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Good Practice Guide
GPG-FM-025A

Waste Minimization/ Pollution Prevention

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Foreword

This United States (U.S.) Department of Energy (DOE) Guide is approved by the Office of Field Management (DOE HQ/FM) and is available for use by all DOE components and their contractors.

Specific recommendations for additions, deletions, or changes that would enhance this document should be sent to:

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This Guide is part of the system of DOE Good Practice Guides, which are intended to provide suggestions for best management practices useful in implementing the requirements of DOE Order 430.1, *Life Cycle Assessment Management*.

This Guide was developed by the Pacific Northwest National Laboratory[(1)] as part of the DOE project *Pollution Prevention (P2) by Design*. *P2 by Design* is sponsored by DOE EM-77, Office of Pollution Prevention, with cooperation from FM-20, Office of Project and Fixed Asset Management. This Guide incorporates the previously issued document "A Proposed Framework for Conducting Pollution Prevention Design Assessments on U.S. Department of Energy Design Projects," PNL-10204, March 1995. This Guide primarily differs from PNL-10204 in format, but has also been updated to include user feedback, examples, and lessons learned through the use of PNL-10204 on various DOE projects in the design phases.

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1. Introduction

This Good Practice Guide provides tools, information, and examples for promoting the implementation of pollution prevention during the design phases of U.S. Department of Energy (DOE) projects. It is one of several Guides for implementing DOE Order 430.1, *Life-cycle Asset Management*. DOE Order 430.1 provides requirements for DOE, in partnership with its contractors, to plan, acquire, operate, maintain, and dispose of physical assets.

The goals of designing for pollution prevention are to minimize raw material consumption, energy consumption, waste generation, health and safety impacts, and ecological degradation over the entire life of the facility (EPA 1993a). Users of this Guide will learn to translate national policy and regulatory requirements for pollution prevention into action at the project level. The Guide was written to be applicable to all DOE projects, regardless of project size or design phase. Users are expected to interpret the Guide for their individual project's circumstances, applying a graded approach so that the effort is consistent with the anticipated waste generation and resource consumption of the physical asset.

This Guide employs a combination of pollution prevention opportunity assessment (PPOA) methods and design for environment (DfE) philosophies. The PPOA process was primarily developed for existing products, processes, and facilities. The PPOA process has been modified in this Guide to address the circumstances of the DOE design process as delineated in DOE Order 430.1 and its associated Good Practice Guides. This modified form of the PPOA is termed the Pollution Prevention Design Assessment (P2DA). Information on current nationwide methods and successes in designing for the environment also have been reviewed and are integrated into this guidance.

Because this Guide focuses on implementing pollution prevention during design, it interfaces with other Good Practice Guides that provide engineering information as well as those Guides providing environmental support (Table 1).

Content and organization of the remaining chapters of this Guide are highlighted as follows:

Chapter 2 - Principles and Processes defines pollution prevention in greater detail, including the regulatory drivers, benefits, and barriers to designing for pollution prevention. It provides detail on conducting a P2DA, and specific considerations for implementing pollution prevention by project phase.

Chapter 3 - Graded Approach offers suggestions for tailoring the P2DA to project circumstances so that the effort is consistent with the degree of anticipated waste generation and resource consumption. It also discusses other methods for integrating pollution prevention into design in lieu of conducting a P2DA.

Chapter 4 - Measuring for Results describes possible indicators that pollution prevention is being appropriately addressed at the project level, as well as specific recommendations for setting pollution prevention project goals.

Chapter 5 - Suggested Reading contains reference to guidance documents useful for implementing pollution prevention during the design phases of projects.

Chapter 6 - Definitions lists the definitions of commonly used pollution prevention and related terms used in this Guide.

Chapter 7 - Assistance refers the reader to other tools and assistance available through the *Pollution Prevention (P2) by Design* project including training, software, technical assistance for individual projects, and a World Wide Web homepage.

Chapter 8 - Related Training provides information on training as well as how to access information about upcoming pollution prevention training events and conferences.

Chapter 9 - Examples describes the results from projects within DOE that have applied pollution prevention concepts and/or conducted an actual P2DA. It also contains examples from private industry.

2. Principles and Practices

2.1 Definition and Scope

Pollution Prevention is defined as "the use of materials, processes, and practices that reduce or eliminate the generation and release of pollutants, contaminants, hazardous substances, and wastes into land, water, and air. Pollution prevention includes practices that reduce the use of hazardous materials, energy, water, and other resources along with practices that protect natural resources through conservation or more efficient use (DOE 1996)."

Thus, the term pollution prevention is not as limiting as a literal interpretation of the phrase suggests. Beyond eliminating the creation of pollution at the source, the definition also includes energy conservation, water conservation, and the protection of natural resources. It also addresses reduction in the use of hazardous materials. Pollution prevention attempts to minimize not only wastes exiting the process, but materials entering and consumed by the process as well. By considering pollution prevention during design, the scope of the analysis expands from operating facilities to inputs and outputs during facility construction and closure/dismantlement as well.

From a regulatory standpoint, the term waste minimization is the predecessor to pollution prevention and applies to hazardous waste only. The term pollution prevention broadens this concept to include the elimination of all pollutants and wastes (hazardous and non-hazardous) to all media (air, land, and water). Design engineers working for a facility that will have a Resource Conservation and Recovery Act of 1976 (RCRA) permit may already be familiar with the requirements to minimize hazardous wastes created or handled by the facility. This guidance attempts to present a proactive approach to go beyond regulatory requirements by preventing all pollutants to all media.

The distinction between pollution prevention and waste minimization can be confusing. Within DOE, pollution prevention includes all aspects of source reduction as defined by the U.S. Environmental Protection Agency (EPA), and incorporates waste minimization by expanding beyond the EPA definition of pollution prevention to include recycling (DOE 1996).

2.2 Regulatory Drivers

This Guide is not intended to ensure that projects achieve environmental compliance (for that purpose, refer to GPG-FM-021, *Environmental Interfaces*). Pollution prevention requires a much broader and more proactive approach beyond strict compliance to be effective. At the same time, it is important to understand, at a minimum, what is required of design projects with respect to pollution prevention and waste minimization.

Some of the major regulatory requirements for pollution prevention are highlighted in Table 2. Only requirements found in federal legislation and executive orders are provided. For more detailed information on pollution prevention regulations, including state regulations, refer to the DOE Pollution Prevention homepage (http://146.138.5.107/EPIC.htm). Individuals are expected to investigate any additional requirements from their DOE operations office, or state or local government. In addition, contractors may have pollution prevention requirements written into company work procedures, or mandated in the particular requirements documents from their customers for specific design projects. Readers are further cautioned about the growing recognition of the importance of pollution prevention in drafting new environmental legislation, so the pollution prevention requirements of Table 2 will undoubtedly continue to expand (Eyring 1994).

Notice in Table 2 that, in general, explicit pollution prevention requirements are mainly targeted at Federal agencies such as the EPA or DOE, or at existing waste-generating facilities holding a permit, and not to projects under design. In the case of the Federal agencies, pollution prevention requirements eventually filter down to existing facilities and design projects in the Federal agencies' implementation of Federal legislation and executive order requirements. For this reason, readers are encouraged to consult company pollution prevention procedures and program plans, as well as DOE site plans and procedures when identifying pollution prevention drivers for projects. As for pollution prevention requirements that apply to existing facilities, it is still critical that the design engineer is cognizant of these requirements so that the facility can obtain the required operating permits.

In addition to the requirements of Table 2, national and international pollution prevention standards are emerging. The American Society for Testing and Materials (ASTM) subcommittee E50.03 on Pollution Prevention, Reuse, Recycling, and Environmental Efficiency has developed a "Standard Guide for Pollution Prevention" (ASTM 1994a), and the International Standards Organization (ISO) committee 207 on Environmental Management has developed standards for life-cycle assessment (ASTM 1994b).

2.3 Benefits and Barriers

The complex system of environmental laws that has evolved over the last 20 years has influenced, at least indirectly, the attributes of new products (Eyring 1994). The laws themselves do not contain explicit design requirements, but the regulatory climate created by the laws has motivated design changes for other reasons such as cost and public perception. Table 2 shows that if a facility will not be RCRA-permitted or manage radioactive waste, there are few explicit regulatory requirements for incorporating pollution prevention into the project design. Nonetheless, many benefits can result from designing with pollution prevention principles, whether required by law or not, as shown in the following examples.

Benefits

Cost savings: A major benefit to a project for considering pollution prevention during design is potential cost savings. Pollution prevention opportunities are more cost-effective when initiated during design because implementation costs are lower and savings are compounded over a longer time period. A pollution prevention-driven design change can result in a stream of savings that, in effect, occur every year over the life of the project.

For the DOE, it is estimated that a cost savings of between $1.25 and $6.65 can be realized per dollar invested in the implementation of pollution prevention during design (Dorsey 1995). Considering that the DOE has approximately $2.8 billion dollars planned for projects with a construction start date of 1996 and later, actively implementing pollution prevention into these projects could yield a significant cumulative cost savings. As an example, it is estimated that waste management costs for Phase 2 of the Los Alamos National Laboratory (LANL) Chemistry and Metallurgy Research (CMR) Facility could be reduced by $50 million dollars through the application of a variety of waste minimization techniques (Durrer and Kennicott 1995).

The private sector is also reporting significant cost savings from moving traditional pollution prevention upstream into design. Dupont Corporation, for example, typically applies a 10-step environmental review procedure to the design of their facilities (Kraft 1992). In one case, three major design modifications were implemented with a combined internal rate of return of 45 percent at a net present value of $6.4 million. At the same time, estimated organic air emissions were reduced by 99 percent (430,000 lb/yr). All three of the design modifications stemmed from pollution prevention ideas.

Additional examples found in Chapter 9 of this Guide further illustrate the cost savings realized by DOE projects as well as by new design/construction projects in the private sector.

Improved perception of regulators and the public: Besides cost, there are other incentives for surpassing the minimum regulatory requirements. Moving beyond compliance through a proactive approach toward pollution prevention will improve a company's relationship with government regulators, stakeholders, and the public. Some of the DOE projects that have implemented pollution prevention (see Chapter 9) cited upcoming public comment periods as a significant driver for voluntarily adopting pollution prevention as a pervasive project policy. Pollution prevention can have a positive effect on other areas of interest to the public such as environmental equity and public acceptance of plant location. In general, pollution prevention offers an opportunity to push beyond the traditional scope of engineering concepts to consider industrial processes in a larger societal context (Eisenhauer and McQueen 1992).

Simplified environmental management: Proactive and comprehensive pollution prevention eases the burden of environmental management. With no (or less) waste to manage, significantly less time is needed for permitting, reporting, monitoring, manifesting, testing, labeling, training, record keeping, and inspecting (EPA 1994; EPA 1992). Equipment for waste handling, worker protection, monitoring, treatment, and storage can virtually be eliminated from a design. Many projects under design throughout the DOE complex, such as waste treatment facilities, may have been unnecessary if pollution prevention had been actively practiced earlier. In this context, the cost of *not* doing pollution prevention today could have a significant impact on the cost of managing DOE waste streams in the future.

Flexibility in design for change: It is much easier to change a drawing than to retrofit a facility. The added benefit of considering pollution prevention during design is that the realm of pollution prevention opportunities is much broader and those selected are easier to implement. In addition, if considered early in the conceptual stages, pollution prevention can provide an incentive to develop innovative technologies to solve particularly difficult pollution problems (CMA 1993). This benefit ties directly into the earlier discussion on cost savings. It is estimated that while only 20% of life-cycle costs are incurred during design, the decisions made during this crucial time period determine up to 80% of the project's total life-cycle costs.

Integrated project concepts: When properly utilized, pollution prevention can serve as a continuous improvement tool throughout the design phases of a project. It can help to increase process knowledge and facilitate gathering of environmental data for permitting and other purposes. It can support any number of ongoing engineering activities such as value engineering, trade-off studies, and safety analysis reports by heightening awareness of the costs and possible health impacts associated with waste generation, and by offering solutions for preventing generation at the source.

