Chapter 3

DEVELOPING A CTSA

The aim of a CTSA is to develop as complete and systematic a picture as possible of the trade-offs among risk, competitiveness (i.e., performance, cost, etc.), and conservation associated with the substitutes in a use cluster. To accomplish this, a CTSA employs a modular approach to data collection and analysis utilizing "information modules." An information module is a standard analysis or set of data designed to build on or feed into other information modules to form an overall assessment of the substitutes. A CTSA records and presents facts collected in the information modules, but does not make value judgements or advocate particular choices.

This chapter summarizes the information module approach, describes the flow of information between modules, and provides an overview of the information modules currently in the CTSA methodology.

RECAP: Key Terms and Concepts

A ***Cleaner Technologies Substitutes Assessment (CTSA)*** is a repository for all of the technical information developed by a DfE project, including risk, competitiveness (i.e., performance, cost, regulatory status, market availability), and conservation data.

A ***use cluster*** is a product- or process-specific application in which a competing set of chemical products, processes, or technologies can substitute for one another to perform a particular function.

A ***functional group*** is: (1) a discrete, functional step of a multi-step process or system; or (2) the chemical components that can substitute for one another to perform a particular function of a chemical mixture.

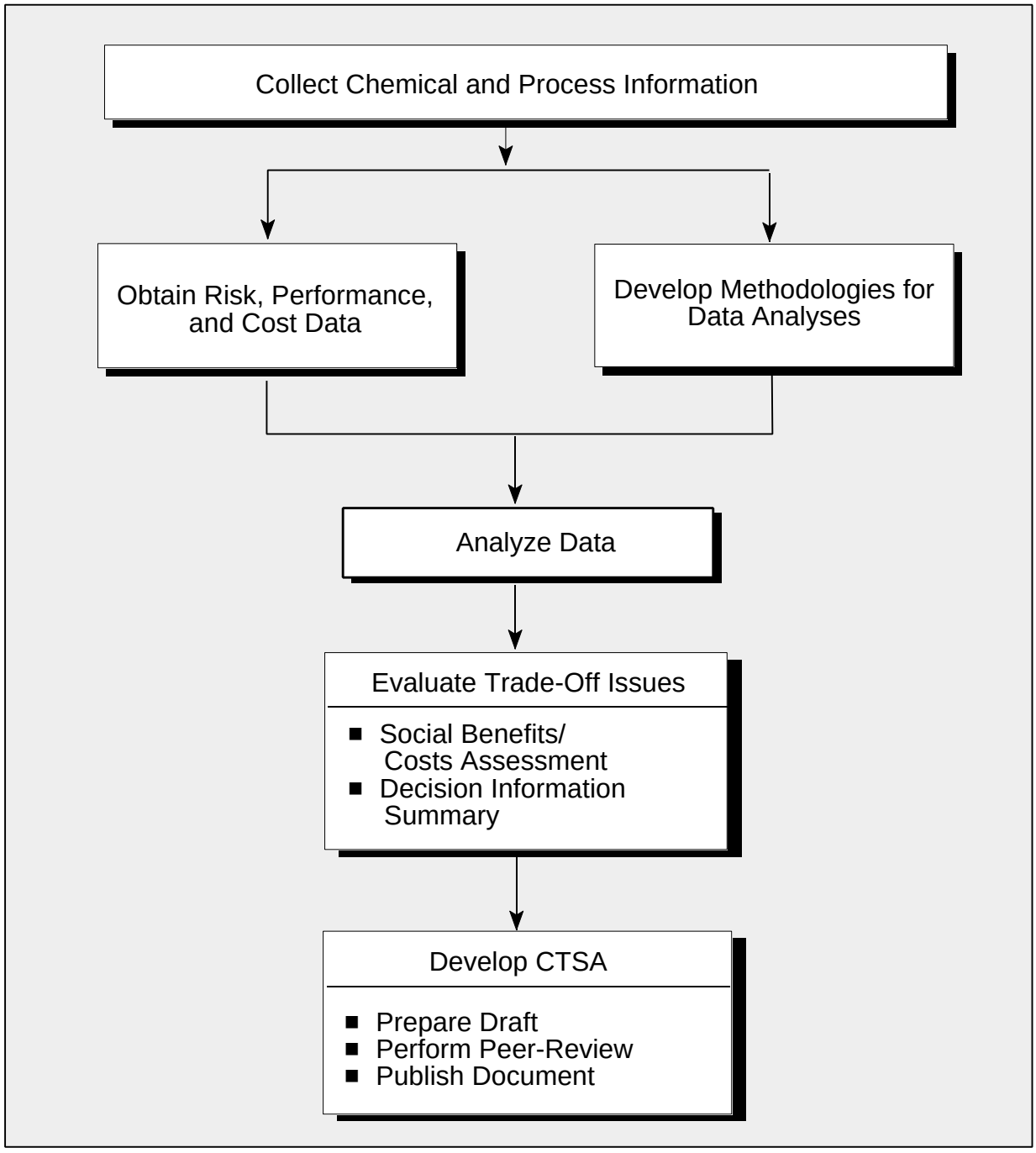
A ***substitute*** or an ***alternative*** is any traditional or novel product, technology, or process that performs a particular function.

A ***substitutes tree*** is a graphical depiction of: (1) the alternative chemical products, technologies, or processes that make up the use cluster; and (2) their relationship to each other within the functional category defined by the use cluster.

An ***information module*** is a standard analysis or set of data on the substitutes. Information modules are designed to build on or feed into one another to form an assessment of the substitutes.

Once a DfE project team determines the project focus, establishes the project baseline, and sets the boundaries of the evaluation, they are ready to begin collecting data and identifying specific methodologies for data analysis. Figure 3-1 is a simplified flow diagram of the process for developing a CTSA.

FIGURE 3-1: STEPS TO PRODUCE A CTSA



A CTSA typically starts with the collection of basic chemical properties and process information, followed by the collection of risk, competitiveness, and conservation data. At the same time, the project team develops methodologies for data analysis to ensure that all necessary data are collected. The next step is to analyze the collected data to determine the relative human health and environmental risk, competitiveness, and resource conservation of alternatives. Past DfE projects have shown that the choice of an alternative will frequently involve making trade-offs. For example, when compared to the baseline, an alternative may cost slightly more, but have substantially reduced risk.

To evaluate the trade-off issues, project partners prepare data summaries related to risk (releases of pollutants to the environment, potential exposure levels, risk of chemical exposure to human health and the environment), competitiveness (performance, cost, market availability, regulatory status), and conservation (energy impacts and effects of resource conservation). All of this information is combined to evaluate the social benefits and costs of implementing an alternative. Finally, the risk, competitiveness, and conservation data summaries are organized together with the results of the social benefits/costs assessment in a decision information summary that records and presents facts, but does not make value judgements or advocate particular choices.

