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Analytical Frameworks for Addressing Physical, Social, and Institutional Changes in Water Resources Planning and Management

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Abstract

The U.S. Army Corps of Engineers (USACE) incorporated lessons learned from Hurricanes Katrina and Rita into an "Actions for Change" initiative to transform planning, design, construction, operation and maintenance, and decision-making processes. Theme 1 has emphasized an integrated, comprehensive, and systems-based approach that shifts focus from individual projects to an interdependent system. In this report, the Incremental Changes to USACE Systems effort focused on using comprehensive and topic-specific analytical frameworks (AFs) for addressing physical, social, and institutional (PSI) changes within water resources planning and management. An AF denotes a planning framework or step-wise process with analytical and synthesis features. The existing USACE six-step planning process represents a comprehensive AF for water resources. Numerous other topic-specific AFs for addressing PSI changes were examined as supporting tools within the USACE six-step process. This report provides examples of AFs that could be immediately useful in planning and managing PSI changes as USACE adopts risk-based project planning, and it suggests additions to the six steps that would be useful in certain scenarios. The report concludes there is no need for USACE to develop a comprehensive AF specifically focused on PSI changes because topic-specific AFs can be used to support the existing USACE six-step process.

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Preface

This study was conducted for Headquarters, U.S. Army Corps of Engineers under Project Number 145759, “Incremental Change Over Time in Watershed/System”. This report was developed under Contract No. W9132T-09-C-0021 and represents work completed by the Incremental Changes to USACE Systems Project Delivery Team. The technical monitor was Dr. Kathleen D. White of the Institute for Water Resources.

The work was performed by the Land and Heritage Conservation Branch (CN-C) of the Installations Division (CN), U.S. Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL). At the time of publication, Dr. Michael L. Hargrave was Branch Chief, CEERD-CN-C; Ms. Michelle Hanson was Division Chief, CEERD-CN. The Deputy Director of ERDC-CERL was Dr. Kirankumar Topudurti, and the Director was Dr. Ilker Adiguzel.

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Unit Conversion Factors

Multiply	By	To Obtain
miles (U.S. statute)	1,609.347	meters
square miles	2.589998 E+06	square meters

1 Introduction

1.1 Background

The U.S. Army Corps of Engineers (USACE) mission is to deliver vital public and military engineering services, partner in peace and war to strengthen our Nation's security, energize the economy, and reduce risks from disasters.

USACE owns and operates more than 600 dams; operates and maintains about 12,000 miles of commercial inland navigation channels; maintains over 900 coastal, Great Lakes, and inland harbors; and restores, creates, enhances, or preserves tens of thousands of acres of wetlands annually under the Corps regulatory program (USACE, 2015). USACE focus areas include water resources planning, watershed management, increasing the productivity of water (e.g., through provision of ecosystem services, hydropower, recreation, and water supply), addressing the link between water and security, and disaster preparedness, response, and recovery.

Numerous challenges confront water resources planners and managers in the United States. Some of the fundamental drivers of these challenges include (USACE 2010, 11–16):

- an aging water resources infrastructure (e.g., dams, levees, and navigation locks);
- population growth and migration causing increased water demands;
- competing uses of water;
- non-point-source pollution involving nutrients and pesticides;
- weather extremes ranging from droughts to floods;
- changing social values regarding water-based recreational needs;
- economic limitations and challenges for all levels of government and their influences on cost-sharing;
- changes in environmental policies and emphases, including greater attention to sustainable water quantity and quality;
- security of water resources and infrastructure from internal and external terrorism threats; and
- consequences of climate change.

1.1.1 Physical, social, and institutional (PSI) changes

In the aftermath of Hurricanes Katrina and Rita, USACE recognized the need to incorporate consideration of physical, social, and institutional (PSI) changes in planning, design, operations, and maintenance. As the Corps of Engineers moves in the direction of risk-based planning, incorporating analytical frameworks (AFs) that anticipate and deal with PSI changes will result in more resilient project planning and implementation in the form of projects that are more adaptable to future demands, conditions, and expectations. This report focuses on the potential use of comprehensive and topic-specific AFs for addressing PSI changes.

This report is the third in a series examining how PSI changes accumulate and affect water resources planning and management (past reports: Canter, Chawla, and Swor 2011, 2014). The Incremental Changes to USACE Systems project was initiated in response to lessons learned from the events of Hurricanes Katrina and Rita in August 2006. The Headquarters, U.S. Army Corps of Engineers (HQUSACE) announcement of "12 Actions for Change," was a set of concepts to guide USACE in transforming its priorities, processes, and planning (USACE 2006). These actions formed the basis for "Actions for Change," a major transformation initiative involving: (1) a comprehensive systems approach to mission execution; (2) implementation and integration of risk-informed decision making; (3) better risk communication to the public and increased public involvement in risk-reduction strategies; and (4) improved professional and technical competence (USACE, 2006). The comprehensive systems approach primarily supports 2009–2014 Campaign Plan Goal 2, "Deliver enduring and essential water resource solutions through collaboration with partners and stakeholders," Objective 2a, "Deliver integrated, sustainable, water resources solutions" (USACE 2009).

1.1.2 Terminology for other changes

In a previous report, the term "**incremental changes**" was used to describe periodic or continuing small-to-large changes over time (Canter, Chawla, and Swor 2011) that can influence hydrologic, geomorphic, ecological, social, and economic conditions in localized areas, at the watershed level, or in a regional river basin context (Canter, Chawla, and Swor 2011).

Institutional changes encompass the numerous modifications to legislation, policies, and regulations that have been implemented (or may be implemented in the future). These changes have individually and collectively contributed to determining how USACE projects are planned, evaluated, designed, constructed, operated, and modified at any given point in time. As societal demands change and the nation's priorities evolve, the myriad of laws, policies, and procedures employed in formulating, evaluating, selecting, designing, constructing, and operating USACE projects reflects national values at some point along the continuum of on-going social changes.

Historic and current changes can reflect the influences of local to regional economic development initiatives on physical processes including land use changes to accommodate housing and various societal demands of increasing populations. For example, runoff hydrographs can be altered in both timing and magnitude as a result of urbanization. Design changes may also occur as a result of new policies reflecting changes in historical practices (e.g., design flood and the introduction of risk considerations in both flood damage reduction and costs). Collectively, these types of changes can be referred to as physical changes.

The term "**analytical framework**" refers to a plan for meeting an identified need. Other terms that may be used include "analytical process," "step-wise process," or "step-wise procedure." One fundamental feature of an AF is that it encourages a holistic consideration of all relevant issues associated with a decision. It also implies transparency in its usage and documentation of how it was used and the outcomes. Of particular conceptual importance is that an AF should include both analysis and synthesis.

1.1.3 Changes over time impacting water resources

Changing physical conditions most directly affect water resources and project performance. Examples of changing physical conditions include watershed development, project infrastructure aging and deterioration, and differing climate or hydrological regimes. These types of changes usually evolve over long periods of time and affect current project performance by imposing conditions differing from those envisioned during project planning, design, and construction many years previous. However, natural disasters can result in sudden changes to watershed conditions that affect water resources and project performance. Whether projects are operated and maintained by USACE or by non-federal sponsors, changes to physical conditions present everyday challenges.

Societal demands reflect public value dimensions of project performance, and these values and demands shift slowly over time as new issues emerge or as physical conditions change. Examples of **changing societal demands** include shifts in damage centers resulting from development, new or increasing demands for water allocations (e.g., water supply vs. flood storage, water quality releases), and emergence of new issues and concerns (e.g., climate change). Changes in societal demands impose requirements on project performance not envisioned at the time of authorization and are often outside of authorized purposes.

Changing institutional requirements are usually imposed by new legislation, regulations, policies, or administrative actions. Examples include laws such as the Clean Water Act (U.S. Congress 1972a) and pursuant regulations, newly listed protected species or habitats, and USACE regulations and guidance. Institutional requirements frequently follow emerging societal demands but lag these demands by a period of time. As with societal demands, institutional requirements may present challenges to project operations not envisioned at the time of project authorization.

