, or (2) twice, i.e., once for your current practice and once for your PP alternative.

Worksheet I for the Tier 1 Cost Protocol has three major blocks (see end of chapter). The left block has summary descriptions of each cost item. The middle block provides room to enter values for the elements of the cash flow. The right block allows for the Tier 1 financial calculations (see Chapter 6).

STEPS	APPROACH
For the current practice and each PP alternative:	
1. Establish what regulations are applicable to your facility.	1. Fill out Regulatory Status Questionnaire (Exhibit 3-1).
2. Estimate hidden capital expenditures expected to be incurred by your facility.	2. Analyze technology-forcing requirements of existing or anticipated regulations.
3. Estimate hidden expenses incurred or expected to be incurred by your facility.	3. Using results from the Regulatory Status Questionnaire (Step 1), fill out Cost Tables 3-1 to 3-14 and report your cash flow estimates on Worksheet I.
4. Complete Middle Block of Worksheet I.	4. Use guidelines presented.

STEP 1: ESTABLISH YOUR FACILITY'S REGULATORY STATUS

Concept and Purpose

The Regulatory Status Questionnaire (Exhibit 3-1) has been developed to determine your facility's regulatory status for purposes of this analysis. The term "questionnaire" does not imply that the government will ask for any information from this exercise. It will not! This questionnaire is for your use only. Likewise, the regulatory descriptions provided in this manual may not be comprehensive, they are intended to be used only as guidelines.

The questionnaire spans all of the regulatory programs covered in this manual (i.e., RCRA, CERCLA, SARA Title III, Clean Air Act, Clean Water Act, OSHA) and presents questions to aid in establishing which specific requirements are applicable to your facility (for both your current practice and PP alternative). To answer the questions, you may need to locate further regulatory information. This information can be obtained by:

- referring to Appendix B of this manual;
- contacting facility personnel familiar with the regulatory aspects of your facility's operations; or
- referring to the regulations or acts pertaining to the programs for which you need information.

Actions

(1) Complete the Regulatory Status Questionnaire

Complete the questionnaire (Exhibit 3-1) by reviewing each of the questions on the right-hand side. If you answer the question affirmatively for your current practice, circule the status number under current practice. If you answer the question affirmatively for your PP alternative, circle the status number under PP alternative. For example, if your facility is a large quantity generator in the current practice (i.e., you produce more than 1000 kilograms of hazardous waste per month), yet in your proposed PP alternative you will completely eliminate your hazardous waste generation, you will circle the status number "1" in the column under the heading "Current Operation" and *will not* circle the status number "1" under the heading "PP Alternative." The circled status numbers will be needed in Step 2 when estimating costs for the specific requirements applicable to your facility.

STEP 2: ESTIMATE HIDDEN CAPITAL EXPENDITURES

Concept and Purpose

EPA's approach to environmental regulations over the past years has emphasized the need to install new technologies in order to protect the nation's environment. Provisions of the Resource Conservation and Recovery Act, the Clean Air Act, and the Clean Water Act provide examples of technology-forcing requirements and regulations promulgated by EPA. In addition to the technology-based federal regulatory requirements, there are many state regulatory programs that can also impose technology-forcing regulatory requirements.

Your firm may incur capital expenditures in the near future to satisfy technology-forcing requirements. For example, if you have an on-site surface impoundment, you may have to retrofit it with a double-liner in order to meet the minimum technology requirements of the land disposal restrictions. The costs of retrofitting will likely be significant and, therefore, you must consider them in the economic evaluation of any PP alternative to your current practice.

EXHIBIT 3-1

REGULATORY STATUS QUESTIONNAIRE
(for current and alternative practices) a/

Status Number		
Current Practice	PP Alternative	Does/Is Your Facility:
Resource Conservation and Recovery Act		
1	1	A RCRA large quantity generator?
2	2	A RCRA small quantity generator?
3	3	A primary exporter of hazardous waste?
4	4	Have hazardous waste storage tank(s) on site?
5	5	Transport hazardous waste?
6	6	A final status TSD facility?
7	7	An interim status TSD facility?
Comprehensive Environmental Response, Compensation, and Liability Act b/		
8	8	Have CERCLA Section 4661 chemicals (see Exhibit B-2-1)
Superfund Amendments and Reauthorization Act, Title III		
9	9	Handle any 40 CFR §355 Appendix A and B extremely hazardous substances at or above their Title III threshold?
10	10	Occasionally release reportable quantities (see 40 CFR §302 and Table 302.4) of CERCLA hazardous substances or any 40 CFR §355 Appendix A and B extremely hazardous substances?
11	11	Maintain any material safety data sheets under 29 CFR §1910.1200(g)(8) (see (22) under OSHA)?
12	12	Have 10 or more employees and fall within SIC codes 2000 to 3999 and within the current calendar year handle 40 CFR §372.65 toxic chemicals above thresholds stated in 40 CFR §372.25?
Clean Air Act		
13	13	A new stationary source (see Exhibit B-4-2 of Appendix B)?
14	14	Emit Section 112 hazardous air pollutants (see Exhibit B-4-3 of Appendix B)?
c/	c/	Within an industry listed in Exhibit B-4-4 of Appendix B?
c/	c/	Have a PSD permit?
c/	c/	Have a nonattainment permit?
Clean Water Act		
15	15	Discharge wastewaters directly to surface water?
16	16	Discharge wastewaters to a publicly owned treatment works (POTW)?

EXHIBIT 3-1 (continued)

REGULATORY STATUS QUESTIONNAIRE
(for current and alternative practices) a/

Status Number		
Current Practice	PP Alternative	Does/Is Your Facility:
Clean Water Act (continued)		
17	17	Occasionally discharge reportable quantities of hazardous substances as defined in 40 CFR §117?
18	18	Have toxic pollutant discharges listed in Exhibit B-5-2 of Appendix B for which chemical-specific standards have been promulgated?
c/	c/	Within an industry listed in Exhibit B-5-3 of Appendix B?
Occupational Safety and Health Act		
19	19	Have less than 10 employees or is it within SICs 52-89 (except 52-54, 70, 75, 76, 79, 80)?
20	20	Have 10 or more employees and is it not within SICs 52-89 (except 52-54, 70, 75, 76, 79, 80)?
21	21	Have OSHA air contaminants as per 29 CFR §1910.1000, Table Z-1, Z-2, or Z-3?
22	22	Handle any hazardous chemicals as defined in 29 CFR §1910.1200(c)?
23	23	A hazardous waste treatment, storage, and disposal facility (regulated under 40 CFR Parts 264 or 264), or a large quantity generator of hazardous waste, or a facility accumulation of hazardous wastes for 90 or more days (as defined in 40 CFR §262.34)?
c/	c/	Handle any OSHA chemicals listed in Exhibit B-6-2?

a/ For further information about the regulatory programs, see Appendix B or the appropriate sections of the Code of Federal Regulations. Other Federal Programs (e.g., Toxic Substances Control Act, Safe Drinking Water Act) and state programs (e.g., New Jersey ECRA) may apply but were not analyzed in this manual due to resource limitations. Note that SARA Section 312 (reporting on emergency preparedness) is covered by Status Number 11 and SARA Section 313 (reporting on environmental releases) is covered under Status Number 12.

b/ Most of these costs are covered in Tier 2, Liability Costs -- Chapter 4.

c/ These questions apply to additional chemical or industry-specific requirements that can impose significant costs, and should be considered. Due to their specific nature, however, these costs are not quantified in this manual.

Actions

(1) Identify Technology-Forcing Requirements

Your responses to the regulatory questionnaire should give you a good picture of existing regulations applicable to your firm under current and alternative practices. To find out about the technology-forcing nature of these requirements, either consult the regulations themselves (see Appendix B for a brief summary), read specialized literature (e.g., newsletters and magazines), consult the State's technical assistance program, or consult any environmental or legal experts available to your firm.

By establishing treatment standards for hazardous wastes and minimum technology requirements for land disposal, the land disposal restrictions provide a good example of technology-forcing requirements. Appendix E contains the treatment standards established under the land disposal restrictions for solvents, dioxins, and California list wastes. Treatment standards also have been or will be established for those hazardous wastes not included in Appendix E (the so-called remaining wastes).

(2) Estimate the Costs of Future Technologies

Estimate the capital outlay necessary to satisfy these technology-forcing requirements and report your estimates on Worksheet I either for the current and alternative practices separately, or incrementally for the PP alternative relative to the current practice. Remember, all cash outflows (costs) must be reported as negative numbers. As suggested in Worksheet I, you can categorize your hidden capital expenditures into the following items: monitoring equipment, preparedness and protective equipment, additional technology, and other. Of course, you can create your own items if these categories do not fit your needs.

STEP 3: ESTIMATE HIDDEN EXPENSES

Concept and Purpose

This step allows you to estimate the hidden expenses resulting from complying with the regulations applicable to the type of operations at your facility (e.g., having hazardous waste storage tanks, having various SARA Title III hazardous substances on site, etc.). Therefore, you will start by taking the regulatory status numbers determined in Step 1 and transferring them onto each of the Cost Tables (Tables 3-1 to 3-14) to help you limit the calculations to only those costs directly applicable to your facility.

Actions

For each of the fourteen types of regulatory requirements (i.e., for each of Tables 3-1 to 3-14), perform the following three actions:

(1) Identify Applicable Regulatory Requirements

For the current practice and the PP alternative, circle applicable status numbers by referring to Exhibit 3-1 as completed in Step 1. For example, if you have a hazardous waste storage tank on site under current practice, then you will have circled Status Number 4 under current practice in Exhibit 3-1. In this case, you will circle Status Number 4 under current practice every time this status number appears in the first column of Tables 3-1 to 3-14.

(2) Estimate the Cost of Each Applicable Regulatory Requirement

Having identified all specific regulatory requirements applicable to your facility (e.g., all notification requirements using Table 3-1), you will now estimate the costs of complying with those requirements as follows:

(a) if you do not recognize the requirement, look it up either in Appendix B under its regulatory program heading, or directly in the Code of Federal Regulations to see what the requirement entails;

(b) Calculate the Annual Cost of the specific requirement by one of the three following methods:

- If you have access to the total annual amount your facility is spending under this requirement, enter it in the Annual Cost Column.

- If you do not know the annual cost, use the cost equation provided with parameter values specific to your facility (i.e., facility-specific values of frequency f, non-labor costs m, time t, and loaded wage w for the specific regulatory requirement). Enter the cost estimate in the Annual Cost column.

