Final Report:

A Collaborative Framework for Office of Pipeline Safety Cost-Benefit Analyses

Prepared by:
The Joint OPS Stakeholder Workgroup

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Executive Summary

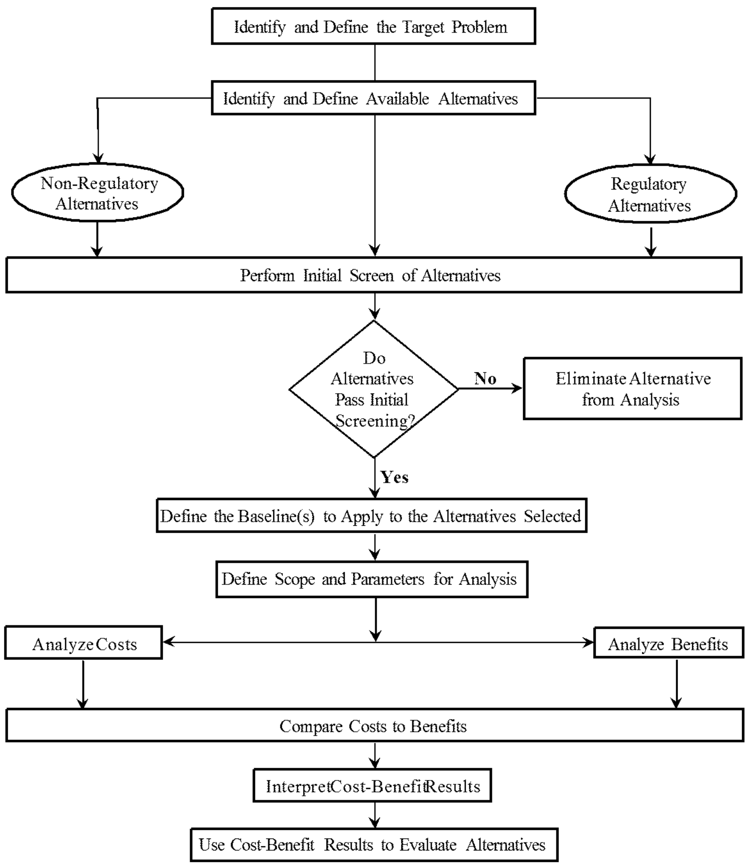
A New Framework for OPS Cost-Benefit Analysis

Economic efficiency is an increasingly important criterion used by the public, industry, and government agencies to evaluate the effectiveness of regulatory alternatives. To this end, the Accountable Pipeline Safety and Partnership Act of 1996 requires that the Office of Pipeline Safety (OPS) identify and compare economic costs and benefits associated with proposed alternatives affecting the pipeline industries. In response to the Act's requirements, OPS formed a stakeholder Workgroup with the goal of evaluating OPS' approach to conducting cost-benefit analyses. In addition to developing guiding principles for cost-benefit analyses, the Workgroup collaboratively delineated the key process components of a standard cost-benefit framework, and pilot-tested the cost-benefit framework using a current alternative (see the *Annotated Bibliography* for more information on key sources used to develop the framework). The major process components of the OPS cost-benefit framework (shown in Exhibit ES-1) are summarized as follows:

- *Identifying and defining the target problem* is the first process step; it involves clearly stating the root source or cause of a problem. This step will lay the groundwork for later evaluation of whether alternative solutions solve the target problem in a cost-beneficial manner.

- *Identifying all available alternatives* for addressing the target problem follows. Alternatives may consist of voluntary or incentive-based programs, regulatory mandates, combinations of voluntary and mandatory requirements, or the no-action alternative. Stakeholders in OPS programs, including pipeline operators, safety professionals, other regulatory agencies, environmental groups, and the public, can serve as creative resources for identifying potential solutions to the target problem. Because it is usually not practical to analyze an expansive list of alternatives, OPS will *screen alternatives* to determine those that possess unique requirements and that have political, technical, and economic feasibility; OPS will then begin to generate preliminary estimates of expected benefits and costs for these alternatives. Results of such screening analyses will be made available for public review.

Exhibit ES-1
Major Process Steps in OPS Cost-Benefit Analysis



- *Defining the analytical baseline* is critical to distinguishing the incremental costs and benefits associated with an alternative from those that would have occurred in the baseline, i.e., in the absence of the alternative. Baseline scenarios are inherently dynamic and therefore uncertain. Thus, specifying the baseline can be challenging. To make credible assumptions about the baseline, it is often useful to organize information according to economic, technological, and regulatory components. OPS will focus analytical efforts on characterizing those baseline parameters that are likely to have the most profound influence on results.

- OPS can generate results that will be most useful to decisionmakers by carefully *defining the scope* of the analysis, i.e., the time period of the analysis, the policy options to be evaluated, categories of costs and benefits that will be addressed, and uncertainties and assumptions included in the analysis. The time period should reasonably approximate the time during which costs will be incurred and benefits will be realized. Upfront consideration of key costs and benefits likely to result from an alternative will engage all stakeholders in the analysis and focus attention on issues that are most likely to influence results.

- OPS will devote most of the analytical effort during the assessment process to *defining and analyzing costs and benefits*. This step involves developing an inventory of likely costs and benefits, and organizing them into logical categories. Costs are typically organized into *direct* and *indirect* categories; benefits are often organized into *economic/commercial*, *safety*, and *environmental* categories. Next, OPS will attempt to develop metrics that describe costs and benefits quantitatively (e.g., units of product). Finally, quantified cost and benefit impacts should be expressed in present value monetary terms where possible, and the analysis should present the distribution of impacts among stakeholders.

- OPS will *use and interpret results from cost-benefit analysis* to identify tradeoffs between potential alternatives, to set priorities, and to revisit alternatives after their promulgation. Despite its usefulness as an analytical tool, cost-benefit analysis cannot be used to prove conclusively that benefits of a program exceed costs (or vice versa) due to inherent imprecision and uncertainty in results. Integrating the findings of cost-benefit analysis into policymaking requires that OPS depict all uncertainty explicitly, and understand its influence on results.

- *For most alternatives, OPS will use existing data sources rather than conducting primary research* (e.g., probabilistic models) when it is necessary to quantify beneficial effects. Even if assessments do not quantify results, stakeholders in OPS programs (i.e., pipeline operators, safety professionals, other regulatory agencies, and environmental groups) can provide information and insights to assist in the assessment of costs and benefits. When costs or benefits cannot be quantified and monetized, OPS will assess them qualitatively.

Guiding Principles

Throughout the cost-benefit analytical process, OPS will take care to follow certain key guidelines for conducting analyses. For example, because estimates of values and outcomes are often subject to significant uncertainty, OPS will use available tools to explicitly account for uncertainty and to then present useful conclusions about the influence of identified uncertainties on the results. In addition, when data describing analytical inputs are not available, OPS will clearly state, explain, and communicate simplifying assumptions. To ensure that analyses are credible and effectively communicate results to decisionmakers, the Workgroup developed a formal set of guiding principles for OPS cost-benefit analyses:

1) The Accountable Pipeline Safety and Partnership Act of 1996 provides the statutory authority for performing cost-benefit analysis for pipeline safety and en-

vironmental alternatives, including standards and regulations proposed by the Office of Pipeline Safety.

2) Cost-benefit analysis is an analytical tool used to assess the change in social welfare (i.e., the economic well-being of society) that would result from regulatory alternatives. The change in social welfare is the difference in the well-being of society under current conditions and industry practices versus those required under proposed alternatives.

3) Cost-benefit analysis will be performed on proposed alternatives that have more than a minimal economic impact. The no-action alternative will be evaluated (i.e., a baseline that reflects maintaining the status quo). Exceptions to performing cost-benefit may include products of negotiated rulemakings, emergency regulations, or adoption of consensus standards.

4) Analytical efforts will be scaled appropriately with respect to the likely significance of proposed alternatives and the range of discretion provided by statute or regulatory mandates.

5) The regulated industry and other stakeholders will be encouraged to work together to identify and provide data and guidance for using data within a cost-benefit analysis. Cost-benefit analysis will include an evaluation of current conditions and industry practices.

6) Cost-benefit analysis will be developed iteratively, incorporating input from stakeholders during each stage of the analysis.

7) Cost-benefit analysis will rest on a foundation of accepted economic theory and will utilize best practice economic methods for the characterization (qualitative or quantitative) of costs and benefits. The Office of Management and Budget's "Economic Analysis of Federal Regulations" under Executive Order 12866 reflects these principles and addresses best practices for economic analysis of significant regulatory actions.

8) Cost-benefit analysis includes uncertainties. Uncertainties will be described explicitly in each analysis, including the magnitude and distribution of each significant source of uncertainty.

9) Assumptions used in OPS cost-benefit analysis will be clearly described (see the *Sample Data Summary Sheet* provided at the end of this report for an example of how assumptions can be presented).

10) When evaluating costs and benefits of proposed alternatives, government and stakeholders will work together to avoid the inclusion of benefits and costs attributable to existing regulations and current practices. This will ensure that only incremental costs and benefits are evaluated in the analysis.

11) When benefits or costs cannot be monetized, other quantifiable measures will be used. When benefits or costs cannot be quantified, analyses will provide qualitative descriptions.

12) Variables will be explicitly stated, described, and referenced to a source and used consistently across alternatives. Examples of variables include: discount rate, project life, cost of averted fatalities and injuries, and depreciation method (again, see the *Sample Data Summary Sheet* for an example of such a presentation).

13) Benefits and costs of alternatives will be evaluated and monetized on a common-year basis for purposes of comparison.

14) Government and stakeholders will cooperate to perform post-cost-benefit review to examine the validity of original assumptions and the accuracy of the expected outcomes of the alternatives.

Value of Cost-Benefit Analysis within OPS Decisionmaking

Cost-benefit analysis is a powerful and flexible analytical tool that provides OPS with a systematic way of organizing and viewing the merits and costs of regulatory alternatives. Even when it is infeasible for OPS to conduct full, quantitative cost-benefit assessments, conducting qualitative analysis or performing preliminary analytical steps (e.g., defining the target problem, identifying alternatives) will provide valuable information that can help to build consensus among stakeholders on key issues. Finally, cost-benefit analysis can also provide OPS with insights about the overall effectiveness of alternatives, as well as empirical results that can be used to define regulatory priorities.

In spite of the advantages of cost-benefit analysis, it should never be the sole basis for decisionmaking. Cost-benefit results are subject to uncertainty, and analyses rarely prove conclusively that the benefits of a program exceed the costs (or visa versa). Thus, decisionmakers should not interpret quantitative results too literally nor should they be bound to a strict cost-benefit test. When used with other tools, however, results from cost-benefit assessments will allow OPS to evaluate both the economic efficiency and overall effectiveness of existing and proposed programs and regulations.

Recommendations

Clearly the use of cost-benefit analysis can significantly inform and improve decisions made by regulatory agencies. It provides a systematic and organized way of understanding the values and costs of alternatives. Like any analytical tool, however, it is effective only if used responsibly and within an appropriate context.

Based on the collaborative process that resulted in the creation of this report and the pilot test of the pipeline mapping analysis, the Workgroup offers the following recommendations for implementing the guiding principles and framework described in this report:

<u>To the Office of Pipeline Safety:</u>

- Publish a notice in the Federal Register announcing the completion of this report, notifying readers of OPS' intent to adopt the recommendations in the report and seeking public comments. Significant public comments should be added to the report in a comments section.
- Post the final report and the significant public comments on the Internet.
- Provide the advisory committee with the tools to conduct peer review, including the OMB guidelines, "Economic Analysis of Federal Regulations Under Executive Order No. 12866" (or subsequent guidelines) and this report. As new members are appointed, provide briefing materials on the committees' role as peer reviewers.
- Provide this report to OPS employees responsible for developing pipeline alternatives, so that they understand the potential use of prospective cost-ben-

efit analyses to help define problems to be resolved, to develop alternative solutions, and to inform decisionmakers of the merits of proposed alternatives.

- Encourage the use of retrospective cost-benefit analyses to examine the effectiveness of existing regulations.
- Continue to use collaborative stakeholder teams to assist in defining problems to be resolved, identifying alternatives to address significant problems, and contributing to cost-benefit analysis of alternatives.
- Publish a list of key variables, references, and source documents that are generally used in all OPS analyses, and publish updates and revisions to these when appropriate.

To the Pipeline Advisory Committees:

- Use the guiding principles and the cost-benefit framework described in this report during deliberations.
- Prepare for offering guidance to OPS during the development of pipeline alternatives by familiarizing yourself with OMB guidelines for economic analysis by federal agencies and the guiding principles and framework for cost-benefit analysis provided by this report.
- Provide leadership to OPS through your evaluation of the basis of cost-benefit analysis, including understanding and examining assumptions and uncertainties.
- Ask that OPS seek additional qualified peer review when pipeline alternatives require specific expertise beyond that which may be available through the advisory committees. When appropriate, the advisory committees should recommend competent third party reviewers to provide objective judgement.

To the Pipeline Industry:

- Participate in the development of cost-benefit analysis through the contribution of reasonable information and data about pipeline operations so that cost-benefit analysis can be based on real-world information to the maximum extent possible.
- Continue to participate in collaborative stakeholder teams to assist in defining problems to be resolved, identifying alternatives to address significant problems, and contributing to cost-benefit analysis of alternatives.

To Other Stakeholders:

- Participate in the development of cost-benefit analysis through the contribution of reasonable information and data about the costs and benefits of pipeline operations so that cost-benefit analysis can be used based on real-world information to the maximum extent feasible.
- Continue to participate in collaborative stakeholder teams to assist in defining problems to be resolved, identifying alternatives to address significant problems, and contributing to cost-benefit analysis of alternatives.

Glossary of Terms

alternatives In this context, alternatives refer to any regulatory or non-regulatory OPS programs or policies that address pipeline safety.

baseline The condition or set of conditions that would exist but for the outcomes associated with an alternative or program. In the context of OPS cost-benefit analysis, baseline would account for the absence of OPS alternatives designed to improve or enhance safety of the interstate natural gas and liquids pipeline system. The baseline is rarely static; rather, it is usually characterized by conditions that are either improving (i.e., a "rising" baseline) or deteriorating (i.e., a "falling" baseline).

benefits Positive incremental effects that result from the implementation of alternatives. Benefits can take the form of avoided costs, i.e., costs that would have taken place otherwise but are prevented by an alternative. For cost-benefit analyses, benefits are often organized into *safety, environmental,* and *economic/commercial* categories.

benefits transfer The application of economic data, functions, or models collected or defined in one benefit valuation setting, to the valuation of benefits in another, similar setting.

bounding analysis A way of interpreting results of cost-benefit analysis that defines the lower and upper boundaries of a range of values that represent a cost-beneficial outcome.

consumer surplus The difference between what a consumer is willing to pay for a good and the actual market price for that good. Consumer surplus is part of the theoretical basis for determining the value, in economic terms, of a change in social welfare (i.e., the well-being of society) resulting from an alternative.

contingent valuation A survey technique used to elicit the public's willingness to pay for goods or services that are not commonly available in markets (e.g., clean air). Contingent valuation surveys involve the use of hypothetical, or "contingent," markets.

costs Unfavorable effects associated with an alternative or policy change. Stated another way, costs are incremental resources used by entities, such as private sector firms, government agencies, or the public, in response to alternatives.

cost-beneficial An evaluation criterion describing the net difference between costs and benefits (i.e., net social welfare) associated with alternative courses of action.

cost-effective A term used to describe the lower cost of two or more alternative courses of action that provide identical benefits.

cost-benefit analysis An analytical tool used to define, quantitatively and qualitatively, the net change in social welfare resulting from alternatives and policy changes, based on the value of their beneficial and unfavorable impacts (i.e., benefits and costs). A primary goal of cost-benefit analysis is to inform regulatory decisionmakers about the relative merits of alternative approaches to solving problems.