1.1.4 Uncertainty management of PSI changes

PSI changes are being more frequently recognized in current water resources planning. As these recognitions are being considered, various uncertainties are also being identified, and attention is being directed to planning and associated needs for uncertainty management. An interesting Institute for Water Resources (IWR) report from the mid-1970s defined a generic methodology by which uncertainty is explicitly considered, reduced where appropriate, and then documented, so that the decision maker is made aware of the uncertainties in a plan and their possible consequences (Decision Sciences Corporation 1974, 2).

The 1974 methodology for the management of uncertainty consisted of four steps: (1) identification and analysis of elements of uncertainty; (2) determination of the significance of each element of uncertainty; (3) estimation of the consequences that may ensue; and (4) action to reduce the impact of the uncertainty to the extent desirable and feasible. Further, the 1974 report includes several illustrations related to managing uncertainty. In fact, the 1974 report is based on a step-wise AF (Decision Sciences Corporation 1974, 14–27); this early report still has relevance for uncertainty management in relation to PSI changes.

1.2 Objective

This report is an evaluation of AFs that can be used to incorporate the effects of PSI changes in USACE water resources planning and management.

1.3 Approach

Dozens of AFs have been developed, but there has been no single framework that can be used for all planning needs for water resources. During the course of evaluating existing frameworks, the authors determined it was not necessary to develop a new AF to address PSI changes. Instead, it was determined that the existing USACE six-step comprehensive planning process could be used as the foundation. Other topic-specific AFs could be used in coordination with this existing, comprehensive AF to address PSI changes.

1.4 Scope

This report describes the USACE six-step process in the context of PSI changes, and it reviews other AFs that can be used to augment the USACE process.

2 The USACE Six-Step Planning Process and Incorporating Physical, Social, And Institutional Changes

The USACE six-step planning process for addressing the development of new plans or projects, or modifying existing ones, is based on a process included in a previous study of principles and guidelines (U.S. Water Resources Council 1983). The current six-step process is a logical, structured approach to problem solving that provides a rational framework for sound planning and/or decision making. The six steps are addressed in Ch. 2 (“Planning Principles”) of Engineering Regulation (ER) 1105-2-100, “Planning Guidance Notebook” (PGN; USACE 2000, 2-2) and listed below.

- Step 1 - Identifying problems and opportunities
- Step 2 - Inventorying and forecasting conditions
- Step 3 - Formulating alternative plans
- Step 4 - Evaluating alternative plans
- Step 5 - Comparing alternative plans
- Step 6 - Selecting a plan

Environmental planning is embedded in the six-step process. For example, evaluation of the environmental effects of alternative plans is incorporated in Step 4; further, it is part of the National Environmental Policy Act (NEPA; U.S. Congress 1970) compliance process. Compliance with the Fish and Wildlife Coordination Act (U.S. Congress 1934) and the process and related requirements of the Endangered Species Act (U.S. Congress 1973) and several other laws are also related to environmental planning. Fish and wildlife mitigation planning may also be included in Steps 4 and 5 (Yoe and Orth 1996). In addition, with more recent emphases on the Corps’ ecosystem restoration mission, mitigation measures may also be included in formulating restoration alternatives (Step 3). Finally, the sustainability principle within the USACE Environmental Operating Principles is routinely being addressed in water resources planning.

Because PSI changes can influence the features and characteristics of water resource plans, PSI changes should be a factor in selecting a recommended plan. A single prescriptive approach cannot be identified for addressing PSI changes; rather, creativity and flexibility will be needed to effectively identify and evaluate such changes and include them in the planning process. Canter, Chawla, and Swor (2011) showed how incremental (PSI) changes could be considered and incorporated in the USACE six-step planning process.

2.1 Step 1 – Identifying problems and opportunities

In this step, problems and opportunities are framed in terms of the federal objective and specific study's planning objectives. Problems and objectives reflect priorities and preferences of the federal government, the non-federal sponsors, and other groups participating in the study process. Problems to be addressed via the planning process should be summarized. Such problems could include the consequences of historical changes in watershed land use on surface runoff patterns and water quality. Other changes could occur from human population increases and the resulting demands on water supply and allocations. Opportunities refer to potential plans and projects that could be developed to address the identified problems (needs).

Another task involves defining the study planning objectives and constraints that can guide the efforts to solve the problems and achieve the opportunities. This task could include the development of clearly defined, specific objectives that are related to both managing PSI changes and responding to increased water demands resulting from such changes.

2.2 Step 2 – Inventorying and forecasting conditions

This step requires inventories of critical resources related to the needs and opportunities identified in Step 1. Such resources can include both biophysical and man-made environments such as water flow regimes, water quality, aquatic ecology, and land uses, as well as demographics, cultural resources, and social and economic characteristics. Information on historical and current conditions should be summarized, along with projections of future without-project conditions for the environmental features (mentioned above) over the period of analysis. Physical and institutional changes resulting from changes in land use, laws, regulations, policies, societal preferences, and their associated consequences, should be integral parts of Step 2. Further, the consequences could be central to the quantification of both problems (needs) and opportunities, as well as the delineation of specific goals (objectives) for a developed project or plan.

2.3 Step 3 – Formulating alternative plans

Iterative plans can consist of systems of structural and nonstructural measures, strategies, or programs that have been developed in response to specific objectives. The multiple features of such plans can be focused on addressing specific needs and objectives. Accordingly, certain features could be directed to reducing the undesirable consequences of types of PSI changes, as well as enhancing the quality of both the biophysical and the man-made environments. Examples related to industrial or urban developments in a watershed include the use of best management practices, green belts, and density limitations of developments. Ecosystem restoration projects could be used to promote the recovery and enhancement of ecologically valuable riparian and aquatic habitats. Local cultural resources protection programs and memoranda of agreements could also be included as mitigation measures for the slow deterioration of cultural resources on USACE lands.

2.4 Step 4 – Evaluating alternative plans

Each plan subjected to detailed comparative evaluation must include forecasted with-project conditions for the critical resources noted in Step 2. The forecasts should encompass the planning horizon. The with-project forecasts should account for the influence of historical-to-current PSI changes, as well as such changes anticipated to occur in the future. The second task under Step 4 involves comparing each action alternative's with-project condition with the without-project condition (the no-action alternative) and documenting the differences between the two. In this regard, it would be anticipated that PSI changes differ between each alternative, so their influence on the features and consequences of each alternative would also differ. The third task involves the characterization of the beneficial and adverse effects of each alternative, including the contributions of PSI changes to each effect. Further, the effects are to be classified by magnitude, location, timing, and duration. The final task is to identify the alternative plans that will be subjected to Steps 5 and 6 in the process. These plans should already include appropriate consideration of PSI changes.

2.5 Step 5 – Comparing alternative plans

The plans brought forward from Step 4 (including the no-action plan) are to be compared relative to their outputs and their beneficial and adverse effects. The comparisons should include monetary and nonmonetary benefits and costs. Identification and documentation of trade-offs between plans are required to support the final recommendations. The effects include those identified during the evaluation phase and any other significant effects identified in Step 5. This comparison step is related to the evaluation step (Step 4); however, in Step 5 the plans are compared against each other and not against the without-project condition. The output of Step 5 is a ranking of plans. Further, the comparisons and rankings should incorporate information on PSI changes based on Steps 2 through 4.

2.6 Step 6 – Selecting a plan

This step involves the recommendation of a single alternative plan. Based on Steps 2 through 5, the recommended plan should include appropriate consideration of historical, current, and future PSI changes. In the process of determining the recommended plan, consideration should be given to four types of included plans: the National Economic Development (NED) Plan, the National Ecosystem Restoration (NER) Plan, the Combined NED/NER Plan, and the locally preferred plan (if applicable). Each of these four plans should encompass appropriate PSI changes.

2.7 Incorporating PSI changes with the six-step process

PSI changes have been, and will continue to be, a part of the six-step process; however, the specific terms “Physical, Social, and Institutional” changes may not have been specifically included. Because PSI changes can influence the features and characteristics of resultant plans, they should be a factor in selection of the recommended plan.

As previously stated, a single prescriptive approach cannot be identified for addressing PSI changes. Instead, creativity will be needed for effectively identifying, evaluating, and including such changes in the planning process. A separate AF is not needed for PSI changes. Rather, it will be more expedient to incorporate PSI considerations into the existing comprehensive six-step planning framework. This concept of incorporating PSI changes into the six-step process is utilized throughout this report, along with the use of nesting for topic-specific AFs.