- If you have neither the annual cost nor a basis on which to estimate your facility-specific parameter values, use or adjust the defaults provided in Tables 3-1 to 3-14. When either equations or defaults/estimates are not provided, you must rely on facility-specific information and best professional judgement to make estimates. Place your cost estimate in the Annual Cost column.

(3) Sum All Costs

Sum all costs in the Annual Cost column and place the total in the space provided at the bottom right of the cost table. After completing the applicable cost tables, transcribe the total annual costs from each table onto Worksheet I in the Cash Flow Estimates column of the middle block.

STEP 4: COMPLETE MIDDLE BLOCK OF WORKSHEET I

Concept and Purpose

Having estimated the total annual costs associated with each type of regulatory requirement (e.g., notification, reporting), you now will report these cost estimates onto Worksheet I and specify the escalation rates and lifetimes associated with these cash flows. For a brief overview and discussion of the concepts of escalation rate and lifetime, please refer to Chapter 2, Step 3.

Actions

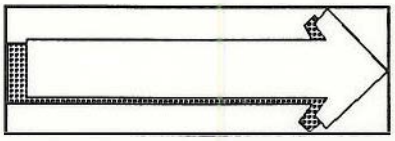
(1) Record the Cash Flow Amount

For each cash flow item, report your cash flow as estimated in Step 3.

(2) Estimate and Record the Escalation Rate

(3) Record the First Year of Cash Flow

(4) Estimate and Record the Lifetime



After completing Worksheet I, you should proceed to Chapter 6. Chapter 6 provides the financial protocol, which will give you instructions on how to (1) complete the right-hand block of the Tier 1 Cost Worksheet (i.e., annualized cash flow), and (2) calculate the annualized cost savings, net present value, and internal rate of return of each PP alternative practice relative to your current practice. These values will allow you to assess the economic feasibility of your PP alternative(s) taking into account usual costs, in addition to hidden regulatory costs.

COST TABLES

TABLE 3-1

Notification

$$C_N = f_N \times [m_N + (t_N \times w_N)]$$

- C_N, annual cost of notification ($ per year)
- f_N, frequency of notification (occurrences per year); e.g., a monthly notification has an f_N of 12
- m_N, non-labor costs associated with notification requirement ($ per occurrence); e.g., materials costs
- t_N, time required to complete a notification (hours per occurrence); e.g., time to gather information
- w_N, loaded wage rate of person(s) completing a notification ($ per hour)

NOTIFICATION COST TABLE

Status Number: Current Practice	Status Number: Alternative Practice	Requirement: Description	Requirement: Citation	Variable a/: f_N (Occ/Yr)	Variable a/: m_N ($/Occ)	Variable a/: t_N (Hrs/Occ)	Variable a/: w_N ($/Hr)	Annual Cost $f_N \times [m_N + (t_N \times w_N)]$ ($/Yr)
		RCRA b/						
3	3	Exportation of hazardous waste notification	§262.53	1	2	2-3	25	
6 7	6 7	RCRA foreign source notification	§264.12(a), §265.12(a)	0-5	1	2	20	
6	6	RCRA permit confirmation	§264.12(b)	1-4	1	2	20	
6 7	6 7	Local notification of operations	§264.37, §265.37	1	3	40	25	
6 7	6 7	Manifest discrepancy notification	§264.72, §265.72	0-125	1	2	25	
		CERCLA e/						
		SARA Title III b/						
9 10	9 10	Facility changes notification	§355.30(d)(1-2)	1-5	1	8	25	
9 10	9 10	Emergency follow-up notification	§355.40(b)(3)	0-2	1	8-16	25	
12	12	Supplier notification requirements	§372.45	0-2	1	2	9	
		CAA b/						
13	13	Startup, monitoring and operations change notifications	§60.7(a)					
14	14	Hazardous emissions test notification	§61.13	1	1	1	25	
		CWA b/						
15	15	NPDES discharge notification	§122.41(h)					
17	17	Hazardous pollutant discharge notification	§117.21					
18	18	Toxic pollutant discharge notifications d/	§129.5(e)(1-2)					
16	16	Industrial User slug loading notification	§403.12(f)					
		OSHA c/						
22 23	22 23	Material Safety Data Sheets	§1910.1200(g)(8)	0.04-8	1	0.25	9	
		State or Local						

TOTAL: $

a/ Default values are based on ICF analysis.
b/ Provision cites are from 40 CFR.
c/ Provision cites are from 29 CFR.
d/ This requirement applies only to the six toxic pollutants marked with an asterisk (*) on Exhibit B-5-2 of Appendix B.
e/ No notification requirement under this act was identified in this analysis. However, regional and local contingency planning may require notification.

TABLE 3-2

Reporting

$$C_R = f_R \times [m_R + (t_R \times w_R)]$$

- C_R, annual cost of reporting ($ per year)
- f_R, frequency of reporting (occurrences per year); e.g., a biennial report has an f_R of 0.5 because it is submitted once every two years
- m_R, non-labor costs associated with reporting requirement ($ per occurrence); e.g., materials costs
- t_R, time required to complete report (hours per occurrence); e.g., time to gather information
- w_R, loaded wage rate of person(s) filing report ($ per hour)

REPORTING COST TABLE

Status Number		Requirement		Variable a/				Annual Cost
Current Practice	Alternative Practice	Description	Citation	f_R (Occ/Yr)	m_R ($/Occ)	t_R (Hrs/Occ)	w_R ($/Hr)	$f_R \times [m_R + (t_R \times w_R)]$ ($/Yr)
		RCRA b/						
1 2	1 2	Generators Biennial Report	§262.41	0.5	5	8	25	
1	1	LQG Exception Report	§262.42(a)	0.1-1.5	1	2	25	
2	2	SQG Exception Report	§262.42(b)	0-0.1	1	0.25	25	
3	3	Primary Exporters Exception Report	§262.55	0.1-1.5	1	2	25	
3	3	Primary Exports Annual Report	§262.56	1	2	2.5	25	
6 7	6 7	TSDF Biennial Report	§264.35, §265.75	0.5	5	8-40	25	
6 7	6 7	TSDF unmanifested waste report	§264.76, §265.76	0-125	1	1	25	
6 7	6 7	Release, fire, explosion, and closure reporting	§264.77, §265.76	2	2	5	25	
		CERCLA f/						
		SARA Title III b/						
11	11	Supplemental MSDS report	§370.21(c)	0.04-8	4	0.5	20	
11	11	Requested MSDS report	§370.21(d)	d/	1	0.25	20	
11	11	Inventory report	§370.25(a)	1	1	5	25	
11	11	Tier II reporting by request	§370.25(c)	0-1	1	5	25	
12	12	Excess of applicable threshold report	§372.30(a)	1	1	8-40	25	
		C A b/						
13	13	Quarterly Compliance and Monitoring Assessment Report	§60.7(c)	4	2	5	25	
13	13	Performance test results reporting	§60.8	4	2	2	25	
13	13	Opacity test results reporting	§60.11	4	2	2	25	
14	14	Hazardous pollutant emissions reporting	§61.10	1	2	8	25	
14	14	Hazardous pollutant monitoring system reporting	§61.14	2	1	5	25	
		CWA b/						
15	15	NPDES permit reporting requirements	§122.411					
16	16	Industrial Users' continued compliance reports	§403.12(e)	2	2	5	25	
18	18	Toxic standards annual compliance report e/	§129.5(d)(2)	1-6	1	5	25	
		OSHA c/						
20	20	Injury and illness reporting each occurrence	§1904.4	0.05-5	1	1.5	20	
20	20	Injury and Illness nnual Summary	§1904.5	1	0.25	1	20	
19 20	19 20	Fatality or hospitalization report	§1904.8	0.005-0.5	0	1-10	20	
19 20	19 20	Occupational Injuries and Illness Survey	§1904.21	1-2	0	0.5-3	20	
		State or Local						
						TOTAL:	$	

a/ Default values are based on ICF analysis.
b/ Provision cites are from 40 CFR.
c/ Provision cites are from 29 CFR.
d/ Site-specific.
e/ This requirement applies only to six toxic pollutants marked with an asterisk (*) on Exhibit B-5-2 of Appendix B.
f/ No reporting requirement under this act was identified in this analysis. However, regional and local contingency planning may have additional reporting requirements.

TABLE 3-3

Monitoring/Testing

$$C_M = f_M \times [m_M + (t_M \times w_M)]$$

- C_M, annual cost of monitoring and testing ($ per year)
- f_M, frequency of monitoring/testing (occurrences per year); e.g., a test performed weekly would have an f_M of 52
- m_M, non-labor costs associated with monitoring/testing requirement ($ per occurrence); e.g., materials coats
- t_M, time required to complete test or monitoring (hours per occurrence), e.g., time to prepare and run equipment, then analyze results
- w_M, loaded wage rate of person(s) filing report ($ per hour)

MONITORING/TESTING COST TABLE

Status Number		Requirement		Variable a/				Annual Cost
Current Practice	Alternative Practice	Description	Citation	f_M (Occ/Yr)	m_M ($/Occ)	t_M (Hrs/Occ)	w_M ($/Hr)	$f_M \times [m_M + (t_M \times w_M)]$ ($/Yr)
		RCRA b/						
6 7	6 7	Hazardous waste chemical and physical analysis	§264.13, §265.13					
6	6	Groundwater monitoring	§264.97					
7	7	Groundwater monitoring/land-based Interim Status TSDFs	§265.90					
		CERCLA d/						
		SARA Title III d/						
		CAA b/						
13	13	Emissions control performance testing	§60.8					
13	13	Continuous monitoring system	§60.13					
13	13	Continuous Opacity Monitoring System	§60.11					
14	14	Hazardous pollutant testing	§61.13					
14	14	Hazardous pollutant monitoring	§61.14					
		CWA b/						
15	15	Effluent stream monitoring and sampling	§122.41(j)					
16	16	Pretreatment standards monitoring	§403.12					
18	18	Daily toxic pollutant sampling d/	§129.5(d)(3)					
		OSHA d/						
		State or Local						

TOTAL: $ _____

a/ No default values are provided.
b/ Provision cites are from 40 CFR.
c/ This requirement applies only to six toxic pollutants marked with an asterisk (*) on Exhibit B-5-2 of Appendix B.
d/ No monitoring/testing requirement under this act was identified in this analysis.