Energy efficiency: As defined earlier, pollution prevention includes resource and energy conservation; thus, energy efficiency can be a strategy toward pollution prevention. Energy efficiency is also a frequent side benefit, even when it is not the primary goal (Burall 1990). By using less energy, pollution associated with the generation of electricity is prevented. The corollary, producing less waste means less energy is consumed in manufacturing a non-product output. A good example is that water saved reduces energy costs necessary to treat and pump the water before it is received by the customer. The link between energy efficiency and environmental sustainability is further illustrated by noting that the same five industries accounting for 90 percent of energy use in the U.S., also produce 95 percent of all hazardous waste and 90 percent of nonhazardous waste (Eisenhauer and Cranford 1994).

Barriers

Although the benefits to design for pollution prevention outweigh the perceived barriers, understanding the barriers at the outset may make it easier to incorporate pollution prevention into a design project. Some of the organizational barriers common to any new initiative are that "business as usual" is generally favored over new initiatives. Environmental issues are not always well-understood within the design community, and design teams may have a perception that environmental designs have an adverse effect on product quality and cost (Fiksel 1994).

The following is a discussion of some common barriers (myths and misconceptions) discovered during implementation of pollution prevention during the design phases of DOE projects.

Lack of tools and information: The biggest barrier to designing for pollution prevention is lack of information and experience. In general, considering pollution prevention during design is a relatively new concept for DOE projects, at least in any formalized sense. However, over the last few years, more information has become available about how various DOE projects are approaching pollution prevention. In addition, tools such as software, design checklists, and specialized training have become available both within DOE and outside DOE, to specifically address how to incorporate pollution prevention during design. This Guide is intended to present these early successes and emerging tools in such a way that individual DOE projects can quickly get started in implementing pollution prevention, customizing their approach along the way to meet project-specific needs.

Impacts on project cost and schedule: A resounding concern for any new design requirement is the impact that it might have on project cost and schedule. While design engineers need tools and information to implement pollution prevention (as described previously), project managers need to know how to schedule and budget for pollution prevention. The case studies and other examples described in Chapter 9 easily justify that the benefits of pollution prevention are attainable and far outweigh the added design costs, if any. They also show that the cost to conduct an assessment has proven to be minimal. Most of the case study teams incorporated their pollution prevention assessments into existing design processes, making it part of the current work scope. Often, the P2DA process formalized and encouraged activities already being considered to reduce waste.

Multiple contractors and contractual barriers: Another barrier to designing for pollution prevention is timing, and the reality that some pollution prevention opportunities implemented during design may not benefit the project until much later. Design phases of projects have their own budget and schedule constraints, and it may be difficult for the project to justify pollution prevention measures that may not realize any measurable savings until operation of the facility, or even at the closure/dismantlement of the facility, long after the contractor responsible for design has left the scene. To overcome this barrier, the P2DA team members need to work closely with customer so that they are informed of any added design costs. This Guide will help readers to compute cost savings data to present options to the customer and demonstrate that added design costs up front contribute to a lower life-cycle cost of the project.

Undeveloped designs and lack of quantitative data: As stated in the benefits section, the earlier pollution prevention is considered during design, the greater the opportunity for cost savings. Paradoxically, the earlier that pollution prevention is considered, the harder it is to obtain quantitative data on its benefits. For existing facilities, pollution prevention initiatives are compared to a baseline of current waste-generating practices. Plant records are available and direct measurement of waste-generating processes is possible. During design, on the other hand, the facility does not yet exist and the design of the facility is constantly changing, becoming more and more detailed with each successive phase. Therefore, an opportunity considered during conceptual design will be more difficult to quantify than during definitive design when the equipment has been specified and vendor data becomes available on its expected performance. Until design detail becomes available, the P2DA analysis will need to make numerous simplifying assumptions that may not be accurate. Nonetheless, it is still critical to begin considering pollution prevention as early as possible. The case study results provided in Chapter 9 illustrate how projects in different design phases, even projects in early planning, have successfully approached pollution prevention.

Treatment of existing waste streams: Some project designers maintain that it is not necessary to consider pollution prevention for a facility that will be handling waste that already exists because nothing can be done to prevent it. However, the methods used to transport, treat, and dispose of existing waste streams are likely to generate secondary waste streams. Therefore, the need to consider pollution prevention during design is still viable, even for new facilities that will be managing existing waste streams. In fact, facilities that will be treating, storing, or disposing of RCRA hazardous waste are required to design for pollution prevention (see Table 2).

2.4 Related Engineering Concepts

This Guide focuses on implementing pollution prevention during design and construction, and as such, it interfaces with all of the other Good Practice Guides that provide engineering information. These interfaces are described in Table 1. Beyond the other Good Practice Guides, the reader will undoubtedly recognize the similar themes and methods pollution prevention has in common with other design concepts and everyday work practices as well. It is important to recognize that pollution prevention is actually an extension of some of the design concepts that are already integral to the DOE design process, e.g., total quality management (TQM), systems engineering, As Low As Reasonably Achievable (ALARA), and good engineering practice.

To some extent, design teams throughout the DOE complex may already be practicing pollution prevention whether they are aware of it or not. By demonstrating that pollution prevention is not a new concept and that it inherently fits into the current design process, it should come naturally to design teams practicing it officially for the first time. If design personnel understand the relationship to the current practices, it will be easier to practice pollution prevention through the P2DA process.

The P2DA process simply provides a more formalized mechanism to systematically quantify anticipated streams and implement pollution prevention design options. The systematic approach allows design teams to demonstrate compliance with regulatory requirements, and to take credit for ongoing pollution prevention activities not previously recognized or documented as such.

Systems engineering: Systems engineering seeks to consider all aspects of system requirements from the earliest stages of design through development, test, and operation. The process ensures that technical control is integrated with funds, cost, schedule, and performance controls. It relays the design concepts of completeness, integrated interfaces, and simplicity. Pollution prevention does not take precedence over the technical requirements of the facility, but it must be considered at the earliest stages and recognized as another project constraint along with cost, schedule, and function. Because systems engineering takes a multi-disciplined and systematic approach to coordinating activities on large projects, it is an excellent framework within which to incorporate pollution prevention concepts into the design (Marchlik and Costello 1994).

As low as reasonably achievable: ALARA is another design requirement related to pollution prevention. The intent of ALARA is to minimize exposure to radioactive and other hazardous materials by using distance, time, and shielding to separate the worker from the hazard. An inherent element of accomplishing ALARA is minimizing, or if possible, preventing to the extent practicable, the hazardous situation in the first place.

Good engineering practice: In actuality, implementing pollution prevention during design is essentially "good engineering practice." It means designing systems with the maximum efficiency and the lowest cost, anticipating and designing for unplanned events, and minimizing the consumption of natural resources. These are fundamental to good engineering practice and are examples of how pollution prevention is implemented during design.

Design for Environment: Pollution prevention has traditionally focused on existing wastes streams, with only recent emphasis on pushing avoidance concepts upstream into design. At the same time that pollution prevention was evolving, DfE was emerging as a new methodology for incorporating environmental principles into design. These two paths, developed in parallel, have common objectives and themes (Fiksel 1994). The merging of these two fields have brought engineers and environmental professionals together to address the "greening" of design methodology. As such, it is helpful to understand the history and some of the concepts of DfE.

Although reference to DfE concepts appeared in engineering texts as early as 1962, the modern DfE movement is in a relative undeveloped state because very few design methodologies specifically address environmental issues (Keoleian and Menerey 1994). Most work in this area has been in planning and tool development rather than implementation of pollution prevention practices on actual design projects. Furthermore, most of the work has been developed by private industry (rather than the government), and therefore focuses on product development rather than large-scale industrial facilities. For example, the American Electronics Association has established a group of U.S. manufacturers tasked with developing a set of DfE technical and management strategies (Allenby and Fullerton 1992).

The term DfE evolves from a design for "X" approach developed by AT&T, where X can be a range of design objectives including manufacturability or reliability (Gatenby and Foo 1990). A major theme of DfE is to design with the entire life cycle in mind: identification of need, conceptual design, preliminary design, detailed design, production or construction, installation, customer use, support, and finally decline and disposal (Fabrycky 1987; Keoleian et al. 1993). As such, a recycling process during operations may or may not be beneficial over the total project life cycle (Lave et al. 1994). These and other principles of DfE have been reviewed and are incorporated into the P2DA process established in the chapters that follow.

Influence of pollution prevention on the engineering profession: It is interesting to note that pollution prevention is now covered as a subject area in the Fundamentals of Engineering examination, required to become an engineer in training. Many professional engineering societies are reorganizing to include pollution prevention representation on society operating committees. Engineering societies are producing texts, training courses, workshops, and presenting technical sessions at national engineering conferences devoted to pollution prevention and related topics such as sustainable development, life-cycle analysis, and DfE.

In addition, some societies are beginning to include pollution prevention issues in their statements on engineering ethics. The World Federation of Engineering Organizations (WFEO), representing more than 80 countries and 10 million engineers, has drafted a code for environmental ethics for its members. Excerpts from WFEO's code are provided in Figure 1.

The International Federation of Consulting Engineers (FIDIC), representing the majority of the world's consulting engineers, also charges its members with ethics and responsibilities through their Environmental Policy Statement (Ellis 1994). Excerpts from FIDIC's policy statement are shown in Figure 2.

Figures 1 and 2 are provided as examples of how pollution prevention and related avoidance concepts are influencing the engineering profession. As a complement to the "how-to" method offered in this guidance, these codes provide specific steps for embodying pollution prevention concepts in all aspects of the engineering profession at all times (not just during a dedicated pollution prevention assessment). Ideally, pollution prevention should be practiced at the onset of design, so that the effort required for additional assessments such as the P2DA becomes minimal.

Total quality management: TQM originated as an attempt to move quality from a paradigm of quality control, identifying defects through inspections and then repairing them (treatment), to one of prevention (i.e., preventing the production of defective products). Pollution prevention is a new paradigm for waste management (EPA 1993a), focusing on waste prevention rather than after-the-fact treatment. Allenby (1993) further elaborates on the relationship between TQM, pollution prevention, and DfE.

Pollution is a quality defect that reduces efficiency and customer satisfaction. When practicing pollution prevention, it is often helpful to look beyond quick fixes and to work with suppliers and customers for help and ideas. Suppliers become very important when implementing ideas related to packaging and transporting of materials. These are the basic principles of TQM.

2.5 Conducting a Pollution Prevention Design Assessment

The earlier sections of this chapter provided an orientation to pollution prevention by defining the term, and discussing benefits, barriers, and interfaces with related engineering concepts. The remainder of this chapter presents a method for systematically incorporating pollution prevention into the design phases of projects. The method is called the P2DA and is a variation of DOE's original PPOA method. PPOAs are widely used in pollution prevention programs across DOE to investigate waste generating processes or activities and to identify pollution prevention alternatives.

The method for conducting a complete P2DA is presented in this section, with additional recommendations unique to each project phase presented in Section 2.6. However, since a complete P2DA may not be practical in some instances, suggestions for limiting the scope of a P2DA can be found in Chapter 3, Graded Approach. Chapter 3 also contain other less prescriptive approaches that may be more appropriate for certain projects in lieu of a P2DA.

The basic framework for the P2DA process is depicted in Table 3. Rather than providing hard copy worksheets, the P2DA provides guidance for drafting electronic spreadsheets, which individual teams can tailor to their projects. These spreadsheets can then be electronically linked as appropriate to other project databases, such as estimates for air emissions or other releases.

Tracking data electronically will make it easier for individual P2DA teams to sum the data, prioritize streams by sorting in order of decreasing cost or waste volume, or otherwise manipulate the data as appropriate to support their P2DA.

2.5.1 Planning and Organization

2.5.1.1 Establish a Team

Before getting started on the P2DA, a team needs to be established. Team selection should consider the following features and members:

- upper management support
- customer buy-in
- diverse and knowledgeable team members
- a team member with pollution prevention training and assigned leadership on the P2DA task
- a team member with comprehensive process knowledge
- a team member from a similar operating facility.

For smaller design projects, the P2DA team may coincide with the design team. For larger projects, the P2DA team will be some subset of the design team, but should have a technical representative from each of the project's applicable design disciplines. For example, in the case of the 1995 Hanford case study project (see Section 9.1.1), the entire design team for this minor facility modification participated in the P2DA (approximately 12 people). However, the case study project at Oak Ridge had over 100 people on the design team, so a subset was selected that included representation from project management, pollution prevention personnel, and the value engineering team (see Section 9.1.2).