3 Combining Analytical Frameworks in Water Resources Planning

The USACE six-step planning process provides a comprehensive AF that can be used to incorporate the consideration and evaluation of PSI changes. However, dozens of other AFs have been developed (Appendix B), many of which could be used in conjunction with the USACE six-step process. Some frameworks are comprehensive, while others are topic-specific. This section explores lessons that can be learned from other comprehensive AFs and presents ways in which topic-specific AFs can be meshed within comprehensive frameworks.

3.1 Lessons from other comprehensive analytical frameworks

3.1.1 U.S. Environmental Protection Agency handbook

In 2008, the U.S. Environmental Protection Agency (USEPA) released a handbook for developing and implementing watershed management plans that also focused on restoring and protecting water quality. Watershed plans are primarily focused on resolving and preventing water quality problems that result from both point source and nonpoint source problems. Although the primary focus of this handbook is on waters listed as impaired under section 303(d) of the Clean Water Act, watershed plans are also intended both to provide an AF to restore water quality in impaired waters and to protect water quality in other waters adversely affected or threatened by point source and nonpoint source pollution. The six steps of watershed planning and implementation process, described in Table 1 (USEPA 2008), are complementary to the Corps' six steps. This watershed-focused process is comprehensive, transparent, and collaborative in its use. The two final steps are focused on implementation and evaluation of the plan. The USEPA handbook is focused on water quality conditions and influences from both point and nonpoint sources of pollution. Hence, this information needs to be addressed in water resources planning, and the Corps could benefit from studying USEPA studies at the watershed level.

Table 1. Steps in watershed planning and implementation process (USEPA 2008, 1-4).

Steps in Watershed Planning	Implementation Process for Watershed Planning (correlated with chapter in handbook)
Step 1: Build partnerships	Ch 3: Build Partnerships
Step 2: Characterize the watershed	Ch 4: Define Scope of Watershed Planning Effort Ch 5: Gather Existing Data and Create an Inventory Ch 6: Identify Data Gaps and Collect Additional Data if Needed Ch 7: Analyze Data to Characterize the Watershed and Pollutant Sources Ch 8: Estimate Pollutant Loads
Step 3: Set goals and identify solutions	Ch 9: Set Goals and Identify Load Reductions Ch 10: Identify Possible Management Strategies Ch 11: Evaluate Options and Select Final Management Strategies
Step 4: Design implementation program	Ch 12: Design Implementation Program and Assemble Watershed Plan
Step 5: Implement watershed plan	Ch 13: Implement Watershed Plan and Measure Progress
Step 6: Measure progress and make adjustments	Ch 13: Implement Watershed Plan and Measure Progress

Users of the Handbook could include, but are not limited to the following entities (USEPA 2008, 1-3):

- **Watershed organizations** that are developing new plans, updating existing plans to meet funding requirements, or considering other watershed issues.
- **Local water-related agencies** that are developing or updating a watershed plan or need references to research a particular subject related to watershed planning.
- **State and tribal environmental agencies** that are developing and reviewing watershed plans, participating as stakeholders on watershed planning committees, or providing guidance to watershed associations.
- **Federal environmental agencies** that have similar planning programs to help identify overlapping activities, provide sources of data, and offer other kinds of financial and technical assistance. Such agencies include USEPA, USACE, Bureau of Reclamation, and others.

There are similarities between the USEPA's watershed planning process and the USACE six-step planning process. Chapter 1 in the USEPA handbook contains an introduction that includes the handbook's purpose, intended audiences, and guidelines on how to use the information provided. Chapter 2 contains an overview of the watershed planning process and highlights common features of typical watershed planning processes. Chapter 3 provides guidance on initial activities to organize and involve interested parties such as identifying stakeholders, integrating other key programs, and conducting outreach.

Chapters 4 through 8 address five themes related to characterizing the watershed. The first theme ("Define Scope of Watershed Planning Effort") discusses the preliminary activities to undertake to start scoping the planning effort. It includes information on defining issues of concern, developing preliminary goals, and identifying indicators to assess current conditions. Chapter 5 addresses gathering existing data and creating an inventory. It includes collecting information from existing reports and datasets. This step is similar to USACE Step 2. USEPA's step focuses on the existing data, while USACE's Step 2 also includes forecasting conditions relevant to the problems and opportunities under consideration. Chapter 5 contains much detail about sources of data, data types, typical uses of data, and physical and natural features. USACE Step 2 talks about developing an inventory of critical resources relevant to the problems and opportunities.

The subject of Chapter 6 is associated with identifying data gaps and collecting additional data if needed. This chapter also includes a discussion on quality assurance/quality control procedures and the development of sampling plans.

Chapters 7 and 8 relate to analyses for characterizing watersheds. For example, Chapter 7 involves primary data analyses to characterize the watershed and pollutant sources. The analyses should be focused on identifying problems and supporting development of the plan. Chapter 7 includes information on the types of data analyses that can be conducted and the tools used. It also discusses how to link the impairments to the causes and sources of pollutant loads. Chapter 8 then focuses on pollutant loads and guidance on using watershed models and other tools to estimate such loads. It discusses computer models, identifies the types of models available, and provides information on how to select appropriate models for the watershed study.

Chapters 9 through 11 are related to establishing environmental goals and identifying solutions related to achieving such goals. Chapter 9 relates to goal settings and the identification of load reductions. This chapter discusses how to set management and water quality goals, develop management objectives, and determine the load reductions needed to meet the goals. This information provides guidance for identifying critical areas to which management efforts can be targeted. Chapter 10 ("Identify Possible Management Strategies") provides an overview of various management measures that might be selected, discusses how to identify existing management efforts in the watershed, and provides technical and policy considerations for selecting management options. Finally, Chapter 11 ("Evaluate Options and Select Final Management Strategies") discusses how to screen and research candidate management options, evaluate possible and potential scenarios, and select the final management measures to be included in the watershed management plan.

Like Chapter 11, the USACE planning Step 4 addresses evaluating alternative plans, comparing with-project conditions and without project conditions for each alternative. In USACE Step 5, alternative plans are compared and finally, in Step 6 a preferred plan is selected. Since the USEPA handbook leads one to develop a watershed plan, much more detail is provided in some chapters on data sources, data gathering, data gaps, analyzing data, and management strategies. The USACE six-step process leads one through the planning steps of a project and not the steps to do a project which would include reconnaissance and feasibility studies. More guidance would be provided during these studies and more data would be collected to develop a NEPA document for the project.

Chapter 12 is directed toward designing an implementation program and assembling the watershed plan. This information provides guidance on establishing milestones and implementation schedules and on identifying the technical and financial resources needed to implement the plan including information/education activities and monitoring and evaluation components. It also discusses how to use various analyses and products to assemble and document the watershed plan.

Finally, Chapter 13 ("Implement Watershed Plan and Measure Progress") provides guidance on using adaptive management techniques to make changes to the watershed plan and on analyzing the monitoring data to determine whether milestones are being met. It also provides guidance on using a watershed plan to develop annual work plans (USEPA 2008, 1-4 and 1-5).

The USEPA's handbook, including a companion six-step process, can be used by the Corps while conducting a feasibility study and preparing environmental documentation. Conversely, the USEPA could use the Corps' reconnaissance and feasibility studies to support their water quality management efforts.