TABLE 3-4

Recordkeeping

$$C_{RK} = f_{RK} \times [m_{RK} + (t_{RK} \times w_{RK})]$$

- C_{RK}, annual cost of recordkeeping ($ per year)
- f_{RK}, frequency of record (occurrences per year); e.g., a record of a monthly performance test would have a f_{RK} of 12
- m_{RK}, non-labor costs associated with recordkeeping ($ per occurrence); e.g., materials costs
- t_{RK}, time required to record information (hours per occurrence), e.g., time to transcribe data
- w_{RK}, loaded wage rate of person(s) keeping records ($ per hour)

RECORDKEEPING COST TABLE

Status Number		Requirement		Variable a/				Annual Cost
Current Practice	Alternative Practice	Description	Citation	f_{RK} (Occ/Yr)	m_{RK} ($/Occ)	t_{RK} (Hrs/Occ)	w_{RK} ($/Hr)	$f_{RK} \times [m_{RK} + (t_{RK} \times w_{RK})]$ ($/Yr)
		RCRA b/						
1 2	1 2	Reports, test results, and waste analysis records	§262.40	5-100	1	0.25	9	
3	3	Exporter's reports and notifications records	§262.57	5	1	0.25	9	
5	5	Manifesting records	§263.22	0-200	1	0.25	9	
6 7	6 7	Operating record	§264.73, §265.73	250	1	0.25	9	
		CERCLA e/						
		SARA Title III b/						
12	12	Excess of threshold reports and documentation	§372.10(a)	0-2	1	1	9	
12	12	Notification determination records	§372.10(b)	0-2	1	1	9	
		CAA b/						
13	13	Startup, shutdown, and malfunction records	§60.7(b)	10	1	1	9	
13	13	Performance test data records	§60.8	4	1	0.25	9	
13	13	Opacity test data record	§60.11	4	1	0.25	9	
14	14	Hazardous pollutant monitoring data records	§61.14	4	1	1	9	
14	14	Hazardous emissions test results records	§61.13	4	1	1	9	
		CWA b/						
15	15	NPDES monitoring records	§122.41(j)					
16	16	Industrial users/POTW pretreatment records	§403.12(1)					
18	18	Toxic pollutant effluent discharge compliance records d/	§129.(5)(d)(1,2)					
		OSHA c/						
19 20	19 20	Occupational injuries and illness log and summary	§1904.2,.6	1-5	3	0.25	9	
23	23	Medical Surveillance program records	§1910.120(o)(2)					
		State or Local						

TOTAL: $

a/ Default values are based on ICF analysis.
b/ Provision cites are from 40 CFR.
c/ Provision cites are from 29 CFR.
d/ This requirement applies only to six toxic pollutants marked with an asterisk (*) on Exhibit B-5-2 of Appendix B.
e/ No recordkeeping requirement under this act was identified in this analysis.

TABLE 3-5

Planning/Studies/Modeling

$$C_{PSM} = f_{PSM} \times [m_{PSM} + (t_{PSM} \times w_{PSM})]$$

- C_{PSM}, annual cost of planning/studies/modeling ($ per year)
- f_{PSM}, frequency of planning/studies/modeling (occurrences per year)
- m_{PSM}, non-labor costs associated with planning/studies/modeling ($ per occurrence); e.g., materials costs
- t_{PSM}, time required to complete planning/studies/modeling (hours per occurrence), e.g., time to gather information, perform calculations, etc.
- w_{PSM}, loaded wage rate of person(s) performing planning/studies/ modeling ($ per hour)

PLANNING/STUDIES/MODELING COST TABLE

Status Number		Requirement		Variable a/				
Current Practice	Alternative Practice	Description	Citation	f_{PSM} (Occ/Yr)	m_{PSM} ($/Occ)	t_{PSM} (Hrs/Occ)	w_{PSM} ($/Hr)	Annual Cost $f_{PSM} \times [m_{PSM} + (t_{PSM} \times w_{PSM})]$ ($/Yr)
		RCRA b/						
6	6	Final Status TSDF detection monitoring program	§264.98					
7	7	Ground-water outline of Interim Status TSDFs	§265.93					
6	6	Final Status TSDF compliance monitoring program	§264.99					
6 7	6 7	Emergency and Contingency Plan Procedures	§264, §265 Subpart D					
6 7	6 7	Cost estimate for facility closure	§264.142, §265.142					
		CERCLA d/						
		SARA Title III d/						
		CAA d/						
		CWA d/						
		OSHA c/						
22	22	Hazard communication program	§1910.1200(e)					
23	23	Safety and health program	§1910.120(o)(3)					
23	23	Emergency response program	§1910.120(1)					
		State or Local						

TOTAL: $

a/ No default values are provided.
b/ Provision cites are from 40 CFR.
c/ Provision cites are from 29 CFR.
d/ No planning/studies/modeling requirements under this act were identified in this analysis.

TABLE 3-6

Training

$$C_T = f_T \times [m_T + (t_T \times w_T)]$$

- C_T, annual cost of training ($ per year)
- f_T, number of employees trained per year (employees per year)
- m_T, non-labor costs associated with training employees ($ per employee); e.g., materials costs
- t_R, time required for one instructor to train one employee (hours per employee); e.g., a two hour training session in which one instructor trains four employees would result in a t_R of 0.5
- w_R, loaded wage rate of person(s) training your employees ($ per hour)

TRAINING COST TABLE

Status Number		Requirement		Variable a/				Annual Cost
Current Practice	Alternative Practice	Description	Citation	f_T (Occ/Yr)	m_T ($/Occ)	t_T (Hrs/Occ)	w_T ($/Hr)	$f_T \times [m_T + (t_T \times w_T)]$ ($/Yr)
		RCRA b/						
2	2	SQG Emergency response coordinator	§262.34(d)(5)(i)					
2	2	SQG waste handling and emergency training	§262.34(d)(5)(iii)					
6 7	6 7	Personnel training	§264.16, §265.16					
6 7	6 7	TSDF emergency response coordinator training	§264.55, §265.55					
		CERCLA/SARA d/						
		SARA Title III d/						
		CAA d/						
		CWA d/						
		OSHA c/						
22 23	22 23	Initial assignment and addition of hazard training	§1910.1200(h)					
23	23	Hazardous waste training	§1910.120(o)(5)					
		State or Local						

TOTAL: $

a/ No default values are provided.
b/ Provision cites are from 40 CFR.
c/ Provision cites are from 29 CFR.
d/ No training requirement under this act was identified in this analysis.

TABLE 3-7

Inspections

$$C_I = f_I \times [m_I + (t_I \times w_I)]$$

- C_I, annual cost of inspections ($ per year)
- f_I, frequency of inspection (occurrences per year); e.g., a daily tank inspection has an f_I of 365
- m_I, non-labor costs associated with inspection requirement ($ per occurrence); e.g., materials costs
- t_I, time required to complete inspection or even prepare for a state performed inspection (hours per employee); e.g., time to gather information
- w_I, loaded wage rate of person(s) involved with the inspection ($ per hour)

INSPECTIONS COST TABLE

Status Number		Requirement		Variable a/				Annual Cost
Current Practice	Alternative Practice	Description	Citation	f_I (Occ/Yr)	m_I ($/Occ)	t_I (Hrs/Occ)	w_I ($/Hr)	$f_I \times [m_I + (t_I \times w_I)]$ ($/Yr)
		RCRA b/						
6	6	Facility/Inspection and inspection schedule	§264.174					
		"	§264.193-.195					
		"	§264.226					
		"	§264.253-.254					
		"	§264.303					
		"	§264.347					
1 & 4	1 & 4	LQG tank inspections	§265.195	250	0	0.50d/	20	
2 & 4	2 & 4	SQG tank inspections	§265.201	125	0	0.50d/	20	
		CERCLA d/						
		SARA Title III b/						
11	11	§ Fire Department inventory inspections	§370.25					
		CAA b/						
13	13	Point source inspections	§60.11					
		CWA b/						
15	15	Compliance inspections	§122.41(i)					
		OSHA d/						
		State or Local						

TOTAL: $

a/ Default values are based on ICF analysis.
b/ Provision cites are from 40 CFR.
c/ On a per-storage-tank basis.
d/ No inspection requirement under this act was identified in this analysis.

TABLE 3-8

Manifesting

$$C_{MF} = f_{MF} \times [m_{MF} + (t_{MF} \times w_{MF})]$$

- C_{MF}, annual cost of writing manifests ($ per year)
- f_{MF}, frequency of manifests (manifests per year); e.g., facility wastes manifested about three times a month would have a f_{MF} of 36
- m_{MF}, non-labor costs associated with manifest writing ($ per manifest); e.g., materials costs
- t_{MF}, time required to write a manifest (hours per manifest)
- w_{MF}, loaded wage rate of person(s) writing manifest ($ per hour)

MANIFESTING COST TABLE

Status Number		Requirement		Variable a/				
Current Practice	Alternative Practice	Description	Citation	f_{MF} (Occ/Yr)	m_{MF} ($/Occ)	t_{MF} (Hrs/Occ)	w_{MF} ($/Hr)	Annual Cost $f_{MF} \times [m_{MF} + (t_{MF} \times w_{MF})]$ ($/Yr)
		RCRA b/						
1 2	1 2	Generators off-site transport manifesting	§262 Subpart B	4-100	0.5	0.25-1	25	
5	5	Transporter shipment manifest	§263.20	4-500	0.5	1-3	15-25	
6 7	6 7	TSDF standard manifesting	§264.71, §265.71	4-500	0.5	0.25-1	25	
		CERCLA c/						
		SARA Title III c/						
		CAA c/						
		CWA c/						
		OSHA c/						
		State or Local						

TOTAL: $

a/ Default values are based on ICF analysis.
b/ Provision cites are from 40 CFR.
c/ No manifesting requirement under this act was identified in this analysis.

TABLE 3-9

Labeling

$$C_L = f_L \times [m_L + (t_L \times w_L)]$$

- C_L, annual cost of labeling ($ per year)
- f_L, number of items labeled per year (labels per year)
- m_L, non-labor costs associated with labeling requirements ($ per label); e.g., materials costs
- t_L, time required to label one item (hours per label)
- w_L, loaded wage rate of person(s) labeling ($ per hour)

LABELING COST TABLE

Status Number: Current Practice	Status Number: Alternative Practice	Requirement: Description	Requirement: Citation	Variable a/: f_L (Occ/Yr)	Variable a/: m_L ($/Occ)	Variable a/: t_L (Hrs/Occ)	Variable a/: w_L ($/Hr)	Annual Cost: $f_L \times [m_L + (t_L \times w_L)]$ ($/Yr)
		RCRA b/						
1 2	1 2	Pre-Transportation labeling	§262.31	4-500	2	0.25	15	12
1 2	1 2	Hazardous waste package marking	§262.32	4-500	2	0.25	15	12
1 2	1 2	Transporter placarding	§262.33	4-500	15	0.25	15	12
		CERCLA d/						
		SARA Title III d/						
		CAA d/						
		CWA d/						
		OSHA c/						
22	22	Hazardous chemical labeling	§1910.1200(f)(4-8)					
		State or Local						

TOTAL: $

a/ Default values are based on ICF analysis.
b/ Provision cites are from 40 CFR.
c/ Provision cites are from 29 CFR.
d/ No labeling requirement under this act was identified in this analysis.