Delphi methods Survey method based on eliciting expert opinion iteratively to construct estimates for specific variables. Delphi methods are often used to develop estimates of anticipated costs to industry of complying with the requirements of specific programs or alternatives.

discounting An analytical approach for converting resource flows paid in the past or future to current values. Discounting is based on the principle that a dollar received today is worth more than a dollar received sometime in the future.

discount rate The rate at which past or future resource flows are converted to present values. For cost-benefit analyses, discount rates reflect either public or private valuation tradeoffs (i.e., the value of forgoing future consumption for present consumption of public or private resources, respectively).

distributional equity The concept that alternatives may create groups that benefit disproportionately as a result of an alternative's impacts, and others that suffer adverse impacts due to an alternative's influence. Decisionmakers often incorporate consideration of distributional equity into policy choices, in addition to criteria which describe whether alternatives are cost-beneficial *(also see cost-beneficial, cost-effectiveness)*.

economic efficiency The concept that, for a given alternative or change, the value of incremental social welfare benefits must equal or exceed that of the incremental social welfare costs created.

general equilibrium models Models that account for dynamic linkages and interrelationships between sectors in the economy, and thus can be used to predict indirect impacts associated with alternatives (i.e., changes in prices, outputs, income, and employment).

incremental (cost or benefit) Denotes an additional change in the value of a variable, such as costs or benefits, attributable to an alternative (*also known as* ***marginal***).

non-use value The component of a natural resource that is valued by individuals apart from any past, present, or anticipated future use of the resource in question.

opportunity cost A cost that results from a decision to employ resources in a certain way (i.e., a lost opportunity to make alternative investments). Opportunity costs are equal to the value of associated foregone resources or investments.

pipeline As defined in 49 CFR Part 192 and Part 195, interstate natural gas and hazardous liquids pipelines regulated by the U.S. Department of Transportation's Office of Pipeline Safety.

present value The current, discounted value of a past or future resource flow.

primary research The process of conducting basic research tasks, such as quantitative risk modeling or contingent valuation surveys, to answer specific research questions. Research methods that rely on values derived from primary research studies (e.g., benefits transfer) are referred to as ***secondary research***.

producer surplus The difference between the price at which a producer is willing to sell a good and the price actually received. As with consumer surplus (*see above*), used to determine the value, in economic terms, of the change in social welfare (i.e., the well-being of society) associated with an alternative.

property value studies/hedonic pricing Studies that use information on the prices paid for real estate as an indication of how individuals value environmental amenities or disamenities. Hedonic pricing is a statistical method used to separate the effects of environmental characteristics on property sales price from the effects of other property characteristics (e.g., quality of school systems).

qualitative analysis Use of qualitative research methods to answer specific research questions; use of these methods provides qualitative rather than quantified descriptions of variables, parameters, or relationships of interest *(also see quantitative analysis)*.

quantitative analysis Use of quantitative techniques (or groups of techniques) to generate estimates of the actual value of specific variables, parameters, or relationships, and to express them in quantified terms (e.g., units of product, dollars). Examples of quantitative techniques include, but are not limited to, probabilistic risk assessment, decision analysis, and Monte Carlo analysis *(also see qualitative analysis)*.

revealed preference methods A group of benefits valuation techniques that infer values for goods or services that are generally not traded in markets, by looking at related goods that are traded in markets (e.g., property). These methods include, but are not limited to, market supply and demand studies, travel cost approaches, and property value studies *(also see stated preference techniques)*.

sensitivity analysis An approach to characterizing the uncertainty associated with estimates of unknown values, based on analysis of the sensitivity of such estimates to changes in underlying parameters. Performing sensitivity analysis provides a range of plausible values that describe to decisionmakers the overall influence of specific sources of uncertainty on the expected outcome.

social welfare A term used by economists that refers to a change in the economic well-being of society; social welfare is measured by net changes in producer or consumer surplus *(also see producer and consumer surplus)*. In this report, *social welfare benefit (or cost)* is used synonymously with *economic benefit (or cost)*.

stated preference methods A group of benefits valuation methods that employ survey techniques to characterize individuals' willingness-to-pay or preferences for environmental quality or resources not typically traded in markets. These methods, which include contingent valuation, involve asking individuals about the value or preferences they place on amenities (such as natural resources) and the quality of those amenities (i.e., respondents state their value) (*also see revealed preference methods*).

transfer payment Payments from one group that are wholly claimed by another group; thus, they represent a redistribution of wealth rather than a net change in social welfare *(also see economic efficiency and social welfare)*.

travel cost studies Valuation studies that use the cost of travel to a site as an implicit price for use of that site; price information is then used to understand demand for the site.

uncertainty The extent to which the estimated value of a variable, relationship, or parameter may differ from its true value. Because the true values of many economic and environmental variables (e.g., rate of future climate change) are inherently unknowable, results of cost-benefit analyses and other economic analyses are generally subject to some uncertainty.

use value The component of value of a natural resource associated with any direct past, present, or anticipated future use of, or contact with, that resource.

willingness-to-pay The concept that the value of goods and services not typically traded in markets, such as environmental amenities, is equal to what consumers are willing to forgo to acquire such goods and services. Willingness-to-pay is a measure of a given consumer's willingness to incur opportunity costs in order to acquire goods or services. In a perfectly competitive market, the difference between a consumer's willingness to pay for a good or service and what he or she is required to pay (i.e., the price) equals consumer surplus *(also see consumer surplus)*.

I. Value and Use of Cost-Benefit Analysis

This report describes a framework developed by the Office of Pipeline Safety (OPS) for analyzing the costs and benefits of its regulations and programs. There are growing efforts to make government more accountable to the public, to enhance government efficiency, and to improve regulatory alternatives designed to protect safety and the environment.[1] Indeed, there is increasing interest about whether the benefits of safety and environmental regulations and alternatives justify the associated costs, particularly as these regulations and alternatives expand in complexity and scope to address more difficult environmental and safety concerns.

Decisions about policy alternatives often involve the consideration and integration of various interrelated issues, including political, social, technical, and economic concerns. Cost-benefit analysis is one tool among many available for evaluating the effectiveness of policy choices. Specifically, cost-benefit analysis can help:

- Define the problem;
- Assess different alternatives for achieving goals;
- Promote efficient resource allocation by enabling more informed decisionmaking by the federal government;
- Provide insights as to the economic efficiency of federal regulations and programs;
- Identify other important factors besides economic efficiency, such as unintended consequences of alternatives and the distribution of costs and benefits among different groups of stakeholders.

II. Requirements For Cost-Benefit Analysis Under the 1996 Pipeline Safety Act

As early as 1979, OPS performed economic analyses to carry out Congressional mandates and to support its regulatory goals and objectives for the hazardous liquid and natural gas pipeline industries. Since 1946, the Administrative Procedures Act and other statutes and executive orders have required federal agencies to perform analyses of the costs and benefits to support their policy decisions. For example, President Reagan issued Executive Order 12291 requiring agencies to perform cost-benefit analyses (known as Regulatory Impact Analyses) of all proposed rules and to select the least costly alternative. The latest requirement, Executive Order 12866, requires that all federal agencies perform cost-benefit analyses for proposed or existing regulations which may have economically significant impacts (defined as an annual impact equal to or greater than $100 million).[2] Executive Order 12866 also specifies that agencies must make a reasonable determination that the benefits of regulations justify the costs and develop the most cost-effective approaches that impose the least burden on society.

[1] The Office of Technology Assessment (OTA) concluded that the "ideal" regulatory and non-regulatory policy instruments for protecting the environment would be as cost-effective and fair as possible, and accommodate increasingly rapid changes in science and technology. (See: "Environmental Policy Tools: A User's Guide," prepared by U.S. Congress, Office of Technology Assessment, September 1995).

[2] "Economic Analysis of Federal Regulations Under Executive Order No. 12866," memorandum for members of the Regulatory Working Group, prepared by the Office of Management and Budget, January 1996.

In addition to E.O. 12866, the Accountable Pipeline Safety and Partnership Act of 1996 contains specific requirements for the Office of Pipeline Safety (OPS) to identify the costs and benefits associated with proposed standards.[3] The Act requires that a standard prescribed under it be "...based on a risk assessment, the reasonably identified or estimated benefits expected to result from implementation or compliance with the standard."[4] The Act also establishes that in doing risk assessments under the Act, the Secretary of Transportation must identify "...regulatory and nonregulatory options that the Secretary considered in prescribing a proposed standard," and must identify "...costs and benefits associated with the proposed standard."[5]

Finally, the Act stipulates that the Secretary of Transportation must propose or issue a standard only after making a reasoned determination that the benefits of the standard justify its costs, unless otherwise required by statute. This statutory mandate for cost-benefit analysis is unique within the Department of Transportation (DOT), and it motivated OPS to revisit existing approaches to conducting economic analysis.

III. Creation of a Joint Cost-Benefit Workgroup

The statutory requirement for cost-benefit analysis and peer review as prescribed in the Accountable Pipeline Safety and Partnership Act of 1996 will most likely result in increased scrutiny of OPS economic analyses. In response to the Act, OPS began by talking with stakeholders about the best means to meet the statutory requirements. OPS then expanded on this goal, and began exploring more effective ways for OPS to perform economic analyses to meet current and future program requirements. Because OPS' experience is that collaboration among stakeholders improves results and reduces conflicts, OPS sought input from stakeholders to carry out its mission. OPS believes that a collaborative process is the optimal approach for meeting statutory requirements for cost-benefit analysis; and that collaboration improves the quality of information used in policy decisions.

An added benefit to using a collaborative approach is that OPS will have greater opportunity to compile information and data needed for analyses. More often than not, the community regulated by an agency possesses much of the information required for analyses. A collaborative framework may result in more effective economic analyses by improving access to higher quality information and data; it may also provide insights on the use and interpretation of data. OPS will continue to work closely with the pipeline industry and other stakeholders to explore methods to leverage its ability to do its mission.

OPS and the pipeline industry held preliminary meetings to review the need for collaborating on cost-benefit analyses of future OPS alternatives and related issues. Both concluded that a collaborative process would improve OPS cost-benefit analyses and would therefore benefit all stakeholders. As a result, a joint OPS/Stakeholder Workgroup formed to develop a collaborative process for performing cost-benefit analyses. After a few initial meetings, the Workgroup realized the necessity for, and the benefits to be gained by, broadening stakeholder participation. The pipeline technical advisory committees also made recommendations to broaden participation in and representativeness of the Workgroup during an early discussion of the development of this report. The initial Workgroup evolved into one composed of representatives from OPS, the National Oceanic and Atmospheric Administration (NOAA), the Department of the Interior (DOI), the American Petroleum

[3] Pub. L. 104-304, October 12, 1996.

[4] Section 60102 of Pub. L. 104-304.

[5] Ibid.

Institute (API), the Gas Research Institute (GRI), the American Gas Association (AGA), the Interstate Natural Gas Association of America (INGAA), the American Public Gas Association (APGA), and a number of hazardous liquid pipeline, natural gas distribution, and natural gas transmission companies.

After exploring stakeholder perspectives and experiences with government economic analyses and the application of these analyses within regulatory decisionmaking, the Workgroup concluded that OPS needed a documented framework, i.e., process and guidance, for conducting collaborative cost-benefit analyses that OPS can use and that stakeholders can understand. The Workgroup believed that such a documented framework is necessary for stakeholders to participate effectively in future OPS pipeline alternatives. The value of such a document framework became apparent based on the large number of issues, concerns, and views expressed in early Workgroup meetings. As envisioned by the Workgroup, the framework consists of a process for interaction among stakeholders representing the government, industry, environmental and safety constituencies, and the public. Goals of the framework include improving OPS cost-benefit analyses, minimizing conflicts and disagreements among stakeholders that may plague the rulemaking process, and producing the right type and amount of information for OPS to carry out its mandates and make regulatory and programmatic decisions. As such, the Workgroup hopes and anticipates that the framework will produce the following:

- More informed decisionmaking in public policy transactions.
- Clearer regulatory priorities and transparent tradeoffs between alternative outcomes.
- Identification of important factors besides economic efficiency for decisionmakers to consider, such as distributional equity (i.e., "winners" versus "losers") or the potential for irreversible or unintended consequences.
- More efficient regulations that solve actual problems.
- More informed stakeholders, more efficient and effective interactions among stakeholders, and decreased potential for prolonged conflicts and litigation.
- Promotion of mutual understanding and interests.

The remainder of this report provides a detailed description of the cost-benefit framework developed by the Workgroup for OPS and approved by the Technical Advisory Committee. In Section IV, we delineate a set of basic guiding principles that should characterize all credible OPS economic analyses. In Section V, we describe each of the major components, or analytical steps, of the collaborative cost-benefit framework and provide detailed guidance for conducting each step. Section VI describes the role of technical advisory committees in reviewing and evaluating OPS economic analyses.

To test, illustrate, and refine the OPS cost-benefit framework, the Workgroup applied the process and guidance to a case study of an actual, recent OPS alternative—a voluntary alternative that requires participants to submit pipeline location information. This case study is presented in Appendix A to this report. Since the goal of the Workgroup was to use this case study as a tool to refine the framework and to illustrate the application of its process and guidance, the Workgroup did not conduct a full quantitative assessment of the mapping alternative. In addition to providing analytical results, Appendix A reviews the challenges inherent to the application of the collaborative framework described in this report to this particular case, as well as a few broadly applicable "lessons learned."

IV. Guiding Principles

Before developing the OPS cost-benefit framework, the Workgroup crafted a set of guiding principles. Developed in a collaborative setting, the guiding principles and the cost-benefit framework reflect and are consistent with standard accepted economic concepts and practices, including those established in the Office of Management and Budget's (OMB) guidance for economic analyses performed by federal agencies. In addition, a variety of other key sources and texts on economic and cost-benefit analysis were referenced for development of this framework (see the *Annotated Bibliography* for the complete list of source documents used). During the Workgroup's exploration of stakeholder perceptions and experiences with economic analyses in regulatory decisionmaking, it became evident that the framework should describe cost-benefit analysis concepts and principles so as to be easily understood by stakeholders who are not economists. Given that the Workgroup's precept is that stakeholder and public comprehension facilitate meaningful participation, all Workgroup participants agreed that the guidance and process for the framework had to be understandable to the layperson if OPS is to fully realize its goals for conducting cost-benefit analyses. With this goal in mind, the Workgroup collaboratively developed the following guiding principles for OPS cost-benefit analyses:

1) The Accountable Pipeline Safety and Partnership Act of 1996 provides the statutory authority for performing cost-benefit analysis for pipeline safety and environmental alternatives, including standards and regulations proposed by the Office of Pipeline Safety.

2) Cost-benefit analysis is an analytical tool used to assess the change in social welfare (i.e., the economic well-being of society) that would result from regulatory alternatives. The change in social welfare is the difference in the well-being of society under current conditions and industry practices versus those required under proposed alternatives.

3) Cost-benefit analysis will be performed on proposed alternatives that have more than a minimal economic impact. The no-action alternative will be evaluated (i.e., a baseline that reflects maintaining the status quo). Exceptions to performing cost-benefit may include products of negotiated rulemakings, emergency regulations, or adoption of consensus standards.

4) Analytical efforts will be scaled appropriately with respect to the likely significance of proposed alternatives and the range of discretion provided by statutory mandates.

5) The regulated industry and other stakeholders will be encouraged to work together to identify and provide data and guidance for using data within a cost-benefit analysis. Cost-benefit analysis will include an evaluation of current conditions and industry practices.

6) Cost-benefit analysis will be developed iteratively, incorporating input from stakeholders during each stage of the analysis.

7) Cost-benefit analysis will rest on a foundation of accepted economic theory and will utilize best practice economic methods for the characterization (qualitative or quantitative) of costs and benefits. The Office of Management and Budget's "Economic Analysis of Federal Regulations" under Executive Order 12866 reflects these principles and addresses best practices for economic analysis of significant regulatory actions.

8) Cost-benefit analysis includes uncertainties. Uncertainties will be described explicitly in each analysis, including the magnitude and distribution of each significant source of uncertainty.

9) Assumptions used in OPS cost-benefit analysis will be clearly described.

10) When evaluating costs and benefits of proposed alternatives, government and stakeholders will work together to avoid the inclusion of benefits and costs attributable to existing regulations and current practices. This will ensure that only incremental costs and benefits are evaluated in the analysis.

11) When benefits or costs cannot be monetized, other quantifiable measures will be used. When benefits or costs cannot be quantified, analyses will provide qualitative descriptions.

12) Variables will be explicitly stated, described, and referenced to a source and used consistently across alternatives. Examples of variables include: discount rate, project life, cost of averted fatalities and injuries, and depreciation method.

13) Benefits and costs of alternatives will be evaluated and monetized on a common-year basis for purposes of comparison.

14) Government and stakeholders will cooperate to perform post-cost-benefit review to examine the validity of original assumptions and the accuracy of the expected outcomes of the alternative.

In the Workgroup's view, these principles represent the most important guidelines for all stakeholders and the advisory committees or other peer reviewers to be aware of when using and evaluating OPS cost-benefit analyses. In the future, OPS may refine, add to, and even change these guiding principles to be consistent with changes in economic theory and methods.