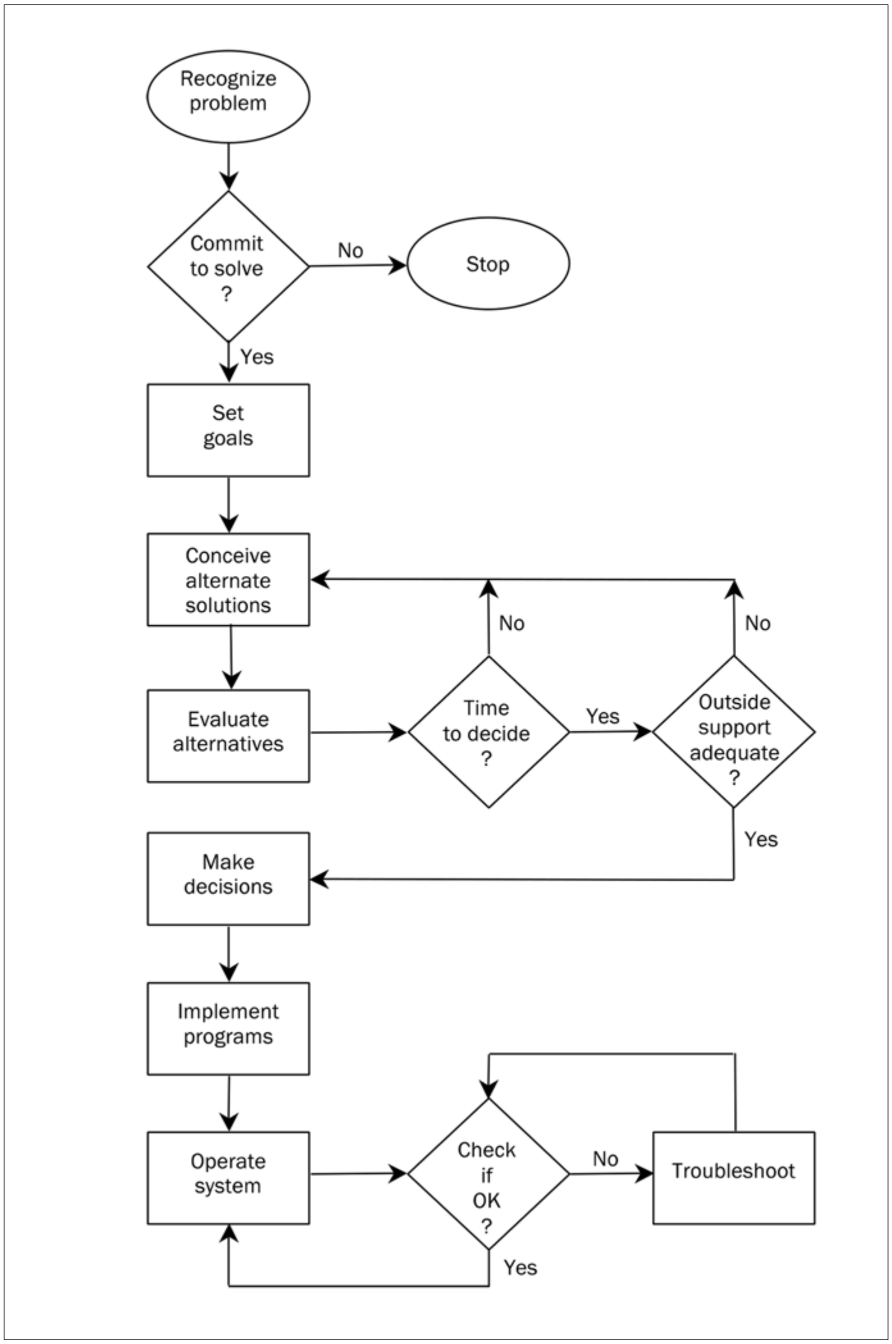
3.1.2 Grigg planning model

Grigg (1985) described a general model for planning and problem solving relative to water resources (Figure 1). The model's specific features are both similar to and supportive of the USACE six-step process. The model starts with recognizing the problems and making a commitment to their solution. The next step is one of formulating goals. These first two steps are similar to USACE Step 1, identifying problems and opportunities and defining the study planning objectives. Step 3 of the Grigg model is to develop alternative solutions to the problem. This step is similar to the USACE Step 3, formulation of alternatives. Step 4 of Grigg model is where impacts are assessed. This step includes environmental impact studies, fiscal impact studies, assessment of risks, and locating an economic optimum solution. Grigg Step 4 is similar to USACE Step 4, evaluating alternative plans.

Grigg's step on identifying feasible alternatives could help the Corps with formulating their alternative plans. Group brainstorming sessions are a good way to do this step. Value engineering techniques can also be helpful to make sure the alternatives are not redundant or confusing, but clear and lean.

While similar to the USACE six-step process, the Grigg model also includes an implementation step. It would be useful to address implementation and follow-through within the USACE process. The operational phase of the project also needs attention. Examples of follow-through can include monitoring the effectiveness of mitigation measures and planning and conducting adaptive management programs for issues or topics for which uncertainties are considerable. Much of the cost involved in water projects is operational cost, and planning is required to control it. Good total management techniques require attention to operational phases of projects.

Figure 1. Analytical framework for water resources planning and problem solving. (after Grigg 1985, 28).



3.1.3 Analytical framework for water resources studies

Delft Hydraulics Laboratory uses different approaches to assess water resources systems and develop management strategies for them. Each water resources system is different and has different problems, and the specific application of any planning approach should address the particular issues involved. What is important in all cases is the process of a comprehensive and systematic analysis together with constant communication among planners, decision makers, and the interested and affected public. This water resources planning study comprises several phases. The description of the phases, the activities in the phases, and the interactions between activities is referred to as the analytical (or conceptual) framework.

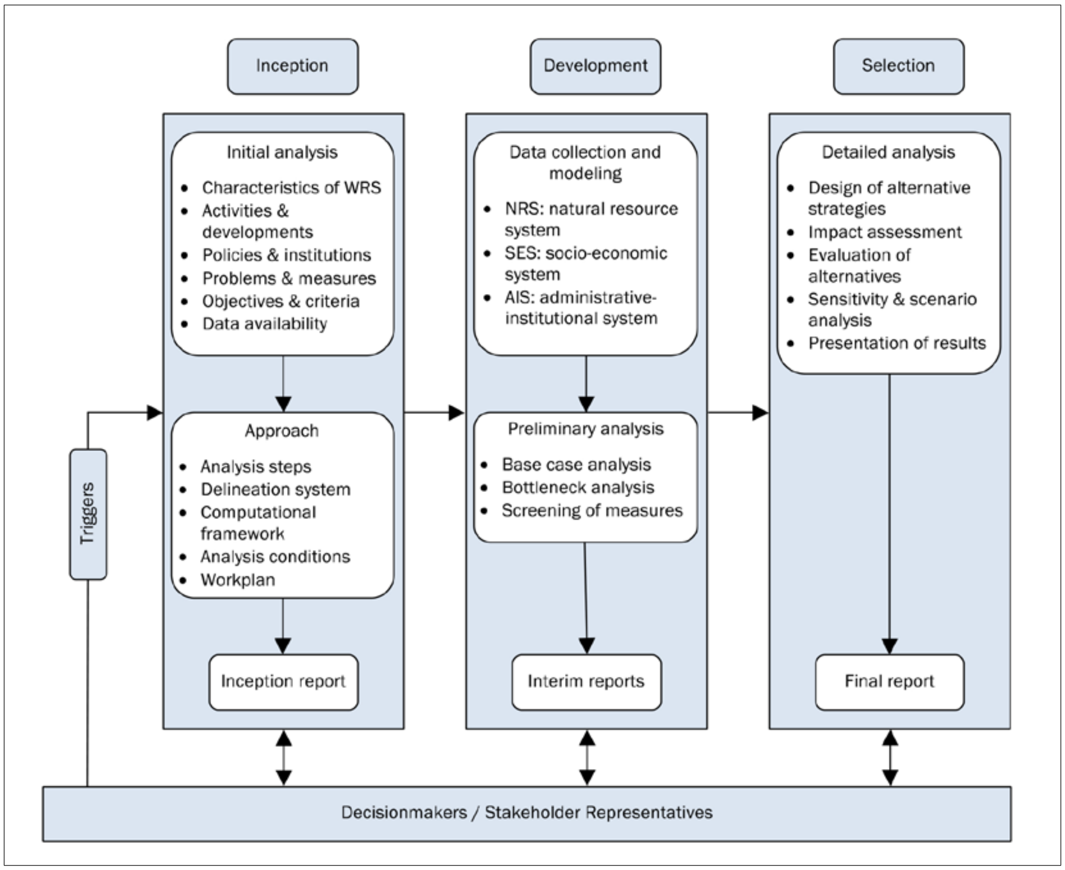
The Delft AF includes three phases: inception, development, and selection (Figure 2; Loucks and van Beek 2005). The framework includes generating single inception and final reports, but generating multiple interim reports associated with the development phase. No specific referral is included to implementation or follow-through. However, the AF includes inputs from decision makers and stakeholder representatives during all three phases. This concept of inclusion should also be interwoven in the USACE six-step water resources planning process. (The generalized Delft AF is supportive of the USACE six-step process.)