TABLE 3-10

Preparedness/Protective Equipment (Maintenance)

$$C_{PPE} = [f_{PPE} \times (m_{PPE} + (t_{PPE} \times w_{PPE}))] + e_{PPE}$$

- C_{PPE}, annual cost of equipment maintenance/replacement ($ per year)
- f_{PPE}, frequency of equipment maintenance/replacement (occurrences per year)
- m_{PPE}, non-labor costs associated with equipment maintenance/replacement ($ per label); e.g., supplies cost
- t_{PPE}, time required to complete equipment maintenance/replacement (hours per occurrence); e.g., time to gather information
- w_{PPE}, loaded wage rate of person(s) performing task ($ per hour)
- e_{PPE}, annual cost of any non-labor items not specifically associated with a single maintenance/replacement operation ($ per year); e.g., maintenance tools and respirators

PREPAREDNESS/PROTECTIVE EQUIPMENT COST TABLE

Status Number		Requirement		Variable a/				Annual Cost
Current Practice	Alternative Practice	Description	Citation	f_{PPE} (Occ/Yr)	m_{PPE} ($/Occ)	t_{PPE} (Hrs/Occ)	w_{PPE} ($/Hr)	$f_{PPE} \times [m_{PPE} + (t_{PPE} \times w_{PPE})]$ ($/Yr)
		RCRA b/						
6 7	6 7	Internal communicating alarm system, fire control equipment, etc.	§264.32-.34 §265.32-.34					
		CERCLA/SARA d/						
		SARA Title III d/						
		CAA d/						
		CWA b/						
15	15	NPDES backup or auxiliary facilities	§122.41(e)					
		OSHA c/						
21	21	Restricted exposure to Table Z-1, Z-2, and Z-3 constituents	§1910.1000					
		State or Local						

TOTAL: $

a/ No default values are provided.
b/ Provision cites are from 40 CFR.
c/ Provision cites are from 29 CFR.
d/ No preparedness/protective equipment requirements under this act were identified in this analysis.

TABLE 3-11

Closure/Post Closure Assurance

Facility-Specific Costs

CLOSURE/POST CLOSURE COST TABLE

Status Number		Requirement		Annual Cost
Current Practice	Alternative Practice	Description	Citation	
		RCRA a/		
6	6	Financial assurance for closure and post-closure	§264.143, §265.143	
		"	§264.145, §265.145	
		State or Local		
			TOTAL:	$

a/ Provision cites are from 40 CFR.

TABLE 3-12

Medical Surveillance

$$C_{MS} = f_{MS} \times [P_{MS} + (t_{MS} \times w_{MS})]$$

- C_{MS}, annual cost of medical surveillance ($ per year)
- f_{MS}, frequency of medical surveillance (occurrences per year); e.g., if 5 employees receive medical checkups twice a year, the f_{MS} is 2 x 5, or 10
- P_{MS}, professional costs associated with medical surveillance ($ per occurrence); e.g., physician cost
- t_{MS}, time required to complete medical surveillance (hours per occurrence);
- w_{MS}, loaded wage rate of person(s) receiving medical surveillance ($ per hour)

MEDICAL SURVEILLANCE COST TABLE

Status Number		Requirement		Variable a/				Annual Cost
Current Practice	Alternative Practice	Description	Citation	f_{MS} (Occ/Yr)	a_{MS} ($/Occ)	t_{MS} (Hrs/Occ)	w_{MS} ($/Hr)	$f_{MS} \times [a_{MS} + (t_{MS} \times w_{MS})]$ ($/Yr)
		RCRA c/						
		CERCLA c/						
		SARA Title III c/						
		CAA c/						
		CWA c/						
		OSHA b/						
23	23	Hazardous waste medical surveillance program	$1910.120(o)(2)					
		State or Local						
							TOTAL:	$

a/ No default values are provided.
b/ Provision cites are from 29 CFR.
c/ No medical surveillance requirement under this act was identified in this analysis.

TABLE 3-13

Insurance and Special Taxes

Requirement-Specific Costs

INSURANCE AND SPECIAL TAXES

Status Number		Requirement		Annual Cost
Current Practice	Alternative Practice	Description	Citation	
6	6	RCRA a/ Financial responsibility requirements	§264.147	
8	8	CERCLA a/ Taxes on certain chemicals	CERCLA Sec. 4661	
		SARA Title III b/		
		CAA b/		
		CWA b/		
		OSHA b/		
		State or Local		

TOTAL: $

a/ Provision cites are from 40 CFR.
b/ No insurance or special tax requirements under this act were identified in this analysis.

TABLE 3-14

Other

OTHER

Status Number		Requirement		Annual Cost
Current Practice	Alternative Practice	Description	Citation	
		RCRA		
		CERCLA		
		SARA Title III		
		CAA		
		CWA		
		OSHA		
		State or Local		

TOTAL: $

Worksheet I
Tier 1 • *Hidden Costs*

☐ Current Practice
☐ Alternative Practice
☐ Incremental

ITEM DESCRIPTION	CASH FLOW INFORMATION				ANNUALIZED CASH FLOW [a]			
	Escalation Rate (r_e, %)	First Year of Cash Flow (t_1, years)	Lifetime (n, years)	Cash Flow Estimate (C, [a])	r_d = 5%	r_d = 10%	r_d = 15%	r_d =
A. DEPRECIABLE CAPITAL EXPENDITURES								
A1 Monitoring Equipment								
A2 Preparedness and Protective Equipment								
A3 Additional Technology								
A4 Other								
B. EXPENSES								
B1 Notification								
B2 Reporting								
B3 Monitoring/Testing								
B4 Recordkeeping								
B5 Planning/Studies/Modeling								
B6 Training								
B7 Inspections								
B8 Manifesting								
B9 Labeling								
B10 Preparedness and Protective Equipment								
B11 Closure/Post Closure Care								
B12 Medical Surveillance								
B13 Insurance/Special Taxes								
B14 Other								

[a] *In thousands of year-0 dollars*

CHAPTER 4

TIER 2 COST PROTOCOL: LIABILITY COSTS

This chapter describes the cost protocol for estimating potential liability costs associated with hazardous waste and materials management. Two types of liabilities are addressed: penalties and fines associated with non-compliance, and other liabilities referred to as future liabilities. The steps and approach outlined below will assist you in completing the middle block of the Tier 2 worksheet (Worksheet II) attached to the end of this chapter.

STEPS	APPROACH
For the current practice and each PP alternative:	
Penalties and Fines	**Penalties and Fines**
1. Identify the regulatory programs and specific requirements for which your facility could be penalized for non-compliance.	1. Check the applicable regulatory programs and requirements in Exhibit 4-1.
2. Estimate the expected annual penalties and fines associated with each program/requirement.	2. Use statistics on penalties and fines summarized in Exhibit 4-1. Compare to historical penalties and fines at your facility.
Future Liabilities	**Future Liabilities**
3. Identify those waste and materials management activities to which future liabilities can attach.	3. Focus on activities that potentially could cause personal injury and property damage (e.g., past and current tank storage and treatment, transportation, and land disposal practices).
4. Estimate the total expected liabilities associated with each activity.	4. Compare to claims, awards, and settlements under known liability cases, or use predictive modeling approach outlined in this chapter.
5. For each activity, estimate the year in which these liabilities are expected to be incurred.	5. Estimate time of travel to exposure points (e.g., drinking water well) or damage areas (e.g., river).
6. For each activity, estimate your company's share of total expected liabilities.	6. Pro-rate total liabilities as a function of your company's relative ability to pay and contribution to waste handled.

INTRODUCTION

Liability costs include penalties and fines due to non-compliance, and future liabilities for remedial action, personal injury, and property damage associated with routine and accidental hazardous releases. Like the hidden regulatory costs of Tier 1 (see Chapter 3), liability costs are hidden because you may not believe that you will incur them or you may underestimate their amount.

The likelihood and amount of liability costs can be very significant. For this reason, you are encouraged to factor estimates of expected liability costs into the aggregate costs for your current practice and your PP alternative. The Tier 2 analysis described below will assist you in estimating the likelihood and amount of liability costs at your facility.

PENALTIES AND FINES

STEP 1: IDENTIFY REGULATORY PROGRAMS UNDER WHICH PENALTIES AND/OR FINES COULD BE INCURRED

Exhibit 4-1 shows the major EPA environmental programs and specific requirements (in footnote) prescribing penalties and fines for non-compliance or violations.[1] Under the Clean Water Act (CWA), for example, Exhibit 4-1 references penalties for NPDES violations, oil or hazardous material spills violations (Section 311(b)), and dredge and fill violations, including wetland protection (Section 404(s)). Check Exhibit 4-1 for those regulatory programs where you could be penalized or fined for non-compliance. Supplement this exhibit with your knowledge of plant operations and any previous penalties and fines imposed on your plant.

STEP 2: ESTIMATE THE EXPECTED ANNUAL PENALTIES AND FINES ASSOCIATED WITH EACH PROGRAM/REQUIREMENT

For each regulatory program, you can use Exhibit 4-1 to estimate the expected annual value of penalties and fines that may be assessed on your plant as follows:

(1) Select a value of the penalty or fine from the range indicated: Exhibit 4-1 shows broad ranges of penalties and fines imposed in Fiscal Year 1987. For example, penalties and fines under RCRA in Fiscal Year 1987 ranged between $500 and $115,000, with a median penalty or fine value of $7,550. Actual penalties and fines will depend on the severity of the violation. Note that Exhibit 4-1 is for Federal enforcement actions only; in particular, Exhibit 4-1 does not reflect penalties and fines imposed by states and local governments. State and local penalties and fines potentially can be higher than Federal penalties and fines.

(2) Enter a value for the probability that you will be penalized or fined in a given year: Exhibit 4-1 provides a column for you to enter your estimate of the probability that your plant will be penalized or fined for non-compliance with this program. The value of the probability must be between 0 and 1 and must reflect past violations at your plant or other similar plants.

(3) Multiply your estimates of dollar value and probability of penalties/fines to obtain the expected value of penalties and fines.