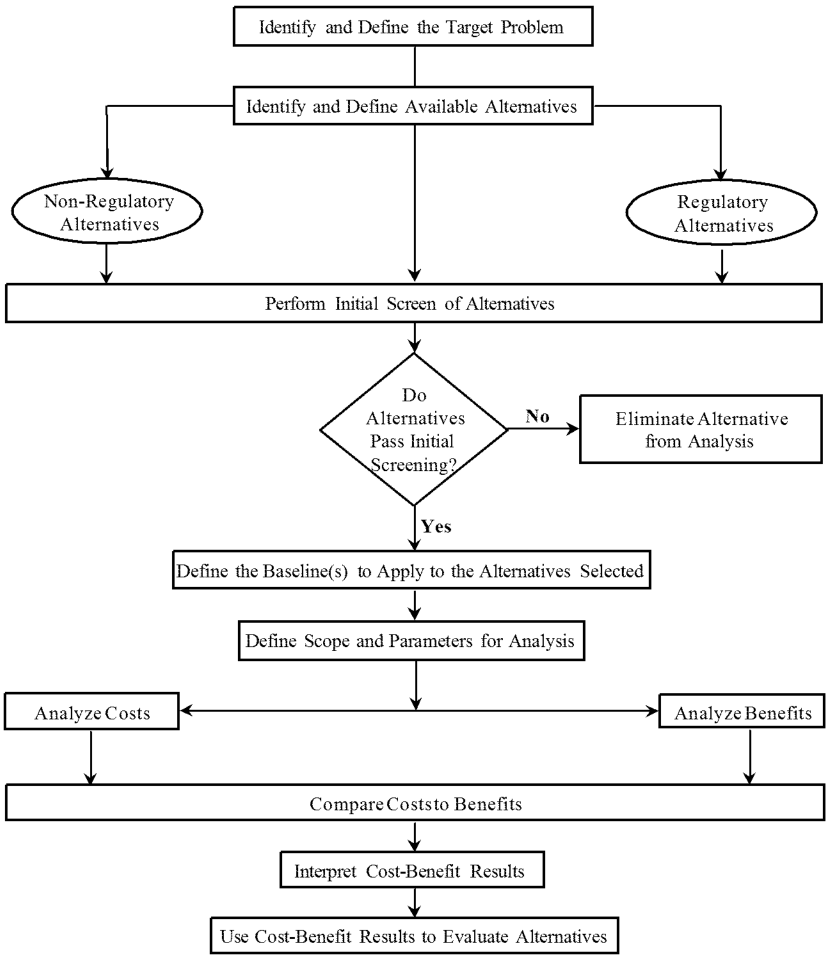
These principles also explicitly lay out important process steps and rules for implementing the framework. For example, Principle 1 states that the statutory mandate for cost-benefit analyses applies not only to new regulations but also to other OPS alternatives. Principle 5 highlights the importance of collaboration between stakeholders and of making data available as part of the collaborative effort. Collaboration and communication between stakeholders is also reflected in several other principles. For example, Principle 6 states the need for stakeholder participation during each stage of the analysis, underscoring the iterative nature of the cost-benefit framework. Principle 14 states the value of performing collaborative post-analysis reviews, which may provide insights as to whether alternatives address the target problem, and whether they prove to be cost-beneficial.

V. Framework for Cost-Benefit Analysis of OPS Alternatives

Background

Over the last two years, a joint OPS/Stakeholder Workgroup has addressed outstanding issues and questions regarding cost-benefit analysis of OPS alternatives. A key result of this collaborative effort is a set of guiding principles for conducting cost-benefit analyses of these alternatives. These guidelines draw on accepted principles of economic and statistical theory that form the methodological basis of regulatory cost-benefit analysis. As part of this effort, the Workgroup reviewed in detail the major components of a standard framework for conducting cost-benefit analysis. This chapter provides a description of each of these components, with the goals of: (1) communicating the outcome of the Workgroup's discussions, and (2) providing guidance that describes each step in the cost-benefit process as it can be applied to future OPS alternatives. The following process steps, as shown in Exhibit 1, are reviewed:

Exhibit 1
Major Process Steps in OPS Cost-Benefit Analysis



- Identifying and Defining the Target Problem
- Identifying Available Alternatives
- Defining the Baseline(s)
- Defining the Scope and Parameters of the Analysis
- Defining and Analyzing Costs
- Defining and Analyzing Benefits
- Interpreting and Using Cost-Benefit Results
- Evaluating the Value and Effectiveness of the Cost-Benefit Process

In the remainder of this chapter, we describe approaches to each of these steps and key analytical issues that may be encountered when analyzing OPS alternatives. (At the end of this report, we also provide a *Sample Data Summary Sheet* that contains an example template of key assumptions, values, and sources used to develop an analysis.)

Identifying and Defining the Target Problem

Many federal programs and alternatives, including OPS alternatives, are designed to address problems not addressed by private markets. For example, the private market may not have economic incentives or access to proprietary information to make available detailed pipeline location data. Because it is not always clear whether a federal alternative is the most appropriate means for addressing a problem, identifying and defining the target problem in some detail is a critical first step of cost-benefit analysis. This step helps to frame a question that is often revisited later in the analysis. That is, this step provides insight on whether an OPS alternative is necessary to achieve the desired result. As such, this step often involves determining if an actual problem exists, the root source or cause of the problem, the manifestation of the problem (e.g., effects on humans or the environment), and the expected trajectory of the problem over time. Further, development of an accurate definition of an alternative's desired outcome is a crucial step toward engaging stakeholders.

Identifying Available Alternatives

The second step of a cost-benefit analysis involves identifying all available alternatives for addressing the target problem. One approach is to group alternatives that involve non-regulatory approaches, such as voluntary or incentive-based programs, other alternatives that mandate specific actions (i.e., traditional "command-and-control" regulation), or combinations of voluntary and regulatory actions. The no-action alternative should always be considered. The objective of listing alternatives is to understand the full range of relevant options that policymakers may have at their disposal. Including options that have different costs and benefits may result in a better understanding of incremental costs and benefits of individual approaches than analyses that evaluate a single alternative or policy end-point.

Next, the alternatives are screened down to a smaller set of options that will be evaluated through cost-benefit analysis. To perform screening, OPS first assesses whether the available alternatives are distinct enough, in terms of both their elements or provisions and their probable impact, to be assessed separately. This step requires OPS to consider whether an alternative may actually be implemented, which is often a function of other factors such as political or technical feasibility. For example, an alternative requiring a new pipeline inspection technology that is still in a prototypical stage of development may not be feasible until the technology becomes commercially available.

Completion of the first process step, identification of the target problem, will provide information to the screening analysis by indicating which alternatives are unlikely to mitigate or solve the target problem. Also, it will provide preliminary evidence as to whether one or more of the available alternatives are cost-beneficial. A command-and-control regulation requiring installation of state-of-the-art inspection technology that increases an industry's costs by an order of magnitude, for example, is not likely to be cost-beneficial. Additionally, even alternatives that have potential to solve the target problem in a cost-beneficial manner may be dominated by other, more attractive alternatives. For example, the voluntary pipeline mapping alternative, analyzed in the Appendix to this report, is one approach that dominates similar command-and-control-based alternatives.

It should also be recognized that the value of identifying multiple alternatives is, in part, discussing those alternatives and considering combining two or more approaches that could prove more effective or cost-beneficial than a single alternative. Allowing time for creative dialogue at an early stage may reduce the overall time required to resolve problems and implement solutions.

Upon completion of the screening step, the analyst should explicitly state which alternatives were screened out or combined for purposes of analysis and why. Furthermore, the basic components or provisions of those alternatives to be included in the analysis should be described. If possible, "ballpark" estimates of expected benefits and costs should be developed. These preliminary estimates could take the form of qualitative or quantitative (i.e., order-of-magnitude) descriptions of likely costs and benefits based on existing knowledge or expert opinion. The questions encountered in developing ballpark estimates will assist the analyst in identifying data requirements and deciding how to focus the technical approach of the analysis. Finally, key groups or populations that may be affected by implementation of alternatives should also be identified during this step.

Guiding Principle 9:
"Assumptions used in cost-benefit analysis will be clearly described."

In conducting a cost-benefit analysis, OPS may make simplifying assumptions in place of imperfect or unavailable data. As stated in Guiding Principle 9, a basic tenet of sound cost-benefit analysis is that, when presenting analytical results, all assumptions should be communicated clearly and transparently. Clarity and transparency of presentation will enhance decisionmaking by providing a more complete picture of the limitations of an analysis.

A general guideline for clearly presenting assumptions used in an analysis is that the audience should not have to search for critical information. Thus, it may be useful to group and present major assumptions (e.g., time period, baseline parameters) in summary form somewhere in the analysis. For example, see the Sample Data Summary Sheet at the end of this discussion. This sheet provides as example template for describing key assumptions, values, data, and sources used to develop an anlysis.

Defining the Baseline(s)

To accurately characterize the impacts of a particular OPS alternative, a cost-benefit analysis should establish the attributes of the baseline situation, i.e., the world as it would look in the absence of the alternative. Only benefits and costs that are incremental to this baseline scenario should be counted in the measure of net social welfare attributable to the new regulation or alternative. It is important to develop baseline assumptions as accurately as possible to provide context to the calculation of benefits and costs that directly result from the promulgation of a new program or alternative.

By definition, the baseline case is highly dynamic, usually characterized by conditions that are either improving or deteriorating. For example, when an industry undertakes practices beyond those required by regulations, the baseline can be said to be improving or "rising." Alternatively, if economic conditions are declining, and industry practices deteriorate as a result of a poor economic outlook, the baseline is said to be "falling." Because current practices and conditions are often difficult to predict with certainty, and conditions in the future are always uncertain, careful specification of the baseline is challenging but also critical to a credible analysis.

A useful approach to beginning the baseline definition process is to organize the information that characterizes the baseline case by its various components, including *economic*, *technological*, and *regulatory* factors. The *economic* component considers trends in economic conditions that, through changes in markets or prices of specific products, may affect the magnitude of costs or benefits absent the alternative. Economic trends often wield strong influence over the ability of private firms and government agencies to make incremental investments and to engage in new activities and programs in the baseline. For example, under improving economic conditions, pipeline operators may invest in projects based on new technologies as access to capital increases. Unfortunately, it is very difficult to forecast economic trends with accuracy, particularly beyond the near-term. Hence, OPS should balance the advantages of scoping the analysis to include major economic baseline trends over the long-run with the cost of doing so.

The *technological* component considers whether important changes in relevant technologies may take place in the absence of the alternative. Determining the technological baseline is occasionally fraught with the same degree of uncertainty as is forecasting economic trends. However, it is often feasible to make reasonable assumptions about the rate of change of a particular relevant technology if adequate research is performed. For example, when assessing the baseline for an OPS alternative that requires pipeline location data, vendors of pipeline mapping software and closely related products (e.g., GIS software) provided OPS with a reasonable range of assumptions regarding the likely future penetration of these technologies within industry and public agencies.

The *regulatory* component of the baseline considers whether other existing or planned regulations or alternatives (i.e., those not included in the alternatives being analyzed) may affect the requirements of the program being assessed. Assessment of the regulatory baseline can be complicated by the presence of multiple regulatory bodies with responsibility over the same facilities.

For each of these components, OPS should attempt to determine which are critical to the analysis, and should then assess the extent to which baseline trends and practices in the industry may evolve over time. Obviously, it may be challenging to forecast all of the components of the baseline case with accuracy. Therefore, it may be reasonable to develop alternative baseline assumptions that characterize what might occur in the absence of a regulation or alternative (i.e., the creation of reasonable upper- and lower-bound estimates for each of the critical factors). In general, OPS should focus on aspects of the baseline case that seem most significant, i.e., those likely to have a profound influence on results. As with all components of an analysis, all uncertainties associated with baseline definition should be identified up front and all assumptions should be clearly stated in the report of the analysis.

Defining Scope and Parameters of Analysis

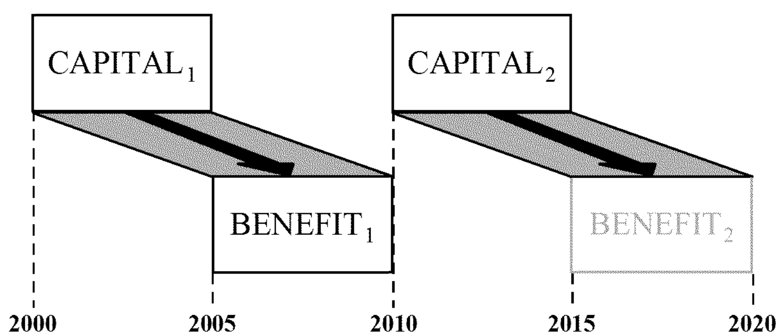
Scoping the parameters to be included in a cost-benefit analysis (i.e., determining exactly what will be analyzed) is critical to focusing analytical resources effectively. This step also provides early insight on how informative results are likely to be, and thus how valuable these results may be to decisionmakers. For example, if only a few categories of benefits and costs are likely to dominate the analytical results, extending the scope to include other benefit and cost categories will probably not provide much additional information of value to decisionmakers. On the other hand, providing information that helps stakeholders understand the significance and overall impact of certain costs and benefits on the outcome is very important. Typical parameters to scope before beginning an analysis are the time period of the analysis and major categories of costs and benefits, as described below.

Time Period of the Analysis

The time period addressed in a cost-benefit analysis should reflect a reasonable approximation of the time during which costs will be incurred and benefits will be realized as a result of an OPS alternative. A logical starting point for an analysis is the point in time at which the baseline scenario and the proposed alternative scenarios begin to diverge, i.e., the time at which these scenarios begin to generate different costs and benefits. OPS must also define the end-date for the analysis.

As a general rule, the same time period should be applied to costs and benefits throughout the analysis. In many cases in which capital investments are required, however, benefits generated by these investments may occur much later in time than the initial capital outlay. For example, as Exhibit 2 illustrates, an investment in new pressure testing equipment ($CAPITAL_1$) creates environmental benefits ($BENEFIT_1$) that begin in 2005, just as the first capital cycle ends. When the timing of costs differs from the timing of associated benefits as in this case, a common approach to establishing a time period is to first determine the timing of one complete cycle of capital costs (i.e., five years). Then, the analysis should determine the time period over which the benefits generated by the capital investment are likely to occur. In this example, the analysis could address the time period to 2010, which represents one full cycle of capital costs and associated benefits; therefore, it would not include the second capital flow ($CAPITAL_2$) or associated benefits ($BENEFIT_2$).

Exhibit 2
Timing of Costs and Benefits



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Categories of Benefits and Costs

A key aspect of defining the scope of an analysis is to consider the major categories of costs and benefits that may result from an alternative. The outcome of this step will lay the groundwork for the analysis. First, developing a list of costs and benefits will provide all stakeholders involved in the analysis an opportunity to identify missing categories, and to understand and contribute to the content of the analysis. Second, this step helps to focus attention and resources on a more limited set of issues (i.e., those categories that most influence overall benefits and costs). Finally, identifying which categories of costs and benefits are likely to be significant in magnitude early in the process will help to define data needs and possible approaches for assessing or quantifying costs and benefits.

Defining and Analyzing Costs

This section reviews the steps involved in analyzing the costs of pipeline alternatives. The goal of a cost analysis is to characterize the incremental economic costs incurred by affected industries, government, and public entities that engage in activities to meet the provisions of an alternative. Costs should be evaluated for each alternative included in the scope of the analysis.

The major steps in cost analysis are as follows:

- Identify and describe the cost categories to be analyzed;
- Quantify the cost impacts of the alternatives; and
- Monetize these cost impacts.

Below, we discuss each of these steps in more detail.

Identify and Describe Cost Categories for Analysis

Costs within a cost-benefit analysis represent the "opportunity cost" of resources used or benefits foregone as a result of a regulatory alternative. That is, the opportunity cost of a decision to employ resources in a certain way is equal to the value of other investments or goods and services foregone as a result of this decision.

The incremental costs of OPS alternatives are incurred by government agencies, private-sector firms, and the public at large. Government agency costs generally result from developing and administering OPS programs, as well as from training, monitoring, reporting, permitting, and enforcement activities. Private sector firms such as pipeline operators typically incur costs to participate in or comply with the requirements of OPS alternatives. These costs can include purchases of capital and equipment, expenditures on employee training programs, or enhanced operation and maintenance of existing pipeline systems. Finally, the public may bear opportunity costs related to OPS alternatives such as costs associated with reduced convenience, lost time, or a slower rate of technological innovation.

The goal of this stage of the assessment is to develop a qualitative understanding of costs before quantifying and monetizing them. To do so, it is useful to first create a complete inventory of cost impacts expected to result from the alternative under consideration. For best results, all potentially affected groups should have input in creating this inventory.