Following the overview of the information module approach below, the flow of information in a CTSA and the steps in Figure 3-1 are discussed in more detail.

OVERVIEW OF THE INFORMATION MODULE APPROACH

The information module approach of the CTSA methodology is modeled after the risk management process that EPA conducts under the authority of the Toxic Substances Control Act (TSCA), with some important distinctions. The following sections describe this risk management process and its relationship to the CTSA process. The benefits of this modular approach are also discussed.

The Risk Management Process

Under TSCA, EPA has regulatory authority to perform the following activities regarding existing chemicals: (1) gather toxicity, production, use, disposal, and fate information; (2) assess human and environmental exposure; (3) determine if a chemical poses unreasonable risks; and (4) take appropriate actions to control these risks, based on a social benefits and costs analysis.[1] TSCA is the only U.S. statute under which multi-media risk assessments are performed as part of the regulatory rulemaking process.

To identify potential risk early in the screening process, EPA uses a two-phase risk management process. Phase 1 is a screening level risk assessment and fact-finding mechanism, intended to ensure that EPA only focusses on chemicals with the potential to present unreasonable risk to

[1] "Unreasonable risk" generally has been interpreted to mean greater overall benefits (reduced risk, etc.) than costs incurred in mitigating the risks.

human health and the environment. If this initial investigation finds that unreasonable risk may exist, chemicals are evaluated further in Phase 2.

Phase 2 is a more detailed and comprehensive risk assessment process that includes a thorough evaluation of the hazards and exposures to specific chemicals, identification of strategies to reduce or eliminate risk, and an evaluation of pollution prevention opportunities. To the extent possible, EPA bases the Phase 2 assessments on existing information, although new data may have to be generated. Each member of an EPA assessment team is responsible for completing one or more standardized analyses (information modules) on the chemicals, including Chemical Properties, Market Information, Chemistry of Use & Process Description, Source Release Assessment, Human Health and Environmental Hazards Summaries, Exposure Assessment, and Risk Characterization modules. These information modules build on or feed into each other to form an assessment of the chemical. EPA's standardized assessment process is designed to promote efficiency and consistency among results. *RM2 Handbook: Preparing RM2 Assessments for Single Chemicals* describes the EPA risk management process in more detail (Carstens, 1996).

Relationship of CTSA Process to EPA's Risk Management Process

The CTSA process is modeled after EPA's risk management process, with these important distinctions:

- *The CTSA process is designed to assist a voluntary decision-making process and, as such, is not as rigorous or detailed an evaluation as the regulatory rulemaking process.* In order to respond to a project team's needs in a timely manner and reduce resource needs, the CTSA process is designed to collect only the information necessary to adequately assist an individual making a voluntary business decision. As such, the data collection and analysis performed in a CTSA are quite detailed, but it is not necessary or intended to be as rigorous as the regulatory rulemaking process. For example, past CTSAs have qualitatively evaluated the social benefits and costs of implementing an alternative, but have not monetized overall social benefits and costs, which may be required for regulatory rulemaking.

- *A CTSA adds additional information modules to collect data on issues related to competitiveness, conservation, and pollution prevention.* A CTSA contains the risk-related information modules in Phase 2 of EPA's risk management process, plus additional modules to address competitiveness issues (e.g., performance, cost, etc.) and conservation issues (energy impacts and resource conservation). A CTSA also compiles extensive information on pollution prevention opportunities, including improved workplace practices that prevent pollution, that may be more comprehensive than those compiled in the risk management process.

By building on EPA's risk management process, the CTSA process has a range of standardized data collection and analytical methods already available that can be tailored to the needs of a specific project.

Benefits of the Modular Approach

The primary benefits of the information module approach arise from its flexible format, allowing DfE project teams to tailor a CTSA to fit their needs. Additional analyses or modules can be added or deleted, depending on the specific concerns and priorities of project participants. Information can be easily organized to meet the requirements of a specific project and of the people who will use the assessment.

For example, a DfE project team that already has information on the performance and cost of alternatives may focus on collecting risk information. The risk data can be compiled in a CTSA along with the previously available data on performance and cost. In another example, an energy-intensive industry such as the aluminum industry may be most concerned with the energy impacts of alternative processes. The project team in this example may elect to focus their efforts on identifying alternatives to reduce energy consumption and place less emphasis on the chemical risk component of a CTSA.