(4) Sum the calculated expected penalties or fines over all programs/requirements and enter the total in the spaces provided at the right-hand column in Exhibit 4 and in Worksheet II.

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[1] Exhibit 4-1 is based on "Overview of EPA Federal Practices, FY 86 and 87," Compliance Policy and Planning Branch, Office of Enforcement and Compliance Monitoring, March 1988.

EXHIBIT 4-1

SUMMARY OF PENALTIES AND FINES UNDER EPA FEDERAL PROGRAMS (FISCAL YEAR 1987)

Check if Applicable	Regulatory Program	Range of Penalties/ Fines Assessed ($) Low	High	Median	Probability of Penalties/Fines	Expected Value of Penalties/Fines
____	**RCRA**	500	115,000	7,550	_____	_____
____	**CAA, Stationary Source**					
	Judicial	-	600,000	65,750	_____	_____
	Administrative	1,270	1,270	1,270	_____	_____
____	**CAA, Mobile Source**					
	Judicial	21,000	180,000	100,500	_____	_____
	Administrative	100	2,600,000	1,000	_____	_____
____	**CWA**	-	1,000,000	50,000	_____	_____
____	**SDWA**					
	Judicial	1,000	6,200	3,000	_____	_____
	Administrative	2,050	10,000	-	_____	_____
____	**TSCA**	-	1,000,000	1,300	_____	_____
____	**FIFRA**	-	25,000	780	_____	_____
					Total	_____

RCRA. Section 3008(a) of RCRA authorizes assessment of a penalty for any person in violation of Subtitle C requirements. Civil penalties may be assessed up to $25,000 per day of violation, depending upon the seriousness of the violation and any good faith efforts to comply with the appropriate requirements.

CAA, Stationary Source Program. Two sources of civil penalty authority: (1) civil judicial under Section 311, limited to $25,000 per day of violation, and (2) civil administrative under Section 120, designed to recover the economic benefit gained through non-compliance.

CAA, Mobile Sources. Violations of the antitampering provisions of Section 203 are subject to a $10,000 penalty (for new car dealers and manufacturers) or a $2,500 penalty (for fleet operators and repair facilities). Violators of the fuels regulations promulgated under Section 211 are potentially subject to $10,000 per day per violation.

CWA. Most penalties are for NPDES violations under Sections 309(d) & (g), including pretreatment. A relatively smaller number of penalties is assessed for violations of Sections 311 or 404. Section 311 deals with oil or hazardous material spills. Section 311(b) authorizes civil penalties of up to $50,000 per violation or $250,000 if the violation is willful. Section 404 deals with dredge and fill violations including wetlands protection. Under Section 404(s), violators are subject to a maximum civil penalty of $25,000 per day for each violation.

SDWA. Under the SDWA, penalties can be assessed for non-compliance with the UIC (Underground Injection Control) and PWS (Public Water System) programs. UIC and PWS violators are subject to a $25,000 per day judicial civil penalty. Violators of public notification, monitoring and recordkeeping requirements are subject in court to $25,000 total civil penalties.

TSCA. Persons who violate Section 15 of TSCA are liable for a civil penalty not to exceed $25,000 for each violation, as authorized by Section 15 of the Act. Criminal penalties of not more than $25,000 for each day of violation may also be imposed upon violators.

FIFRA. Civil penalties not to exceed $5,000 for each offense are authorized under Section 14(a) of FIFRA. Violations of the Act are also subject to criminal penalties of no more than $25,000 or one year in jail.

FUTURE LIABILITIES

STEP 3: IDENTIFY WASTE MANAGEMENT COMPONENTS TO WHICH LIABILITIES CAN ATTACH

Future liability (FL) costs can attach to both current and alternative waste management practices. Future liability costs are strictly equal to zero if and only if your company generates no hazardous waste and releases no hazardous materials. Opportunities for future liabilities can arise from non-permitted potential releases as well as permitted releases. In particular, you may want to focus your attention on the following waste management activities to which significant future liabilities can attach:

- Treatment or storage in tanks;
- Transportation; and
- Land disposal (on-site or off-site).

STEP 4: ESTIMATE TOTAL EXPECTED LIABILITIES

There are seven types of liability costs that are potentially associated with each waste or materials management activity:

- Soil and waste removal and treatment (FL1, Exhibit C-1, Appendix C):
- Ground-water removal and treatment (FL2, Exhibit C-2, Appendix C);
- Surface sealing (FL3, Exhibit C-3, Appendix C);
- Personal injury (FL4, Exhibit C-4, Appendix C);
- Economic loss (FL5, Exhibit C-5, Appendix C);
- Real property damage (FL6, Exhibit C-6, Appendix C); and
- Natural resource damage (FL7, Exhibit C-7, Appendix C).

You can estimate the magnitude of total liabilities associated with each waste and materials management activity by comparing your particular activities to other known activities where actual claims, awards, or settlements have been documented. Real-life liabilities generally are reported in specialized literature, such as environmental newsletters, as well as newspapers.

You can also use the conceptual framework outlined in Appendix C for developing these liability costs. If you choose to use the methodology described in Appendix C, you must be careful in handling the numbers presented. Specifically, keep in mind the uncertainties inherent to the problem at hand and the numerous assumptions made to establish a predictive modeling approach. Because Tier 2 is judgmental in nature, your estimates of future liabilities will reflect subjective corporate policy and not precise, scientific calculations.

To assist in estimating the costs to be used in Worksheet II (Page 4-7), an intermediate worksheet is presented in Exhibit 4-2. You should complete Exhibit 4-2 for your PP alternative compared to your current practice, taking into account any residual future liabilities due to current and past practices. Exhibits C-1 to C-8 of Appendix C illustrate how you can estimate the magnitude of future liability costs for each of the seven types of future liabilities for each applicable waste management practice, and the first year of cash flow.

EXHIBIT 4-2

COST TABLE FOR FUTURE LIABILITIES

Type of Liability	Exhibit # in Appendix C a/	Tanks Treatment/Storage	Transportation	Land Disposal
Soil and Waste Removal and Treatment	C-1			
Ground-Water Removal and Treatment	C-2			
Surface Sealing	C-3			
Personal Injury	C-4			
Economic Loss	C-5			
Real Property Damage	C-6			
Natural Resource Damage	C-7			
Total Liability (TL)	NA			
Your Share of Total Liability (f_L)	NA			
Cash Flow Estimate (= TL x f_L)	NA			
First Year of Cash Flows b/	C-8			

NA = Not Applicable

a/ Refer to Appendix C, Exhibits C-1 through C-8, for preliminary illustrative guidance on how to estimate each type of liability and the first year of cash flow. Note, however, that Appendix C is meant only to be illustrative of the concept and mechanics of future liabilities associated with hazardous materials and waste management. Appendix C cannot and should not be used for definite answers to the very complex problem of liabilities.

b/ The timing of future liabilities is very important because, other things being equal, liabilities incurred in a distant future have a smaller net present value, and therefore a lesser impact on the economic feasibility of a PP alternative, than liabilities incurred in the near future.

STEP 5: ESTIMATE YEAR WHEN LIABILITIES ARE EXPECTED TO BE INCURRED

Because you have calculated penalties and fines on an expected annual basis, penalties and fines are expected to be incurred annually starting from the first year (year 1), and until the end of the PP project. Therefore, set the first year equal to 1 for penalties and fines in Worksheet II.

For future liabilities, the first year of cash flow is obtained by completing the last line in Exhibit 4-2. This calculation is presented in Exhibit C-9 for each waste management pracitce. Perform the calculations and enter your results on Exhibit 4-2 and on Worksheet II.

STEP 6: ESTIMATE YOUR SHARE OF TOTAL FUTURE LIABILITIES

This step applies only to future liabilities. For off-site disposal or transportation, where not all of the waste disposed or transported is yours, you are not necessarily liable for all the waste. To account for this you should calculate a liability fraction, alpha, which ranges from 0 to 1. As a first approximation for calculating alpha, you can use the following formula:

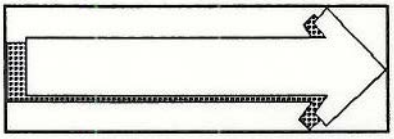
$$\text{alpha} = Q / Q_t$$

where

Q = Your waste quantity contributed; and
Q_t = The total quantity of waste managed.

A factor of zero would mean that you are not liable (perhaps for financial reasons) for your waste, whereas a factor of one would mean that you are fully liable for the waste involved in the activity. Enter your value for this factor in Exhibit 4-2 for each activity.

The final step in filling out Exhibit 4-2 is summing for each waste management practice the seven types of future liability costs and multiplying them by their corresponding liability factors, alpha. Enter this product as the "Cash Flow Estimate" in Exhibit 4-2 as well as in the appropriate cells of Worksheet II.



After completing Worksheet II, you should proceed to Chapter 6. Chapter 6 guides you through the financial protocol with instructions on how to (1) complete the right-hand block of the Tier 2 Cost Worksheet (i.e., annualized cash flows), and (2) calculate the annualized cost savings, net present value, and internal rate of return of each alternative PP practice relative to current practice. These values will allow you to assess the economic feasibility of your PP alternative(s) taking into account liabilities, in addition to usual and hidden costs.

Worksheet II
Tier 2 • *Liability Costs*

☐ Current Practice
☐ Alternative Practice
☐ Incremental

ITEM DESCRIPTION	CASH FLOW INFORMATION				ANNUALIZED CASH FLOW [a]			
	Escalation Rate (r_e, %)	First Year of Cash Flow (t_1, years)	Lifetime (n, years)	Cash Flow Estimate (C, [a])	r_d = 5%	r_d = 10%	r_d = 15%	r_d =
A. PENALITIES AND FINES								
B. FUTURE LIABILITIES								
B1 Treatment or Storage in Tanks								
B2 Transportation								
B3 Disposal in Landfills								
B4 Other								

[a] *In thousands of year-0 dollars*

CHAPTER 5

TIER 3 COST PROTOCOL: LESS TANGIBLE COSTS

This chapter outlines the steps for assessing the less tangible costs of pollution generation and, conversely, the less tangible benefits of pollution prevention. The steps and approach outlined below will assist you in completing the middle block of the Tier 3 worksheet (Worksheet III) attached at the back of this chapter.6

STEPS	APPROACH
1. Qualify less tangible benefits of pollution prevention.	1. Ask yourself whether corporate commitment to pollution prevention would favor and strengthen consumer acceptance, employee/union relations, and corporate image.
2. Quantify less tangible benefits of pollution prevention.	2. Estimate dollar impacts on operating and maintenance expenses and revenues of anticipated qualitative effects.