Direct Costs

Exhibit 3 displays one approach to composing an inventory of cost categories relevant to OPS pipeline alternatives. The major cost categories shown here are *direct* and *indirect* costs. *Direct* costs, comprised of *one-time* and *on-going* cost subcategories, are generally more amenable to evaluation because they are incurred directly by private firms, government agencies, or public entities and are usually accounted for discretely. For direct costs, actual cost data or accurate estimates of costs are often readily available. *One-time* direct costs are usually purchases of capital assets that generate a stream of future benefits and whose costs are amortized, i.e., spread out over the expected lifetime of the asset.[7] To participate in OPS alternatives, industry is likely to incur the majority of direct, one-time capital costs. Examples of typical capital costs resulting from OPS alternatives may include, but are not limited to, control devices, computer hardware, physical pipeline infrastructure, land, or monitoring equipment.

Exhibit 3
Potential Costs of OPS Alternatives

Cost Categories	Cost SubCategories	Example Cost Impacts	Availability of Cost Data
Direct	One-Time (Capital)	• Capital purchase of hardware for in-line inspection devices • Installation of capital equipment	Usually available; capital costs and related expenses are typically tracked explicitly by accounting systems.
	Ongoing	• Operation and maintenance of capital equipment • Monitoring/oversight activities • Training pipeline employees • Administrative activities	Usually available; these cost categories may be lumped into facility overhead, thus requiring additional research and analysis.
Indirect	Producer and Consumer Surplus Losses	• Price increases for consumer goods • "Crowding out" of private investment • Loss of time or convenience • Slowing of technological innovation	Highly data-intensive; requires estimates of changes in prices, quantities, and elasticities of demand and supply; may require dynamic modeling. For OPS initiatives, these impacts are usually evaluated qualitatively.

Government entities may incur direct, one-time capital costs also but are more likely to incur on-going direct costs such as administration expenses. *On-going* costs are another subcategory of direct costs. These are costs that are incurred periodically by entities to maintain capital assets or to conduct other continuous activities related to an alternative. On-going costs are usually not amortized, but are attributed to the period in which they are incurred. Examples of common on-going costs include:

- **Operations and Maintenance:** Operations and maintenance costs (or "O&M" costs) are expenses related to operating and maintaining capital equipment, infrastructure, or physical assets. These costs are often expressed as a percentage of annual capital costs.

- **Administrative Costs:** Administrative costs may include expenses for supplies and other non-capital equipment (e.g., office supplies), time spent reviewing standards, performing paperwork and related administrative duties, technical support, and other labor.

- **Training Costs:** Some pipeline safety alternatives may not require capital equipment, but may require pipeline operators to train employees in certain procedures designed to improve safety. The costs of training these employees is an ongoing cost. Salaries and related benefits for personnel are also considered ongoing costs.

[7] Some one-time expenses, such as costs for acquiring software, may not be amortizable under existing tax laws.

Indirect Costs

Indirect costs are the second major category of costs resulting from OPS alternatives. These represent opportunity costs, often borne by the public or private sector industries, resulting from the indirect influence of OPS alternatives on markets and related entities. Indirect costs can be thought of as negative changes in market conditions that cause real economic losses for consumers or producers.[8] For example, an alternative which causes a reduction in the supply of a certain good (or service) and thus an increase in the price of that good (or service) creates real economic losses that are attributable to the alternative. These types of losses are referred to as *consumer* and *producer surplus* losses.

Consumer surplus equals the difference between the maximum amount a consumer is willing to pay for a unit of a good or service and what they are required to pay for a unit (i.e., the market price). Producer surplus equals the difference between the amount a producer is paid for a unit of a good or service and the minimum amount the producer would accept to supply that unit. Changes in consumer or producer surplus will result when the impacts of an OPS alternative are substantial enough to influence market supply or demand conditions, in turn creating significant price changes.

Each analysis should establish the extent to which markets will be affected. Other indirect impacts may warrant more detailed consideration. For example, "crowding out" of private capital investment is one type of producer surplus loss that could result if an OPS alternative requires significant investments on the part of affected firms.[9] If these investments affect the amount of capital available to a firm, they may then "crowd out" or compete with a firm's ability to make other profitable investments in assets and equipment. Output and profits may fall commensurately, resulting in producer surplus losses.

Estimating indirect cost impacts (i.e., consumer and producer surplus losses) such as "crowding out" effects often requires sophisticated economic modeling techniques.[10] Hence, because of the resources generally required to employ these models, quantitative analysis of these effects may be outside the scope of most OPS cost-benefit analyses, but OPS should address indirect impacts qualitatively when possible.

Other Factors to Consider

A few factors should be considered in the process of identifying important cost categories. First, it is common to overlook benefits foregone (i.e., costs) as a result of implementing a new OPS program or alternative. Foregone benefits are beneficial impacts that would

[8] In this context, the terms *economic loss* and *economic cost* are synonymous with *social welfare loss*, a more technical term used by economists to refer to economic costs. Throughout this discussion, we use the former terms for simplicity and clarity.

[9] An extensive literature exists addressing the impacts of environmental and other public regulation on the productivity and competitiveness of firms and industries, including "crowding out" effects. A brief list of references on this topic includes: (1) Jaffe, Adam B., Steven R. Peterson, Paul R. Portney, and Robert N. Stavins, *Environmental Regulation and International Competitiveness: What Does the Evidence Tell Us?*, Discussion Paper 94-08, Resources for the Future, 1994; (2) Jorgenson, Dale W., and Peter J. Wilcoxen, 1992, "Impact of Environmental Legislation on U.S. Economic Growth, Investment, and Capital Costs," in Donna L. Brodsky, ed., *U.S. Environmental Policy and Economic Growth: How Do We Fare?,* Washington, D.C.: American Council for Capital Formation; (3) Viscusi, W. Kip, "Frameworks for Analyzing the Effects of Risk and Environmental Regulations on Productivity," *American Economic Review*, Vol. 73, No. 4, 1983; and (4) Robert H. Haveman and Gregory B. Christainsen, "Environmental Regulations and Productivity Growth," *Environmental Regulation and the U.S. Economy,* Washington, D.C.: Resources for the Future, 1981.

[10] General equilibrium models are commonly used to estimate indirect costs impacts when these impacts have far-reaching consequences for the economy. The strength of these models is that they can explicitly account for linkages between sectors of the economy, but they can also be relatively expensive, data-intensive, and time-consuming to develop.

have taken place in the baseline, but that are lost, often unintentionally, as a result of the decision to implement OPS program activities. For example, an alternative requiring the installation of inspection devices may require operators to shut down segments of pipe for a short time. This may disrupt continuous product supply, resulting in real economic costs. It is easy to overlook foregone benefits when cataloging cost impacts, but in some cases, they may exemplify an important opportunity cost and should be classified as such.

Second, analysts should take care to avoid categorizing transfer payments as costs or as benefits. Transfer payments reflect only a redistribution of wealth. That is, they are resources gained or lost by one group that are wholly offset by gains or losses realized by another entity. For example, a reduction in insurance premiums that results from an improvement in pipeline safety is a transfer payment rather than an economic cost or benefit, if the reduction in premiums is matched by a reduction in insurance claim payments. Identifying transfer payments is often useful in characterizing the distributive impacts of alternatives; however, they should not be classified as or included in net costs and benefits.[11]

Finally, it is noteworthy that OPS is a federal agency funded by user fees paid by pipeline operators, rather than through appropriations of federal government revenues. This introduces an interesting nuance to the analysis of the costs of OPS alternatives. Whereas an analyst would normally categorize costs borne by a federal agency as *government* costs, in the case of OPS, program costs incurred to enact programs and alternatives are effectively passed on to industry in the form of user fees. These costs could thus be categorized as *private* or *quasi-private* costs, instead of as *government costs*. Making this distinction may be a more accurate depiction of the distributive impacts of an alternative (i.e., which groups benefit or experience losses).[12] Whether costs attributed to OPS alternatives are categorized as private or government costs, however, will not influence the absolute value of total costs will be the same.

Quantify the Cost Impacts

After identifying distinct categories of costs, the next step is to develop quantitative measures of the magnitude of each category of cost. Developing quantified cost measures is sometimes as simple as reading cost data from an accountant's report, but more often requires additional analysis or research to discern the timing or true extent of costs that should be attributed to an alternative. In many cases, the analyst will need to estimate such costs given a lack of factor-specific data.

Cost metrics that are not already expressed in a monetized form are typically expressed as units of a commodity or service with economic value. For example, hours of engineering staff time, numbers of computer workstations, and contract services hired are all examples of cost metrics derived from performing a quantitative analysis of costs. Below we describe available methods typically used to develop quantified cost estimates.

- **Existing Cost Data:** All firms in the pipeline industry maintain extensive data and information describing their cost structure, not only for tax reporting purposes but for managing business operations. Most government agencies also track cost data to estimate the costs of various programs, but these cost data are often less precise and disaggregate than industry data. Industry concerns about cost data becoming available to competitors can be a factor that limits

[11] The term *transfer payments* denotes payments that take place which are not true changes in consumer or producer surplus, that is they are not costs or benefits that count in a cost-benefit analysis. This concept should not be confused or interchanged with *benefits transfer*. *Benefits transfer* refers to one type of method for quantifying benefits (see definition on p. 26).

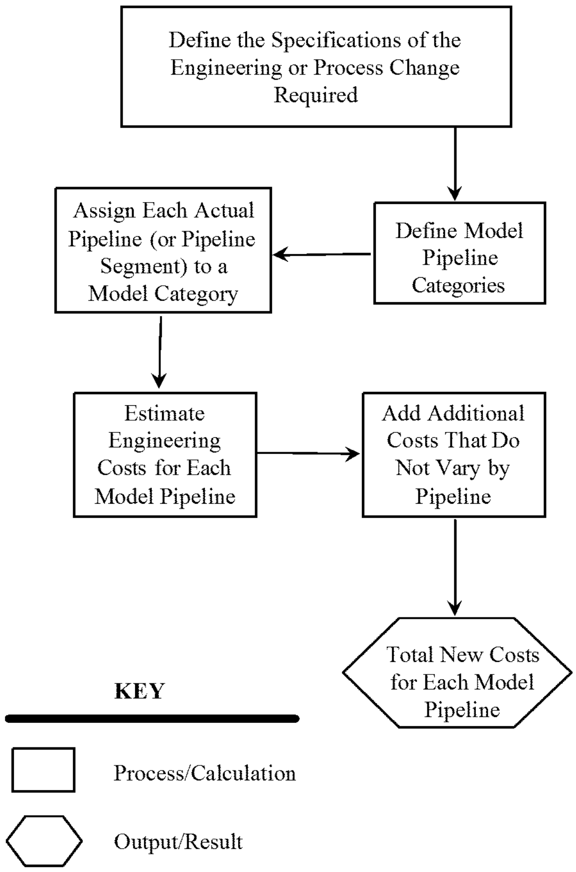
[12] We discuss the importance of considering distributive impacts later in this report.

analysts' ability to obtain detailed data describing actual industry costs.[13] Government cost data are generally more available. However, as is the case with some industry data, these data may require additional interpretation before they are suitable to use in cost-benefit analysis.

- **Cost Surveys:** Cost surveys may be formal, written survey instruments that are administered to operators or they may be less formal surveys, such as informal interviews with industry engineering staff. Typically, a cost survey is administered to a sample selected from the affected universe of firms or entities; care must be taken to scale sample cost data to develop an estimate for all affected entities. Information from such surveys can be significantly improved if the surveys are developed collaboratively with stakeholders.

- **Engineering Cost Approaches:** Engineering cost approaches or models are often used to determine incremental costs to industry when actual cost data are not available, such as when an alternative requires purchase and installation of innovative control equipment. Engineering cost models are constructed by defining the specifications of engineering or process changes required (i.e., capital, operating, and maintenance expenses) and then costing out all of the components of these changes. An example of a widely used engineering cost model involves the estimation of costs based on simulations of required process changes to engineering conditions at an actual or prototypical "facility." In the case of the pipeline industry, a model "facility" could be defined as a segment of pipeline or an entire pipeline with distinct characteristics. Results from this simulation modeling exercise are then applied to other affected facilities (i.e., pipelines or pipeline segments), taking into account variability across the characteristics of the facilities to which results are applied. Exhibit 4 displays the basic structure of this type of engineering cost model for pipeline systems. This approach may be appropriate for some OPS alternatives, but is less useful if pipelines and pipeline operators exhibit significant differences in key characteristics that cause them to realize significantly different costs.

Exhibit 4
Overview of Engineering Cost Approach



Note: When used for analyzing OPS initiatives, a model pipeline could represent an operators' entire pipeline system or a segment of a pipeline system.

- **Delphi methods/expert opinion:** Delphi methods involve arriving at an estimate based on the opinion of groups of industry and government experts. With a Delphi approach, testimonies from experts are collected iteratively and are

[13] It is common for industries or firms, often through trade or professional associations, to provide aggregate cost data to shield confidential business information (CBI), or to present cost data using alternative metrics (e.g., percentage of total facility operating costs).

often used to build subjective probability distributions around key cost parameters. Analysts should take care when using this approach to choose a representative group of experts, and to reflect the full range of opinion provided.

Ideally, each of the above methods will yield cost metrics that are easily monetized; many will be acquired in a form already monetized.

Monetize the Cost Impacts

After quantifying the cost impacts of the alternative, the next step in analyzing costs involves arriving at a value for costs expressed in monetary terms. Expressing costs in common monetized terms allows for both absolute and relative considerations of the magnitude of different cost categories. In addition, if benefits have also been monetized, this step allows for a quantitative comparison of costs and benefits.

In general, developing monetized estimates is usually much more straightforward for costs than for benefits. This is due to the fact that most of the metrics used to quantify costs, such as labor hours, gallons of lost product, or units of capital or machinery, are economic goods that are traded directly in markets at monetized values. Additionally, costs are generally tracked very carefully by private firms.

Despite the relative ease of monetizing costs that have been quantified using standard metrics, analysts should nonetheless be alert for potential complicating factors. For example, if an analyst calculates the number of additional labor hours incurred by engineers within a firm due to an alternative, these labor hours could be multiplied by the average engineering labor rate. However, because firms also incur overhead costs associated with professional labor, a more accurate measure of cost is equal to labor hours times a "fully loaded" labor rate. This is a rate that includes average overhead expenses associated with each employee-hour. Another major consideration when monetizing costs is careful treatment of costs that occur in different time periods.

Monetizing Costs Over Time

Costs of pipeline alternatives are often incurred by industry, government, and the public at different points in time. For example, capital costs may be incurred by pipeline operators immediately following promulgation of an alternative and at regular intervals as capital equipment expires, while the costs of maintaining capital equipment may be incurred annually over the life of the equipment. Costs to government, on the other hand, are often highest in early stages of program or policy development.

Cost flows that occur in different time periods should not merely be summed to arrive at an estimate of total cost. This is because money and other economic resources have a "time value," that is, they are worth more in the present than at some point in the future. Another way of expressing this is that a dollar paid today is worth more than a dollar paid in the future because the individual holding the dollar can invest it and earn a return.

To reflect the value of future benefit and cost flows as if they had occurred in the current period, economists apply a basic financial procedure called discounting. Discounting accounts for the time value of money and resources by expressing values occurring in the future in terms of their value as if received today, or their "present value."[14] Exhibit 5 shows how discounting influences the value of a cash flow with a present value of $1,000.

[14] The present value of a stream of future costs, for example, is calculated using the following formula:

$$PresentValueof\ Costs = \frac{Cost_0}{(1+r)^0} + \frac{Cost_1}{(1+r)^1} + \frac{Cost_2}{(1+r)^2} + \ldots + \frac{Cost_t}{(1+r)^t}$$

where r equals the rate of discount, and t represents the time periods in which the cost is incurred.