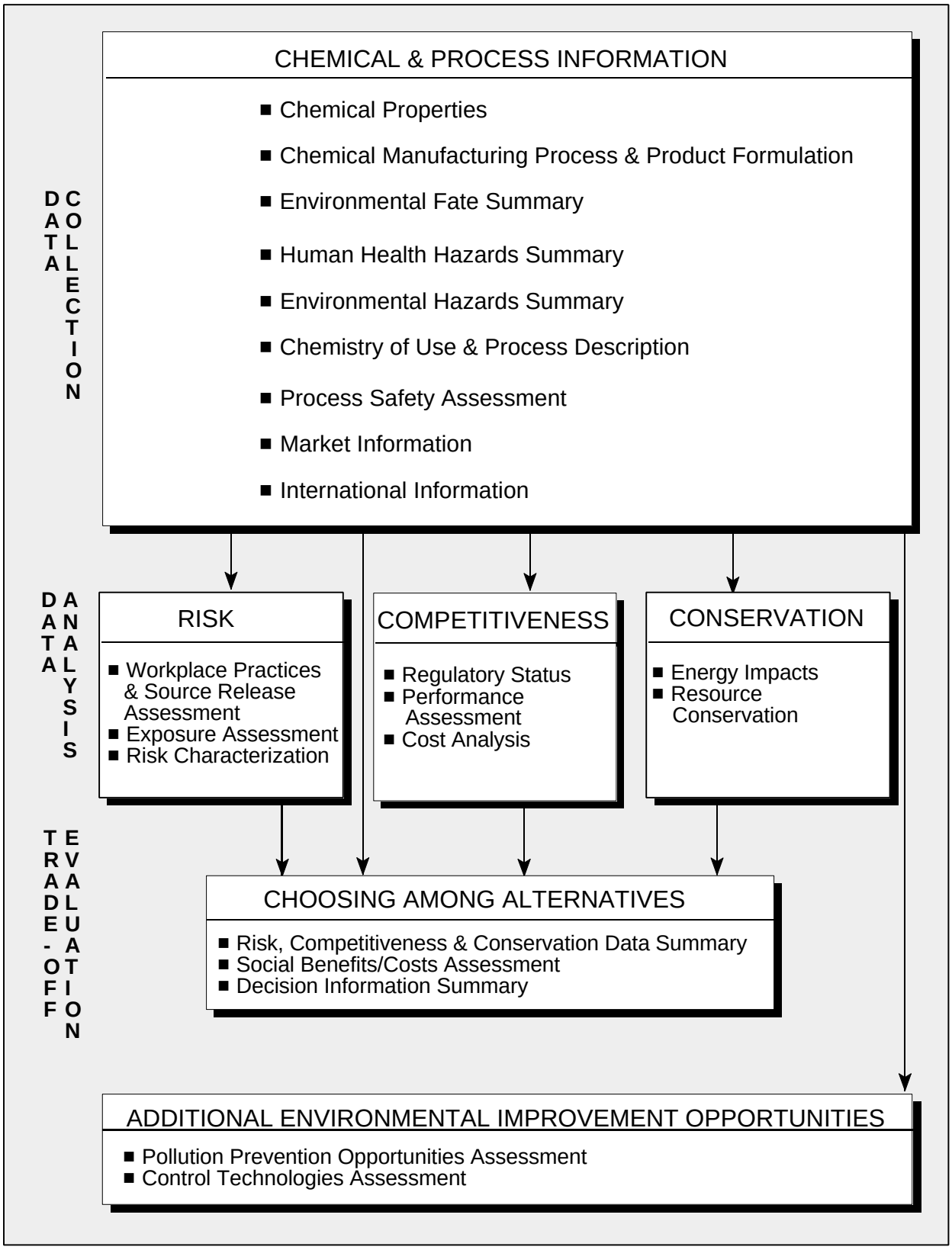
FLOW OF INFORMATION IN A CTSA

A CTSA can be viewed as a three-stage process involving data collection, data analysis, and an evaluation of the trade-offs among risk, competitiveness, and conservation. Figure 3-2 illustrates the basic flow of information in a CTSA. Each of the bullets in the figure represents one of the information modules that may be included in a CTSA. The modules included in a specific CTSA can vary, depending on the information needs of the project team.

Basic chemical and process information are collected in the first stage for use in the analyses performed later in a CTSA. In the data analysis stage, the chemical and process-specific information are combined with additional data and systematically analyzed in eight modules. These modules are divided into three groups focussing on risk, competitiveness, and conservation. In the third stage, the results of the analytical modules are brought together to evaluate the trade-offs to an individual and to society among risk, competitiveness, and conservation considerations. Again, the goal of a CTSA is not to recommend specific alternatives, but to present the trade-offs among risk, competitiveness, and conservation in a way that allows decision-makers to select the alternative that best fits their own goals, values, and requirements. The choices of substitutes are made by individuals outside of the CTSA process.

Throughout the CTSA process, data are collected on additional environmental improvement opportunities, particularly pollution prevention opportunities that could be implemented regardless of which substitute is used. The Control Technologies Assessment module may or may not feed directly into the overall evaluation of alternatives, depending on whether or not the alternatives are affected by existing regulations and the information needs of the project team.

FIGURE 3-2: CTSA INFORMATION FLOWS



Although the CTSA process is depicted in Figure 3-2 as a linear, step-wise process, DfE project teams frequently work on the data collection and data analysis components at the same time. For example, a project team may begin by collecting preliminary data on the regulatory status of substitutes from the Regulatory Profile document to ensure that chemicals being banned or phased-out are eliminated from consideration early in the CTSA process. In addition, data requirements and information needs frequently cycle between modules to ensure that the appropriate data needs are identified and data requirements are met. If a performance demonstration project is planned as part of the Performance Assessment module, it is an excellent opportunity to collect data on cost, energy use, and resource consumption. This means that the appropriate data requirements should be identified first in the Cost Analysis, Energy Impacts, and Resource Conservation modules, respectively.

The interactive nature of the modular approach requires careful coordination between disciplines to ensure consistency of goals and terminology so that the modules fit together in a final analysis. For example, one must be careful from module to module that similar terminology and units are employed. Something as simple as a chemical name must be verified with a Chemical Abstract System Registry Number (CAS RN)[2] since chemical synonyms can be confused or used differently by different disciplines.

Table 3-1 gives an overview of each of the information modules currently in the CTSA process. The following sections summarize the data collected or analytical results of each module and list some of the uses of data. The module descriptions in Part II of this publication describe in detail the data that are transferred to and from each module.

Chemical and Process Information

Table 3-2 lists the information modules that develop data on basic chemical properties and process information, some of the primary outputs from these modules, and how the data are used in a CTSA. DfE technical workgroup members typically begin by collecting data on basic chemical properties and developing a process description of the use cluster. However, data collection for these modules do not have to be complete before the project team begins collecting data needed for other modules in a CTSA.

[2] A CAS RN is a unique identification code assigned to a chemical.

TABLE 3-1: OVERVIEW OF CTSA INFORMATION MODULES		
Component	**Module**	**Overview**
Chemical & Process Information	Chemical Properties	The chemical and physical properties of a substance are characteristics which identify it from other substances. In this module, the physical and chemical characteristics of the chemicals in the use cluster are detailed.
	Chemical Manufacturing Process & Product Formulation	The Chemical Manufacturing Process & Product Formulation module describes: (1) the process for manufacturing the chemicals in the use cluster; and (2) the chemical product formulation process, if applicable. Past CTSAs have qualitatively described these processes. However, if up-stream processes are being quantitatively evaluated in a CTSA a more quantitative description would be needed.
	Environmental Fate Summary	The environmental fate of chemicals describes the processes by which chemicals move and are transformed in the environment. Some of the processes that should be addressed include: persistence in air, water, and soil; reactivity and degradation; migration in groundwater; removal from effluents by standard waste water treatment methods; and bioaccumulation in aquatic or terrestrial organisms.
	Human Health Hazards Summary	Human health hazards assessment is the process of identifying the potential effects that a chemical may have on humans who are exposed to it, and of determining the levels at which these effects may occur. Exposure to a chemical may occur by inhalation, oral, or dermal routes through the production, use, or disposal of the chemical or products containing the chemical. Human health toxicity data are combined with data from the Exposure Assessment module to assess human health risk in the Risk Characterization module.
	Environmental Hazards Summary	Environmental hazards assessment is the process of identifying the adverse effects that a chemical may have on organisms in the environment. Currently, the CTSA process for environmental hazards assessment focuses on aquatic toxicity. This module collects data on measured or predicted toxicity of chemicals to aquatic organisms to characterize potential hazards of chemical discharges to receiving waters. Toxicity data are combined with data from the Exposure Assessment module to assess ecological risk in the Risk Characterization module.
	Chemistry of Use & Process Description	The Chemistry of Use & Process Description module identifies: (1) the chemical/physical properties which contribute to the effectiveness of the chemicals in the use cluster; and (2) the process in which the chemicals are used. A process flow diagram is created that schematically describes the process operations, equipment, and material flows.
	Process Safety Assessment	The Process Safety Assessment module screens potential chemical substitutes to determine if they could potentially pose a safety hazard in the workplace. Process operating characteristics and workplace practices are combined with physical hazard data, precautions for safe handling and use, and other data to determine if a substitute might pose a safety hazard.
	Market Information	The Market Information module contains economic data used to evaluate the importance of the target industry sector to the overall market and conversely, the economic importance of the alternatives to the industry sector. Market information includes chemical/technology cost information, production, and manufacturing volumes, and an analysis of market trends that could affect future supply and demand.
	International Information	The International Information module collects data pertaining to the use or production of alternatives in other parts of the world, the impact of international trade on the selection of alternatives, and the impacts of switching to an alternative on international trade. Primarily, international trade issues are driven by the source and availability of alternatives and possible indirect costs (e.g., taxes, tariffs, etc.) imposed on alternatives.