INTRODUCTION

You will need to perform the Tier 3 analysis if the PP project is not cost-justified through Tier 2. "Less tangible" costs are included in this fourth tier of the analysis because (1) the likelihood of incurring these costs, and conversely of benefitting from avoiding them, is relatively uncertain, and (2) the magnitude of these costs is difficult to quantify. Like Tier 2, therefore, Tier 3 is judgmental in nature and will reflect subjective corporate policy and not precise scientific calculations. One way to perform the Tier 3 analysis is to determine what the Tier 3 benefits would have to be (by difference) to just match the required financial payback (e.g., your firm's minimum acceptable rate of return). For example, if a PP project yields an estimated 16.9 percent return through Tier 2, then the Tier 3 analysis would have to show additional net revenues sufficient to achieve the minimum acceptable rate of return (say 18 percent). For a PP project with annualized costs of $100,000 and a 10-year lifetime, this would mean that the net after-tax Tier 3 impact on sales, customer/community relations, etc. would have to be at least $3,000 per year. It would then be up to the corporate decision makers to determine whether less tangible benefits associated with improved corporate image, increased sales, etc. are worth $3,000 per year. Alternatively, EPA knows of certain firms who, because of inability to correctly specify all Tier 3 types of impacts, have explicitly sanctioned the use of a lower hurdle rate (e.g., 16 percent instead of 18 percent) for investment in PP projects.

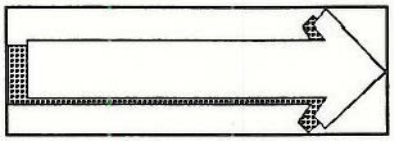
STEP 1: QUALIFY LESS TANGIBLE BENEFITS OF POLLUTION PREVENTION

Corporate commitment to pollution prevention can have a positive impact on many intangible factors such as product acceptance by the consumer, employee/union relations, and corporate image. Qualitatively describe the benefits of pollution prevention in the bottom part of Worksheet III. In particular, provide a qualitative description of which factors are significant, the basis for which they are considered to be significant, and the anticipated impact.

Although it is very difficult to say with certainty that intangible factors will affect costs, it is reasonable to assume that they may. For example, by publicizing PP efforts, a service or product may be better accepted by the consumer, resulting in more articles being sold. Firms may improve employee/union relations by reducing or eliminating the amount of waste managed in the workplace, thereby making the workplace safer and reducing the likelihood of potentially costly employee/union demands for health benefits and safety improvements. Finally, if a firm can use an innovative pollution prevention program to distinguish itself from its competitors, for example, by being nominated for a local, state, or private environmental excellence award, the firm may receive favorable publicity or attention that can serve to further promote its services or products. Each of these factors -- consumer acceptance, employee/union relations, and corporate image -- can be favorably affected by an innovative PP effort.

STEP 2: QUANTIFY LESS TANGIBLE BENEFITS OF POLLUTION PREVENTION

If your firm has performed marketing analyses or has other relevant information, you may be able to quantify the benefits of pollution prevention. Worksheet III allows you to adjust the estimates of expenses and/or revenues calculated in previous tiers in order to reflect the less tangible benefits of pollution prevention. As with previous tiers, you will need to enter the escalation rate, the first year of cash flow, lifetime, and the adjustment to the cash flow estimate. For example, if your PP alternative will result in a two percent increase in sales, you will report the corresponding net (i.e., after subtracting total additional costs of production) increase in sales as an adjustment to the cash flow estimate for operating revenues.



After completing Worksheet III, you should proceed to Chapter 6. Chapter 6 guides you through the financial protocol with instructions on how to (1) complete the right-hand block of the Tier 3 Cost Worksheet (i.e., annualized cash flows), and (2) calculate the annualized cost savings, net present value, and internal rate of return of each alternative PP practice relative to current practice. These values will allow you to assess the economic feasibility of your PP alternative(s) taking into account less tangible costs, in addition to future liabilities, and usual and hidden costs.

Worksheet III
Tier 3 • *Less Tangible Costs*

☐ Current Practice
☐ Alternative Practice
☐ Incremental

ITEM DESCRIPTION	CASH FLOW INFORMATION				ANNUALIZED CASH FLOW [a]			
	Escalation Rate (r_e, %)	First Year of Cash Flow (t_1, years)	Lifetime (n, years)	Cash Flow Estimate (C, [a])	r_d = 5%	r_d = 10%	r_d = 15%	r_d =
A. ADJUSTMENT TO EXPENSES								
B. ADJUSTMENT TO OPERATING REVENUES								

[a] *In thousands of year-0 dollars*

TIER 3 COST FACTORS

Consumer Acceptance

☐ YES ☐ NO

Justification *(Please justify)*

Employee/Union Relations

☐ YES ☐ NO

Justification *(Please justify)*

Corporate Image

☐ YES ☐ NO

Justification *(Please justify)*

CHAPTER 6
FINANCIAL PROTOCOL

This chapter presents the financial protocol for evaluating the economic feasibility of your PP alternative based on the cash flow estimates obtained using the cost protocol. You will evaluate financial indicators commonly used by firms; these financial indicators allow you to compare costs occurring at different times in the future. Specifically, Chapter 6 will show you how to estimate the net present value, internal rate of return, and annualized cost savings of your PP alternative at each tier of the analysis.

You will perform the financial calculations after completing each of the four tiers of the cost calculations, i.e., after each of Chapters 2 through 5. That is, you will estimate key financial indicators of the economic feasibility of your PP alternative on the basis of your costs estimates through Tier 0, 1, 2, and 3.[1] For the Tier 2 analysis, for example, you will estimate key financial indicators taking into account (Tier 0) usual costs, (Tier 1) hidden regulatory costs, and (Tier 2) liability costs.

STEPS	APPROACH
For the tier whose cost calculations you have just completed:	
1. For the current practice and the PP alternative, evaluate annualized cash flows associated with each cash flow item.	1. Using equations provided, complete the right-hand block of the cost worksheet (Worksheet 0, I, II, or III) for current and alternative practices.
2. Evaluate incremental annualized cash flows; i.e., annualized cash flows for the PP alternative relative to the current practice.	2. Complete the cost summary worksheet; i.e., Worksheet IV.
3. Evaluate key financial indicators of your PP alternative; i.e., after-tax total annualized savings, net present value (NPV), and internal rate of return (IRR).	3. Complete the financial worksheet (Worksheet V) using the equations provided.
4. Assess whether your PP alternative is economically feasible.	4. Compare your estimates of financial indicators to standard financial criteria or hurdles for investing in pollution prevention or similar projects.

[1] You need not perform higher tier analysis (e.g., Tier 2 or Tier 3 analysis) if your PP project is economically feasible at the lower tier (e.g., through Tier 1 or Tier 2 costs).

STEP 1: EVALUATE ANNUALIZED CASH FLOWS FOR EACH CASH FLOW ITEM

Concept and Purpose

This section first discusses the concept and rationale for discounting and annualizing future cash flows. Because annualization requires the selection of a "discount rate," this section then explains how to choose the discount rate.

Discounting and Annualization

In order to properly evaluate the economic merits of your PP alternative relative to your current practice, it is important to make sure that all costs are considered on an equal basis. In particular, you must take into account the lifetime of equipment purchased and the cost or earnings potential of money. For example, your PP alternative may require equipment costing $100 while it would save annual labor and supplies costs of $25 per year. Over four years, the total dollar savings would equal the cost of the equipment. Because you could otherwise invest the money (e.g., in a savings account earning 5-1/4% interest), your PP alternative in this case would be attractive only if the equipment lifetime is longer than 4 years. If the lifetime of your new equipment is less (e.g., 2 years) then you may be financially better off not changing your current practice and instead investing the money in the savings account. To account for lifetime and other considerations, this financial protocol uses a general approach based on "discounting" and "annualization" of cash flows. The result of this approach is an estimate of the average, uniform cash flow that would be needed each year to obtain the same net present value (value in dollars today) of the cash flows of a PP alternative.

Choosing the Discount Rate, r_d

As you may have already noted, all Worksheets (i.e., Worksheets 0 through V) contain four columns for estimating annualized cash flows: three columns for discount rate values of 5 percent, 10 percent, and 15 percent, and a fourth column for an unspecified value of the discount rate. This is done to give you maximum flexibility in choosing your own discount rate.

You will need to do the calculations for a discount rate value equal to your firm's minimum acceptable rate of return, i.e., the minimum return on investment that your firm expects before investing in a new project. See Action 2 of this step for information on how to determine your firm's minimum acceptable rate of return.

You will also need to determine the Internal Rate of Return (IRR) of your PP project, i.e., the discount rate value that gives you total annualized savings through the tier equal to $0. Typically, you will do the financial calculations many times, using a different value of the discount rate every time, until you determine the discount rate that will give you total annualized savings through the tier of $0. This is the IRR of your PP project. Step 3 of this chapter explains how you can determine the economic feasiblity of your PP alternative using the minimum acceptable rate of return and the Internal Rate of Return.

Actions

(1) Combine Common Cash Flows

You may combine certain cash flows before annualizing them in order to reduce the number of calculations that are required to complete the financial protocol. Specifically, you may combine cash flows under the same cash flow category (e.g., expenses) provided these cash flows have the same:

- escalation rate, r_e
- beginning year, t_i

- lifetime, n
- cash flow type (i.e., one-time or recurring).

For purposes of calculating annualized cash flows (see Action 3 in this step), there are two types of cash flows: "one-time" and "recurring." One-time cash flows happen only once. For example, the initial purchase and the salvage value of any equipment are both "one-time" costs; they do not occur repeatedly. Recurring cash flows are cash flows that are paid out or received on a repeating basis. For example, the annual cost of purchasing chemicals or of maintaining equipment are both recurring, because they are incurred every year of the project lifetime. Exhibit 6-1 identifies the type of cash flow for each cash flow item in the cost worksheets. Note that the types of cash flow are distinct from the cash flow categories recognized in the cost worksheets (i.e., depreciable capital expenditures, expenses, operating revenues, and liabilities). For example, some expenses are one-time expenses such as permitting costs, while others are recurring expenses such as operating and maintenance costs of labor and supplies. Place the totals for combined cash flows into the cost worksheet (i.e., Worksheet O, I, II, or III) and proceed to the calculation of annualized cash flows (Action 2 in this step).