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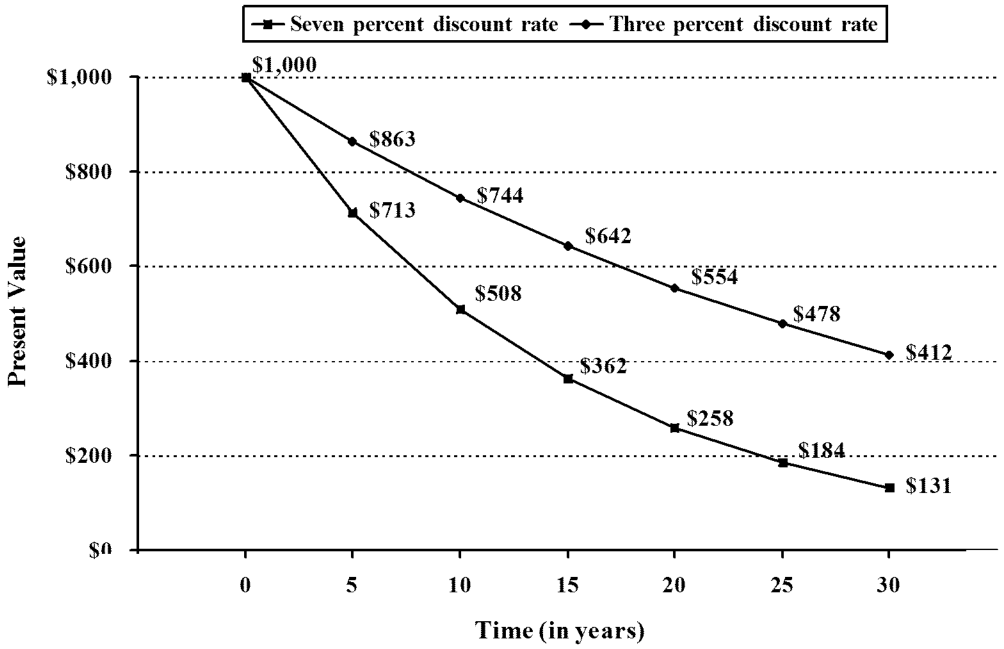
This exhibit also shows that the rate chosen to discount future resources exerts a strong influence on present value, and in turn influences the calculation of total costs. The higher the discount rate used, the smaller the present value of future costs. As shown above, using a seven percent rate of discount results in a smaller present value in year 30 than under a three percent discount rate. Among economists and federal agencies, there are varying opinions about what discount rate is appropriate for use in regulatory cost-benefit analysis. While a private discount rate is appropriate for use in analyzing private investments or costs incurred by private firms, it may not be appropriate in assessing benefits and costs the public.

Exhibit 5
Discounting Present Value of $1,000



Government agencies differ over whether private or social discount rates should be applied to public investments. At the high end of the range, the U.S. Office of Management and Budget (OMB) recommends the use of a private discount rate of seven percent for evaluating public investments. The OMB believes that this rate approximates the incremental pre-tax rate of return on an average investment in the private sector in recent years.[15]

Other government agencies, such as the Congressional Budget Office, and the General Accounting Office, recommend using a social discount rate to discount the benefits and costs of public investments.[16] Unlike private discount rates, which equal the rate of return on investment, social discount rates reflect the rate at which society is willing to trade off present consumption for future consumption. Social discount rates are based on the notion that most individuals place more weight on consumption by future generations than is indicated by the rate of return on private investment.[17] Therefore, to reflect higher values for future benefits, social discount rates will tend to be lower than private discount rates.

[15] Office of Management and Budget, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, Circular No. A-94, October 29, 1992, p. 9. A "real" discount rate refers to a discount rate that has already been adjusted for inflation.

[16] Hartman, Robert W., (Congressional Budget Office), "One Thousand Points of Light Seeking a Number: A Case Study of CBO's Search for a Discount Rate Policy," *Journal of Environmental Economics and Management*, Vol. 18, No. 2, Part 2, 1990. U.S. General Accounting Office, Discount Rate Policy, GAO/OCE-17.1.1, 1991.

[17] An extensive literature on social discount rates exists. For recent contributions, see: (1) Freeman, A. Myrick III, *The Measurement of Environmental and Resource Values*, Washington, DC: Resources for the Future, 1993; (2) Arnold, Frank S., *Discounting from a Social Perspective: First Principles*, prepared for the Office of Toxic Substances, U.S. Environmental Protection Agency, 1986; (3) Lind, Robert C., "Reassessing the Government's Discount Rate Policy in Light of New Theory and Data in a World Economy with a High Degree of Capital Mobility," *Journal of Environmental Economics and Management*, Vol. 18, No. 2, Part 2, 1990; and (4) Lyon, Randolph M., "Federal Discount Rate Policy, the Shadow Price of Capital, and Challenges for Reforms," *Journal of Environmental Economics and Management*, Vol. 18, No. 2, Part 2, 1990.

The Congressional Budget Office prefers a social discount rate based on a range from zero percent to four percent.[18] Several studies support the Congressional Budget Office's estimate.[19] Note that OPS should not endorse a specific discount rate or range of rates for use in all OPS cost-benefit analyses; instead, this discussion aims to present examples of reasonable values that have withstood the scrutiny of peer review. As noted in Guiding Principle 12, regardless of the discount rates or range of rates employed in OPS analyses, the choice of discount rate values should always be justified, stated explicitly, and applied with consistency.

Although discounting should be done consistently, it may be appropriate to apply different rates of discount to different cost categories. As a general rule for OPS analyses, direct incremental costs to industry should be addressed using an appropriate discount rate (e.g., the prime rate) that reflects the cost of capital, while categories of costs incurred by public agencies may be discounted using the social rate of discount. To facilitate this application of discount rates, OPS may choose to begin grouping costs accordingly early in the process of identifying costs. In addition, when presenting the results of a cost-benefit analysis, the analyst should describe the sensitivity of the results to the chosen discount rate.

Defining and Analyzing Benefits

This section reviews the key methodological steps involved in assessing the benefits of pipeline safety and environmental alternatives. The goal of benefits analysis in this context is to understand and characterize the outcomes of alternative alternatives, including economic, environmental, and safety effects. These changes often represent reductions in negative conditions relative to the baseline scenario (e.g., fewer releases relative to what would have occurred in the absence of the alternative).

The major steps involved in benefits assessment are as follows:

- Identify and describe the benefit categories to be analyzed;
- Quantify the physical effects of the alternative; and
- Monetize these effects.

In the following section, we discuss each of these steps in more detail.

Identify and Describe Benefit Categories for Analysis

The diverse objectives of pipeline safety and environmental alternatives require analysis of an equally diverse set of benefits. These benefits derive from changes in the physical characteristics of pipelines, operational requirements, and provision of information to operators, regulators, response teams, and the public. Some alternatives may seek general prevention of product releases. In these cases, potential benefits are broad in nature and may include oversight deemed to improve safety, improved protection of environmental resources, and/or avoidance of a variety of economic costs. Other alternatives may have a

[18] Hartman, Robert W., 1990, op cit., p. S-4.

[19] The following studies suggest that the social discount rate ranges from about zero percent to four percent: Lind, Robert C., "A Primer on the Major Issues Relating to the Discount Rate for Evaluating National Energy Options," in Robert C. Lind, ed., *Discounting for Time and Risk in Energy Policy*, Washington, DC: Johns Hopkins University Press for Resources for the Future, 1982; and Barro, Robert J., et al., *World Real Interest Rates*, Working Paper No. 3317, Cambridge, MA: National Bureau of Economic Research, 1990.

more specific focus, ensuring the safety of certain workers or avoidance of interruption in supplies to product users.

Because of the diversity of potential benefits, a key first step in assessing benefits is to inventory the full set of beneficial outcomes associated with the alternatives under consideration. During this process, involvement of key stakeholders will be essential; varying perspectives will ensure that relevant and significant benefit categories are identified and addressed.

The goal of this step is to compile a qualitative understanding of possible benefits. To determine the appropriate categories for assessment, benefits analysts may first review existing research and, if necessary, meet with experts to identify the possible physical effects.

Exhibit 6 reviews benefit categories potentially relevant to pipeline alternatives. It is important to note that not all of these benefit categories come into play for a given alternative; for instance, an alternative may have little or no influence on safety, instead focusing on prevention of environmental effects. In general, alternatives that focus on pipeline safety are not designed to address human exposure to materials that cause chronic health effects; such health effects are generally addressed by the regulatory programs of EPA, OSHA and other authorities (i.e., state agencies).

One major category of benefits focuses on changes in economic activity. In most cases, characterizing economic benefits involves evaluating avoided economic losses that would occur without the alternative. Key subcategories of economic benefits include the following:

- **Avoided Costs to the Pipeline Industry:** Pipeline operators incur a number of direct losses as a result of releases. At the simplest level, lost product represents a cost to the industry. In addition, releases necessitate response and clean-up expenditures, recovery of product, and remediation of site.

- **Avoided Costs to Other Industries:** A variety of other industries could incur costs as a result of releases from pipelines. For example, tourist economies may incur losses as a result of major releases or incidents because of decreased expenditures at restaurants, hotels, boat rental establishments, and other commercial establishments; these decreased expenditures may lead to losses in economic welfare. Releases and explosions may also affect intake of water for industrial use (contact and non-contact) as well as municipal use, forcing reliance on more expensive water sources. Releases and explosions may also have economic implications for the product users; for example, industrial facilities may be shut down temporarily until product supplies are restored. Finally, releases to surface water may affect commercial fishing activity.

Secondly, some OPS alternatives may yield safety benefits. Specific subcategories may include the following:

- **Decreases in Mortality Effects:** Mortality effects include deaths from acute exposures. Acute mortality effects include deaths from explosions, major releases, or other events.

- **Decreases in Morbidity Effects:** Morbidity effects include illnesses or injuries associated with acute exposures. Acute morbidity effects may include injuries from fires or explosions, and illnesses from intensive exposures to released product.

Finally, alternatives may yield benefits related to avoided loss of environmental quality. This category of benefits focuses on preventing damages to ecosystem functions and services:

Exhibit 6
Potential Benefits of OPS Alternatives

Benefit Categories	Benefit Subcategories	Examples	Common Monetization Method(s)
Safety	Reduced Mortality Effects	Avoided deaths from fires/explosions and industrial accidents	• Value of life estimates (based on wage-risk studies or contingent valuation) • Benefits transfer
	Reduced Morbidity Effects	Avoided acute injuries/illnesses due to worker or public exposure	• Cost of illness/injury • Willingness to pay to avoid injury/illness • Benefits transfer
Environmental	Improved Ecosystem Health/Avoided Ecosystem Damages	Avoided terrestrial and aquatic ecosystem health effects/avoided damages (physical damage to ecosystem)	• Contingent valuation • Other methods depend on service flow in question
		Avoided effects on biodiversity/species populations	• Contingent valuation
	Avoided Non-Market Losses for Resource-Dependent Activities	Avoided recreational use losses (e.g., pleasure boating, hunting, fishing, hiking)	• Travel cost method • Contingent valuation • Property value models • Benefits transfer
		Avoided effects on environmental aesthetics	• Travel cost • Contingent valuation • Property value models • Benefits transfer
	Avoided Losses to Intrinsic Values	Avoided subsistence losses	• Value of harvest • Wage tradeoff
		Avoided reductions in existence values	• Contingent valuation
Commercial/ Economic	Avoided Costs to Pipeline Industry	Avoided lost product	• Market value
		Avoided property damages (public or private)	• Cost of repair/restitution
		Avoided clean-up and response	• Cost of clean-up
	Avoided Costs to Other Commercial Industries	Avoided changes in commercial transportation (water and land)	• Increased cost of alternative transport
		Avoided losses in tourism	• Market value
		Avoided disruption of drinking water and industrial water usage (including non-process, non-contact cooling water) due to degradation of intake water	• Increased treatment costs • Increased cost of alternative supplies • Cost of plant shutdown
		Avoided market disruption for product users	• Depends on industry/sector involved and losses caused by interrupted supply of product
		Avoided commercial fisheries damage	• Market value
	Avoided Property Damages (public and private)	Avoided damage to farms or farm products	• Property value/market value
		Avoided damage to groundwater	• Contingent valuation • Property value models
		Avoided damage to soil	• Value of harvest • Cost of repair/restoration
		Avoided property value depreciation from contamination or clean-up	• Property value/market value

- **Avoided Physical Damages to Ecosystems:** Direct physical damages to ecosystems occur as a result of releases from pipelines, which may include vegetation damage, loss of individual plants and animals, and damages to natural features resulting from emergency response activities.

- **Avoided Loss of Ecosystem Service Flows:** Releases may interrupt service flows associated with natural resources. While these services and the associated losses may not be reflected in commercial markets, individuals incur real changes in their economic welfare. For example, a release may preclude use of surface water for recreational boating and fishing, activities from which individuals derive value. Likewise, releases may reduce the aesthetic appeal of surface water or terrestrial areas, affecting people who live and work near them. Finally, in rare instances, releases may affect individuals relying on resources (e.g., fish) for subsistence.

- **Avoided Loss of Intrinsic Values:** Economists have demonstrated that individuals value ecological quality. For example, improved environmental quality may yield increases in biological diversity in a terrestrial or aquatic ecosystem. While ecological quality may yield direct benefits for humans (e.g., biodiversity may enhance wildlife viewing and other recreation), benefits analysts may also consider the intrinsic value of protecting and restoring the natural environment.

The overall objective of this initial step is to identify the full set of benefits to be considered and to describe qualitatively the nature of the potential benefits. The participants may wish to prepare a table that lists the benefit categories and reaches preliminary conclusions regarding each category's relevance and the likely direction (i.e., positive or negative) of the effect.[20] This type of qualitative characterization can help participants determine how to focus resources in the quantitative analysis stage of the benefits assessment.

Quantify Physical Effects of the Alternative

After selecting the benefits categories to be assessed, the next step is to quantify the physical impacts related to each category. Analysts usually compile data on the extent, timing, and severity of the effects, focusing on the changes attributable to each policy option in comparison to the baseline. Analysts evaluate the likely fate and transport of product through the environment and its potential effects on humans, ecological systems, and economic activity under the baseline and each policy option. These estimated physical effects serve as the foundation of the monetization process discussed in the following.

Exhibit 7 presents the general framework associated with conducting primary research to quantify the physical impacts of a pipeline alternative that seeks to prevent product releases.[21] As shown, the basic procedure consists of modeling product releases, characterizing the fate and transport of product in the environment, characterizing changes in the exposure of key receptors, and translating these exposures into physical effects on humans, ecosystems, and economic activity.

As a general rule, OPS alternatives will not be significant enough to merit expending the resources required to conduct these types of primary research. Instead, OPS will probably use "off-the-shelf" modeling tools, or values for key parameters derived from existing studies that are based on primary research. Although more efficient from a resource perspective, there are analytical challenges inherent to using existing tools and secondary approaches. We describe a few of these key issues as follows:

- **Availability:** Studies may not be available that reflect values for effects of concern, particularly since many effects of OPS alternatives are unique to pipeline operations. If primary research does not exist, qualitative research may be an appropriate alternative. Instead of quantifying effects, for example, the analysis may consist of physical effects based on expert opinion.

- **Relevance/Applicability:** Existing primary research provides information about effects and interactions within specific contexts. For example, existing studies may provide information about the fate and transport of crude oil within a coastal salt marsh ecosystem. To apply values from these studies to estimate

[20] In many cases, net effects should be considered. For example, an alternative that requires modification of pipelines may increase the risk of product releases.

[21] As noted earlier, not all pipeline alternatives focus on product release prevention. These types of alternatives, however, entail analysis of the broadest and most inclusive set of benefits; therefore, the discussion below focuses on methods for quantifying the physical effects of release-prevention programs.

fate and transport of a different product (e.g., No. 2 fuel oil) in a similar ecosystem, adjustments will be needed to address differences between these two contexts. If differences between research contexts are too profound, OPS may not be able to use existing research to generate valid estimates.

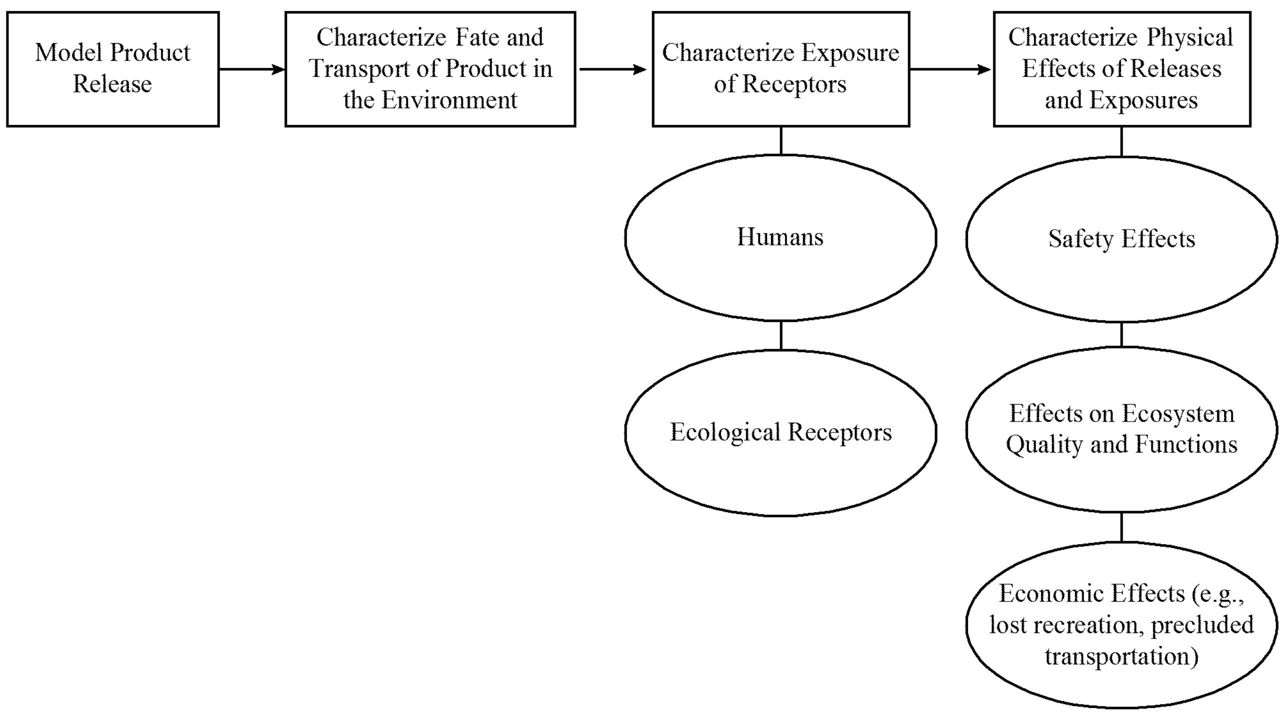
- **Quality:** Existing data must be of sufficient quality to be applied within OPS analyses. Current academic literature will provide insights as to whether "best practices" and methods were used in primary research efforts.