In general, management may or may not be represented on the P2DA team, but should be supportive of the team's objectives and goals. The team should have a leader responsible for coordinating the efforts of all technical disciplines. This will generally be either the project manager or an environmental engineer trained in pollution prevention concepts and requirements. If possible, all members of the team should be trained in pollution prevention concepts (see Chapter 8 for available training).

The team can acquire a valuable resource by recruiting a technical liaison from a similar operating facility. This person(s) can provide insights to current practices, specifically efficiencies and inefficiencies. This is often difficult to evaluate in the design stage when the physical system is not easily visualized. Understanding processes and intended uses of a facility is critical to identifying creative pollution prevention solutions. In the case of the LANL case study (see Section 9.1.3), a radioactive liquid waste treatment facility was being designed to replace an existing facility that had operated beyond its design life. A representative from the existing facility proved to be beneficial in conducting the P2DA for that project.

To alleviate some of the contractual barriers discussed earlier in this chapter, it may make sense to involve other contractors, and even the customer in the P2DA. For example, if it is known during the preliminary design that a portion of the facility or a specific system will go to a subcontractor for design/construct, it is best to involve that contractor as early as possible. If necessary and appropriate, readers may want to consider adding pollution prevention design requirements directly to subcontracts. Similarly, the customer needs to be aware of the status and results of the P2DA, and may have already evaluated some of the pollution prevention opportunities that will be identified during the P2DA.

The design team should not be limited solely to project members. Others with expertise outside the project team, such as in industrial health, environmental compliance, or purchasing, for example, may be included. Table 4 describes how various participants in the DOE design process can participate in the project's P2DA (EPA 1993a).

2.5.1.2 Budget for the P2DA

The likelihood of a successful P2DA increases with the extent to which it has been budgeted and planned. However, because the P2DA process is so new, it is difficult to estimate the cost to conduct one. Other related projects may provide some indication of how much it will cost to do the P2DA. DuPont spends approximately two percent of their preliminary design budget to do an environmental review. At the Kansas City Plant, a graded approach is used to do PPOAs on existing waste streams. PPOAs take an average of 40, 60, and 130 hours for level 1, 2, and 3 PPOAs, respectively. A very complicated PPOA took a documented 310 hours (Pemberton et al. 1994). For a small facility modification in definitive design at Hanford, the cost of the P2DA was simply the cost for the design team to attend the P2DA training session (12 people for 6 hours). All other activities were integrated into existing work scope. However, for a much larger project earlier in design at Los Alamos, $1.2 million was budgeted for pollution prevention, but the estimated potential cost savings was $50 million. If the project is very early in the planning phase, the budget for the P2DA could come from the National Environmental Protection Act (NEPA) planning budget if the project requires an Environmental Assessment (EA) or Environmental Impact Statement (EIS). The cost of the P2DA depends on the extent of the analysis (see

Chapter 3, Graded Approach). When considering the cost and how it will be budgeted, be sure to consider that up-front planning in the P2DA can lower other project costs, such as permitting and offsite dose calculations required by the Safety Analysis Report (SAR).

Also consider that there may be additional sources, other than project funds, to pay for the added cost of the P2DA. Site operating contractors have a vested interest in design and may be able to help promote or even fund P2DAs for design projects. Contact the operating contractor's pollution prevention program office. PPOAs are an integral part of the operating contractor's pollution prevention program, so they may be willing to fund a PPOA for a design project. DOE Headquarters may also be a funding source.

2.5.2 Step 1—Quantify Anticipated Waste Streams and Resource Consumption

"A well-defined problem is half solved" holds particularly true for the P2DA process. It is in the process of identifying streams and their origin that the ideas for eliminating or minimizing those streams come about. This step of the P2DA is the most critical because it will provide the data to determine the strategy to proceed. Data on waste generation will be used to prioritize streams and define the scope of the remainder of the P2DA. The time spent on the remainder of the P2DA should be allocated appropriate to the priority of the stream.

Also note that because pollution prevention includes resource conservation and reduced hazardous materials use, the P2DA should not be limited to identifying waste streams, but should also include identifying energy and resource intensive processes. The *P2-EDGE* software, discussed later in this Guide, provides specific opportunities for both waste prevention and resource conservation.

2.5.2.1 Identify Anticipated Waste Streams

Identifying anticipated waste streams is more difficult for a P2DA than for a PPOA process where the process physically exists and is operating. To identify anticipated waste streams during design, readers need to consider wastes that will be generated during construction, operations, and closure/dismantlement of the facility. Pollution prevention is a multimedia approach that requires examination of air emissions, liquid wastes, and solid wastes. Furthermore, wastes are not just generated by the primary facility processes, but by support functions (e.g., utilities) and facility maintenance as well. Finally, waste stream identification requires an examination of not only routine continuous and batch processes, but non-routine processes as well.

The considerations described above: life-cycle stage, waste media, and process versus secondary streams (maintenance, utilities, and non-routine events) have been used to establish a framework for identifying future waste streams. Table 5 is a partial listing of potential waste streams for generic facilities. It is not meant to be exhaustive, but to provide a starting point for identifying anticipated waste streams. In addition to this table, depending on what design stage a project is in, any environmental documentation for anticipated waste streams should also be reviewed. The NEPA process required as part of pre-project planning examines the environmental impacts of the proposed project. If a project is in a later design stage, the permit applications that are being developed may also contain information on the anticipated waste streams and management methods.

2.5.2.2 Quantify Anticipated Waste Streams

Gathering the data to quantify waste streams that will be generated is more difficult than quantifying existing processes because the physical system does not exist yet. Direct measurement is impossible, and plant records or other historical data are nonexistent. Therefore, estimates need to be drawn from vendor data or preliminary calculations used to size equipment. To some extent, waste generation may also be estimated based on the operating parameters established by the project's requirements documents. Another technique is to look at a similar facility that is in operation, and to project waste generation rates based on an extrapolation of the operating facility's waste/production ratio.

Table 6 summarizes the information that will need to be recorded for each waste stream identified in Table 5. A simple spreadsheet can be setup to track and total the streams.

2.5.3 Step 2—Establish Strategy

Information regarding Step 2 is provided in Chapter 3, Graded Approach.

2.5.4 Step 3—Identify Pollution Prevention Design Opportunities

When the scope and goals of the P2DA have been established (Chapter 3), the next step is to identify specific design changes that would prevent or minimize the anticipated waste streams. These design changes are called P2DOs, or pollution prevention design opportunities.

Traditional techniques for identifying pollution prevention opportunities in the PPOA process also hold for the design process. These techniques include brainstorming sessions, cause/effect diagrams, nominal group techniques, and benchmarking the best practices and technologies of industry.

One useful technique for identifying P2DOs is to record, for each stream listed in Table 5, whether that stream is non-useful (waste), recyclable, or a possible feed for another process within the facility (CMA 1993). For example, gray water can possibly be used for irrigation in lieu of raw water. Organizing streams by non-useful, recyclable, or feed will help readers to identify P2DOs. Opportunities are discovered by matching candidate processes to waste streams that are potential feeds, or by designing mechanisms to recycle the recyclable streams back into the process or offsite. Non-useful streams should be eliminated or minimized at the source to the extent possible. Specific opportunities for pollution prevention are provided in the *P2-EDGE* software.

Like the P2DA manual, the *P2-EDGE* software is a tool developed under the umbrella of the DOE Project *P2 by Design*. *P2-EDGE* contains over 250 P2DOs, sorted first into the 16 divisions of the Construction Specifications Institute (CSI) master format system, then further sorted by the EPA's pollution prevention hierarchy: source reduction, recycling, treatment, and environmentally safe disposal (Dorsey et al. 1994b). *P2-EDGE* software provides a filtering function for reviewing only those opportunities that are appropriate, based on design phase and project size. The database of P2DOs is not meant to be exhaustive, but to stimulate additional pollution prevention ideas. Case study participants who tested the prototype *P2-EDGE* software during 1994 commented that it is a good "idea jogger." *P2-EDGE* software is multimedia-based, with a graphical user interface that provides the user easy access to reference materials, photographs, and examples to support determination of whether to implement the P2DO on the user's project. Instructions for obtaining a copy of the *P2-EDGE* software can be found in Chapter 7.

While brainstorming for additional P2DOs, it is helpful to think of major categories of process/ product improvements such as process substitution, process control, more efficient facility layout, inventory management, equipment modifications, production process modification, recycled content products, or spill prevention and control techniques. A related technique is to brainstorm ideas along a specific design strategy, such as design for recyclability, design for disassembly, design for eco-efficient materials management, design for durability, design for life extension, design for maintenance, design for energy conservation, design for water conservation, or design for hazardous materials reduction (Fiksel 1994).

One other technique for identifying P2DOs is to look at lessons learned from similar operating facilities. In these cases, the design needs to strike a balance between not duplicating previous design efforts, yet fostering a continuous improvement approach. For example, new designs should phase out products or processes from current operations with unacceptable environmental impacts.

From an engineering perspective, new ideas for P2DOs come more readily when the project team is working within the framework of an environmental design strategy. Several basic ways to improve a product's design are suggested by Quakernaat and Weenk (1993):

1. Use energy, raw materials, and resources in a rational manner.

2. Purify fuels, raw materials, and resources in advance.
3. Reduce the discharge of substances that have an environmental impact.
4. Recycle substances, materials, and products.
5. Modify products in an ecologically sound manner.
6. Use renewable raw materials, energy, and resources.
7. Prevent the leaching of residual waste.

2.5.5 Step 4—Analyze Design Alternatives

The two elements of analyzing P2DOs are 1) determining the scope of costs to consider, and 2) deciding with what to compare implementation. Several EPA guidance documents outline techniques for computing financial costs for pollution prevention opportunities (EPA 1994; EPA 1993b; EPA 1992). These guidances provide a framework for computing usual costs, hidden regulatory costs, and less tangible costs. Usual costs include capital (buildings and equipment) and operating expenses. Less tangible costs include such items as future liabilities and worker health benefits. The users of this Guide are encouraged to reference these documents for more complete information.

With respect to DOE design projects, full cost accounting is complicated by the fact that the design detail is not fixed, so neither is the cost. Table 7 provides a simplified cost sheet for a P2DO. The cost sheet serves as a framework for individual projects to develop their own spreadsheets to be compatible with other project records. The reference column should contain the calculations or supporting documents used to arrive at the individual cost estimates.

Values recorded in Table 7 that are added *costs* should appear as positive values and those that are *savings* should appear as negative values. Tabulated values represent *the difference* in cost for the P2DO versus some baseline of comparison (typically, the current design configuration). For example, a P2DO may be less costly to implement than the current design configuration, in which case the implementation cost is negative, representing a savings to the project.

Implementation cost is a one-time cost. The table also requires computation of annual costs. As with implementation cost, annual estimates should be recorded as positive values for added costs and negative values for savings. If the annual savings outweigh the costs, then a simple payback period can be computed by dividing the implementation cost ($) by the annual savings ($/yr). Again, the reader is encouraged to consult additional reference materials for conducting cost comparisons between design alternatives (EPA 1994; EPA 1993b; EPA 1992).

2.5.6 Step 5—Document Results

At this point in the P2DA process, the team has identified the major waste streams, established the scope of the analysis depending on budget and schedule constraints, brainstormed P2DOs within the boundaries of the P2DA scope, and computed implementation cost and potential savings for the more promising P2DOs. Now it is time to choose which P2DOs are cost effective or otherwise attractive for implementation. Finally, the P2DA effort needs to be integrated into project records. This includes 1) implementing design changes as a result of selected P2DOs, and 2) communicating overall waste reduction successes to the customer, regulators, and other project stakeholders.

Depending on the design stage, it may be appropriate to include the cost evaluation worksheets for selected P2DOS as formal calculations, assigning a calculation number so that it is officially tracked within the project management system. By doing so, the drawings, specifications, design reports, etc., that are impacted by P2DO implementation are clearly identified. Similarly, if inputs to the calculations change, then the P2DO cost evaluation can be updated and reevaluated for cost effectiveness. Design changes as a result of selected P2DOs need to be reflected on the impacted drawings or specifications, and clearly communicated to interfacing design disciplines.