(2) Determine Your Firm's Minimum Acceptable Rate of Return

You need to pinpoint the minimum rate of return that your company is willing to accept before investing in pollution prevention projects. Technically, the minimum acceptable rate of return is the after-tax cost of raising money from investors and lenders. If the project has a high enough return to provide investors and lenders with the money they expect, they will continue to invest, and your firm should continue to invest in projects that provide that rate of return.

If yours is a moderately large, multi-plant company, then you are likely to have a finance department with guidelines on investment decisions. In this case, you should consult with your finance managers about the hurdles they use for decisions regarding investment projects. These hurdles typically are described in the form of minimum rate of return. Your firm may be willing to accept a lower rate of return on a PP project simply because of the difficulty in quantifying the benefits of Tier 3 (see Chapter 5, Introduction).

If you are a small firm with no structured policy guidelines for investment decisions, then you need to find out what other similar businesses do (e.g., check with your trade association). In the absence of any information, a minimum rate of return of 12 to 17 percent may be acceptable provided inflation is no greater than about 5 percent.

(3) Calculate Annualized Cash Flows

For each cash flow item or combination of cash flow items (as per Action 1), calculate annualized cash flows for various values of the discount rate using Equations (6.1) through (6.6) and Exhibits 6-1 through 6-3 as appropriate. In particular, calculate annualized cash flows for a discount rate equal to your firm's minimum acceptable rate of return (see Action 2 above). Report your estimates of annualized cash flow in the right-hand block of the cost worksheet; i.e., Worksheet 0, I, II, or III depending on whether you have just completed Tier 0, 1, 2, or 3 of the cost protocol.

Estimating Annualized Cash Flows

The annualized cash flow (ACF) is technically defined as the uniform amount that, over the period considered, returns the same net present value as the actual cash flow. A common example is a fixed-rate mortgage. The "net present value" is the current amount of the loan, which is the amount of cash that the bank is providing for the loan. The "annualized cash flow" is the amount of the annual loan payment needed to repay the loan. From the bank's standpoint, the repayment stream has the same value as the amount of the loan, after considering the interest that can be earned on comparable loans.

EXHIBIT 6-1

TYPE OF CASH FLOW FOR EACH CASH FLOW ITEM

Cost Tiers	Cost Worksheet	Type of Cash Flow	
		One-Time	Recurring
Tier 0	0	A1 to A6, B1 to B6	B7 to B14, C1 to C2
Tier 1	I	A1 to A4, B5	B1 to B4, B6 to B14
Tier 2	II	B1, B3	A, B2
Tier 3	III	None	All

"One-time" cash flows are those that occur only once, such as purchasing equipment or selling equipment for salvage. "Recurring" costs are those that happen every year, or on a repeating basis, such as annual maintenance costs, or the costs of labor and consumable supplies. References in the exhibit are to the line numbers of the specific cost worksheets.

For each cash flow item in the cost worksheets (Worksheets 0, I, II, or III), you can calculate the annualized cash flow using the following formula:

$$ACF = PVF1 \times AF \times CF \quad (6.1)$$

where

ACF is the Annualized Cash Flow;
PVF1 is a Present Value Factor;
AF is an Annualization Factor; and
CF is the Cash Flow Estimate.

The annualized cash flow (ACF) is the constant amount that would have to be paid or received every year to have a value equal to the economic value of the PP alternative. Because the amount does not increase with inflation, it is considered to be in "nominal" dollars. In other words, an ACF of $100 would mean that the PP alternative has the same value as an investment that would provide a check each year of $100 over the lifetime of the PP alternative. With a fixed-rate mortgage, for example, the monthly payments are in "nominal" dollars -- the payments stay the same in spite of any inflation.

The cash flow estimate (CF) is in the fourth column of the middle block of the cost worksheets (Worksheets 0, I, II, and III). Because it has the potential to rise with inflation, it is considered in "year-0" or "current" year dollars. For example, assume that a cash flow estimate corresponds to paying a technician for 10 hours of labor per year. In developing the cash flow estimate CF, you would use the current pay rate for a technician, multiplied by 10 hours. The financial calculations described in this chapter account for the fact that inflation will lead to increased wage levels, and higher labor costs in the future, for 10 hours of labor per year.

PVF1 and AF are "dimensionless." That is, they are simply factors that are used to transform the actual cash flow estimation to annualized cash flow estimates; they do not have a unit of measure, or "dimension," such as dollars. The equations and tables for determining both the present value factor and the annualization factor are provided next.

The present value factor PVF1 depends on the beginning year, lifetime, discount rate, escalation rate, and the type of cash flow. For a one-time cash flow, the present value factor is equal to:

$$PVF1 = p^{n_i} \quad (6.2)$$

For a recurring cash flow, the present value factor is equal to:

$$PVF1 = p^{n_i} \times PVF2 \quad (6.3)$$

where

$$PVF2 = (1-p^{n}) / (1-p) \quad (6.4)$$

and

$$p = (1+r_e)/(1+r_d) \quad (6.5)$$

The parameters in Equations (6.2) through (6.5) are defined as follows:

t_i is the first year of cash flow (the first year it starts or the only year it occurs);
r_e is the escalation rate (the estimated rate at which prices will rise, or the inflation rate); and
r_d is the discount rate (the rate that will allow you to annualize your cash flows).

Exhibit 6-2 presents pre-calculated values of PVF2 for ranges of values of the parameter p and lifetime n. You may use this exhibit instead of Equations (6-4) and (6-5) to determine PVF2.

EXHIBIT 6-2

TABLE OF VALUES OF PRESENT VALUE FACTOR 2 (PVF2)

Lifetime	Parameter p = $(1+r_e)/(1+r_d)$								
(n, Yrs)	0.85	0.89	0.93	0.97	1.01	1.05	1.09	1.13	1.17
2	1.85	1.89	1.93	1.97	2.01	2.05	2.09	2.13	2.17
4	3.19	3.39	3.60	3.82	4.06	4.31	4.57	4.85	5.14
6	4.15	4.57	5.04	5.57	6.15	6.80	7.52	8.32	9.21
8	4.85	5.51	6.29	7.21	8.29	9.55	11.03	12.76	14.77
10	5.35	6.26	7.37	8.75	10.46	12.58	15.19	18.42	22.39
12	5.72	6.85	8.31	10.21	12.68	15.92	20.14	25.65	32.82
14	5.98	7.31	9.11	11.57	14.95	19.60	26.02	34.88	47.10
16	6.17	7.68	9.81	12.86	17.26	23.66	33.00	46.67	66.65
18	6.31	7.98	10.42	14.07	19.61	28.13	41.30	61.73	93.41
20	6.41	8.21	10.94	15.21	22.02	33.07	51.16	80.95	130.03
22	6.48	8.39	11.39	16.28	24.47	38.51	62.87	105.49	180.17
24	6.53	8.54	11.78	17.29	26.97	44.50	76.79	136.83	248.81
26	6.57	8.65	12.12	18.23	29.53	51.11	93.32	176.85	342.76
28	6.60	8.74	12.41	19.13	32.13	58.40	112.97	227.95	471.38
30	6.62	8.82	12.67	19.97	34.78	66.44	136.31	293.20	647.44

Values on this table were calculated using Equation (6.4). To use the table, first calculate p. For example, if you estimate that costs will escalate at 4 percent (r_e = 4%) and are using a discount rate of 12 percent (r_d = 12%), then p = (1+0.04)/(1+0.12) = 0.93. Then, find the row corresponding to the expected equipment life (n), and follow it horizontally to the column corresponding to p. The value you read is PVF2. For example, if the estimated lifetime (n) is 10 years and p is 0.93, then PVF2 equals 7.37.

The annualization factor is a function of the discount rate and lifetime. The annualization factor is equal to the following:

$$AF = [r_d \times (1+r_d)^n] / [(1+r_d)^n - 1] \quad (6.6)$$

Exhibit 6-3 presents pre-calculated values of AF for various values of the discount rate r_d, and lifetime n. You may use this exhibit instead of Equation (6.6) to determine AF.

(4) Sum Annualized Cash Flows by Category

When all the annualized cash flows have been calculated on the cost worksheet, add them together in order to obtain total annualized cash flows for each of the cash flow categories on the worksheet. For instance, after calculating annualized cash flows for all cash flow items on Worksheet 0, sum all annualized cash flows under depreciable capital expenditures, expenses, and revenues and report these sums in lines A, B, and C, respectively.

STEP 2: EVALUATE INCREMENTAL ANNUALIZED CASH FLOWS

Concept and Purpose

You use this step to determine the incremental annualized cash flows for your PP alternative relative to your current practice; i.e., the cash flows of your PP alternative minus those of your current practice. If you have completed the cost protocol (Tier 0, 1, 2 or 3) incrementally, then you need not complete Worksheet IV and you may proceed to Step 3 directly.

Actions

(1) Report Total Annualized Cash Flows by Category on Worksheet IV.

If you performed the tier just completed using two worksheets for current and alternative practice, transcribe onto Worksheet IV the annualized cash flows by cash flow category. Do this for the alternative and current practices and for different values of the discount rate. For example, upon completing Tier 0, copy the total annualized cash flows from lines A, B, and C of the Tier 0 worksheets (Worksheet 0 completed once for alternative and once for current practices) onto lines a, b, and c of the cost summary worksheet (alternative and current blocks of Worksheet IV, respectively).

STEP 3: EVALUATE KEY FINANCIAL INDICATORS OF YOUR PP ALTERNATIVE

Concept and Purpose

This step will guide you through the calculation of key financial indicators of the economic feasibility of your PP alternative. You will calculate the following financial indicators:

- total annualized savings (TAS);
- net present value (NPV); and
- internal rate of return (IRR).