TABLE 3-1: OVERVIEW OF CTSA INFORMATION MODULES		
Component	**Module**	**Overview**
Risk	Workplace Practices & Source Release Assessment	The Workplace Practices & Source Release Assessment module identifies: (1) the workplace practices that contribute to environmental releases and worker exposure; and (2) the sources, amounts, and characteristics of environmental releases.
	Exposure Assessment	Exposure assessment is the quantitative or qualitative evaluation of the contact an organism (human or environmental) may have with a chemical or physical agent, which describes the magnitude, frequency, duration, and route of contact.
	Risk Characterization	Risk characterization (also referred to in the CTSA process as risk integration) is the integration of hazard and exposure information to quantitatively or qualitatively assess risk. Risk characterization typically includes a description of the assumptions, scientific judgments, and uncertainties that are part of this process.
Competitiveness	Regulatory Status	The Regulatory Status module determines the statutes and regulations that govern a particular chemical or industrial process.
	Performance Assessment	The Performance Assessment module measures how well a substitute performs to meet the functional requirements of the use cluster. In order to allow a comparative evaluation of the performance of baseline products or processes with the performance of substitutes, performance data are collected for both. This module provides assistance in developing methodologies for obtaining comparative performance data.
	Cost Analysis	The Cost Analysis module identifies the costs associated with the baseline process, as well as suitable substitutes, and calculates comparative costs between the baseline process and the substitutes. As a minimum, the cost analysis should identify the direct costs of the baseline process and the substitutes. If time and resources permit, data are also collected on indirect and future liability costs as well as any less-tangible benefits that occur through the implementation of a substitute.
Conservation	Energy Impacts	Energy consumption, either during the manufacture of a chemical or the use of a substitute product, process, or technology can vary with a selected chemical or process change. This module provides a procedure for evaluating the energy impacts of substitutes in a use cluster.
	Resource Conservation	Resource conservation is the process of selecting and using products, processes, or technologies that minimize the overall consumption of resources while effectively achieving a desired function. This module addresses materials use rates and provides methods for identifying the relative amounts of resources or materials consumed as a consequence of changing from a chemical, process, or technology to a substitute.

TABLE 3-1: OVERVIEW OF CTSA INFORMATION MODULES		
Component	**Module**	**Overview**
Additional Environmental Improvement Opportunities	Pollution Prevention Opportunities Assessment	Pollution prevention is the process of reducing or preventing pollution at the source through changes in production, operation, and raw materials use. This module provides methods for identifying pollution prevention opportunities that can provide additional benefits beyond the benefits realized if one of the alternatives evaluated in the CTSA is implemented.
	Control Technologies Assessment	Control technologies are methods which can be used to minimize the toxicity and volume of pollutants. This module provides methods for identifying control technologies that may be suitable for on-site treatment and disposal of product or process waste streams.
Choosing Among Alternatives	Risk, Competitiveness & Conservation Data Summary	The Risk, Competitiveness & Conservation Data Summary module organizes data from the risk, competitiveness, and conservation components of a CTSA together with data from the Process Safety Assessment, Market Information, and International Information modules to: (1) identify the trade-off issues associated with any one substitute; and (2) compare the trade-off issues across substitutes. Data summaries are transferred to the Social Benefits/Costs Assessment and to the Decision Information Summary modules for further analysis.
	Social Benefits/ Costs Assessment	Social Benefits/Costs Assessment is the process of qualitatively and systematically evaluating the impacts made on all society by individual decisions. Social benefits/costs assessment includes the benefits and costs to the individual of alternative choices (referred to as private benefits and costs) and the benefits and costs to others who are affected by the choices (referred to as external benefits and costs). Consideration of these effects in decision-making by industry could result in improvements for industry and society as a whole.
	Decision Information Summary	The Decision Information Summary is the final module of a CTSA. It combines the results of the Risk, Competitiveness & Conservation Data Summary with the Social Benefits/Costs Assessment to identify the overall advantages and disadvantages of the baseline and the substitutes from both an individual business perspective and a societal perspective. The actual decision of whether or not to implement an alternative is made by individual decision-makers outside of the CTSA process, who typically consider a number of other factors, such as their individual business circumstances, together with the information presented in a CTSA.

TABLE 3-2: CHEMICAL AND PROCESS INFORMATION		
Module	**Summary of Results**	**Uses of Data**
Chemical Properties	Basic chemical properties, including chemical identity (CAS RN), structure, vapor pressure, water solubility, density, melting and boiling points, flammability, chemical synonyms.	Identify potential chemical substitutes; provide chemical identity and/or properties data to almost all other modules in a CTSA.
Chemical Manufacturing Process & Product Formulation	Description of chemical manufacturing and chemical product formulation processes.	Input to other modules to evaluate environmental impacts of chemical manufacturing and chemical product formulation, if up-stream processes are being evaluated in a CTSA.
Environmental Fate Summary	Chemical fate property values; summaries of processes by which chemicals degrade and are transported in the environment.	Combine with source release data from the Workplace Practices & Source Release Assessment module to assess exposure.
Human Health Hazards Summary	Effects that chemical exposure may have on humans and the levels at which these effects may occur.	Guide the selection and use of chemicals less toxic to humans; combine with exposure data to characterize risk to human health.
Environmental Hazards Summary	Toxicity of chemicals to the aquatic environment; aquatic toxicity concern concentrations.	Guide the selection and use of chemicals that are less toxic to aquatic organisms; combine with exposure data to characterize ecological risk.
Chemistry of Use & Process Description	Process flow diagram of substitutes; characteristics of the chemicals contributing to their effectiveness.	Identify potential substitutes; provide basis for Workplace Practices & Source Release Assessment module.
Process Safety	Potential safety hazards posed by alternatives; precautions or actions needed to mitigate potential safety hazards.	Guide the selection and use of safer alternatives; trade-off issue evaluated in the Social Benefits/Costs Assessment and the Decision Information Summary modules.
Market Information	Total U.S. production of chemicals and total use by the industry; chemical and equipment prices; market trends.	Help set the boundaries of the evaluation; identify market trends that could effect the availability of substitutes; inform the Cost Analysis and Exposure Assessment modules; identify potential substitutes; potential trade-off issue in the Social Benefits/Costs Assessment and the Decision Information Summary modules.
International Information	Alternatives and market trends in international markets; international trade issues.	Identify potential substitutes; assess international implications of choosing an alternative; potential trade-off issue evaluated in the Social Benefits/Costs Assessment and the Decision Information Summary modules.