The second objective of communicating overall results to stakeholders can be achieved either by adding text describing the overall P2DA effort and results directly into design reports, or, for more-detailed P2DAs, the approach and results can be submitted in a standalone report that can be attached as an appendix to the design reports or even permit applications.

The final step in the P2DA process is to reevaluate goals and to plan for subsequent P2DAs in future design stages. This can be done by adding the study to the project's work breakdown structure, or otherwise earmarking dollars and personnel hours for analysis on a continuous improvement basis.

2.6 Specific Considerations by Project Phase

The number of pollution prevention design opportunities decreases with each successive design phase because the design solution generally becomes increasingly narrow as the design detail develops. Furthermore, it is estimated that 70 percent of a product's life-cycle cost is determined by its design (Oakley 1993). For these reasons, it is critical to consider pollution prevention as early as possible in a project. The later a new concept is implemented into a design, the greater the impact it has on project cost. Although it is never too late to consider preventing pollution, it should be regarded as a tool for continuous improvement with its greatest potential impact in early design consideration.

The phases for DOE projects are described in GPG-FM-001, Project Management Overview. Because of the complex nature and diversity of DOE projects, the terminology may differ across organizational elements. However, the project management system generally consists of preconceptual activities, a conceptual phase, and an execution phase that includes acceptance and turnover. The remainder of this section describes opportunities and recommendations for including pollution prevention into the various project phases.

2.6.1 Preconceptual Activities

General Pollution Prevention Strategy

This phase leads to the formal start of a project through the identification of a need and development of mission need documentation. Up-front project planning in this phase ensures that the project is executed within technical, schedule, and cost baselines. Although a P2DA will not be conducted during preconceptual activities, it is critical to ensure that pollution prevention concepts become a part of the project plan and overall strategy.

Specific Opportunities for Pollution Prevention

The guidance for completing a justification of mission need includes a preliminary environmental strategy and states that pollution prevention, waste management issues, and recommendations for NEPA documentation determination should be included (GPG-FM-001). In addition, the justification of mission need should always correlate to the Departmental Strategic Plan and program mission. The 1996 Pollution Prevention Program Plan (DOE 1996) is the DOE's principle pollution prevention program planning document. The justification of mission need should be consistent with the policy and goals set forth in that plan.

2.6.2 Conceptual Activities

This phase marks the formation of the project team and initiation of planning activities. At the end of conceptual activities, the design needs to be sufficiently developed to establish a project cost baseline, and to begin an effective preliminary design. The end result usually means tradeoff studies have been identified and developed into final design criteria, and the configuration baseline has been established. Specific opportunities for pollution prevention throughout these activities are described below.

2.6.2.1 Project Planning Documents

Project Charter: The type(s) of project planning documents will vary depending upon the complexity of the project. Project charters can be used to describe the overall guidelines and parameters within which the project will be managed. DuPont uses a 10-step process to incorporate environmental reviews into facility design. The third step defines the environmental objectives of the project through the project charter. Elements of the DuPont Environmental Charter are shown in Figure 3. This charter can be used as an example for writing environmental objectives into DOE project charters.

Project Plan: The project plan guides project execution and is drafted during the earliest stages of project initiation. It is continually revised with each successive design stage to ensure it encompasses the evolving technical, schedule, and cost baselines. There are several opportunities for including pollution prevention in the project plan. For example, the P2DA or equivalent analysis can be written into the work breakdown structure as a specific product or report of the current design stage. Correspondingly, the schedule, which must be consistent with the work breakdown structure, can include provisions for conducting the P2DA. The risk assessment portion of the project plan can describe how pollution prevention techniques will be used to minimize risks associated with potential environmental, safety, and health hazards. The project plan should include specific actions for meeting ES&H objectives including policy, organization, training, environmental permits, reviews and audits, and management procedures to minimize risks.

Each of the following items offer an opportunity for including pollution prevention principles in the project planning document:

Policy - Management policy should clearly reflect the philosophy of preventing the creation of waste at the source whenever possible. Waste that cannot be prevented should be reused or recycled wherever feasible. As an example, the pollution prevention policy adopted by the LANL CMR Facility is provided:

> “The CMR Facility and Phase 2 Upgrade Management (project management) will demonstrate a sustained and integrated commitment to conserving resources and minimizing waste and pollutants during all phases of planning and implementation of the upgrades project. Preference will be given to minimize the generation of waste whenever possible, recycle waste that cannot be eliminated at the source whenever technically and economically feasible, and give prime consideration to reducing or eliminating waste over treatment, storage, and disposal of waste. Waste minimization shall be incorporated as a core value of the project and shall be developed as a core competency of all project participants. The tenets of pollution prevention, waste minimization, reduction, and elimination shall be incorporated in all aspects of the project’s decisionmaking process.”

Organization - The project team should be organized to include or have access to pollution prevention skills.

Training - Plans to train project staff in the concepts and methods of pollution prevention should be included.

Environmental Permitting - The P2DA should be coordinated with the permitting process. Data gathered for permitting can be used to support the P2DA and vice versa. Pollution prevention successes should be communicated to the regulators and to the public.

Reviews and Audits - The P2DA is an example of an environmental review that may complement other planned reviews.

Management Procedures - These procedures should include provisions for implementing the project's pollution prevention policy and charter.

2.6.2.2 Design Criteria Package

General Considerations

During the development of the design criteria package, it is not appropriate to conduct a P2DA because identifying and implementing specific design approaches is counterproductive to writing design requirements. Design requirements should not be prescriptive or specify a particular design solution. However, even without the P2DA, the methods used to derive project requirements have significant impact on the ultimate waste generation for the project.

Design requirements cannot be overly restrictive or too broad. If the requirements are too broad, the project runs the risk of proceeding along an incorrect design path because of vague requirements, only to change later at great expense. Similarly, if requirements are overly restrictive, they may preclude implementation of novel pollution prevention designs.

Specific Opportunities for Pollution Prevention

- Special security, environmental, safety, and health needs: Under the heading of environmental needs, an item can be added to the design criteria package requiring that pollution prevention be practiced to the maximum extent practicable. Conducting a P2DA can be recommended as one method for satisfying and documenting this requirement.

- Floors and finishes; insulation, moisture-proofing, roofing: The design criteria package should include a requirement to maximize purchase of recycled content products and products with no or minimal toxic and hazardous constituents.

- Heat recycling and/or recovery: Heat recycling is one method of pollution prevention. The design criteria package should require heat recycling and/or recovery to the maximum extent practicable.

- Energy conservation parameters for mechanical systems: Pollution prevention includes energy conservation. The design criteria package should include energy conservation parameters for mechanical systems.

- Process water or cooling water needs: Water conservation should be taken into account when determining water needs.

- Energy conservation measures for lighting: Pollution prevention opportunities for conservation through lighting measures should be included.

2.6.2.3 Conceptual Design

General Pollution Prevention Strategy

The objectives of conceptual design are to develop a project scope, ensure project feasibility and attainable performance levels, identify project risks, and develop a cost estimate and schedule. This is the earliest design stage that a P2DA can be conducted. The P2DA will not be as quantitative as in subsequent stages, but the opportunities for pollution prevention design features are greater because the design is less defined and more flexible.

Specific Opportunities for Pollution Prevention

- Safeguards against potential environmental damage and methods for mitigating environmental hazards*:* There are no hazards (and therefore no safeguards) associated with waste streams that can be avoided all together.

- Types and materials of construction, basic facility drawings, and outline construction specifications: Materials of construction should emphasize recycled content products and recyclable products. The use of "like" materials wherever possible will facilitate source separation upon dismantlement. Outline specifications should include provisions for vendors to take back and recycle packaging materials. Preference should be given in specifications to recycled content products and less hazardous products over hazardous counterparts.

- Space allowances for various functions: Facility layout should economize building materials required for construction (i.e., minimize space while retaining function).

- Energy consumption and types of energy supply: Energy should be conserved and renewable energy sources should be considered wherever practicable.

- Decontamination and disposal requirements: How will the facility be decommissioned? What specific design features will facilitate dismantlement and maximum ability to recycle building materials?

- Water conservation initiatives and associated design/construction features: Water conservation is included in the definition of pollution prevention and should be incorporated into the design as appropriate.

2.6.3 Execution Phase

During this phase, the project progresses from a conceptual design into a detailed design. It continues through design execution and includes final completion and acceptance of the project. Typical activities include preliminary design, detailed design, and construction.

2.6.3.1 Preliminary Design

General Strategy for Pollution Prevention

Preliminary Design continues design development from conceptual design and needs to be sufficiently detailed to fix the project scope and features. Because the project scope is fixed after Preliminary Design, it is crucial to get any major pollution prevention features into the design at this time. Any pollution prevention successes in later design phases or construction will have less potential for significant impact. If a P2DA was conducted during conceptual design, it will be a simple matter of updating the P2DA, given the new design information established during this design phase. The P2DA will become more detailed and additional P2DOs may be identified for systems that are more defined than in conceptual design.

Specific Opportunities for Pollution Prevention

- Preliminary tradeoff studies: Design alternatives should evaluated for waste generation, resource consumption and other environmental effects.

- Development of outline specifications for construction and specifications for equipment procurement: Specifications should relay pollution prevention requirements to prospective suppliers. Provisions for vendors to minimize packaging, take back packaging, employ reusable totes, etc., should be considered. Materials and equipment should use recycled content products, minimum toxicity or hazardous constituents materials, and recyclable materials to the extent practicable.

- Additional analyses of health, safety, and environmental protection: The P2DA can be developed as, or in conjunction with, an environmental protection analysis. If a P2DA has not been conducted during conceptual design, it is still appropriate to begin the analysis during preliminary design.

- Development of preliminary construction estimates and methods of construction performance: Methods of construction performance should include provisions for minimizing generation of construction wastes. Cost estimates generated can be used to support the cost evaluation portion of the P2DA.

- Further evaluation and selection of energy conservation measures and energy sources of supply: Energy conservation is included in the definition of pollution prevention. Energy conservation features should be incorporated into the design to the extent feasible.

- The PSAR and P2DA are complementary exercises. Hazards identified through the PSAR should be evaluated for potential pollution prevention mitigating features in the P2DA. Data developed in support of the PSAR can be used to quantify waste streams during the P2DA.

2.6.3.2 Detailed Design

General Strategy for Pollution Prevention

Detailed Design continues design development using the approved Preliminary Design as its basis. Detailed design needs to be sufficiently detailed to allow construction to begin. Most of the pollution prevention design opportunities during this phase will be detailed design considerations such as selecting coating systems with minimal environmental impacts, specifying recycled content products, and integrating pollution prevention concepts into operating manuals. If a P2DA was conducted during preliminary design, it will be simple to update the P2DA given the new design information established during Detailed Design. The P2DA will become more detailed and additional P2DOs may be identified for systems that are more defined than in Preliminary Design.

Specific Opportunities for Pollution Prevention

- Development of final working drawings and specifications for procurement and construction: Specifications should relay pollution prevention requirements to prospective suppliers. Provisions for vendors to minimize packaging, take back packaging, employ reusable totes, etc., should be considered. Materials and equipment should use recycled content, recyclable, and low toxicity material to the extent practicable.

- Development of a detailed cost estimate: Cost estimates generated can be used to support the cost evaluation portion of the P2DA. Cost estimates should include complete environmental life-cycle costs.

- Prepare analyses of health, safety, environmental, and other project aspects: This is an opportunity to refer to the P2DA as an environmental protection analysis. If a P2DA has not been conducted during Preliminary Design, it is still appropriate to begin the analysis during Detailed Design.

2.6.3.3 Construction and Acceptance

During construction, the facility is built to the Detailed Design. The purpose of Acceptance is to verify that construction workmanship, materials, and equipment conform to the approved drawings. Construction by its very nature presents a very difficult problem in controlling costs and preventing waste and error. Having a method or program in place during construction to control waste is very important. It is estimated for a typical office building, that the amount of waste generated during construction is approximately equivalent to the amount of waste generated over the entire first decade of operating the office building (reference). Even if no previous pollution prevention analysis has been conducted during design, it is still important to consider pollution prevention during construction. If this is the case, opportunities for implementing pollution prevention in the facility's operation or closure/dismantlement this late into the project are less likely.