In order to calculate these financial indicators accurately, you must account for tax effects on your change in cash flow. Once tax is accounted for, you then may directly calculate the TAS and NPV at any discount rate, and iteratively calculate the IRR. Worksheet V does three things, it: (1) takes the incremental

EXHIBIT 6-3

TABLE OF VALUES OF ANNUALIZATION FACTOR (AF)

Lifetime	Discount Rate (r_d, %)							
(n, Yrs)	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0
2	0.5188	0.5378	0.5569	0.5762	0.5956	0.6151	0.6348	0.6545
4	0.2658	0.2820	0.2986	0.3155	0.3327	0.3503	0.3681	0.3863
6	0.1815	0.1970	0.2130	0.2296	0.2467	0.2642	0.2823	0.3007
8	0.1395	0.1547	0.1707	0.1874	0.2048	0.2229	0.2415	0.2606
10	0.1143	0.1295	0.1457	0.1627	0.1806	0.1993	0.2186	0.2385
12	0.0975	0.1128	0.1293	0.1468	0.1652	0.1845	0.2045	0.2253
14	0.0855	0.1010	0.1178	0.1357	0.1548	0.1747	0.1954	0.2169
16	0.0766	0.0923	0.1094	0.1278	0.1474	0.1679	0.1893	0.2114
18	0.0697	0.0855	0.1030	0.1219	0.1420	0.1632	0.1852	0.2078
20	0.0641	0.0802	0.0981	0.1175	0.1381	0.1598	0.1822	0.2054
22	0.0596	0.0760	0.0942	0.1140	0.1351	0.1573	0.1802	0.2037
24	0.0559	0.0725	0.0911	0.1113	0.1329	0.1554	0.1787	0.2025
26	0.0528	0.0696	0.0885	0.1092	0.1311	0.1541	0.1777	0.2018
28	0.0501	0.0671	0.0864	0.1075	0.1298	0.1531	0.1769	0.2012
30	0.0478	0.0651	0.0847	0.1061	0.1288	0.1523	0.1764	0.2008

Values on this table were calculated using Equation (6.6). Generally, your firm selects a discount rate based on the cost of raising additional money from investors and by borrowing. Typical project lifetimes depend on the expected lifetime of the equipment. In some cases, equipment may become obsolete and be replaced before wearing out. If you expect that to happen, you should use the expected time before the equipment will be replaced.

annualized cash flows (developed either incrementally in the cost worksheet or by subtraction in Worksheet IV), (2) estimates the tax effects on cash flows, and (3) allows the direct calculation of the net savings for the tier just completed. The worksheet then allows the calculation of the IRR.

Actions

(1) Report the Incremental Annual Cash Flows on Worksheet V.

If you completed Worksheet IV, (i.e., you performed the tier just completed using current and alternative practice worksheets), subtract each cell in the current block from the corresponding cell in the alternative block and transcribe the difference into the corresponding cell in Worksheet V. For example, the hypothetical facility in Tier 0 (see Appendix D, Section D.2.2) subtracted 0 from -4.41 and arrived at -4.41 (corresponding to alternative less current on line a, r_d = 5%) and placed it in Worksheet V on line a, r_d = 5%. If you performed the tier analysis incrementally, you would directly transfer the values by cash flow category onto Worksheet V.

(2) Calculate the Tax Liabilities

Taxes make an important difference in the actual costs or benefits of a PP alternative. Because expenses can be deducted from revenues, some of the costs of a PP alternative are paid for through reduced taxes. There is, however, a big difference in the tax treatment of different types of expenses. Current expenses, such as labor and material costs, can all be deducted in the year they are incurred. Capital expenditures, such as the purchase of equipment, must be deducted gradually by estimating depreciation. Because the tax reduction for capital expenditures is spread out over a longer time period than the tax reduction for current expenditures, the value of the tax benefit is less.

For each value of the discount rate r_d, calculate your company's incremental tax liability due to the PP project using the following Equations (6.7) and (6.8) and report your tax liability on line e of Worksheet V:

$$TAX = - r_t \times [(FD \times a) + b + c + e] \quad \text{where} \tag{6.7}$$

TAX is the incremental tax liability for the PP alternative;
r_t is your company's effective tax rate (Federal and State taxes);
FD is a factor to allow for depreciation of capital expenditures; and
a, b, c, and e correspond to the lines on Worksheet V.

Note that Equation (6.7) assumes that penalties and fines do not decrease your tax liability. That is, the equation assumes that penalties and fines may not be deducted from income for tax purposes.

You need to obtain the effective tax rate (r_t) applicable to your company from your finance or accounting managers. The effective tax rate is the sum of applicable Federal and State tax rates. In general, you may assume a Federal tax rate of 34 percent under the new tax law (Tax Reform Act of 1986). State tax rates vary from state to state and generally are around ten percent.

Under the tax laws passed in 1986, equipment similar to pollution control equipment may be depreciated over a 7-year period using the 200-percent double-declining-balance method. The depreciation factor, FD, for this depreciation schedule may be calculated using the following formula:[2]

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[2] Equation 6.8 works by calculating the value today of the depreciation from $1 worth of investment. For example, the first term, $0.14/(1+r_d)$, divides the fraction of the investment that can be deducted after the first year (14 percent), and "discounts" it to the beginning of the year.

$$FD = 0.14 / (1+r_d) + 0.25 / (1+r_d)^2 + 0.17 / (1+r_d)^3 + 0.13 / (1+r_d)^4 + 0.09 / (1+r_d)^5 + 0.09 / (1+r_d)^6 + 0.09 (1+r_d)^7 + 0.04 / (1+r_d)^8 \quad (6.8)$$

Exhibit 6-4 displays values of the depreciation factor (FD) for various values of the discount rate r_d. You may this exhibit instead of Equation (6.8) to determine FD.

(3) Calculate the Net Savings for the Tier

For each discount rate, add lines a through f and place the total into line g. This total is the net annualized savings (losses if negative) of your PP alternative for the tier just analyzed, i.e., taking into account the cash flow items reflected in the tier.

(4) Calculate the Total Savings through the Tier

For each discount rate, add line g to the total savings through the previous tier. The sum is the total annualized savings through the tier just completed, i.e., taking into account all cash flows reflected in this tier and all previous tiers. By definition, net savings for Tier 0 and total savings through Tier 0 are the same. On the other hand, total savings through, say, Tier 2 are the sum of net savings for Tier 2 (line g of Worksheet V, Tier 2) and total savings through Tier 1 (Worksheet V, Tier 1).

(5) Calculate Net Present Values for the Tier and through the Tier

To calculate the net present values, divide the total annualized savings by the annualization factor (Equation (6.6) or Exhibit 6-3). When employing this equation make sure that the lifetime (n) is set equal to the project lifetime, usually equal to the longest lifetime of any capital equipment purchased.

(6) *Calculate the Internal Rate of Return*

A common method of evaluating projects is to determine the "internal rate of return," or IRR. The internal rate of return is the discount rate where the net annualized costs or savings are zero. For example, assume that you could invest $1,000 today, and receive $1,200 in one year. The IRR for the investment would be 20 percent. That is, if your discount rate were exactly 20 percent, you would be indifferent between keeping the $1,000, and investing it to receive $1,200 in one year. The actual value to you either way is identical. If your discount rate were 16 percent, however, you would want to invest the money, because the rate of return on the investment is higher than the rate you require for other investments, or than the rate you must pay lenders and investors for money. If your actual discount rate were 25 percent, you would not want to invest the money, because it costs you more to obtain the money to invest than you would receive by investing.

At any given tier of the cost protocol, the IRR is the discount rate for which the total savings through that tier are equal to zero. To calculate the IRR, you need to repeat all the calculations completed to this point for different judiciously selected values of the discount rate, until the estimated total savings through the tier are calculated to be zero. The discount rates for which you already have calculated annualized cash flows and net and total savings should provide you with good data points on which to base your first guess of the IRR.

EXHIBIT 6-4

TABLE OF VALUES OF DEPRECIATION FACTOR (FD)

Discount Rate (r_d)	Depreciation Factor (FD)
2.5%	0.9159
5.0%	0.8426
7.5%	0.7784
10.0%	0.7219
12.5%	0.6719
15.0%	0.6274
17.5%	0.5877
20.0%	0.5521
22.5%	0.5200
25.0%	0.4910
27.5%	0.4646
30.0%	0.4406

This exhibit was calculated using Equation (6.8). The exhibit clearly shows that FD decreases as the discount rate increases. That is, as the discount rate increases, the present value of the stream of depreciation allowances over seven years decreases.

STEP 4: EVALUATE ECONOMIC FEASIBILITY OF YOUR PP ALTERNATIVE

Concept and Purpose

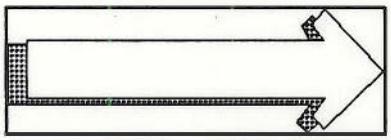
You have finished calculating key financial indicators for the PP alternative through the tier just completed. You must now compare these estimates of total savings, net present value, and IRR to financial criteria or hurdles for investing in new projects. You may either (1) conclude that your PP alternative is or is not economically feasible or (2) move to the next tier of the cost protocol.

Actions

(1) Compare Estimates of Financial Indicators to Financial Criteria

If, for a discount rate value equal to the minimum rate of return, the total annualized savings (or, equivalently, the net present value) through the tier are positive, then your PP alternative is economically feasible on the basis of the cash flow items considered up through the tier just completed. Alternatively, if the IRR of your PP alternative is greater than or equal to your firm's minimum acceptable rate of return, then your PP alternative is economically feasible.

(2) Conclude Analysis or Move to Next Tier of the Cost Protocol



If Action 2 above concludes that your PP alternative is economically feasible, or if you have just completed Tier 3 of the cost protocol, then the analysis of your PP alternative can stop here for all practical purposes. Otherwise, move to the next tier of the cost protocol, which will help you take into account other types of costs and cost savings than those considered thus far. If you are moving to Tier 1, 2, or 3 of the cost protocol, go to Chapter 3, 4, or 5 of this manual, respectively.

Worksheet IV

Cost Summary

(In thousands of year–0 dollars)

Tier ☐

ITEM DESCRIPTION	ANNUALIZED CASH FLOW			
	r_d= 5%	r_d= 10%	r_d= 15%	r_d=
Alternative				
a. DEPRECIABLE CAPITAL EXPENDITURES				
b. EXPENSES				
c. OPERATING REVENUES				
d. PENALTIES AND FINES				
e. FUTURE LIABILITIES				
Current				
a. DEPRECIABLE CAPITAL EXPENDITURES				
b. EXPENSES				
c. OPERATING REVENUES				
d. PENALTIES AND FINES				
e. FUTURE LIABILITIES				

Worksheet V

Financial Worksheet

(In thousands of year–0 dollars)

Tier ☐

ITEM DESCRIPTION	ANNUALIZED CASH FLOW [a]			
Alternative Less Current	r_d = 5%	r_d = 10%	r_d = 15%	r_d *
a. DEPRECIABLE CAPITAL EXPENDITURES				
b. EXPENSES				
c. OPERATING REVENUES				
d. PENALTIES AND FINES				
e. FUTURE LIABILITIES				
f. TAX LIABILITIES				
g. NET SAVINGS FOR TIER				
Total Savings				*IRR*
THROUGH TIER 0				
THROUGH TIER 1				
THROUGH TIER 2				
THROUGH TIER 3				

[a] *Cash flow estimates for alternative less current, by definition, is the same as cash flow estimates for incremental analysis.*