Data collected in many of the chemical and process information modules will be partially driven by the boundaries of the evaluation, as determined by the project team (see Chapter 2). For example, the data collected in the Market Information module typically includes chemical and equipment market trends and the amounts used by the industry under study. However, an energy-intensive industry especially concerned about energy impacts may be more interested in energy sources (i.e., hydroelectric, coal, etc.) and trends in energy prices. In this example, the data needs for the Energy Impacts module might drive the scope and direction of the Market Information module.

Risk

Table 3-3 lists the risk-related information modules from Figure 3-2, some of the primary outputs from these modules, and some of the uses of the risk-related data. These modules typically build upon data compiled in the chemical and process information modules.

TABLE 3-3: RISK[a,b]

Module	Summary of Results	Uses of Data
Workplace Practices & Source Release Assessment	Survey of workplace practices; profile of a model facility, including worker activities potentially resulting in chemical exposure, and the nature and quantity of both on-site and off-site chemical releases.	Provide environmental release data and information worker activities to the Exposure Assessment module; identify pollution prevention or control technology opportunities.
Exposure Assessment	Occupational, consumer and ambient exposures, including routes of exposure, estimates of dose, and ambient concentrations.	Guide the selection and use of alternatives with reduced potential for chemical exposure; identify sources of chemical exposure and identify methods for reducing exposure; input to the Risk Characterization module; potential trade-off issue evaluated in the Social Benefits/Costs Assessment and Decision Information Summary modules.[c]
Risk Characterization	Potential risk to human health from ambient environment, consumer and occupational exposures; potential risks to aquatic organisms.	Guide the selection and use of alternatives with reduced risk to human health and the environment; identify sources that pose greatest risk to human health and the environment; guide in selecting ways to manage risks; trade-off issue evaluated in the Social Benefits/Costs Assessment and Decision Information Summary modules.

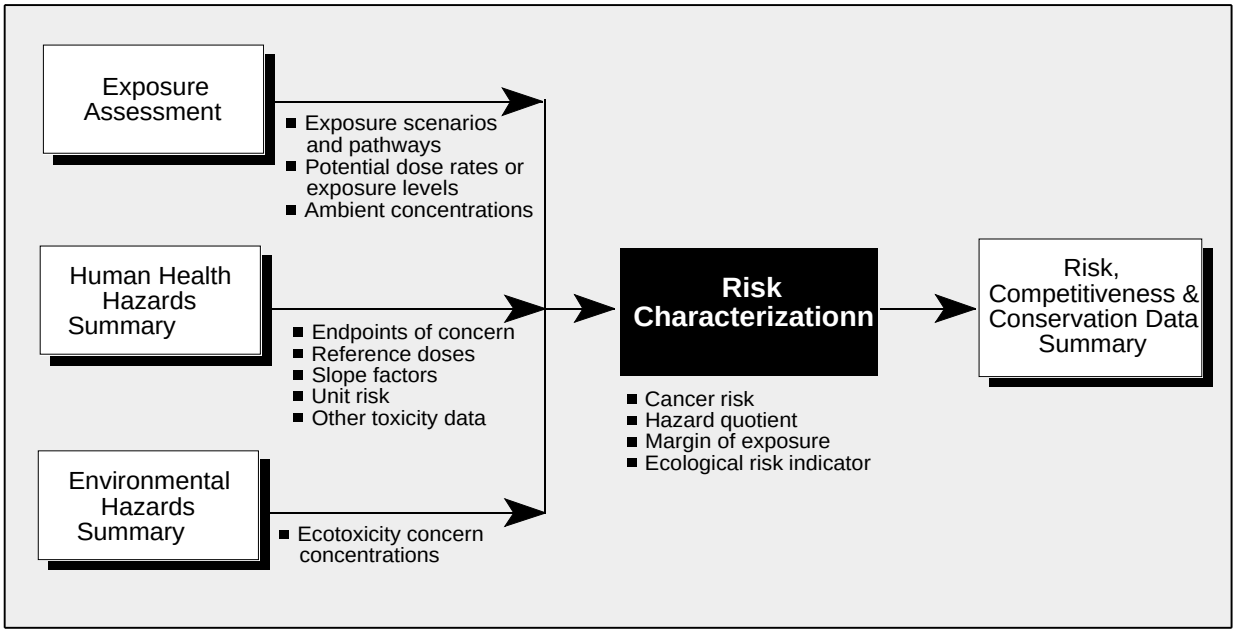
a) Data for the chemical hazard component of risk (risk is the integration of hazard and exposure) are collected in the Chemical & Process Information component of a CTSA.

b) The risk summary of the Risk, Competitiveness & Conservation Data Summary module presents process safety concerns together with other risk-related data. However, process safety data are collected in the data collection stage of a CTSA since some process safety data, such as data regarding chemical safety hazards, are needed in the data analysis stage. Early collection of process safety data can also ensure that substitutes posing unacceptable safety hazards are not carried through the entire CTSA evaluation process.

c) Exposure levels may be included in these modules if risk could not be characterized due to a lack of hazard data.

For example, Figure 3-3 shows the flow of information into and out of the Risk Characterization module. The Exposure Assessment module identifies potential routes of exposure, estimates potential dose rates or levels of exposure, and estimates concentrations in the ambient environment from use or disposal of the chemicals in the use cluster. The Human Health Hazards Summary and Environmental Hazards Summary[3] modules provide information on the doses or concentrations of chemicals at which adverse health or environmental effects may occur. The exposure data and hazard data are then combined to characterize the potential risk of chemical releases to human health and the environment. Similar flow diagrams for each module are in the module descriptions in Part II of this publication. The flow diagrams illustrate the transfers of data between modules and list two or three examples of data elements that are transferred. Not all interconnections are shown in the flow diagrams; the focus is on linkages directly related to a particular module.