Despite the limitations of using existing research from different contexts, OPS will use this approach when building quantitative assessments; otherwise, they will revert to characterizing impacts qualitatively. Because of the care and precision required in applying primary research, it is useful to review the types of quantitative techniques that comprise primary research methods. The sections below discuss the required analyses in more detail.

It should be noted that characterization of the physical effects of a pipeline safety alternative can represent the most challenging aspect of benefits estimation. Most significantly, because pipelines are linear in nature and traverse large, diverse geographic areas, specifying the potential spatial distribution of releases expected under baseline and alternative scenarios is difficult. As a result, it may be difficult to identify the populations and environments that will be affected by a given alternative.

These constraints have important implications for modeling the effects of an alternative and for subsequent analysis of benefits. Overall, a single point estimate of benefits associated with an alternative will rarely be feasible. One option is to rely on probabilistic modeling that estimates a range of physical effects as a function of underlying physical parameters (see below). Likewise, case study approaches are another option that may be

Exhibit 7
Quantifying Physical Effects through Primary Research



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useful for characterizing potential benefits of an alternative. Case studies could be selected to reflect the diversity of affected environments and outcomes associated with releases or other changes in pipeline performance and safety.

Model Product Release

Analysts must determine how an alternative will affect product releases. In most cases, this will require probabalistic models incorporating historical data and / or engineering estimates (e.g., fault analysis) on pipeline failure rates under various conditions (e.g., enhanced inspection and maintenance procedures), as well as subjective judgments on the part of experts (see text box). These releases may be event-based in nature (e.g., spills) or slower, continuous releases. The release estimates produced by this step could serve as the inputs for fate and transport modeling or other existing models. In addition, the monetization step will incorporate these estimates directly to determine the benefits of decreased product losses.

Analysis of Release Risks

In the Pipeline Risk Management Manual, W. Kent Muhlbauer notes that many approaches exist for assessing product release risks. These techniques include Hazard Operability Study (Haz Ops), quantitative risk assessment, fault tree analysis, and subjective approaches such as scenario building and indexing.

Muhlbauer focuses on a risk assessment system that combines several of these techniques. The approach relies on an indexing or scoring system wherein numerical values are assigned to various attributes of the pipeline system to characterize release risks. The scoring is based on a combination of statistical failure data and expert judgment elicited in a Haz Ops setting (i.e., meetings where scenarios are developed and analyzed by a team of experts). The scoring system allows comparison of the relative importance of key risk factors (e.g., corrosion, design, and operation factors). The resulting score reflects the relative risk associated with different physical and operational conditions, information that can be used to guide risk management decisions.

Other, more quantitative approaches may yield more specific information on the range of potential release quantities. For example, quantitative risk assessment and fault tree analysis link together the probabilities associated with equipment failure, safety system failure, and other events to assess accident frequency and release size.

Source: W. Kent Muhlbauer, Pipeline Risk Management Manual, Second Edition, Houston, TX: Gulf Publishing Company, 1996.

Model Fate and Transport in the Environment

Analysts with specialized expertise must characterize the fate and transport of product in the affected environmental media. Potential modeling requirements are diverse, and depend on the alternative in question and the type of releases, explosions, or other impacts resulting from liquid or natural gas pipeline being analyzed. For example, continuous releases from underground pipelines could be analyzed by modeling transport of product through soil and subsurface aquifers.

Apart from the environmental medium affected, numerous other factors will affect fate and transport modeling. These factors include the following:

- Product characteristics such as viscosity, volatility, vapor pressure, and / or solubility;
- Environmental conditions; and
- The nature and timing of initial response measures, which may also affect fate and transport.

These types of factors will affect both the choice of model for analyzing fate and transport as well as the specification of the model chosen.

Characterize Exposure and Physical Effects

The process for characterizing exposure and physical effects varies according to endpoint, i.e., the category of benefits in question. Below, we consider effects on safety, environmental resources, and economic activity.

Quantifying Safety Effects

As discussed, one type benefit is reduction in acute mortality and morbidity effects. These effects are most commonly associated with explosions or possibly with release events that would be reduced by the alternative. Models for estimating the frequency of acute mortality and morbidity will rely primarily on historical data on deaths and injuries associated with release events.

Quantifying Environmental Effects

Conducting primary research of the physical effects of a change on environmental receptors requires an understanding of the chemical, physical, and biological relationships that lead to ecological changes. The first task in modeling ecological effects involves estimating changes in the level of exposure of affected ecosystems to the chemical, physical, or biological perturbation introduced by a release. Once exposure has been assessed, the modeling task involves estimating the ecological response to the perturbation. Ecological risk assessment is the process used by ecologists to define the likelihood that an adverse ecological effect will occur as a result of a natural or manmade stress factor. For policy analysis, these assessments often rely on established guidelines.[22]

Ecological risk assessments can be undertaken for individual species (e.g., to determine the effect of chemical exposure on an endangered bird species) or for an entire ecosystem. The ecological risk assessment describes the effects of a stress factor on an ecological endpoint in terms of the magnitude of the effect (e.g., percentage reduction in fish population), duration, spatial distribution, and time period of recovery. Metrics used to express the magnitude of the stress may include hazard quotients (the ratio of the exposure to expected effect levels), dose-response relationships, or measures of population decline from chemical-specific process models.

When conducting ecological risk assessments, ecologists may undertake primary field observation to meet the specific needs of the assessment. Again, in most cases, OPS will rely on existing risk data, functions, or models rather than conduct primary research. For example, models exist to estimate the effects of chemical concentrations in the environment on the populations of various species. This approach may lead to substantial uncertainty in the resultant risk estimates (e.g., due to extrapolation of the chemical sensitivity from one species to another), and the applicability of these existing sources of information must be considered on a case-by-case basis. As with all aspects of benefits estimation, uncertainties should be communicated clearly to the reader.

Quantifying Effects on Resource Use and Economic Activity

The benefits assessment may also require characterization of the effects on economic activity. These effects may follow from physical changes in environmental quality. For example, a release may close a swimming beach; the benefits assessment would include an estimate of the number of beach days lost as a result of the closure, taking into account the degree to which swimmers have access to substitute beach resources.

Other changes in economic activity may occur independent of specific effects on ecological resources. For example, a release may preclude use of a shipping channel during containment, assessment, and cleanup operations. Characterization of the changes in activity caused (e.g., use of substitute transportation routes) may play an important role in the

[22] Other types of analyses exist that are substantially similar to ecological risk assessment, such as the injury assessments undertaken as part of natural resource damage assessments and environmental assessments undertaken to meet the requirements of the National Environmental Policy Act.

monetization of benefits. Similarly, releases (or concern over potential releases) may lead to an interruption in supply for a product user; the benefits analysis should characterize the associated outcomes, e.g., number of days of production suspended at an industrial facility.

Monetize the Physical Effects of the Alternative

The third step in analyzing benefits involves framing benefits in monetary terms. Monetization of benefits presents the distinct advantage of placing costs and benefits on standardized terms, allowing easy comparison. In the sections below, we briefly review the economic valuation techniques available for monetizing environmental, safety, and other benefits.

Methods for Valuing Environmental Effects

Many of the economic benefits yielded by pipeline alternatives are associated with improvements or protection of environmental goods and services not traded in commercial markets. As a result, special valuation techniques may be needed to monetize benefits. Below, we discuss groups of these techniques and their application.

Revealed Preference Methods

In the absence of market data on the value of environmental improvements, one category of methods for assessing values of environmental goods involves looking at related goods that are traded in markets. These methods are generally referred to as "revealed preference" methods, because people's behavior in associated markets is used to reveal the value they place on the environmental improvements. Methods that fall into this category include the following:

- **Market Supply and Demand Studies:** For certain benefits, a market exists for the affected natural resource and this market provides direct information on the value of the resource. For example, the value of increases in commercial fishing yields often can be derived from market data.

- **Travel Cost Studies:** In some cases, releases may affect the availability or quality of recreational opportunities. The value of this impact is reflected in how the demand for that opportunity shifts with these availability or quality changes. Travel cost studies consider how the demand for trips taken to a site depends on resource quality characteristics, including the cost of travel to the site and substitute sites (in terms of both travel expenditures and travel time). As the individual chooses to recreate, he or she implicitly undertakes a transaction of travel cost for site access, which varies across individuals and available sites. The recreation decisions individuals make in light of the variation in these implicit prices provide the basis for estimating recreational site and site quality values.[23]

- **Property Value Studies:** These studies use information on the prices paid for property as an indicator of how individuals value environmental amenities and disamenities. Statistical models can be used to separate the effects of environmental characteristics on sales price from the effects of other characteristics

[23] Freeman, A. Myrick, *The Measurement of Environmental and Resource Values*, Resources for the Future, Washington, DC, 1993.

(e.g., number of bedrooms, quality of school systems); this approach is generally referred to as hedonic property valuation. An alternative approach, referred to as the repeat sales or panel data approach, compares sales prices for the same properties over time, e.g., before and after release events.

Stated Preference Methods

Stated preference methods are another category of valuation approaches that employ survey techniques to characterize individuals' willingness to pay for environmental quality or other resources not typically traded in markets. At a basic level, these models involve asking individuals about the value they place on amenities such as natural resources and the quality of those amenities, i.e., respondents "state" their values.

Most stated preference studies completed to date are contingent valuation surveys.[24] Indeed, the contingent valuation methodology has been employed in over 1,600 studies of environmental quality issues such as water pollution and impacts on public parks.[25] A number of these surveys have supported specific rulemakings and programs, such as a study of non-use values associated with the implementation of different dam operation alternatives for the Glen Canyon Dam.[26] In its simplest form, contingent valuation uses questionnaires to describe a program or policy that would prevent or eliminate environmental injuries, asking respondents how much they would be willing to pay for the program or policy. For example, a survey may ask respondents if they are willing to pay $100 per year for a program to protect and restore an estuary.

Contingent valuation has two key advantages. First, it can potentially capture the full range of values associated with a resource, including the values people hold for ecological quality independent of their use of the resource. In addition, contingent valuation does not rely on behavioral data, which may be impractical to obtain, to reach conclusions regarding resource values. That is, it can yield economic benefit estimates for hypothetical scenarios, e.g., environmental conditions not yet experienced.

In general, the contingent valuation approach has been used to estimate use values. However, when used to estimate willingness to pay for non-use values (i.e., values held independent of the individual's use of the resource), contingent valuation has been the subject of controversy among economists.[27] Some believe that contingent valuation studies of non-use values overstate actual willingness to pay, and are concerned about the reliability and validity of the estimates. Other economists believe that these criticisms are either

[24] Economists are developing stated preference methods that address some of the criticisms of the contingent valuation method. Most notably, conjoint analysis asks individuals to trade off various attributes of a product or program. For example, respondents may be asked to rate or rank resource management programs that differ in a number of attributes, including expected environmental effects (e.g., increased fish populations, decreased health risk). "Price" information (i.e., the cost of the program) is often included as an attribute. From the trade-offs expressed, the analyst can estimate the marginal utility associated with each attribute, as well as the value of the overall program (Johnson, et al., 1996). While conjoint analysis has been applied to only a few resource management problems, it represents a potential alternative for valuing recreational opportunities and ecological quality.

[25] See Carson, Richard T., Nicholas E. Flores, and Jennifer L. Wright, "Contingent Valuation and Revealed Preference Methodologies: Comparing the Estimates for Quasi-Public Goods," Department of Economics Discussion Paper 94-07, University of California, San Diego, May 1994.

[26] U.S. Department of the Interior, "Glen Canyon Dam: Final Non-Use Values Study Summary Report," prepared by Hagler Bailly Consulting for the Bureau of Reclamation, October 1997.

[27] For a comprehensive critique of contingent valuation, see Diamond, Peter and Jerry Hausman, *Contingent Valuation: A Critical Assessment*, North Holland Press, 1993.

overstated or can be adequately addressed through appropriate methodological refinements.[28] Specifically, these criticisms include, but are not limited to, the following:

- For a variety of reasons, respondents' stated intentions may not equal true willingness to pay. For example, observers have noted that respondents may not carefully consider personal budget constraints when stating willingness to pay.[29]

- Likewise, individuals' bids may be affected by the "warm glow" of giving. That is, bids may reflect individuals' interest in contributing to a worthy cause rather than their true value for the resource in question.

- Respondents may be able to express values for clearly understood commodities, but may be unable to express values for more abstract or unfamiliar commodities (e.g., groundwater quality).

- Individuals may have difficulty understanding the scale of the resource they are being asked to value.[30] For example, rather than focusing on a specific bay affected by pipeline releases, the respondents may offer bids that reflect their general willingness to pay for healthy coastal resources.

Due to the importance of the method in many natural resource damage assessments, a panel of eminent economists was convened by the National Oceanic and Atmospheric Administration (NOAA) to evaluate whether the contingent valuation method should be applied to estimate lost non-use values for the purposes of damage assessment. The panel concluded that "contingent valuation studies can produce estimates reliable enough to be the starting point of a judicial process of damage assessment, including lost non-use values," provided that a number of conditions are met in the design, implementation, and interpretation of the contingent valuation survey.[31]

Benefits Transfer

All of the monetization methods discussed above call for primary research (e.g., collection of field data). Primary research, however, generally will not be undertaken often by OPS due to cost or time limitations. Instead, many analyses can rely on information contained in the existing economic benefits literature. That is, they use relevant information from an existing study (or studies) to estimate benefits of the policy or program at hand. For example, it might not be feasible to estimate the economic benefit of improved recreational opportunities at a site, but it may be possible to establish a benefit estimate based on careful review of the existing literature on sites with similar characteristics. Because it avoids the effort and expense associated with primary research, benefits transfer can be particularly useful in, and is commonly applied to, preliminary screening analyses.

Developing a reliable benefits transfer analysis requires that the analyst locate information in relevant studies and apply this information in a sophisticated manner. In particular, the resource addressed in the study must have characteristics analogous to the site under consideration (often called the "policy" site), taking into account all characteristics

[28] See, for example, Hanemann, W. Michael, "Valuing the Environment Through Contingent Valuation," *Journal of Economic Perspectives*, Vol. 8, No. 4, Fall 1994, pp. 19-43.

[29] Arrow, Kenneth, et al., *Report of the NOAA Panel on Contingent Valuation*, January 1993.

[30] See 58 FR, Preamble, Section III (Response to Comments), Subpart S (Nonuse Values and CVM), July 22, 1993.

[31] See: 58 FR 4601-4614.

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that might affect the way an individual values the site. For example, a benefits transfer involving recreational fishing must consider how the study site and policy site compare in terms of the relative aesthetic quality of the sites, the predominant method of fishing, the predominant species sought, the proximity of the site to population centers, the availability of substitute fishing sites, and other factors.

When performing benefits transfer, it is important to avoid mechanical application of values from existing studies. Unless conditions at the study site and the policy site are identical, willingness to pay values should be adjusted to account for differential factors. The most reliable benefits transfer approaches involve application of multi-variate models that allow the analyst to adjust willingness to pay figures on the basis of key factors.

In addition, the benefits transfer analysis should rely only on high-quality studies. The studies should be based on adequate data, sound economic methods, and correct empirical techniques. For example, studies that rely on population samples should use state-of-the-art sampling methods, with sample sizes and response rates sufficient to generate and obtain statistically reliable results. Articles from peer-reviewed economics journals are more likely to follow accepted practices and may therefore offer more reliable findings.

Methods for Valuing Safety Effects

Valuation of mortality and morbidity benefits of pipeline alternatives entails variations on some of the methods discussed above. Below, we briefly review these specific applications.