Discussion of the Delft AF in Loucks and van Beek (2005) mentions identifying needs, prioritizing issues, and setting targets for sectors or regions. The first task is to assist the decision makers in further specifying the objectives and subject of the analysis. This is similar to USACE Step 1 where clear objectives are identified. It is noted within the **inception phase** in Delft that objectives change over time; therefore, constant and effective communication between analysts and their clients is absolutely essential. An inventory of activities and ongoing developments is part of the “initial analysis” section under the inception phase. In part, this inventory is similar to USACE Step 2, where critical resources are inventoried. The results of inception phase are documented in an inception report which describes components of the water resources system.

The **development phase** includes model development and data collection followed by preliminary analysis to identify possible solutions for problems being addressed. Analysis of physical components, socio-economic system, and administrative and institutional system are part of this phase. There is some parallel between this phase and USACE Step 4 that entails evaluation of alternative plans.

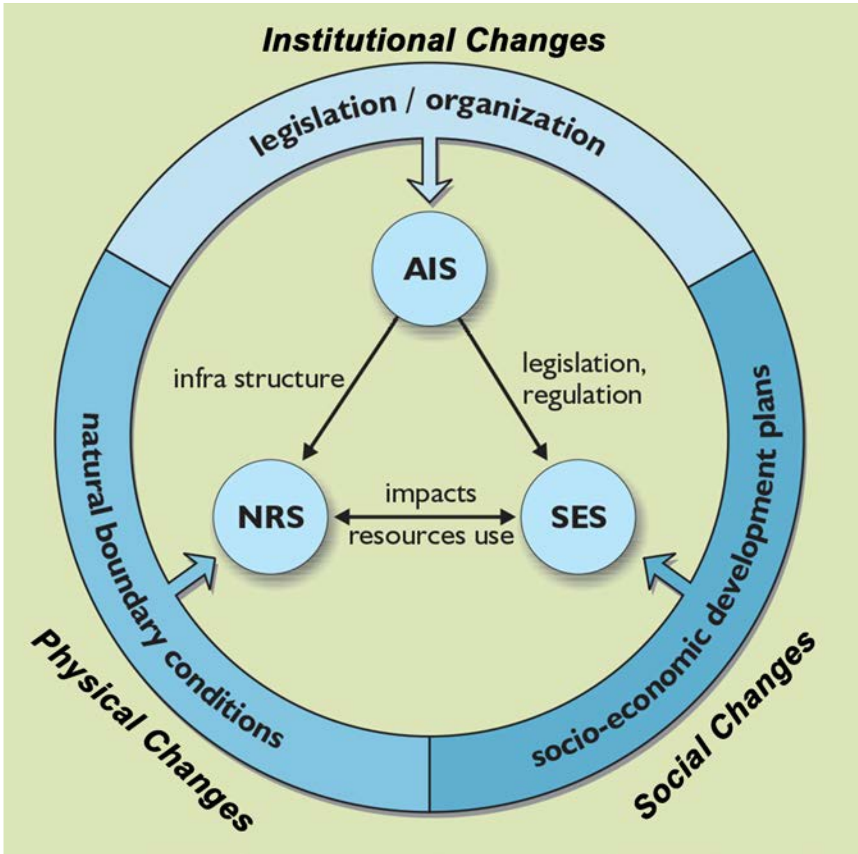
In the **selection phase**, promising measures are combined into strategies. Effects of various strategies are assessed and a limited set of promising ones is defined. The design of strategies is an iterative process. Results of selected strategies are presented to allow the decision maker to compare alternatives with respect to given criterion. This phase is similar to USACE Steps 5 and 6 (i.e., to compare alternative plans and select the plan).

Figure 2. Typical analytical framework for water resources studies (after Loucks and van Beek 2005).



Appendix E of Loucks and van Beek (2005) discusses project planning and analysis. It mentions the context for water resources planning includes: administrative and institutional system (AIS), natural resources system (NRS), and socioeconomic system (SES) (Figure 3). These systems incorporate some of the PSI changes described in this report.

Figure 3. Context for water resources planning
(after Loucks and van Beek 2005, 649).



As shown in Figure 3, Loucks and van Beek describe **NRS** to be bounded by natural conditions such as climate and (geo) physical conditions. System boundaries depend on physical characteristics—an example would be a groundwater or a surface water system. NRS system consists of physical processes and chemical and biological characteristics. The physical processes in a NRS are transport and storage within subsystems, and transport between the subsystems. A useful concept for describing the biological characteristics is the ecosystem. Ecosystems are dynamic networks of interrelated parts which, to a certain extent, are capable of aut0-repair when some parts are lost.

SES is formed by the demographic, social, and economic conditions of surrounding economies. The economic system generally does not have a physical boundary like the natural system. Examples of SES boundary conditions are the state of the world economy, the value of the U.S. dollar, or the price oil. The socio-economic part of water resources system (WRS) can be identified by identifying the main water-using and water-related activities, the expected developments in the study area, and the parameters that determine these developments.

AIS is formed by constitutional, legal, and political systems. Like the NRS and SES, it has elements that define its boundaries and its processes. In most cases, AIS elements like the central government are divided into sectors that each has to be characterized such as public works, irrigation, agriculture, forestry, environment, housing, industry, mining, and transport.

3.2 Combining a comprehensive analytical framework with supporting topic-specific analytical frameworks

Topic-specific or targeted AFs can be used within the USACE comprehensive six-step framework. The topic-specific or targeted AFs can be viewed as supporting frameworks, or AFs which can be “nested” within the comprehensive framework. Appendix A describes many AFs that can be nested within the USACE six-step planning structure, including examples focused on environmental compliance requirements and supporting tools, as well as many that were developed for very specific cases. Knowledge about the contents of Appendix A can be useful in matching topic-specific AFs to USACE’s comprehensive framework. Creative thinking may be necessary in intertwining such topic-specific AFs into the comprehensive one. However, this approach can be useful and provides consistency for addressing the environmental consequences of physical, social, and institutional changes within existing AFs. Refer to Appendix C for additional background reading on AFs related to water resources planning.

3.3 Observations

AFs are generally divided into two types, comprehensive and topic-specific. Comprehensive AFs are used to conduct an overall water resources planning process, while topic-specific AFs are used to answer individual issues that are components of an overall process. In this chapter, three comprehensive AFs were discussed and compared to the USACE six-step planning process. Although there are differences such as number of specific steps and descriptors used, each framework includes an essentially similar process to that of USACE’s six-step process. One difference noted was inclusion of an implementation step in some processes. The USACE six-step process could benefit by including implementation because operational aspects such as costs of operation, maintenance, and adaptive management are necessary life-cycle project considerations. All three examples noted in this Chapter can be effectively used to plan water resources projects and their management.

4 Analytical Frameworks Used in Policy Evaluations

Policy changes over time represent institutional changes associated with water resources planning and management. This section focuses on examples of AFs used in policy evaluations, also referred to as policy assessments (PAs) or policy impact assessments (PIAs), along with Strategic Environmental Assessments (SEAs).

PA refers to the assessment of all outcomes of policies being planned, being proposed, or already in existence, whereas PIA refers to a broader focus that includes all outcomes in addition to meeting objectives which might result from implementing the policy (Boothroyd 1995).

SEAs refer to initial regional or sector impact studies which focus on broader-scale planning issues such as siting requirements and generic impact mitigation requirements. In the United States, SEAs are typically associated with programmatic environmental impact statements (EISs). SEA is an important decision tool that helps to incorporate sustainability principles in the policy-making process. An SEA can influence and improve decision making that contributes to an environmentally and sustainable integrated context for the development of policies and plans.

The USACE planning process is primarily focused on evaluating the engineering and economic characteristics of alternative design and operational choices along with the consequences of such choices on environmental resources, natural resources, sociocultural conditions, and economic conditions within designated study areas. However, NEPA regulations call for impact studies related to policies and larger-scale plans and programs; such studies are also required for specific projects and permit applications. Accordingly, institutional changes associated with new policies or proposed changes in existing policies, and the consequences of both, need to be evaluated from several viewpoints.