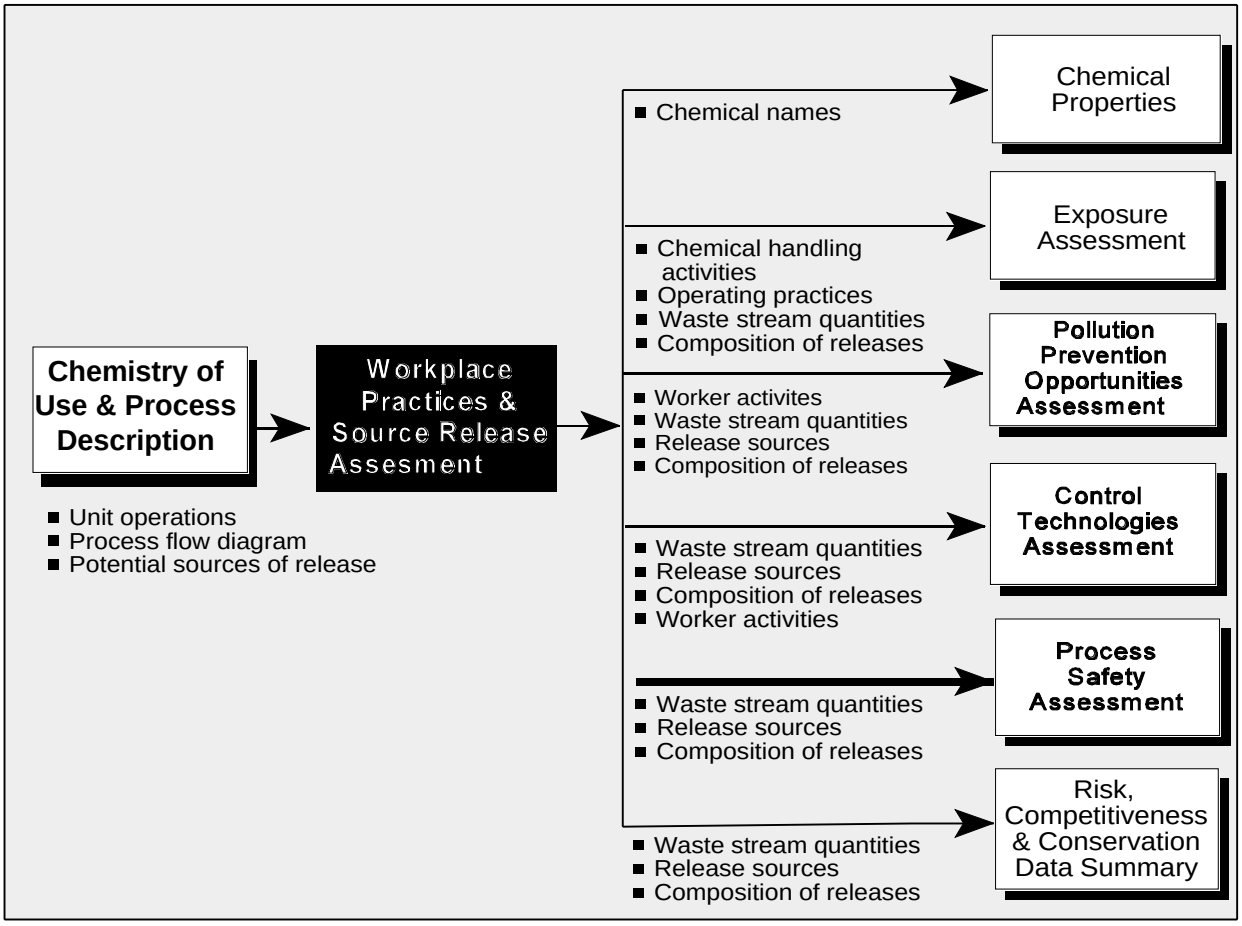
FIGURE 3-3: RISK CHARACTERIZATION MODULE: EXAMPLE INFORMATION FLOWS



[3] Environmental hazard summaries prepared in CTSA pilot projects and the module description in this publication focus on aquatic toxicity. Other techniques and information could be used to assess other environmental hazards, such as avian toxicity.

In another example, data on how workers store, handle and use chemicals, the sources of chemical releases, and the nature and quantity of releases from a typical facility are generated in the Workplace Practices & Source Release Assessment module (Figure 3-4). Past CTSA projects have designed a Workplace Practices questionnaire to collect industry-wide data in order to develop a model of a typical facility. The Workplace Practices questionnaires developed for the Screen Printing Project and the PWB Project are presented in Appendix A.

FIGURE 3-4: WORKPLACE PRACTICES & SOURCE RELEASE ASSESSMENT MODULE: EXAMPLE INFORMATION FLOWS



The Chemistry of Use & Process Description module provides preliminary information on the process to guide the design of the Workplace Practices questionnaire and inform the source release assessment. Operating practices and environmental release data from the Workplace Practices & Source Release Assessment module are used in a variety of modules, but are particularly important to developing exposure scenarios and estimating exposure. These data are also used to identify pollution prevention opportunities or sources that can be controlled to mitigate chemical releases. By studying workplace practices in the screen reclamation process, the DfE team identified several simple workplace practices that screen printers can use to reduce chemical usage, exposure and risk, such as keeping solvent containers closed when not in use or draining excess solvent from cleaning rags into closed containers.

Competitiveness

Table 3-4 lists the competitiveness modules from Figure 3-2, some of the primary data or results obtained from these modules, and some of the uses of these data. These modules are designed to develop industry-wide data on some of the issues traditionally important to industry when choosing among alternatives, such as performance and cost. The information is developed using a consistent basis, such as cost per unit of production, to facilitate comparison of the alternatives.

TABLE 3-4: COMPETITIVENESS[a]

Module	Summary of Results	Uses of Data
Regulatory Status	Regulatory status of alternative chemicals, processes, and technologies.	Guide the selection and use of alternatives with reduced regulatory costs; help select subset of alternatives for evaluation; trade-off issue evaluated in the Social Benefits/Costs Assessment and Decision Information Summary modules.
Performance Assessment	Effectiveness of alternatives in achieving the desired function; energy and natural resources consumption data; cost data.	Guide the selection and use of more effective, efficient alternatives; provide data to the Energy Impacts, Resource Conservation and Cost Analysis modules; trade-off issue evaluated in the Social Benefits/Costs Assessment and Decision Information Summary modules.
Cost Analysis	Capital, operating, and maintenance costs of alternatives; indirect costs; may include other costs, such as liability costs, or less tangible benefits or costs (e.g., benefit of improved sales due to proactive corporate environmental policies).	Guide the selection and use of more cost-effective alternatives; trade-off issue evaluated in the Social Benefits/Costs Assessment and Decision Information Summary modules.