Specific Opportunities for Pollution Prevention

- Indoctrination of construction contractor: The contractor should understand the project's pollution prevention policy, objectives, and charter as described in the project management plan.

- Contractor develops subcontracts and purchase orders and procedures: Subcontractors should be held to the same pollution prevention standards and practices as the design team.

- Contractor determines equipment and material delivery schedules: Delivery schedules should preclude, to the extent practicable, waste generation due to expired products.

- Equipment fabrication: The EPA has established guidelines for integrating pollution prevention into the fabricated metal products industry (EPA 1990).

- Construction equipment requirements: The project should investigate surplus equipment availability from previous construction projects.

- Construction plant - shops, warehouses, temporary construction facilities, roads, water supply, sewage collection and disposal: Check into combining with other construction needs in the area.

- Construction Supervisor training program: This training program should include provisions for pollution prevention training.

- Acceptance testing - hydrostatic, pneumatic, electrical, ventilation, mechanical functioning, and run-in tests of portions of the facility: Test procedures should account for waste generation, including ways to minimize waste generation from inspection activities.

3. Graded Approach

DOE Order 430.1 requires that DOE elements use a value-added, quality-driven, graded approach to life-cycle asset management. In the case of pollution prevention, the effort should be commensurate with the expected degree of waste generation and resource consumption throughout the life of the project. If a graded approach is properly applied, any expense of implementing pollution prevention changes during design should be paid back by the resulting cost savings throughout the life of the facility.

3.1 Determining Level of Detail for the P2DA

There are a couple of different methods for limiting the scope of the P2DA analysis to be commensurate with the complexity of the project: 1) choose a subset of waste streams to target based on a prioritization scheme, or 2) limit the scope of the analysis to one or more specific pollution prevention design strategies. In either case, anticipated waste streams and areas of significant resource consumption (energy use, water consumption, building materials, etc.) need to be identified and quantified. Once this has been determined, the boundaries of the P2DA can be narrowed to appropriately encompass the areas of major environmental concern or greatest expected return on investment.

3.1.1 Prioritizing and Selecting Specific Waste Streams

There are a variety of ways to prioritize waste streams. The most straightforward method is to sort the spreadsheet established using the format of Table 6 by total cost. All stream costs can be summed to a total project cost. It would not be uncommon to find that a majority of the total waste generation could be attributed to only handful of culprit waste streams. At a minimum, the P2DA should cover those waste streams with a significant individual contribution to the total anticipated waste. The actual boundary for which streams to include in the P2DA can be arbitrarily cut off after a specified percentage of total project cost is represented. One rule suggests neglecting items that account for less than 1 percent of total inputs and outputs (EPA 1993a).

Of course, cost may not always be the best method of prioritization. Because radioactive and RCRA-permitted waste streams are required to be minimized, these streams should be retained within the scope of the P2DA.

3.1.2 Employing Specific Pollution Prevention Strategies

A second approach for limiting the scope of the P2DA would require an understanding of the underlying cause for the major waste streams and devising design strategies to address these causes. For example, if the major wastes are expected during construction, one possible strategy might be to emphasize procurement of refurbished or excessed equipment and select materials with recycled content. If priority waste streams are anticipated to occur during operations, employing innovative designs to minimize the area required for radiological control zones could prove to be key. If priority waste streams are anticipated to occur during closure, the emphasis might best be placed on designing for ease of decontamination and decommissioning.

If the types and causes of waste streams are well-understood, conducting the P2DA around a few select strategies can provide good pollution prevention results without having to perform a detailed analysis on every anticipated stream. The examples provided from private industry (see Section 9.3) illustrate how focusing on one or two design strategies can yield enormous pollution prevention and cost savings.

3.2 Alternatives to Conducting a P2DA

This Guide is not intended to be so prescriptive as to require that a P2DA be conducted throughout the design phases of every DOE project. Rather the P2DA is presented as a tool for systematically considering pollution prevention during design and for documenting the results of that process.

As shown in Table 1, pollution prevention is related to many other management systems employed in the acquisition of DOE assets. Depending on the nature of the project and the extent that these related Guides are being implemented, a P2DA may not be necessary at all. In the case of the Oak Ridge Transuranic Processing Facility (see Section 9.1.2), pollution prevention was integrated directly into the value engineering process in lieu of a formal P2DA. This was effective because the project was in the initial design phase, so a detailed P2DA was impractical.

Other successful alternatives to a P2DA have been observed. The LANL CMR Facility was also early on in project planning, so a Waste Minimization/Pollution Prevention Strategic Plan was developed. The strategic plan states the project pollution prevention policy, sets pollution prevention goals, and describes the organizational and staff responsibilities for meeting those goals. It also outlines an approach, highlighting the major engineering areas that will be targeted for pollution prevention, including some early strategies such as the reduction in size of radiological control areas and sorting for reuse, recycle, treatment, or disposal.

4. Measuring for Results

4.1 Pollution Prevention Indicators

Indicators that pollution prevention is being implemented on a project might include

- pollution prevention concepts appear in project policy and planning documents
- indoctrination of project staff to pollution prevention concepts
- a completed P2DA report or inclusion of pollution prevention in the project design report(s)
- documented evidence that pollution prevention was considered during engineering tradeoff studies
- inclusion of pollution prevention in design reviews, as appropriate.

4.2 Setting Pollution Prevention Goals

Setting goals will further help a project team to prioritize streams and activities. When considering a project's pollution prevention goals, contact the site/facility pollution prevention coordinator for suggestions on making goals consistent with the site/facility waste minimization plan. For example, if the site/facility participated in the EPA's 33/50 program to voluntarily reduce use of 17 toxic chemicals by 50 percent by 1995, it would be appropriate for a project to consider a parallel goal.

When setting goals, it is necessary to have a baseline by which to compare. It may therefore be helpful to compare proposed P2DOs against the "no action" scenario, the environmentally compliant scenario, or the best pollution prevention practices scenario. Do not compare new goals to the previous design stage estimates. Because the design is becoming increasingly more detailed with each successive stage, understanding of waste generation and therefore the volume estimates will increase accordingly, sometimes despite waste reduction opportunities being implemented into design. The most straightforward method of evaluating goals is to compare to the "no action" scenario. Regardless, all goals established should be measurable and provide a challenge to improve over the current design.

Goals can be established in terms of reducing a specific waste stream by a specified percentage based on current data of anticipated waste generation, or, it may be a simpler goal to implement a certain number of design opportunities. Another example of a practical goal might be to recoup the cost of the P2DA study through cost savings estimated from implementing P2DOs. Other areas for setting design goals are listed in Table 8 (Fiksel 1994).

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5. Suggested Reading

5.1 Pollution Prevention Policy and Requirements

U.S. Department of Energy. 1996. *Pollution Prevention Program Plan: 1996.* DOE/S-0118, Office of the Secretary, U.S. Department of Energy, Washington, D.C.

Pollution Prevention Act of 1990 (PPA), P.L. 101-508, November 5, 1990, published at 104 Stat.1288, 42 U.S.C 13101 et seq.

Executive Order 12856, Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements, 58 FR 41981 (August 6, 1993).

Executive Order 12873, Federal Acquisition, Recycling, and Waste Prevention, 58 FR 54911 (October 20, 1993).

5.2 Pollution Prevention Guidance

5.2.1 Pollution Prevention During Design (Design for Environment)

American Institute of Architects. *Environmental Resource Guide.* A subscription that offers in-depth analyses of various building materials, and reports and case studies on topics relevant to design, construction, and the environment. Contact: AIA , 9 Jay Gould Ct. P.O. Box 753, Waldorf, Maryland 20604. (800) 365-ARCH.

Austin Green Builder Program. *Green Building Guide: A Sustainable Approach.* Environmental and Conservation Services Department, Austin, Texas.

Bonneville Power Administration, Seattle City Light, and Seattle Dept. of Parks & Recreation. *Designing with Vision, Public Building Guidelines for the 21st Century.* Contact: (206) 682-4042.

Chemical Manufacturers Association (CMA). 1993. *Designing Pollution Prevention into the Process: Research, Development, and Engineering*. CMA, Washington, D.C.

Ellis, M. D. (editor). 1994. *The Role of Engineering in Sustainable Development*. American Association of Engineering Societies, Washington, D.C.

Environmental Building News. A bimonthly newsletter on environmentally sustainable design and construction. Contact: RR1, Box 161, Brattleboro, Vermont 05301. (802) 257-7300.

National Park Service. *Guiding Principles of Sustainable Design*. 1993. Government Printing Office, Washington, D.C.

Mackenzie, D. 1991. *Design for the Environment*. Rizzoli, New York.

Oregon Department of Environmental Quality. 1994. *Environmental Handbook for Oregon General Construction Contractors: Best Pollution Prevention Practices.* Eugene, Oregon. (541) 686-7888

U.S. Environmental Protection Agency. 1993. *Life Cycle Design Guidance Manual: Environmental Requirements and the Product System*. EPA/600/R-92/226. Washington, D.C.

5.2.2 Pollution Prevention - General

Higgens, T.E. 1995. *Pollution Prevention Handbook.* CRC Press. International Standard Book Number 1-56670-145-7.

Pollution Prevention Review. John Wiley & Sons, Inc., 605 3rd Ave., New York 10158. Quarterly journal, $175/yr. Contact: (212) 850-6475.

U.S. Environmental Protection Agency. 1992. *Facility Pollution Prevention Guide*. EPA/600/R-92/088, Washington, D.C.

6. Definitions

Affirmative Procurement Program: A program that ensures that items composed of recovered materials will be purchased to the maximum extent practicable, consistent with federal laws and procurement regulations.

Design for Environment (DfE): The systematic consideration during design of issues associated with environmental safety and health over the product life cycle.

Decommissioning: The process of closing and securing a nuclear facility, or nuclear materials storage facility, so as to provide adequate protection from radiation exposure and to isolate radioactive contamination from the human environment.

Disposal: Waste emplacement designed to ensure isolation of waste from the biosphere, with no intention of retrieval for the foreseeable future.

Effluent: Treated wastewater or airborne emissions discharged into the environment.

Environment(al): Air and water quality, land disturbances, ecology, climate, public and occupational health and safety, and socioeconomic environments (including nonavailability of critical resources and institutional, cultural, and aesthetic considerations). For conciseness, these are normally referred to as environmental, safety, and health considerations.

Environmentally Preferable: Products or services with a lesser or reduced effect on human health and the environment when compared with competing products or services serving the same purpose. This comparison may consider raw materials acquisition, production, manufacturing, packaging, distribution, reuse, operation, maintenance, or disposal of the product or service.

Hazardous Waste: The statutory definition found in section 1004(5) of RCRA (42 USC 6903) is a solid waste or combination of wastes that because of its quantity, concentration, or physical, chemical, or infectious characteristics may a) cause or significantly contribute to an increase in mortality or in serious irreversible, or incapacitation reversible illness, or b) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of, or otherwise managed. Criteria for identification and listing of hazardous waste are found in Title 40 of Code of Federal Regulations, Part 261.

High Level Waste: The highly radioactive waste material resulting from reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and solid waste derived from the liquid, which contains a combination of transuranic waste and fission products in concentrations requiring permanent isolation.

Inventory Analysis: Identifies and quantifies all inputs and outputs associated with a system including materials, energy, and residuals (waste remaining after all usable materials have been recovered).

Life Cycle: The stages of the life of a product, process, or package, beginning with raw material acquisition; continuing through processing, materials manufacture, product fabrication, transportation, distribution, and use; and concluding with any variety of waste management options including recycling.

Life-cycle Analysis: The comprehensive examination of the environmental and economic effects of a product throughout its lifetime including new material extraction, transportation, manufacturing use, and disposal.

Life-cycle Cost: The sum total of the direct, indirect, recurring, nonrecurring, and other related costs incurred or estimated to be incurred in the design, development, production, operation, maintenance, support and final disposition of a system over its anticipated useful lifespan. Where system or project planning anticipates use of existing sites or facilities, restoration and refurbishment costs should be included.

Life-cycle Design: A systems-oriented approach for designing more ecologically and economically sustainable product systems. Life-cycle design couples the product development cycle with the physical life cycle of the product and integrates environmental requirements into the earliest stages of design, so the total impacts caused by the system can be minimized.

Low-Level Waste: Radioactive waste not classified as high-level, transuranic waste, spent nuclear fuel, or byproduct material.