Policy development is often a precursor to the promulgation of plans, programs, projects, and permit applications; therefore, such policies should be carefully evaluated prior to their implementation. Several conceptual benefits for conducting PIA “upfront” have been advanced including: (1) involving more government and public actors in assessment of key decisions; (2) increasing assessment efficiency by applying it to one macro policy rather than many individual projects; (3) widening the range of options assessed; and (4) improving assessment of cumulative, synergistic, and secondary impacts (Wood and Dejeddour 1992).

A common theme in AFs for policy evaluation is the need to assess current topic-specific legislation, guidance, and policies and then, determine their relevance to proposed new or modified policies. Three examples of information sources on these topics for the Corps include the *Environmental Desk Reference* (Martin 2002) which summarizes 70 federal laws and 40 Executive Orders (EOs), a review of USACE mitigation policies (Canter 2003), and an analysis of existing regulations and guidance which need to be updated to address incremental changes (Canter and Atkinson 2011). Users of these and similar resources should check the latest Headquarters USACE (HQUSACE) guidance for details regarding USACE policy on implementing and complying with statutes and EOs.

4.1 Examples of analytical frameworks

4.1.1 United Kingdom Department of the Environment

As part of an international study of the effectiveness of EIA in multiple countries, it was noted that PIA refers to the assessment of all outcomes of policies being planned, proposed, or already in place. So defined, a PIA is conceptually akin to technology assessment or the broader view of social impact assessment. Further, a PIA can and should clarify the issue(s) a policy addresses, review all options and potential outcomes, and then ask whether current objectives and directions are the “right” ones (Sadler and Verheem 1996, 39). Further, they noted a five-step AF for policy appraisal which had been developed by the Department of the Environment (DOE) in the United Kingdom (DOE 1991). Table 2 delineates the five steps (ibid., 107). It should be noted that the steps routinely refer to policy, plan, or program which are the three situations where PIAs typically apply. Some interesting observations related to the steps in Table 2 through Table 4 are:

- Knowledge of existing policies and their relationships to new or modified policies is fundamental in policy appraisal.

- Environmentally related policies need to be evaluated relative to environmental problems to be addressed and the existing related policies, guidance, or regulations.
- Formulation of policy alternatives and their systematic evaluation, along with their refinement via mitigation or compensation, is similar to Steps 3 through 6 in the USACE planning process.
- Follow-on monitoring and evaluation of the outcomes of the selected policy are similar to current attention to adaptive management in EIA or SEA processes. USACE could set up monitoring as necessary and indicate how monitoring results of projects will be collected and used to evaluate implementation of the policy, plan, or program.

Two additional examples of policy appraisals in the United Kingdom are shown in Table 3 and Table 4, respectively. Table 3 includes a seven-step integrated policy appraisal process encompassing Departments of the Environment, Transport, Local Government, and Regions (DETR 1998). Table 4 includes eight refined steps for policy appraisal in the UK (Sadler 2005). Systematic comparisons of the steps in Table 2, Table 3, and Table 4 reveal similarities and flexibilities between each of the three examples.

Table 2. Basic steps in an analytical framework for policy appraisal in the United Kingdom. (Sadler and Verheem 1996, 107).

Step	Summary of Step
1	List the objectives of the policy, plan or program including the formal decisions that need to be taken, and identifying the constraints. As part of this step, consider the objectives and priorities; identify any conflicts and tradeoffs between them; indicate how binding the constraints are and whether they might be expected to change over time or are negotiable; and take into account the results of public involvement if this has taken place.
2	Analyze existing environmental problems and protection objectives. This step should include focus on the main problems that could be affected by the policy, plan or program, either negatively or positively; use relevant environmental policy plans to list the relevant environmental protection objectives for these problems; and also employ extended screening or scoping as appropriate.
3	Specify feasible alternative options for planning decisions and identify their environmental consequences. This step includes identifying and evaluating environmental issues and impacts, as well as cumulative impacts and sustainability issues; do not disregard likely effects simply because they are not easily quantifiable.

Step	Summary of Step
4	Identify measures to mitigate or compensate resultant environmental problems or concerns and delineate a preferred option. Attention should be given to the analysis of those impacts which are material to the decision: compare them with relevant environmental protection objectives; compare alternative options; adapt where necessary policy options to the results of the impact identification; include a "with and without proposal" comparison; and test the sensitivity of the outcome of the analysis to possible changes in conditions or to the use of different assumptions.
5	Set up any monitoring necessary and decide at which stage to evaluate the implementation of the policy or related action. Wherever possible: identify further requirements for assessment; specifically list any related projects, activities, etc. that may require EIA at the project level; and indicate how monitoring results of projects will be collected and used to evaluate the implementation of the policy, plan, or program.

Note: See the following reference for additional information – Department of the Environment (DOE) 1991.

Table 3. Steps and related guidance in the United Kingdom's integrated policy appraisal process (after DETR 1998).

Step– Title	Guidance
1 – Preliminary Policy Analysis	Define the need for and context of a policy proposal and the main alternatives. Conduct an options appraisal against the base case (do nothing or do minimum) to judge the impact of the proposal. (Impact infers changes in the biophysical, social, and socio-economic conditions in pertinent local to regional to national areas.)
2 – Screening	Assess the proposal against the checklist of questions in the Integrated Policy Appraisal guidance. Carry out further analysis for each category of questions where the effect is more than negligible.
3 – Preliminary Impact Assessment	Address what is known already (or can be easily identified) about the impact of the policy proposal for each screened in category. Use quantitative indicators if possible; otherwise a brief qualitative assessment will suffice.
4 – Distributional Impact	Undertake a similar evidence-gathering process as above to identify how the impact of the policy proposal is expected to differ across various sectors.
5 – Risk	Should address uncertainties that need to be addressed in a more detailed appraisal. Some impacts will need to be based on reasonable suppositions.
6 – Review the Proposal	Consider which adverse effects could be mitigated by modifying the proposal, and which have to be traded off against the beneficial effects.
7 – Detailed Appraisal	Undertake detailed appraisals as the proposal develops and as needed for impacts in relevant categories noted herein. Refer to Supplementary Guidance in such cases; either directly or as a guide to appropriate sources and methods.

Table 4. Refined steps in policy appraisal in the United Kingdom (Sadler 2005, 149).

Step	Focus
1	Summarize the policy issues under consideration, list the objectives (goals) to be accomplished, and identify possible trade-offs, conflicts, and constraints.
2	Specify the range of options for achieving the objectives, including the “do nothing” option.
3	For the range of options, identify and list all anticipated impacts on the environment and consider mitigation measures to offset them.
4	Assess the significance of the impacts of the options in relation to other costs and benefits.
5	Quantify costs and benefits of the options as possible or necessary.
6	Use an appropriate method to value costs and benefits including those based on monetary values, ranking, or physical quantities; as appropriate, can omit inferior options.
7	State the preferred option with reasons for doing so.
8	Monitor and evaluate the results of the preferred option, making appropriate arrangements for doing so as early as possible.

Note: see the following references for additional information:

Department of the Environment (DOE) 1991; Department of the Environment, Transport, and the Regions (DETR) 1998

4.1.2 Australian model for policy making

A general model for governmental policy in Australia (Nitz and Brown 2001) includes an eight-stage loop that suggests a continuing process related to policy development, implementation, evaluation, and refinement (Figure 4).

Figure 4. Model of the policy-making process in Australia. (after Nitz and Brown 2001, taken from Bridgman and Davis 2000).