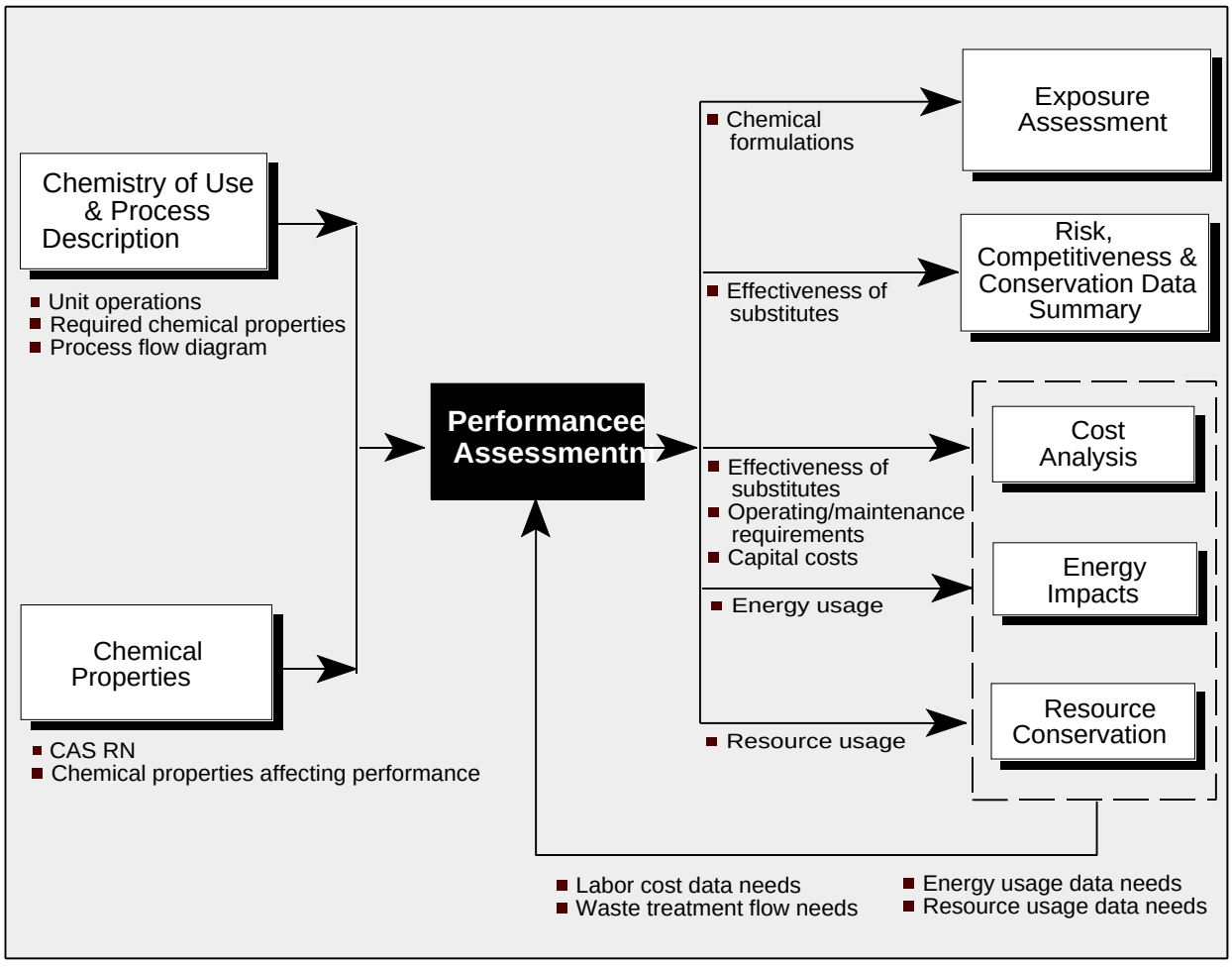
a) The competitiveness summary of the Risk, Competitiveness & Conservation Data Summary module presents market information and international information concerning the availability of substitutes together with other competitiveness-related data. However, these data are compiled in the data collection stage of a CTSA since some information, such as chemical use volumes, may be needed to help set the boundaries of the evaluation and for data analysis (e.g., in the exposure assessment).

The Performance Assessment module is an example of an interactive module that is designed to fulfill data needs of other modules as well as evaluate the comparative performance of the substitutes. The goal of the Performance Assessment module is to collect standardized data on objective evaluation criteria as well as subjective issues such as operator impressions of an alternative. The Performance Assessment module typically involves a performance demonstration of alternatives in a laboratory or manufacturing setting in the presence of an

unbiased observer; but may only involve an assessment of existing performance information. Because a performance demonstration is conducted under controlled or standardized conditions, it also provides an excellent opportunity for collecting data for other modules, such as the Energy Impacts, Resource Conservation, and Cost Analysis modules.

Figure 3-5 illustrates the flow of information into and out of the Performance Assessment module. If a performance demonstration project is planned, data needs for the Cost Analysis, Energy Impacts and Resource Conservation modules are identified in these modules and included in a performance demonstration project workplan. The performance demonstration team is then responsible for collecting the data and communicating data back to the appropriate module. A performance demonstration project can also be used to collect exposure data on new alternatives not in use by the industry.

FIGURE 3-5: PERFORMANCE ASSESSMENT MODULE: EXAMPLE INFORMATION FLOWS



Conservation

Table 3-5 lists the information modules related to conservation issues. The primary data or results of these modules and some of the uses of these data are also identified. The results of these modules can be used by themselves to guide the selection and use of alternatives that conserve energy and other resources. In a CTSA, the results of these modules are usually combined with other modules to identify the trade-offs among alternatives.

TABLE 3-5: CONSERVATION

Module	Summary of Results	Uses of Data
Energy Impacts	Sources and rates of energy consumption of alternatives.	Guide the selection and use of less energy-intensive alternatives; provide energy consumption rates to the Cost Analysis module; trade-off issue evaluated in the Social Benefits/Costs Assessment and Decision Information Summary modules.
Resource Conservation	Types of resources consumed; sources and rates of resource consumption of alternatives.	Guide the selection and use of less resource-intensive alternatives; provide resource consumption rates to the cost analysis module; trade-off issue evaluated in the Social Benefits/Costs Assessment and Decision Information Summary modules.

Additional Environmental Improvement Opportunities

Table 3-6 lists the Pollution Prevention Opportunities Assessment and Control Technologies Assessment modules, the primary results of these modules, and some of the uses of these data. These modules can be stand-alone modules or build on other sections of a CTSA. For example, in past DfE industry projects, the Pollution Prevention Opportunities Assessment module has focussed primarily on pollution prevention opportunities above and beyond the implementation of a substitute, such as improved workplace practices. The Control Technologies Assessment module can be used to identify control technologies required for regulated alternatives or to identify potentially feasible treatment technologies.