Mixed Waste: Waste that contains both radioactive and hazardous components as defined by the Atomic Energy Act and the Resource Conservation and Recovery Act, respectively.

Non-routine Waste: Wastes produced from environmental restoration program activities, including primary and secondary wastes associated with retrieval and remediation operations. Non-routine wastes are a direct result of past operations and activities rather than current processes.

Pollution Prevention: The use of materials, processes, and practices that reduce or eliminate the generation and release of pollutants, contaminants, hazardous substances, and wastes into land, water, and air. Pollution prevention includes practices that reduce the use of hazardous materials, energy, water, and other resources along with practices that protect natural resources through conservation or more efficient use.

Pollution Prevention Opportunity Assessment: A systematic, planned approach used to evaluate input materials and parameters of a process, identify pollution and waste exiting the process, and generate and evaluate options for pollution prevention.

Pollution: Any emission, effluent, spill, discharge, or disposal to air, land or water, whether routine or accidental.

Reclamation: The process of regenerating or recovering a usable product from a material (e.g., recovery of lead from spent batteries and regeneration of spent solvents).

Recovered Material: Waste materials and by-products that have been recovered or diverted from solid waste, not including materials and by-products generated from, and commonly reused within, an original manufacturing process.

Recyclable: The ability of a product or material to be recovered from, or otherwise diverted from, the solid waste stream for the purpose of recycling.

Recycling: The series of activities, including collection, separation, and processing, by which products or other materials are recovered from the solid waste stream for use as raw materials in the manufacture of new products other than fuel for producing heat or power by combustion.

Renewable: The capability of being replenished quicker than the supply is being depleted to meet present, near-term, or future demand. Time and quantity are the critical elements in measures of renewability.

Routine Waste: Waste produced from any type of production operation, analytical and/or research and development laboratory operations, "work for others" operation, or any other periodic and recurring work that is considered ongoing in nature.

Source Reduction: Any practice that reduces the amount of hazardous substances, pollutants, or contaminants entering any waste stream or otherwise released into the environment (including fugitive emissions) before recycling, treatment, or disposal.

Sustainable: The ability to maintain a process or project through time without increasing harm to the environment. Overuse or non-renewable use of resources may decrease future productivity, thereby lowering sustainable yields. An additional factor defining sustainability is the amount and kind of environmental impacts caused by natural resource use. Even if the resources are abundant, systems that rely on certain resources may not be sustainable if this resource consumption results in major environmental impacts.

Treatment: Any method, technique, or process designed to change the physical or chemical character of waste to render it less hazardous, safer to transport, store, dispose of, or reduce in volume.

Waste: Any material generated other than intended product(s).

Waste Minimization: Any action that avoids or reduces the generation of waste by source reduction, improving energy efficiency, or by recycling. This action will be consistent with the general goal of minimizing present and future threats to human health, safety, and the environment. The term waste minimization generally applies to RCRA hazardous waste.

Waste Prevention: Also known as source reduction; any change in the design, manufacturing, purchase or use of materials or products (including packaging) to reduce the amount or toxicity of waste prior to recycling or disposal. Waste prevention also refers to the reuse of products or materials. The term waste prevention generally applies to sanitary or municipal solid waste.

Waste Reduction: Preventing or decreasing the amount of waste being generated through waste prevention, recycling, or purchasing recycled and environmentally preferable products. The term generally applies to sanitary or municipal solid waste.

7. Assistance

Additional assistance for using this Guide during the design phases of DOE projects can be obtained from the *P2 by Design* project. *P2 by Design* is sponsored by DOE EM-77, Office of Pollution Prevention, with support from FM-20, Office of Project and Fixed Asset Management. In addition to this Guide, *P2 by Design* has developed additional tools and information to assist DOE design personnel:

1. a six-hour training course, *Orientation to Pollution Prevention for Facility Design*
2. a software program, *P2-EDGE (Pollution Prevention Environmental Design Guide for Engineers)*, for identifying, evaluating, and documenting pollution prevention opportunities
3. a worldwide web homepage for deploying these products and other useful information.

P2 by Design staff are also available to answer your technical assistance questions and have been involved with targeted assistance to specific projects throughout the DOE.

The training course familiarizes participants with the concepts of pollution prevention and demonstrates how the design or modification of a facility can affect the generation of waste throughout the life of a facility. Participants use this Guide and the ***P2-EDGE*** software program to practice the process of incorporating pollution prevention strategies during the design phase on actual facility projects.

The *P2-EDGE* software program was developed to give engineers and architects an “edge” in lowering costs and minimizing environmental effects by quickly identifying appropriate pollution prevention strategies during the design process. The *P2-EDGE* database contains 250 opportunities for implementing pollution prevention strategies during design and includes documented examples, pictures, and references. *P2-EDGE* software features allow the user to **add** new pollution prevention opportunities to the database and associated data specific to a project, **edit** the existing data, **filter** out the opportunities that do not apply to a specific project, **search** the database for opportunities that match key words or text phrases, and **generate reports** to track the pollution prevention efforts through all design phases.

The *P2 by Design* tools are available through the project’s WWW homepage located at http://W3.pnl.gov:2080/DFE/home.html. The *P2-EDGE* software/user’s guide can be downloaded from the homepage to a Windows environment PC with a 386 or better microprocessor. The *P2 by Design* DfE homepage also contains information about Design for Environment, hyperlinks to other DfE homepages, resources from the project, cost savings and waste avoidance results from case studies, conference papers, and a bibliography of recommended literature.

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8. Related Training

Training on the use of this Guide is available through the *P2 by Design* project. Inquiries, questions, or comments can be sent to the project homepage suggestion box located at http://W3.pnl.gov:2080/DFE/home.html.

If you are interested in more general pollution prevention training, information on upcoming pollution prevention events (including training) can be found at *EPIC*, DOE's Pollution Prevention homepage located at http://146.138.5.107/EPIC.htm.

The DOE Office of Pollution Prevention (EM-77) hosts an annual Pollution Prevention Conference that includes technical sessions, workshops, and exhibits. You may also want to check your professional society for discipline-specific pollution prevention training.

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9. Examples

9.1 P2 by Design Case Studies

As part of the *P2 by Design* project (see Chapter 7, Assistance), a *Case Study* task was conducted in fiscal year (FY) 1995. In exchange for participation, case study design teams received training at their sites by the *P2 by Design* project, as well as technical assistance as needed throughout the remainder of the case study effort. Projects were identified based on a letter of invitation/ application process that was conducted through DOE EM-77.

Three projects, one each from Hanford, Oak Ridge, and Los Alamos, were selected as case studies. The three projects represented a wide range of project sizes, types of facilities, and design phases. To conduct their assessments, the project teams were given training, pollution prevention design guidelines, *P2-EDGE* software, and technical assistance as needed. From June to October 1995, the teams conducted their assessments and reported on their pollution prevention successes in monthly and final reports. The remainder of this section contains a more-detailed discussion of the case study process and results drawn from the Case Study final report (Engel 1995).

9.1.1 Hanford Tank System Upgrades

The Hanford Site project was the "Construction of Interim Status Tank System Upgrades of 219-S Tank System (Project W-178)." This project was for the design of the secondary containment of the tank system at the 222-S Laboratory. The 219-S facility is a RCRA-permitted Treatment, Storage and Disposal facility for laboratory mixed low-level wastewater, and the upgrade is required for Final Part B permitting. When the design assessment began, the project was in the definitive design phase and construction had begun at the end of the assessment. The project's budget for FY 1995 was $750,000 and $2,000,000 for FY 1996. This project was the smallest of the three projects and in the latest design phase.

The Hanford Site project was managed by ICF Kaiser Hanford company and they combined their design team and pollution prevention group resources to conduct the assessment. Training was conducted for nine design engineers and pollution prevention personnel. Additional assessment meetings were held during weekly project meetings, minimizing the impact on the project. The project team estimated that the only additional cost of doing the assessment was the time spent taking the training, about $1,800 in labor costs for nine people. Other costs were considered part of the normal job responsibilities of the personnel involved.

Seven opportunities were evaluated and five were incorporated into the final design or recommended for implementation at the appropriate time. The savings and waste reductions for these opportunities are summarized in Table 9. Descriptions of the seven opportunities can be found in the Case Study final report (Engel 1995).

Overall, the Hanford Site 219-S design project will realize a waste avoidance between 28.5 and 42.1 m^3 of low-level mixed waste, as well as hazardous product substitution. This will yield a cost savings of $27,216 to $31,708 for an investment of $1,800 for training.

9.1.2 Oak Ridge Transuranic Processing Facility

The Oak Ridge Site project was the "Construction of the Transuranic Processing Facility." The scope of this project was to design and construct a facility at the Oak Ridge National Laboratory to process various types of transuranic wastes for eventual disposal, including sludge, contact-handled solids, and remote-handled solids. The facility had been near design completion, but had been sent back for redesign to reduce the cost of design and construction; thus, when the design assessment began, the project was in the functional design phase. The project's budget for FY 1995 was $15 million and $22 million for FY 1996. Construction is expected to be completed after 2002. This project was the largest of the three projects and in the earliest design phase.

The Oak Ridge Site project is managed by DOE-Oak Ridge with help of Oak Ridge contractors. The Oak Ridge management team placed the design assessment in their ongoing Value Engineering (VE) study, making pollution prevention its own chapter in the VE study report. Training was conducted for 21 design engineers and pollution prevention personnel. Fourteen people were identified as core team members, with four others as additional resources.

Using the previous design as a baseline, the pollution prevention assessment is intended to continue through the subsequent design phases of the project. Preparation was completed to establish the tools and structure to complete full assessments and implementation later in the design. This included establishing a core team; creating an inventory of waste streams during construction, operations, and closure; formal incorporation of pollution prevention into the VE study; and use of *P2-EDGE* to determine potential opportunities. A majority of the opportunities from *P2-EDGE* (149, 63%) were identified as "will be considered," starting with the conceptual design. Approximately 108 hours were spent conducting the assessment thus far, for a total of approximately $9,000. Opportunities considered can be found in the Case Study final report (Engel 1995).

Three pollution prevention opportunities had already been included in the design prior to the assessment: use of storage tank supernatant for tank and pipeline sluicing instead of process water; testing of underground piping for integrity prior to backfilling; and use of prefilters upstream of HEPA filters to maximize the useful life of HEPA filter and reduce radioactive waste (see Table 10). However, since the project was in such an early design phase, no specific design assessments were conducted and no quantitative waste reduction or cost savings were calculated.

9.1.3 Los Alamos Radioactive Liquid Waste Treatment Facility

The Los Alamos project was the "Construction of Radioactive Liquid Waste Treatment Facility." The Radioactive Liquid Waste Treatment Facility (RLWTF) will process all radioactive liquid wastes from LANL, replacing an aging treatment facility. When the design assessment began, the project was in the conceptual design phase. The project's budget for FY 1995 was $2.8 million and $2.5 million for FY 1996. Construction is expected to be completed in the year 2002. This project was the median size of the three projects and in the median design phase.

The Los Alamos project was managed by LANL and they combined their design team and pollution prevention group resources to conduct the assessment. Training was conducted for 17 design engineers and pollution prevention personnel from both LANL and subcontractors. The assessment was managed by a full-time graduate student/summer intern and the Pollution Prevention Program Office (P3O).

The P3O staff worked the design assessment through the Best Demonstrated Available Technologies (BDAT) Analysis. This analysis is required by DOE Order 5400.5 and the P3O had been requested to participate at about the time the design assessment was to begin. Their focus then was on the process design (operation) of the facility, rather than on construction. Realizing that significant savings could be found by reviewing the sources and type of influent to the RLWTF, the assessment was broken into two parts: the BDAT Selection P2DA, which reviewed alternative treatment technologies for the RLWTF; and the generator segregation and pretreatment P2DA, which focused on reducing waste from the facilities sending waste to the RLWTF.

The BDAT Selection P2DA was conducted during the BDAT process by placing P3O personnel on the BDAT selection team. Roughly 200 hours ($7,000 unburdened) were spent conducting the pollution prevention assessment. In reviewing the options, it was discovered that the most efficient waste treatment process (in terms of how effectively the waste is treated) was not always the process that generated the least waste. The pollution prevention assessment greatly effected the BDAT selection and is documented in the formal BDAT records. No quantitative analysis was provided on cost savings or waste avoidance.