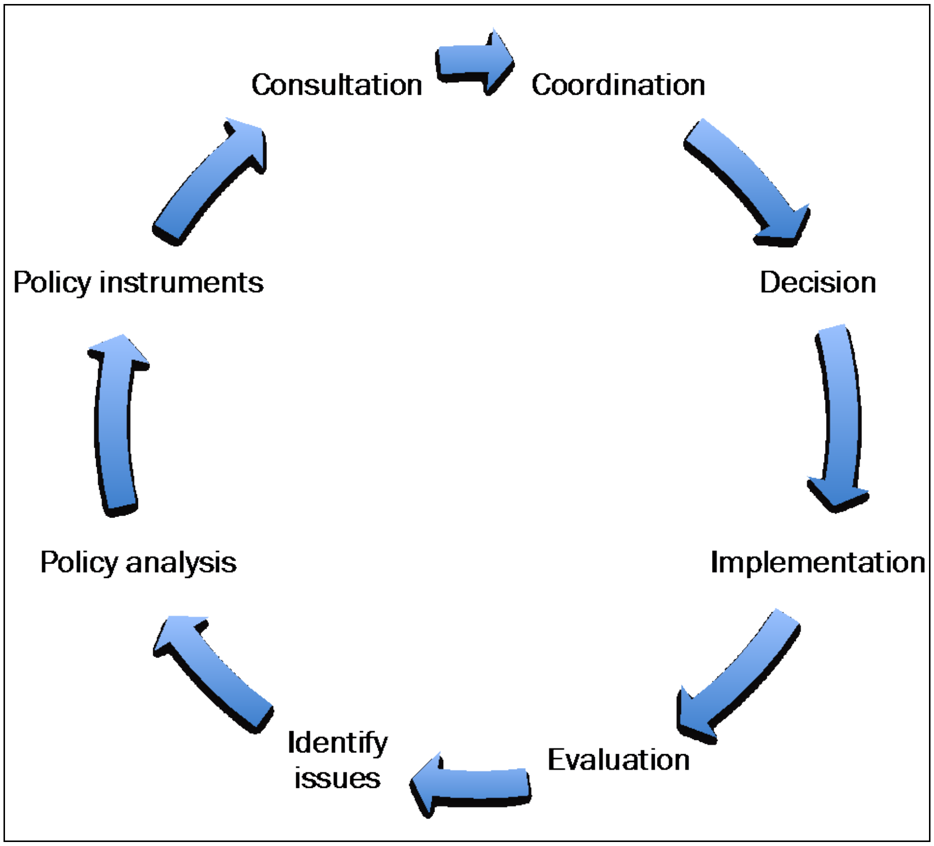


Table 5 shows how SEAs could be used in policy evaluation and decision making. Information related to the eight stages is summarized in Table 5 with the third and fourth columns delineating how SEA could be used in policy evaluation and decision making (Nitz and Brown 2001, 336–337). As can be seen, the SEA columns give considerable attention to the environmental consequences of policy choices. Table 5, which can be referred to as an AF for policy development and evaluation, is an excellent tool that USACE can use for various stages of policy formulation and determining which issues will require analysis.

Table 5 provides a tool for analyzing and understanding the processes for policy formulation. While the order and length of the policy-making stages, the nature and quality of the analyses, the level of consultation and coordination, and the makeup of stakeholders are different, the underlying policy-making cycle is fundamentally present. The EIA practitioner would have to mold the SEA to fit each policy-making activity. Within each of the policy-making stages, the decisions to be made, the type of environmental information required, and the time and resources available can be identified ahead of time by the SEA practitioner. The third column of Table 5 identifies the decisions and actions that will be made by the policy makers within each stage. This framework provides the environmental assessment practitioner with a roadmap to the design of an effective SEA and confirms that, in order to be effective, consideration of SEA design must occur at the beginning of the process. From this framework, it can be seen that policy making is an iterative and cyclical process where policies are constantly re-evaluated in light of new information, and SEA procedures are adapted accordingly.

Table 5. Analytical framework for policy making in Australia (after Nitz and Brown 2001).

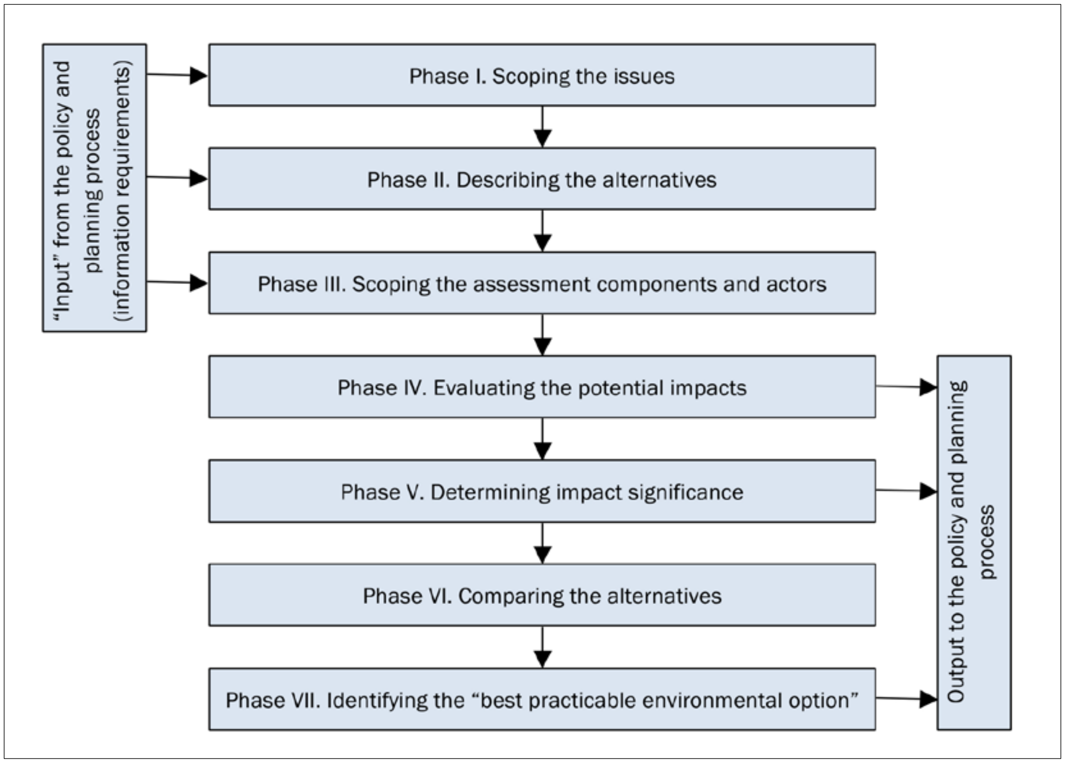
Stages of policy making		Focusing the SEA	
		Identify decisions/actions by policy makers within each stage	Potential contributions of the SEA
Identify issues	New issues emerge requiring policy attention or need to reconsider existing policy issue	• Which issues will require analysis? • Decide "non-issues"	• Environmental monitoring data and analysis / state-of-environment reporting • Trends in other jurisdictions • Environmental briefing for policy advisors / politicians for agenda setting
Policy analysis	Information gathered and research into nature of policy issue	• Formulate the problem • What are goals and objectives? • Which parameters to include? • Which alternatives will be investigated? • Which potential policy responses will be investigated?	• Scope problem's environmental aspects • Environmental data collection and prediction • Suggesting, and environmental analysis of, alternatives • Agency and ministerial briefs on environmental issues and possible solutions

Stages of policy making		Focusing the SEA	
		Identify decisions/actions by policy makers within each stage	Potential contributions of the SEA
Policy instruments	Identify possible mechanisms (e.g. legislation, taxation or government funding) for dealing with policy issues	• Which policy instruments? • Choose instruments	• Scope and assess environmental implications of different policy instruments
Consultation	With general community and interested groups to inform policy analysis and test feasibility of proposed policy responses	• Who are relevant stakeholders? • What consultation strategy? • Assess options in light of consultation	• Identify relevant stakeholders and appropriate consultation strategies • Conduct consultation
Coordination	Coordination among government departments and agencies to identify conflicting objectives, interests and responsibilities	• What are budgetary implications of proposed policy response • Is this consistent with other policies?	• Assess consistency of proposals with existing environmental policies / initiatives • Policy submission on to decision makers
Decision	Decision to adopt particular policy response	• Who are the final decision makers? • Where and when will decision be made? • Decide policy response	• Policy submission and ministerial briefs on environmental consequences
Implementation	Implement policy response through establishing policy instruments and adjusting administrative structures	• What are resource implications of implementation? • What are the legal and administrative requirements?	• Assist in developing programs to implement environmental dimensions (mitigation?) of policy • Program development
Evaluation	Evaluation of effects of policy response, including efficiency, effectiveness and appropriateness to policy	• Is policy response effective (outcomes, effectiveness)?	• Evaluate environmental consequences of policy response and measure against sustainability criteria

4.1.3 Canadian energy policy

Noble (2002) evaluated five Canadian energy policy scenarios via the use of SEA, a multi-criteria decision process, and input from a panel of experts. The study was sponsored by the Canadian Institute for Social and Economic Research and conducted at the University of Saskatchewan. A generic seven-phase SEA framework served as the AF for this policy-related study (Figure 5). The figure below delineates the seven SEA phases, supported by input from and providing output to the policy and planning process.