TABLE 3-6: ADDITIONAL ENVIRONMENTAL IMPROVEMENT OPPORTUNITIES

Module	Summary of Results	Uses of Data
Pollution Prevention Opportunities Assessment	Methods to prevent pollution through improved workplace practices or equipment modifications.	Raise employee awareness of the benefits of pollution prevention; implement pollution prevention activities or complete program to reduce risk and costs.
Control Technologies Assessment	Methods to reduce chemical releases, and thus, exposure and risk through control technologies.	Identify applicable control technologies; provide control technology requirements to the cost analysis.

Choosing Among Alternatives

Table 3-7 lists the final information modules of a CTSA where data from the other modules are brought together to form an assessment of the baseline and alternatives. The Risk, Competitiveness & Conservation Data Summary module prepares data summaries of data collected in both the data collection and data analysis stages of a CTSA. These data summaries are provided to the Social Benefits/Costs Assessment module for an evaluation of the net benefits or costs to society of implementing a substitute as compared to the baseline. The results of the Social Benefits/Costs Assessment are presented together with the risk, competitiveness and conservation data summaries in the Decision Information Summary module. In addition to presenting information collected throughout a CTSA, the Decision Information Summary module discusses the uncertainty in the information and recognizes that there are additional factors beyond those assessed in a CTSA which individual businesses may consider when choosing among alternatives. None of these modules recommend alternatives, since the final selection of an alternative will depend on the situation and values of those making the selection.

TABLE 3-7: CHOOSING AMONG ALTERNATIVES

Module	Summary of Results	Uses of Data
Risk, Competitiveness & Conservation Data Summary	Risk, competitiveness, and conservation data summaries, including uncertainties in the data, and data interpretation, as appropriate (e.g., assignment of high, medium, or low concern levels to human health and environmental risk data).	Input to the Social Benefits/Costs Assessment and Decision Information Summary modules.
Social Benefits/Costs Assessment	Qualitative assessment of benefits or costs of substitutes in terms of effects on health, recreation, productivity, and other social welfare issues; identifies who will benefit and who will bear the costs.	Guide the selection and use of alternatives that provide societal benefits and have reduced social costs; trade-off issue evaluated in the Decision information Summary module.
Decision Information Summary	Identifies trade-off issues associated with any one substitute; compares the trade-off issues across substitutes; does not recommend substitutes.	Lay out information to allow individual businesses to make the best choice for their particular situation, while considering social benefits and costs of individual choices.

Data are organized in the trade-off evaluation modules to accomplish the following:

- Identify the trade-off issues associated with any one substitute (e.g., reduced worker exposure but increased operating costs; reduced risk but increased energy consumption and reliance on scarce natural resources).

- Compare the trade-off issues across substitutes.

The goal is to present the data in a manner that allows individual businesses to make the best choices for their particular situation, while considering the social benefits and costs of their decision. For example, the alternative preferred by different shops within an industry sector may vary depending on the performance required for customer satisfaction, the required turn-around time, or water and energy costs. A business located in an urban area might be more concerned about volatile organic compounds (VOCs) that contribute to photochemical smog than aqueous waste streams released to the local publicly-owned treatment works, particularly when the business considers the impacts to society of the cumulative effect of many businesses emitting VOCs.

If an alternative is clearly superior in all respects, except it does not meet one of several performance requirements, it may be time to reevaluate the performance requirements. For example, unbleached paper made from 100 percent recycled fiber may not meet the traditional brightness performance criteria of virgin paper, but many consumers concerned about the environmental effects of the chlorine bleaching process are willing to accept less brightness for less pollution. This illustrates how performance needs can vary from business to business, sometimes allowing for more or fewer choices among the alternatives identified. In another example, an industry may find that a new substitute with reduced risk performs within acceptable limits, but does not perform as well as the current industry standard. If performance was the only criteria, clearly the industry standard would prevail. Factoring the reduced risk into the evaluation, however, makes the new substitute preferable as long as performance requirements are met.

IDENTIFYING DATA ANALYSIS METHODS AND ANALYZING DATA

The DfE project team will need to identify the specific methods they will use to analyze the project data and evaluate the risk, performance, cost, and other environmental impacts associated with each alternative. The module descriptions in Part II of this publication give guidelines for data analysis and provide references for analytical models. The Screen Printing: Screen Reclamation CTSA (EPA, 1994c) and the Lithographic Blanket Wash CTSA (EPA, 1996a) provide examples of the methods used for those projects. The following appendices are reproduced from either the Screen Printing Screen Reclamation or Lithographic Blanket Wash CTSAs:

- Appendix B, Environmental Releases and Occupational Exposure Assessment.
- Appendix C, Population Exposure Assessment for Screen Reclamation Processes.
- Appendix D, Background on Risk Assessment for Screen Reclamation Processes.
- Appendix E, Background and Methodology for Performance Demonstration.

- Appendix F, Chemical Volume Estimates.
- Appendix G, Cost Analysis Methodology.
- Appendix H, Environmental Fate Summary Initial Review Exposure Report.
- Appendix I, Risk, Competitiveness & Conservation Data Summary and Social Benefits/Costs Assessment.
- Appendix J, Cost of Illness Valuation Methods.

DEVELOPING A CTSA DOCUMENT

A CTSA document is the repository of all of the technical information collected in a DfE industry project. As a minimum, it should include the following:

- A profile of the use cluster describing the overall product or process in which the use cluster occurs; market information; the traditional products, processes, and technologies in the use cluster; and potential substitutes, including those evaluated in the CTSA, those not evaluated, and the reasons for excluding substitutes from evaluation.
- Information on chemicals in the use cluster, including the basic chemical properties data, market data, hazards summary data, and regulatory status.
- Summaries of the methodologies used to evaluate each of the trade-off issues (e.g., risk, performance, cost, social benefits and costs, energy impacts, resource conservation, process safety, international implications, and regulatory status).
- Results of the evaluations, including a summary of the trade-off issues.
- Descriptions of other environmental improvement opportunities identified during the course of the CTSA.

The project team circulates a draft CTSA for review and comment among the project partners and other interested parties. The team responds to comments and publishes a final document for dissemination to anyone interested in a compilation of all the project's technical work. Usually the project team will develop summary reports to disseminate to a wider, less technical, audience.

Design for the Environment: Building Partnerships for Environmental Improvement (EPA, 1995a) describes how to develop summary reports to communicate the results of a DfE industry project.