The second P2DA involved reviewing the generator segregation and pretreatment processes, before waste is sent to the RLWTF. By influencing the influent to the RLWTF, a greater effect on waste streams coming from the RLWTF could be realized. The largest waste generators out of 87 potential waste generators were reviewed by P3O personnel and strategies are being put in place to complete implementation. This process will be ongoing at an estimated 20 hours per month. Results from the P2DAs are summarized in Table 11. Opportunities 2 and 3 are tentative pending ROI funding. Descriptions of these opportunities can be found in the Case Study final report (Engel 1995).

9.1.4 Los Alamos Waste Management Unit

Before the 1995 case study task, the *P2 by Design* project completed a more general, qualitative case study task in 1994. One of the design projects from that case study task went on to pursue the P2DA process more fully afterwards. This LANL project was the "Construction of the Waste Management Unit, TA-63. This project involves the construction of a single facility to treat and store solid hazardous and mixed waste at LANL. When the design assessment was conducted, the project was in the definitive design phase. The design project's budget for FY 1995 was $7,000,000 and construction is expected to be completed in 1999.

The project is managed by LANL and subcontracted to Benchmark Environmental to conduct the pollution prevention assessment. The study cost approximately $64,500, which included reviewing the pollution prevention design checklist and making special recommendations for storm water waste reductions in storm water runoff from the waste handling and storage buildings. Benchmark personnel participated in the design meetings as pollution prevention champions with significant success. Approximately 130 operational and design recommendations from the checklist were incorporated, although the design was on hold as of June.

None of the pollution prevention opportunities were quantified for either waste reduction or cost savings. Examples of design changes included site and spill controls that prevent spills from contaminating large amounts of storm water and the addition of gloveboxes, which reduced the requirement for anticontamination clothing.

9.2 The Tritium Supply and Recycling Preliminary Environmental Impact Statement

The team for the Tritium Supply and Recycling project actively included pollution prevention into their preliminary environmental impact statement (PEIS) with favorable results (Fluor Daniel 1996). The NEPA requires that the environmental analysis be integrated as early as possible into the design process. The analysis was conducted prior to the conceptual design phase for the Tritium Supply and Recycling PEIS.

In developing data to support the PEIS, the participants identified design changes to improve potential environmental impacts. For example, the design was modified to incorporate the use of recycled sanitary wastewater because the environmental analysis showed that a significant amount of water was needed for cooling a specific facility. As another example, PEIS data showed that existing glovebox designs would be responsible for emitting large quantities of nitrogen and argon gases. A purification system was added to the design to allow for recycling these gases. The project team felt that, although these changes would have likely been addressed later in the design process, their early identification improved the quality of the alternatives analysis while also facilitating the design process.

Aside from these two specific examples, the team documented several general advantages that an environmental impact analysis can bring to the design process. For example, preparing the EIS exposed the design to a variety of experts outside the design team who might not otherwise be involved. Overall, the EIS process resulted in changes to the design requirements, which in turn changed the EIS data. The team felt that these iterations on both the EIS analysis and the design itself, if carefully planned and integrated, resulted in added efficiency and value to the project as a whole.

9.3 Examples from Outside DOE

Table 12 highlights pollution prevention measures incorporated into the design of a variety of government and private sector buildings. Additional examples of federal buildings showcasing pollution prevention features can be found on the FEMP homepage at http://www.eren.doe.gov.

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Figures and Tables

Excerpts from the WFEO Code of Environmental Ethics for Engineers

The WFEO Committee on Engineering and Environment, with a strong and clear belief that man's enjoyment and permanence on this planet will depend on the care and protection he provides to the environment, states the following principles.

To all Engineers:

When you develop any professional activity

- Strive to accomplish the beneficial objectives of your work with the lowest possible consumption of raw materials and energy and the lowest production of wastes and any kind of pollution.
- Study thoroughly the environment that will be affected, assess all the impacts that might arise in the state, dynamics, and aesthetics of the ecosystems involved, urbanized or natural, as well as in the pertinent socio-economic systems, and select the best alternative for an environmentally sound and sustainable development.
- Be aware that the principles of ecosystemic interdependence, diversity maintenance, resource recovery, and interrelational harmony form the basis of our continued existence and that each of those bases poses a threshold of sustainability that should not be exceeded.

Figure 1. WFEO's Code of Environmental Ethics

Excerpts from the FIDIC Environmental Policy Statement

The role of the engineer should result in:

- careful evaluation of the environmental benefits and adverse impacts of proposed projects
- conservation of energy
- reduction in the use of non-renewable resources and increased reuse of materials
- reduced waste production through improved industrial processes, better transportation and distribution systems, and recycling of waste products
- effective transfer of environmental knowledge and experience

General actions for consulting engineers:

- Keep informed on global environmental trends and issues
- Discuss environmental problems with professionals from other disciplines
- Provide information to clients, the public and government about environmental problems and how adverse effects can be minimized
- Actively support and participate in all forms of environmental education
- Promote research and development relevant to protecting and improving the environment

Project actions for consulting engineers:

- Recommend that environmental studies be performed as part of all relevant projects
- Evaluate the positive and negative environmental impacts of each project. Evaluate the basic functions and purposes behind a project, suggest alternatives if environmental risks emerge.
- Develop improved approaches to environmental studies. Environmental effects should be considered early in the planning process. Studies should evaluate long term consequences.

Figure 2. FIDIC's Environmental Policy Statement

Example Environmental Charter for Dupont Projects

To: Design facilities to operate as close to emission/discharge-free as technically and economically feasible.

In a manner that:

- Complies with existing and anticipated regulations.
- Develops investment options to reduce or eliminate all gaseous, liquid, and solid discharges based on best environmental practices.
- Considers waste management options in order of the pollution prevention hierarchy: 1) Source reduction, 2) recycle, 3) treatment, and 4) disposal.
- Interacts with other internal and external processes and facilities to generate a combined net reduction in emissions. Actions leading to a net increase in environmental impacts despite reductions within the design project, are not considered to be in compliance with this charter.
- Lists, where possible, specific goals for emissions and discharge reductions, especially with regard to hazardous and toxic substances.

So that: New facilities will provide a competitive advantage in the marketplace based on their environmental performance.

Figure 3. Sample Environmental Charter

Table 1. List of Interface Descriptions Between Pollution Prevention (GPG-FM-025) and Other Good Practice Guides

Good Practice Guide	Description of Interface with Pollution Prevention (GPG-FM-025)
GPG-FM-001 Project Management Overview	Describes the different project phases, and recommendations for each. Calls out the need to include pollution prevention in the preliminary environmental strategy developed as part of the mission need documentation. See Section 2.6 of this Guide for detailed pollution prevention considerations by project phase.
GPG-FM-002 Critical Decision Criteria	Pollution prevention and related requirements are woven throughout the environmental, safety, and health criteria for each of the project key decisions. For example, key decision 1 requires that the waste stream contents have been estimated and pollution prevention strategies have been included in the conceptual design criteria.
GPG-FM-003 Engineering Tradeoff Studies	Pollution prevention effectiveness of the different alternatives plays heavily into the risk and cost decision criteria.
GPG-FM-011 Value Engineering	Under development.
GPG-FM-021 Environmental Interfaces	Describes the Pollution Prevention Act of 1990 and other regulatory drivers containing pollution prevention elements. Advises that a preliminary environmental strategy should be part of the mission-need documentation for a project and that the strategy should address pollution prevention.
GPG-FM-023 Safety Analysis	Under development.
GPG-FM-024 Site Development Planning	Site selection is closely integrated with the NEPA process. Environmental impacts are required to be identified along with proposed actions that will avoid or minimize adverse effects of these actions upon the quality of the human environment.
GPG-FM-032 Life-Cycle Cost (LCC)	LCC is a tool that can be used to defend potentially higher up-front costs for pollution prevention in return for lower total project costs. The Guide emphasizes the point that the earlier that tradeoffs are made, the fewer resources are used to explore inferior alternatives. This is an important consideration for advocating the early implementation of pollution prevention methods during design.
GPG-FM-033 Comprehensive Land-use Planning	Describes the supporting principles of ecosystem management and sustainable development as the basis for the Department of Energy's Land and Facility Use Policy. Pollution prevention is integrally tied to both principles as a method for protecting the environment.

Table 2. Pollution Prevention Requirements

Regulation/Order	Who/What is Subject	Summary of Requirements
Pollution Prevention Act of 1990	a) United States b) EPA c) Owners/ Operators required to report Superfund Amendment and Reauthorization Act (SARA) 313 releases	a) National Policy: establishes the pollution prevention hierarchy to prevent pollution at the source whenever feasible, followed by reuse/ recycle, then treatment, and disposal only as a last resort. b) Establish a pollution prevention office and national pollution prevention program. c) Add source reduction and recycling report to annual release report (Emergency Planning and Community Right to Know Act [EPCRA] form R).
National Energy Policy Act of 1992 (EPACT) (public law 102-486)	DOE	Requires DOE to work with other federal agencies to reduce energy use and its environmental impacts. Authorizes efforts to improve energy efficiency and pollution prevention technologies.
a) RCRA 3002(b) b) RCRA 3005(h)	a) RCRA manifest reporters b) RCRA permitees for treatment, storage, and disposal facilities (TSDs)	a) Requires manifest reporter to: I) certify they have a program in place to reduce volume and toxicity of waste, and ii) certify that methods used for TSD are the best available method(s) which minimize present and future threat to human health and the environment. b) same as (a), but as a permit condition.
Clean Air Act	EPA	Directs EPA to consider pollution prevention technologies when selecting Maximum Achievable Control Technology (MACT)
Clean Water Act	a) EPA b) Industrial Facilities	a) Directs EPA to promote the inclusion of pollution prevention technologies in industrial effluent standards, and promote source reduction in industrial water effluent guidelines. b) Requires industrial stormwater discharge facilities to have an onsite pollution prevention plan.
Executive Order 12873: "Federal Acquisition, Recycling, and Waste Prevention"	Federal Agencies/ Contractor-Operated Facilities	Initiate solid waste prevention, recycling, and affirmative procurement programs. Promote waste reduction through recycling and use of energy efficient and recycled content materials.

Regulation/Order	Who/What is Subject	Summary of Requirements
Executive Order 12856: "Federal Compliance with the Right-to-Know Laws and Pollution Prevention Requirements"	Federal Agencies/ Contractor-Operated Facilities	Requires development of a pollution prevention strategy and development of a goal to reduce toxic chemical releases by 50% by the end of 1999.
Executive Order 12843: "Procurement Requirements and Policies for Federal Agencies for Ozone-Depleting Substances"	Federal Agencies/Contractor-Operated Facilities	Requires federal agencies to maximize the use of safe alternatives to ozone-depleting substances; evaluate existing and future uses and needs for such materials and evaluate plans for recycling; and revise procurement practices and modify specifications and contracts to substitute non-ozone-depleting substances to the extent practicable.
Executive Order 12902: "Energy Efficiency and Water Conservation at Federal Facilities"	Federal Agencies/Contractor-Operated Facilities	Builds on Energy Policy Act and its predecessors to stimulate energy and water conservation and develop renewable energy sources. New facilities are required to minimize life-cycle cost and meet CFR 435, local building codes, or a Btu/GSF ceiling.
Executive Order 12898: “Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations”	Federal Agencies	Requires Federal agencies to identify and address disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations.