The most commonly used approach for valuing changes in fatal risks considers the "value of a statistical life." This term refers not to the value of an identifiable life, but to the value of relatively small changes in the risk of death for members of a defined population. A number of studies have estimated the value of a statistical life, using a variety of techniques. Thus, the approach commonly used for valuing statistical lives for policy purposes applies benefits transfer techniques to develop a range of estimates.

To support benefit-cost analysis of transportation safety projects, DOT currently uses a value of $2.7 million (in 1995 dollars). DOT uses this value consistently in analyses across each of the transportation modes they regulate (e.g., aviation, highway, rail, shipping), so that assessments of safety benefits are comparable across all transportation modes including pipeline. The DOT figure falls in the range of literature-based values of statistical life saved applied by other federal agencies. For example, EPA applies a best estimate of $5.8 million (in 1997 dollars) per statistical life saved, with a lower bound of $0.7 million and an upper bound of $16.3 million.[32]

The most common approach to valuing morbidity is the cost-of-illness method, which derives values from the medical costs and, in some cases, lost work time associated with each illness (or injury). To value illness and injury in assessments of transportation projects, DOT uses fractions of the value of a statistical-life estimate to value injuries in five classes, ranging from minor to critical (Kaplan, 1995). The use of cost-of-illness values alone may substantially understate people's willingness to pay to avoid disease. Most notably, cost of illness estimates generally do not consider the value of averting the residual pain and suffering that accompanies many illnesses and injuries.

To address this potential bias, benefits analysts may consider estimates of total willingness to pay as well as cost-of-illness values. Willingness to pay estimates are often derived from contingent valuation surveys. Given concerns about the reliability and validity of

[32] These estimates are devised using the results of 26 studies, including 21 wage-risk studies and five contingent valuation studies, and were subject to substantial peer review as part of the U.S. EPA's retrospective analysis of the Clean Air Act.

contingent valuation studies, analysts may want to present estimates based both on willingness-to-pay as well as cost-of-illness approaches when monetizing health and safety benefits, thus providing a range of values and providing readers of the analysis with a better understanding of uncertainties.

Methods for Valuing Avoided Cost Effects

In addition to the benefits requiring the special valuation techniques discussed above, pipeline alternatives may lead to a variety of benefits associated with avoided costs. The monetization of these benefits calls for methods based on assessment of the avoided costs with which they are associated. Most notably, the prevention of releases or explosions would reduce losses of key services provided by natural resources such as the provision of drinking water (i.e., surface water or groundwater) or by infrastructure such as roads and highways. The economic benefit of such improvements can be measured in terms of the value of the costs avoided. Examples of potential avoided cost benefits include the following:

- The avoided cost of assessment, cleanup, and restoration costs associated with incidents and accidents.
- Releases may affect municipal and industrial users of groundwater and surface water by requiring additional treatment or by forcing users to secure alternative water sources for a period of time. The incremental cost represents a potential benefit of water supply protection.
- If any incident or accident leads to an interruption in product delivery, thus disrupting production at an industrial facility, costs may include lost revenue during downtime, increases in production costs as a result of securing replacement energy sources, or costs associated with restarting suspended operations (e.g., cost of restarting gas-fired boilers or furnaces).

Estimation of such avoided-cost benefits is very straightforward in terms of monetization, but is very case-specific and generally requires gathering of local or regional data.

Guiding Principles 12 and 13 state that: "Variables will be explicitly stated, described, and referenced to a source and used consistently across alternatives. Examples of variables include: discount rate, project life, value of averted fatalities and injuries, and depreciation method."

and

"Whenever possible, benefits and costs of alternatives will be evaluated and monetized on a common-year basis for purposes of comparison."

If OPS is able to quantify and monetize both benefits and costs within an analysis, they should take care to adhere to both of these Guiding Principles. As described in Guiding Principle 13, to compare monetized benefits and costs occurring at different points in time on a common-year basis, OPS should apply a discounting procedure to express each past or future resource flow in terms of their value in the present (see Monetizing Benefits Over Time). Exhibit 8 illustrates how the sums of two different sets of cash flows occurring at different points in time (i.e., $457,971 and $395,050) can be compared after being discounted.

Guiding Principle 12 states that all variables used in an analysis should be explicitly stated, described, and referenced to a source and used consistently across analyses. With discount rates in particular, it is a good practice to present the value of discount rates used in any exhibits as well as in the body of the analysis. As Exhibit 8 states clearly, both sets of cash flows in this example are discounted using a three percent discount rate.

A good "rule of thumb" for presenting variables, assumptions, sources, and other key building blocks of an analysis is to provide enough detail such that an independent analyst could reconstruct and validate results using the data provided. In the Appendix to this report, we provide this data in the Data Summary of the Mapping Cost-Benefit Analysis table. Analysts can decide whether it is more appropriate to present this information in a single table, in multiple places throughout the report, or in both.

Monetizing Benefits Over Time

The benefits of pipeline alternatives typically will be realized at various points of time in the future, rather than being realized immediately. For example, under a release-prevention alternative, the frequency, timing, and potential size of product releases will be compared to releases expected in the base case; i.e., the benefits are realized each time an incremental release is avoided. Similarly, benefits may be realized slowly over time as affected environmental resources recover from the effects of the release and service flows associated with the resources are restored.

To standardize these types of future benefit streams we can use discounting procedures to develop a present value of benefits over time. As noted in our cost analysis discussion, the principle behind discounting is the "time value of money." In the context of benefits estimation, this principle is illustrated in Exhibit 8. This exhibit contrasts the present value of two benefit streams, one realized in the near term, the other realized later in the discounting period. As shown, the undiscounted benefits each add to $500,000, but the present value of benefits realized (i.e., from 1999 to 2003) in the near term is greater than those realized in the longer term (i.e., 2004 to 2008). This example illustrates how the timing of benefits can influence the total benefits calculated for an alternative.

Exhibit 8
Discounting Monetized Benefits Over Time

	Scenario A: Present Value of $100,000 Received Annually from 1999 to 2003		Scenario B: Present Value of $100,000 Received Annually from 2004 to 2008	
Year	Undiscounted Cash Flows, 1999 to 2003	Present Value of Cash Flows, 1999 to 2003	Undiscounted Cash Flows, 2004 to 2008	Present Value of Cash Flows, 2004 to 2008
1999	$100,000	$97,087	$0	$0
2000	$100,000	$94,260	$0	$0
2001	$100,000	$91,514	$0	$0
2002	$100,000	$88,849	$0	$0
2003	$100,000	$86,261	$0	$0
2004	$0	$0	$100,000	$83,748
2005	$0	$0	$100,000	$81,309
2006	$0	$0	$100,000	$78,941
2007	$0	$0	$100,000	$76,642
2008	$0	$0	$100,000	$74,409
Total Present Value	**$500,000**	**$457,971**	**$500,000**	**$395,050**

Note: These present value calculations assume a discount rate of 3 percent.

As mentioned in the cost analysis discussion, the choice of discount rate can greatly affect the monetized results. Specifically, the larger the discount rate, the smaller the present value of the benefits. For example, the illustration in Exhibit 8 uses a discount rate of three percent. Using a higher rate of seven percent would change the present value of Scenario A benefits to about $410,000 and the Scenario B benefits to about $290,000. Consistent with our discussion of the timing of benefits, benefits realized far in the future will influence the estimated present value very little unless small discount rates (e.g., zero to three percent) are used.

Finally, it may also be appropriate to apply different discount rates to different benefits. For example, economic benefits that are realized in their entirety by pipeline operators, such as avoided costs of clean-up and response, should probably be addressed using a higher discount rate that reflects the cost of capital to industry. Conversely, benefits realized in whole or in part by the public should be discounted using a social rate of discount. Early in the benefits identification process, OPS should begin to note which benefits are realized publicly and those realized privately.

Interpreting and Using Cost-Benefit Results

Because the methodologies used in evaluating benefits and costs can be diverse and complex, the results of the analysis must be carefully interpreted and applied. Below, we discuss factors that OPS decisionmakers should consider when using cost-benefit results.

Relative and Absolute Magnitude of Cost-Benefit Findings

The standard framework for interpreting cost-benefit results involves comparing the relative magnitude of the monetized costs and benefits. To the extent that benefits exceed costs, the alternative is considered cost-beneficial and potentially worthy of implementation.

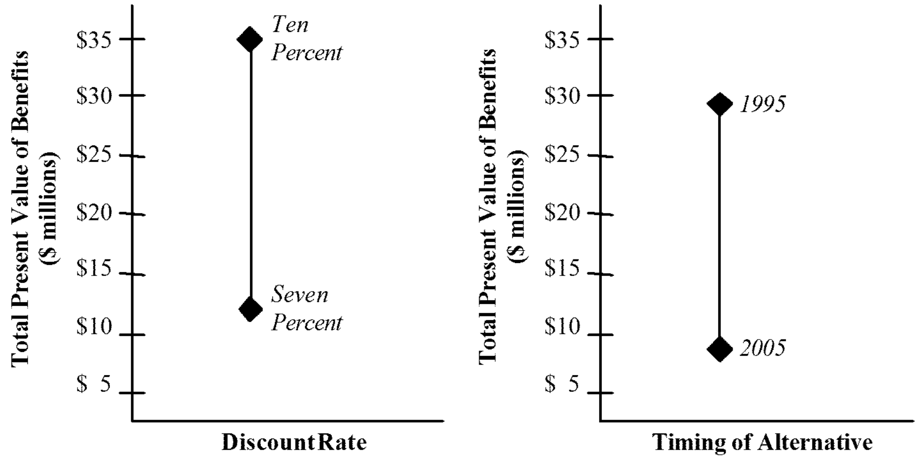
Of course, this "textbook" interpretation of cost-benefit results encounters a variety of obstacles in practical settings. Most notably, the analysis will likely yield costs and benefits that cannot be quantified or expressed in monetary terms. Integrating these findings into the policy decision requires a more collaborative and qualitative process, but is essential to sound policymaking.

In addition to considering the relative magnitude of benefit-cost results, decisionmakers can derive information from the absolute magnitude of costs and benefits. The absolute magnitude of costs will suggest whether the alternative has a major impact on industry and regulators; this in turn affects how decisions should be approached (e.g., major changes may warrant discussion and evaluation by stakeholders) and how cost information should be communicated to affected parties. The absolute magnitude of benefits will determine the degree to which environmental groups, the public, and the affected industry are interested in the alternative, and the extent to which they should be consulted in decisionmaking.

Consideration of Uncertainty

Most estimates of economic values and outcomes have a significant degree of uncertainty associated with them. To develop credible analyses, OPS should explicitly account for uncertainty by identifying key elements or parameters that introduce uncertainty; then, the analysis should depict this uncertainty for decisionmakers through sensitivity analysis and present useful conclusions about its influence. The most common approach to sensitivity analysis is to estimate the change in economic outcomes while varying a single parameter, leaving other parameters at their base value. Sensitivity analyses of this type can be illustrated in a variety of ways. One common approach is to present the effect of the uncertain parameter through a two-dimensional graphic (e.g., a curve) showing estimates associated with different levels of an uncertain parameter. Another graphic device is the "box and whisker" plot of the type shown in Exhibit 9. The box and whisker plots show the extent of variation around the mean estimate of benefits when an uncertain parameter varies. The example presented shows how the present value of benefits associated with a hypothetical alternative would vary with parameters such as the discount rate and the time at which the program is implemented. For example, variations in the discount rate, holding all else constant, yield high and low estimates of $35 million and $12 million, respectively. Similarly, varying the time at which an alternative is implemented, holding the discount rate and other variables constant, yields high and low estimates of $29 million and $8 million, respectively. Each of these variables will contribute independently to the total uncertainty associated with the estimate of net benefits.

Exhibit 9
Sensitivity Analysis Illustration: Influence of Key Variables or Benefits



Probabalistic modeling represents a more advanced method of uncertainty analysis. One common technique is Monte Carlo simulation. A Monte Carlo model calls for the user to provide the statistical distribution of key uncertainty parameters affecting an outcome variable. The model uses the underlying distributions to generate a distribution of potential values for the outcome variable, allowing the analyst to determine the probability of any given outcome.

Guiding Principle 8 states that: "Cost-benefit analysis includes uncertainties. Uncertainties will be described explicitly in each analysis, including the magnitude and distribution of each significant source of uncertainty."

The actual or "true" value of variables within a cost-benefit analysis is difficult and often impossible to ascertain, even with the best analytical techniques. Even when OPS does not quantify costs and/or benefits, an analyst can usually characterize the direction of uncertainty through the process of conducting qualitative assessments. For example, in the Appendix to this report, the value of certain benefits of pipeline mapping is uncertain, but we developed a sense that most benefits are positive in value but in some cases, relatively insignificant in magnitude. Alternatively, when costs and benefits can be quantified, Exhibit 9 illustrates that uncertainty can also be described in quantitative terms. Either way, an analysis should avoid seeming to tell the reader more than is known, and users of cost-benefit analysis should be attuned to the imprecision inherent to estimating the value of physical, social, and economic variables.

Assessing Equity Impacts and Other Policy Concerns

Beyond the factors explicitly addressed in a benefit-cost assessment, a number of additional considerations may influence decisionmakers' attitudes toward an alternative. An understanding of stakeholder concerns will be needed to determine which of these factors is relevant, the degree to which each factor should be analyzed, and the weight it should be given in the decision.

Equity effects associated with a policy change represent an important family of additional policy considerations. Decisionmakers may find a policy less desirable if it imposes disproportionate costs on key subpopulations. Such equity effects and other policy concerns may be addressed by other analyses that supplement a cost-benefit analysis. For example, the Regulatory Flexibility Act, as amended, requires federal agencies to analyze impacts of regulatory actions on small entities (businesses, nonprofit organizations, and governments), and to consider alternatives that minimize such impacts while achieving regulatory objectives. It is important, then, to coordinate the various types of analyses that may be required so that they complement each other without duplicating effort.

Under certain federal regulatory requirements, OPS may be *required* to perform additional analyses of regulatory alternatives in addition to cost-benefit analyses. These required analyses generally aim to determine whether the costs and benefits and related impacts are equitably distributed, among affected entities or populations. Regulations that may require OPS to consider additional impacts include are the 1994 Executive Order on Environmental Justice, the Unfunded Mandates Reform Act of 1995, the Regulatory Flexibility Act of 1980, and the Small Business Regulatory Enforcement and Fairness Act of 1996. These statutes are described in greater detail below.

The Unfunded Mandates Reform Act of 1995

The Unfunded Mandates Reform Act of 1995 defines two categories of unfunded federal mandates—intergovernmental and private sector mandates—which must be considered. Unfunded federal mandates are defined as the following:

- Any provision in legislation, statute, or regulation that would impose an enforceable duty on state, local, or tribal governments or the private sector except on a condition of federal assistance or a duty arising from participation in a voluntary federal program; or

- Any provision that would reduce or eliminate federal financial assistance to state, local, or tribal governments for compliance with pre-existing regulations.

The Act intends to curb the imposition, in the absence of full consideration by Congress, of federal mandates on state, local, and tribal governments without adequate federal funding. Unfunded mandates may result in an inequitable distribution of costs and benefits. In cases where OPS initiates unfunded mandates, they must determine the budgetary impacts of the mandate upon state, local, and tribal governments and upon the private sector, with special consideration given to smaller parties.

If an OPS regulatory alternative imposes an unfunded federal mandate resulting in expenditures of $100 million or more in any one year on smaller government bodies (i.e., state, local, and tribal governments) in the aggregate or on the private sector, the Act requires OPS to prepare an analysis that must include the following:

- Identification of the provision of the federal law under which the rule or regulation is promulgated;
- An assessment of the costs and benefits of the mandate, including the extent to which federal resources (e.g., financial assistance) will be available to carry out the mandate;
- An estimate of future compliance costs;
- An estimate of the effect on the national economy (if feasible and relevant); and
- A description of the Agency's prior consultation with affected governments, including issues and concerns raised and the evaluation of these issues.

In the case of the voluntary pipeline mapping alternative, for instance, OPS is probably not required to conduct such an analysis because the proposed alternative would not create a new "enforceable duty" for state, local, or tribal governments. Rather, states' duties associated with mapping (described in the Appendix to this report), such as developing repositories, arise from voluntary participation in the mapping program.

The Regulatory Flexibility Act of 1980/Small Business Regulatory Enforcement and Fairness Act of 1996

The Regulatory Flexibility Act of 1980 requires federal agencies to consider impacts of regulatory alternatives on small entities (i.e., businesses, not-for-profit organizations, and government agencies). The purpose of the Act is to ensure that laws and regulations designed for application to large scale entities are applied uniformly to small entities, and that laws and regulations do not impose unnecessary and disproportionately burdensome demands on small entities. The Small Business Regulatory Enforcement and Fairness Act of 1996 provides small entities with ways to participate in the federal regulatory process and meaningful opportunity for redress of excessive enforcement activities.

To determine whether small entities are disproportionately affected by a regulatory alternative or mandate, OPS must assess whether the distribution of costs and benefits among entities is equitable, (i.e., whether small entities are subject to unfair or disproportionate requirements, such as reporting and recordkeeping). OPS could accomplish this by identifying and grouping affected entities according to size (i.e., by number of employees, annual revenues). Total costs and benefits from a regulation or mandate could then be allocated according to these size categories, and assessed as to whether the distribution is equitable among different classifications. For example, for any regulatory alternative considered, OPS would first need to determine which pipeline operators and government agencies are affected. Then, OPS would identify various size categories for grouping operators (i.e., operators that are considered "small"). After grouping the affected operators according to size, OPS could allocate the total costs and benefits of an alternative according to these categories, and assess whether smaller operators face disproportionately onerous requirements.

The 1994 Executive Order on Environmental Justice

Executive Order 12898 focuses federal agency attention on concerns that minority and / or low-income populations may bear a disproportionate amount of adverse health and environmental effects. For example, certain populations may incur disproportionate increases in environmental risks or other costs (e.g., disruption from pipeline repair). Similarly, a certain geographic region may incur a greater share of costs without realizing a concomitant share of benefits. Executive Order 12898 creates an interagency working group to provide federal agencies with guidance on identifying, assessing, addressing, and responding to these types of environmental justice issues.

Value and Effectiveness of the Cost-Benefit Process

Cost-benefit analysis is one of the most useful analytical tools available for organizing and comparing information about the favorable and unfavorable impacts of OPS alternatives. Public policy invariably involves tradeoffs between difficult and often competing choices. Hence, an important role of cost-benefit may be to define these tradeoffs with enough transparency and clarity to enable policymakers to finalize decisions and to allow these entities affected by the final decision to understand, if not support, these decisions.

When developing cost-benefit analyses, OPS may also wish to consider the internal advantages that the assessment process offers. By providing empirical results which strengthen the quality of debate between stakeholders about relevant policy tradeoffs, cost-benefit analysis of the type described here can provide a focal point for the implementing organization. That is, the process itself can function as a forum for interaction, bringing together groups that traditionally have few opportunities for direct collaboration. The resulting dialogue itself often yields better decisions, independent of the formal analysis conducted.

In spite of the many advantages of cost-benefit analysis, it should never be the sole criterion for decisionmaking. As stated in the discussion of uncertainties inherent to economic analysis, estimates of costs and benefits are likely to differ from their "true" values due to biases introduced through the use of different valuation techniques, data, and assumptions.[33] While cost-benefit analysis is a flexible tool that often provides valuable empirical results, decisionmakers should thus be wary of interpreting quantitative results too literally and should never be bound by a strict cost-benefit test.[34] Due to inherent imprecision and uncertainty in results, cost-benefit cannot always prove conclusively that the benefits of a program exceed the costs (or visa versa). Additionally, many elements within an analysis can only be assessed qualitatively but may nonetheless be critical to a sound decision. Often, the best an analyst can do is a "bounding analysis" that defines what range of benefits (or costs) would be required, at minimum, for an alternative to be cost-beneficial.

In conclusion, results from the process of conducting cost-benefit analysis, as well as other analytical outcomes (i.e., results of small business impact assessments), can be used by agencies to set regulatory priorities more effectively and to conduct strategic planning. Using cost-benefit to revisit regulations and alternatives after their promulgation, to determine both programs' economic efficiency and overall effectiveness at addressing the defined problem, holds great promise for creating more accountable and efficient policymaking. The value of this approach is specifically stated in Guiding Principle 14. If conducted as such, it can enable OPS to evaluate program effectiveness relative to program goals, a step which has been missing from OPS regulatory efforts in the past.

[33] "Benefit-Cost Analysis in Environmental, Health, and Safety Regulation: A Statement of Principles," prepared by Kenneth Arrow, Maureen Cropper, George C. Eads, Robert W. Hahn, Lester B. Lave, Roger G. Noll, Paul R. Portney, Milton Russell, Richard Schmalensee, V. Kerry Smith, and Robert N. Stavins; published jointly by The Annapolis Center, American Enterprise Institute, and Resources for the Future, 1996.

[34] In particular, policymakers should avoid the use of a popular cost-benefit metric, the ratio of benefits to costs. It is a common but misguided practice to use this ratio to consider implementation of programs with a ratio greater than (or equal to) one. This simple ratio provides no insights about uncertainty or the relative magnitude of costs and benefits, nor does it provide any information about the distribution of costs and benefits among affected groups.

Sample Data Summary Sheet

This is an example of a data summary that could be used to describe key assumptions, data, and sources used for each alternative, thereby allowing an analyst to begin independent validation of analytical results.

Statement of the Target Problem: ____

____

____

________________________________ (Source:)

Alternative Assessed in the Analysis: ______________________________________

____

____

____

Definition of Baseline(s):

Economic Conditions: ____

____

________________________________ (Source:)

Regulatory Conditions: ____

____

________________________________ (Source:)

Technological Conditions: ____

____

________________________________ (Source:)

Scope and Parameters of Analysis: ____

____

____

____

Key Quantitative Assumptions:

Discount rate (government):	______ percent (Source:)
Discount rate (private):	______ percent (Source:)
Cost of Capital:	$______ (Source:)
Project life:	______ years (Source:)
Depreciation method:	______ (Source:)
Depreciation life:	______ (Source:)
Value of averted fatality:	$2.7 million (Source: DOT memorandum, 1995)
Value of averted injury:	Ranges from $5,400 to $2.7 million, depending on the severity of the injury. (Source: DOT memorandum, 1995)

Sample Data Summary Sheet (continued)

Key Qualitative Assumptions: ______________________________

____

____

____

Summary of Results :

Costs: ______________________________

____

____

____

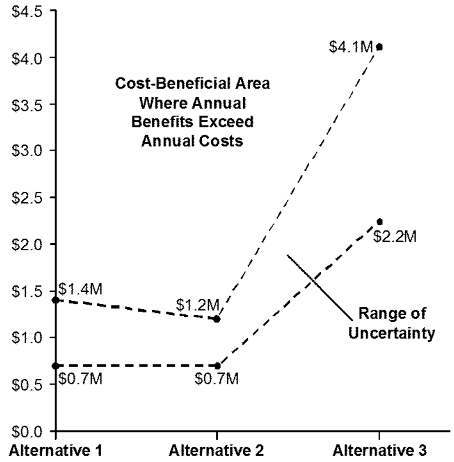
Benefits: ______________________________

____

____

____

Example Cost-Benefit Summary of Pipeline Alternatives
(millions of dollars per year, in present value)



Use and Interpretation of Cost-Benefit Results: ______________________________

____

____

____

Effectiveness/Limitations of the Analysis: ______________________________

____

____

____

VI. Roles and Responsibilities of the Pipeline Advisory Committees

In addition to requirements for cost-benefit analysis of OPS alternatives, the Accountable Pipeline Safety and Partnership Act of 1996 specifies that OPS must submit cost-benefit results and risk assessment information to relevant advisory committees established to support OPS on technical and policy issues. These committees include the Technical Pipeline Safety Standards Committee, and the Technical Hazardous Liquid Pipeline Safety Standards Committee.

A key responsibility of these advisory committees is to provide peer review and evaluation of OPS risk assessment information, including cost-benefit analyses. Specifically, the Act has provisions that each committee must: (1) evaluate the merit of the data and methods used within analyses, and (2) when appropriate, provide recommendations relating to assessments and to associated standards or alternatives.

Based on the requirements in the Accountable Pipeline Safety and Partnership Act of 1996 and the deliberations of the Workgroup, the following recommendations are offered to the advisory committees:

- Prepare for offering guidance to OPS during the development of pipeline alternatives by familiarizing yourself with OMB guidelines for economic analysis by federal agencies and the guiding principles and framework for cost-benefit analysis provided by this report.

- Provide leadership to OPS through your evaluation of the basis of cost-benefit analysis, including understanding and examining assumptions and uncertainties.

- Ask that OPS seek additional qualified peer review when pipeline alternatives require specific expertise beyond that which may be available through the advisory committees. The advisory committees should recommend competent third party reviewers that provide objective judgment.

VII. Recommendations

Clearly the use of cost-benefit analysis can significantly inform and improve decisions made by regulatory agencies. Cost-benefit analysis is a powerful and flexible tool that provides a systematic and organized way of understanding the values and costs of alternatives. Like any analytical tool, it should be used within the context of the regulatory process.

Based on the collaborative process that resulted in this report, the Workgroup offers the following recommendations for implementing the guiding principles and framework described in this report:

<u>To the Office of Pipeline Safety:</u>

- Publish a notice in the Federal Register announcing the completion of this report, notifying readers of OPS' intent to adopt the recommendations in the report and seeking public comments. Significant public comments should be added to the report in a comments section.

- Post the final report and the significant public comments on the Internet.
- Provide the advisory committee with the tools to conduct peer review, including the OMB guidelines, "Economic Analysis of Federal Regulations Under Executive Order No. 12866" (or subsequent guidelines) and this report. As new members are appointed, provide briefing materials on the committees' role as peer reviewers.
- Provide this report to OPS employees responsible for developing pipeline alternatives, so that they understand the potential use of prospective cost-benefit analyses to help define problems to be resolved, to develop alternative solutions, and to inform decisionmakers of the merits of proposed alternatives.
- Encourage the use of retrospective cost-benefit analyses to examine the effectiveness of existing regulations.
- Continue to use collaborative stakeholder teams to assist in defining problems to be resolved, identifying alternatives to address significant problems, and contributing to cost-benefit analysis of alternatives.
- Publish a list of key variables, references, and source documents that are generally used in all OPS analyses, and publish updates and revisions to these when appropriate.

To the Pipeline Advisory Committees:

- Use the guiding principles and the cost-benefit framework described in this report during deliberations.
- Prepare for offering guidance to OPS during the development of pipeline alternatives by familiarizing yourself with OMB guidelines for economic analysis by federal agencies and the guiding principles and framework for cost-benefit analysis provided by this report.
- Provide leadership to OPS through your evaluation of the basis of cost-benefit analysis, including understanding and examining assumptions and uncertainties.
- Ask that OPS seek additional qualified peer review when pipeline alternatives require specific expertise beyond that which may be available through the advisory committees. When appropriate, the advisory committees should recommend competent third party reviewers to provide objective judgement.

To the Pipeline Industry:

- Participate in the development of cost-benefit analysis through the contribution of reasonable information and data about pipeline operations so that cost-benefit analysis can be based on real-world information to the maximum extent possible.
- Continue to participate in collaborative stakeholder teams to assist in defining problems to be resolved, identifying alternatives to address significant problems, and contributing to cost-benefit analysis of alternatives.

To Other Stakeholders:

- Participate in the development of cost-benefit analysis through the contribution of reasonable information and data about the costs and benefits of pipeline operations so that cost-benefit analysis can be used based on real-world information to the maximum extent feasible.

- Continue to participate in collaborative stakeholder teams to assist in defining problems to be resolved, identifying alternatives to address significant problems, and contributing to cost-benefit analysis of alternatives.

Annotated Bibliography

During the preparation of this report, the Workgroup referenced numerous sources on cost-benefit analysis and related topics. In addition to the general sources listed below, we list additional references that provide guidance on special topics in regulatory cost-benefit analysis, including benefits valuation techniques, discounting, and the appropriate role of cost-benefit analysis in decisionmaking.

Cost-Benefit Analysis

U.S. Environmental Protection Agency. "Guidelines for Preparing Economic Analysis," draft report prepared by the Office of Policy, Planning, and Evaluation; final to be completed June 1999.

An updated version of EPA's original guidelines for economic analysis from 1983. Covers major analytical topics in preparing economic and regulatory impact analyses, including an overview of the role of economic analysis in environmental policymaking, analyzing benefits and costs, discounting, uncertainty, assessment of other impacts, and the use of results in decisionmaking. Some topics are addressed rather technically, but generally accessible to the layperson.

Office of Management and Budget. "Economic Analysis of Federal Regulations Under Executive Order No. 12866," memorandum prepared for members of the Regulatory Working Group, January 1996.

A general discussion of best practices for federal agencies to follow when preparing economic and cost-benefit analyses of federal regulatory actions. Developed by the Council of Economic Advisors, this guidance is generally aimed at a non-technical audience, and provides broad consideration of the analysis of the baseline, costs, and benefits, as well as examining alternative approaches and identifying the need for proposed actions.

Arrow, Kenneth; Maureen Cropper, George Eads, Robert Hahn, Lester Lave, Roger Noll, Paul Portney, Milton Russell, Richard Schmalensee, V. Kerry Smith, and Robert Stavins. 1996. "Benefit-Cost Analysis in Environmental, Health, and Safety Regulation: A Statement of Principles," published by the Annapolis Center, the American Enterprise Institute, and Resources for the Future.

Report by leading economists on the role of economic analysis in the development of environmental, health, and safety regulations. Provides two sets of basic guidelines, including: 1) guidelines for decisionmakers when using such analyses, and 2) guidelines for improving the quality of analyses. The guiding principles in this report closely parallel the guidelines presented in this report. Written for and very accessible to a lay audience.

Dorfman, Robert. 1993. "An Introduction to Benefit-Cost Analysis." in R. Dorfman, and N. Dorfman, (eds.). <u>Economics of the Environment: Selected Readings</u>. New York: W. H. Norton.

Provides a concise description of the standard approach to performing cost-benefit analysis. Includes sections addressing valuation of non-market benefits (including contingent valuation), uncertainty, and a discussion of cost-effectiveness as an alternative to cost-benefit analysis. Very accessible to the layperson, with excellent exhibits to illustrate key concepts.

Gramlich, Edward M. 1990. A Guide to Benefit-Cost Analysis, 2nd ed.: Englewood Cliffs, New Jersey: Prentice-Hall, Inc.

A general, frequently referenced text on benefit-cost analysis. Designed for public policy analysts rather than economists, so generally accessible to the layperson with some training in microeconomics. Covers many pertinent analytical topics, such as: the need for government action, valuation of costs and benefits, distributional equity, uncertainty, indirect impacts, and costs and benefits occurring at different times.

Benefits Valuation

Freeman, A. Myrick. 1993. The Measurement of Environmental and Resource Values: Theory and Methods. Washington, D.C.: Resources for the Future.

A general text on environmental and natural resource economics. Provides a good overview of many topics relevant to cost-benefit analysis of environmental and safety alternatives, including welfare measures of value, non-use values, and direct and indirect valuation methods.

Mitchell, Robert C. and Richard T. Carson. 1990. Using Surveys to Value Public Goods: The Contingent Valuation Method. Washington, D.C.: Resources for the Future.

A frequently referenced textbook on the contingent valuation method. Develops the theoretical basis for the method, examines potential sources of error and bias in estimates generated using this method, and provides guidelines for proper implementation of a contingent valuation study. Generally accessible to the layperson.

Discounting

Office of Management and Budget. October 1992. *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, Circular No. A-94.

Hartman, Robert W. 1990. "One Thousand Points of Light Seeking a Number: A Case Study of CBO's Search for a Discount Rate Policy," *Journal of Environmental Economics and Management*, Vol. 18, No. 2, Part 2.

Lind, Robert C. 1990. "Reassessing the Government's Discount Rate Policy in Light of New Theory and Data is a World Economy with a High Degree of Capital Mobility," *Journal of Environmental Economics and Management*, Vol. 18, No. 2, Part 2.

Lyon, Randolph M. 1990. "Federal Discount Rate Policy, the Shadow Price of Capital, and Challenges for Reforms," *Journal of Environmental Economics and Management*, Vol. 18, No. 2, Part 2.

This set of papers provides guidance and varying opinions about the selection and use of discount rates within economic analyses. Moderately technical in nature.

Using Cost-Benefit Results in Decisionmaking

Hahn, Robert W. and Robert E. Litan. 1997. "Improving Regulatory Accountability," published by the American Enterprise Institute and the Brookings Institution, Washington, D.C.

Promotes the use of cost-benefit analysis as an important tool for increasing the accountability of government policies and programs. Includes specific recommendations for improving the quality and accessibility of economic analyses.

Office of Management and Budget. September 1997. "Report to Congress on the Costs and Benefits of Federal Regulations," prepared by OMB's Office of Information and Regulatory Affairs, Washington, D.C.

Provides an estimate of the total annual costs and benefits of federal regulatory programs, and specific recommendations for improving the quality of economic analyses, including a call for improved data, more consistent use of assumptions and methods across programs and agencies, and careful use of cost-benefit results during the regulatory reform process.