Table 3. Basic Framework for the P2DA

Planning and Organization
• Organize team • Budget and schedule the P2DA
Step 1—Characterize Waste Streams
• Identify anticipated streams (construction, operations, closure/dismantlement) • Quantify streams: source (unit operation/activity), regulatory status, expected frequency/ duration/volume, unit cost, total cost. Worksheet 1. Waste Stream Descriptions
Step 2—Establish Strategy
• Prioritize streams • Set boundaries for remainder of P2DA • Establish goals (See Chapter 3 - Graded Approach)
Step 3—Identify Pollution Prevention Design Opportunities
• Brainstorming techniques • Using the *P2-EDGE* • Benchmarking Successful Techniques/Lessons learned • Establishing design strategies
Step 4—Analyze Design Alternatives
• Cost analysis • Environmental analysis • Select P2DOs to implement Worksheet 2. P2DO Cost Evaluation
Step 5—Document Results
• Implement selected P2DOs into design • Measure progress/reevaluate goals • Generate P2DA Summary Report • Schedule follow up P2DA

Table 4. Prospective P2DA Team Members

Job Function	Potential Contribution to the P2DA
Customer	Authorize added design cost for P2DA in order to lower total project cost; provide information about needs and environmental preferences; offer feedback on design alternatives.
Project Management	Establish P2DA team; establish project's environmental policy; set goals and establish measures for success; develop environmental strategy.
Pollution Prevention Subject Matter Contact	Provide overall guidance to the team on pollution prevention techniques and practices. Communicate the project's pollution prevention successes to the regulators and the public.
R&D staff	Develop and transition innovative technologies for source reduction.
Designers	Create a design concept that meets environmental criteria while still satisfying all other important functions.
Process engineers	Design processes to limit resource inputs and pollutant outputs.
Cost Estimators	Assign environmental costs to products; calculate hidden, liability, and less tangible costs.
Purchasing	Give designers feedback on existing products and demand for alternatives, including recycled content and low toxicity products; select suppliers with demonstrated low-impact operations; assist suppliers in reducing impacts of their operations to ensure steady supply at lower costs.
Industrial Hygiene/Safety	Inform designers of added costs such as protective equipment, ventilation, and air monitoring associated with product application during construction; provide environmental information on selected products; assist with comparing material choices for environmental impact.
Regulatory compliance/ permitting	Interpret statutes and promote pollution prevention to minimize cost of regulation and possible future liability.
Waste Management Professionals	Offer information about the fate of industrial waste and retired consumer products and options for improved practices.
Risk Assessment	Safety Analysis report includes estimates of offsite doses that require estimates for emissions. Therefore, some quantification of waste streams during design is necessary regardless of whether a P2DA is performed. This information should be shared between the Safety Analysis Report authors and the P2DA team.

Table 5. A Partial List of Anticipated Waste Streams by Facility Life Cycle Stage (CMA 1993; Kraft 1992)

Media	Construction/Start-up	Operations	Dismantlement/Closure
Air Emissions	Primary: - dust - open burning - construction equipment exhaust - VOC emissions (paint, glue, etc. Utilities: - diesel generator exhaust Maintenance: Non-routine events:	Primary: - stacks - vents - fugitive emissions from pumps, valves, flanges, seals, etc. Utilities: Maintenance: Non-routine events: - tank and equipment leaks	Primary: - fugitive dusts - demolition equipment exhaust - radioactive air emissions Utilities: Maintenance: Non-routine events:
Liquid Effluents	Primary: - water remaining from pressure testing of piping - waste cleaning solvents - cleanup waste from masonry tools Utilities: Maintenance: - waste oils, coolants, etc., from construction equipment Non-routine events: - oil drum or gas storage tank leaks - runoff	Primary: - solvents - lab samples - surplus chemicals - waste oils, lubricants - stormwater runoff - filter backwash - heat transfer fluids - cooling tower water Utilities: - sewage and other waste water Maintenance: - water rinses - cleaning solutions - waste oils and lubricants from equipment Non-routine events: - spills - fire suppression water	Primary: - decontamination solutions Utilities: Maintenance: - waste oils, coolants, etc., from demolition equipment Non-routine events:

Media	Construction/Start-up	Operations	Dismantlement/Closure
Solid Wastes	Primary: - scrap building materials - outdated or out of spec construction materials - building materials damaged during shipment or storage - general construction debris - paint wastes: brushes, drop cloths, cans, stirrers, etc. Utilities: Maintenance: - tires - batteries - used oil Non-routine events:	Primary: - spent catalysts - ion exchange resins - filters - sludge - packaging - personal protective equipment - office and cafeteria waste - chemicals/products - rags, wipes Utilities: - fly ash Maintenance: - scrap metal from used/broken equipment Non-routine events: - spill cleanup	Primary: - old equipment - steel - concrete - insulation - general demolition debris Utilities: Maintenance: Non-routine events:

KEY

Primary: Anticipated waste streams from normal operation of the process or facility being designed.
Utilities: Anticipated waste streams associated with supplying utilities (electricity, raw water, compressed air, etc.) to the process or facility being designed.
Maintenance: Anticipated waste streams associated with maintaining the equipment and infrastructure of the process or facility being designed.
Non-routine events: Anticipated waste streams from non-routine events such as leaking equipment, equipment failure, or use of emergency systems such as fire suppression.

Table 6. Waste Stream Information Worksheet

Stream Name	Source	Waste Class	Volume	Unit Cost	Total Cost	Reference
Construction Waste Streams						
Operating Waste Streams						
Dismantlement/Closure Waste Streams						

Instructions

Stream Name: Give a descriptive name, or even a number to facilitate tracking of this stream throughout the P2DA.
Source: Name the unit operation or activity that generates the stream. Specify whether the activity is continuous or batch and routine versus non-routine.
Waste Class: Indicate whether the stream is low level waste (LLW), high level waste (HLW), mixed waste, non-radioactive hazardous waste, or non-radioactive non-hazardous waste. Refer to DOE Order 5820.2A (DOE 1988) for definitions of these waste forms.
Volume: Provide the estimated volume of the stream over its entire life. In order to estimate volume, a separate calculation may be required, taking into account the expected frequency and duration of the waste generating activity. Calculations or supporting spreadsheets should be included in the reference column.
Unit Cost: Provide the estimated unit cost to manage the stream. The DOE waste cost avoidance model may be helpful for averaging cost by waste type: LLW, HLW, mixed waste, etc. (INEL 1994). Or Chapter 4, the section "Analyze Design Alternatives," will address how to compute costs in more detail. Readers may elect to revisit this column.
Total Cost: Estimated volume times unit cost.
References: List the documents where information was obtained so that the spreadsheet can be updated as the design evolves. Also reference any calculations performed to compute the waste volume or cost columns.

Table 7. P2DO Cost Evaluation Worksheet

Cost Item	Total Cost (Savings) ($)	References
Implementation Cost (one-time, $)		
Purchased Equipment		
Installation		
Materials		
Utility Connections		
Engineering/Architect		
Development		
Permitting		
Start up/Training		
Administrative		
(Other)		
Total Implementation Cost (Savings) ($)		
Incremental Operating Costs (annual, $/year)		
Change in raw materials consumption		
Change in maintenance requirements		
Change in labor (including productivity)		
Change in disposal cost		
Change in utilities cost		
(Other)		
Total Operating Cost (Savings) ($/year)		
Intangible Costs		
Penalties and Fines		
Future Liabilities		
Worker Exposure/Health Benefits		
Total Intangible Cost (Savings) ($/year)		

Cost Item	Total Cost (Savings) ($)	References
Total Annual Cost (Savings) ($/year) (Total Operating Cost + Total Intangible Cost)		
Payback Period (years) (Implementation Cost ÷ Total Annual Savings)		

Table 8. Example Areas for Environmental Design Goals

Energy: • Total energy required to operate facility • Renewable energy consumed during facility life
Emissions: • Total waste generated during construction, production, or closure/dismantlement • Total waste generated during entire facility life • Air emissions over life of facility • Waste outputs to material inputs ratio
Materials Management: • Reduction in number or volume of hazardous products used • Percent of recycled content products used • Percent of recyclable products used • Percent of packaging recycled
Environmental: • Construction and operating cost • Cost savings associated with P2DOs

Table 9. Hanford Pollution Prevention Design Opportunities Summary

Opp. #	Opportunity Title	Quantity and Type of Waste Avoided/ Resources Saved	Added Cost to Design	Cost Savings	Payback and/or ROI
1	Scrap Metal Recycling	LLMW- 0.28 m^3	none	$3,864	N/A
2	Hydrotesting Tanks	none	none	none	N/A
3	Tank Cleanout Alternative	LLMW (liquid) - 27,256 L (27 m^3) 40,884 L (41 m^3)	unknown	$9,000 - $13,492	N/A
4	Pump Selection and Siting	LLMW - unknown amounts	none	none	N/A
5	Paper Waste Reductions	Sanitary, amount not determined	none	unknown	N/A
6	Product Substitution	none	none	unknown	N/A
7	Cell Decontamination	LLMW - 1.04 m^3	unknown	$14,352	N/A
	TOTAL	28.5m^3 - 42.1m^3	$1,800	$27,216 - $31,708	N/A

Table 10. Oak Ridge Pollution Prevention Design Opportunities Summary

Opp. #	Opportunity Title	Quantity and Type of Waste Avoided/ Resources Saved	Added Cost to Design	Cost Savings	Payback and/or ROI
1	Use of storage tank supernate for tank and pipeline sluicing instead of process water and reduce radioactive waste	N/A	N/A	N/A	N/A
2	Testing of underground piping for integrity prior to backfilling	N/A	N/A	N/A	N/A
3	Use of prefilters upstream and HEPA filters to maximize the useful life of HEPA filter	N/A	N/A	N/A	N/A

Table 11. Los Alamos Pollution Prevention Design Opportunities Summary

Opp. #	Opportunity Title	Quantity and Type of Waste Avoided/ Resources Saved	Added Cost to Design	Cost Savings	Payback and/or ROI
P2DA	BDAT SELECTION P2DA				
1	Select least waste generating treatment technology	N/A	\$7,000	N/A	N/A
P2DA	GENERATOR SEGREGATION & PRETREATMENT P2DA				
2	TA-55, Magnetic Separation for Treatment of Caustic Waste Streams (an alternative, Freeze Drying, was also reviewed for this waste stream)	18 drums of transuranic waste and 23 drums of low-level waste	\$875,000	N/A	665%
3	TA-53, Elimination of the Liquid Rad/Mixed Waste Stream	276,000 gallons per year	\$1,925,000	\$2,000,000 per year	290%
4	CMR Facility, Phase II Upgrade Design Review	16,200 yd^3, mainly low-level waste	\$1,200,000	\$50,000,000	N/A

Table 12. Examples from Industry

Building	**Pollution Prevention Strategy/Measures**	**Outcome**
Rose Garden Basketball Arena, Oregon (Campbell 1996)	Construction site recycling	Recycled 95% of construction waste destined for landfill, for a cost savings of $191,000.
Energy Resource Center, Southern California Gas (Campbell 1996)	Construction site recycling	Recycled or reused 65% of the project waste and reused materials from the building that formerly occupied the site.
Duracell Corporate Headquarters Building, Bethel, Connecticut (Campbell 1996)	Affirmative Procurement (environmentally preferred products)	Used construction materials with recycled content, wood from sustainably managed forests and low VOC-paint.
Factory-built integrated solar home, Falmouth, MA (Thayer 1995)	Passive solar with photovoltaics	Saves $840/yr in space heating and cooling bills . Implementation cost was $3500 for a 4 year payback.
Reno Post Office, Reno, NV 1986 (Roodman & Lenssen 1995)	Lighting upgrade and lowered ceiling height to improve lighting quality and efficiency at a cost of $300,000.	Saves $50,000/yr in energy and maintenance, and $500,000/yr in worker productivity.
Pennsylvania Power and Light, Allentown, PA, early 1980s (Roodman & Lenssen 1995)	Lighting upgrade and reorientation of fixtures at cost of $8,362.	73% drop in energy and maintenance, 13% gain in productivity.
International Nederlanden Bank, Amsterdam, 1987 (Roodman & Lenssen 1995)	New building used energy-efficient design and avoidance of toxic materials at added cost of $700,000.	Saves $2.4 million/yr in energy and reduced absenteeism by 15%.
Village Homes, Davis, CA, 1975-1981 (Roodman & Lenssen 1995)	220-home subdivision designed to capture 50-75% of heat from sun, incentives for non-motorized transportation, natural drainage and edible landscaping.	12% premium in average home value.
Lockheed Building Sunnyvale, CA, 1983 (Roodman & Lenssen 1995)	New building used daylighting, efficient lights and an open layout at added cost of $2 million.	Saves $500,000 in energy and 15% gain in productivity.
Esperanze del Sol, Dallas, TX, 1994 (Roodman & Lenssen 1995)	New residential construction of low-income, energy-efficient and solar-oriented houses at a cost of $13 added annually to mortgage payments.	Saves $450/yr in energy.

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