Figure 5. Generic seven-phase analytical framework applied to Canadian energy policy evaluations (after Noble 2002).



In Noble's 2002 work, a panel of experts also evaluated the same five alternative policy scenarios as they related to meeting Canadian energy needs to 2050 by using eleven environmental, economic, and social assessment criteria. To incorporate this into the AF being used (Figure 5), the analytical hierarchy process (AHP) method by Saaty (1977) was used in Stages IV–VII of the AF. The input of the experts was aggregated using the Delphi method. The robustness of the assessment results were then evaluated using sensitivity analysis.

The systematic way the five alternatives were evaluated is similar to the USACE six-step planning process of formulating alternatives that includes the "no action" alternative or "future without project conditions." The output of an SEA does not present "the decision," but a systematic evaluation of alternatives, resulting in the decision-making agency being able to make an informed choice. Similarly, the USACE planning process, recommends a plan that is shown to be "preferable" to taking no action. In the USACE process, the decision to select the recommended plan begins at the district level and continues at the headquarters level through subsequent reviews and approvals.

4.1.4 World Bank

The World Bank (1993) produced a guidance document that is applicable for sectoral (transportation, water, energy, etc.) analyses in specific regions. The sectoral environmental assessment (EA) offers an opportunity for sector-wide EA before investment priorities have been determined. It also supports integration of environmental concerns into long-term development and investment planning. Sectoral EAs are suitable for analysis of institutional, legal, and regulatory aspects related to the sector, and for making comprehensive and realistic recommendations regarding environmental standards, guidelines, law enforcement, and training, thus reducing the need for similar analysis in downstream EA work (World Bank 1993). The sectoral analyses are also well suited to consider cumulative impacts of multiple on-going and planned investments within a sector, as well as impacts from existing policies and policy changes.

This AF is based on the following topics:

- policy, legal and administrative framework (for the sector);
- project description (policy, plan, or program);
- baseline environmental data;
- environmental impacts of selected project;
- analysis of alternatives;
- mitigation plan;
- environmental management and training;
- environmental monitoring plan; and
- public consultation.

It would be helpful to incorporate sectoral analyses into the USACE process. The section outlining policy, legal, and administrative framework would be an important part of the sectoral EA to help USACE analyze both the national legal environment and sector-specific policies.

The World Bank (1996) also created a tool to aid development planners in designing policies, programs, and projects that are environmentally sustainable for a region as a whole (including all sectors). This guidance has applicability for river basin planning, as well as coastal zone planning and management. The information within this guidance includes two broad considerations: designing the study and executing the study. Designing the study involves understanding the regional planning framework, defining the spatial context, determining the optimal multi-sectoral focus, limiting the study goals while retaining an integral focus, setting up appropriate institutional arrangements, developing a detailed study scope (terms of reference), planning appropriate public consultation, and defining a review process. The AF for executing the study should generate written information for the following topics:

- policy, legal, and administration framework (national and regional);
- baseline conditions (physical, biological, socioeconomic, and cultural environment);
- description of development policy, plan, and associated projects;
- inventory of other policies, plans, and projects;
- cumulative impact assessment;
- analysis of alternatives;
- recommendations toward an optimal regional policy or plan; and an
- environmental management strategy.

4.2 Observations regarding policy evaluations

This chapter has highlighted the fact that AFs already exist that are related to the evaluation (or assessment or impact assessment) of new or modified policies, and such policies can relate to scientific and/or social issues. These AFs typically include steps related to identifying policy choices (alternatives) and evaluating them regarding their environmental, economic, and social consequences. The included examples provide practical information related to policy-oriented AFs.

Further, a blended AF could be developed and used for evaluating physical, social, and institutional changes related to new or modified policies for water resources planning and management. The section above serves as a reminder that policy evaluations need to be conducted in the context of existing relevant laws, regulations, and policies and acknowledge that new issues emerge that require policy attention or need reconsideration of existing policy issues.

5 Comprehensive Analytical Frameworks Used by Other Federal Water Resources Agencies

This chapter contains summary information on protocols and steps used by three federal water resources agencies: the U.S. Bureau of Reclamation (USBR), the Natural Resources Conservation Service (NRCS), and the Tennessee Valley Authority (TVA). The six-step water resources planning process used by USACE can be used as a reference point for comparing the protocols used by the three federal water resources agencies. The six steps used by USACE are described in Chapter 2 of this report (The USACE Six-Step Planning Process).

5.1 U.S. Bureau of Reclamation

The USBR, which is part of the U.S. Department of the Interior, has developed a 10-step decision process guide for water resources planning and management (U.S. Bureau of Reclamation 2010). The 10-step process (Table 6) is focused on stakeholder involvement, so technical and scientific issues are downplayed. However, the delineated steps are in consonance with the USACE six-step planning process.

Table 6. Ten-step decision process guide for water resources planning and management (USBR 2010).

Step	Guidance
1. Identify needs	Examine the existing knowledge base and gather additional necessary data. Identify the area of influence (problemshed), the existing limitations (legal, physical, etc.), and the issues and concerns through public involvement and scoping. Catalogue the various perceptions of needs from various publics.
2. Develop objectives	Determine the objectives (those needs that your process may help to meet). You may need to spend some time separating out underlying real needs from stated positions. The rest of the decision process will focus on meeting these objectives.
3. Identify resources and constraints	Figure out what you have to work with and what the boundaries of the study are. Determine the relationships and influences between available resources (physical, social, and political). These resources provide a reality check – they determine how you will be able to meet the objectives.

Step	Guidance
4. Identify potential options	Brainstorm options or components of solutions. These will provide multiple ways to address each objective. Consider all options presented at this point – they will be winnowed down later.
5. Establish and apply screening criteria	Determine standards that each option must meet in order to work and weed out fatal flaws. Apply the criteria to each option consistently to develop a set of viable options.
6. Develop alternatives	Combine options to form alternatives. Develop a wide range of alternatives, including no action. Check each alternative to ensure that it meets the objectives.
7. Evaluate alternatives	Develop evaluation criteria to rank the alternatives. Perform analyses and weigh tradeoffs to compare alternatives.
8. Select the alternative (of choice)	Present the analyses to the decision maker and the public. The decision maker then selects a workable alternative and explains the rationale to the public.
9. Implement the decision	Identify and fund responsible implementers to carry out the decision. Find and communicate with newly affected and interested publics.
10. Monitor and adapt (if necessary)	Make sure the solution continues to work by providing for maintenance and operation of physical structures and administration of institutional solutions. Examine the situation and modify the solution when necessary. Afterwards, discuss the decision process and let others know what worked and what did not. Carry these lessons over into future problem-solving efforts.

Steps 1, 2, and 3 of the USBR's decision process are, respectively: to identify the problem, identify the purpose, and determine resources and constraints are encompassed in USACE Step 1: to identify problems and opportunities. Both processes mention framing or bounding the problem, involving stakeholders, and finding a range of potential solutions. The USBR process says "You will get reasonable decisions when decisionmakers, team members, and other participants have identified and understood key issues" (USBR 2010, Step 1). Together, issues and concerns delineate the problems that clamor to be addressed and that drive actions. In both decision processes, constraints include legal influences, regulations, authority, staff, and funding.

The USBR's process Step 3 provides an example of tools that can be used to determine resources and constraints, which would be helpful to the USACE process. Tools include graphical information system (GIS); physical, social, biological process maps; flow charts; influence diagrams; and issue maps (e.g. endangered species, water demands). USBR process Steps 4, 5, and 6—to develop options, establish and apply screening criteria, and develop alternatives, respectively—relate to USACE Step 3, formulation of alternative plans. One thing to note (USBR process Step 6) is examining the interaction of specific options, which can lead to combinations that enhance the overall effectiveness. This examination can also reveal potential problems or adverse impacts that must be either avoided or mitigated.

USBR process Step 7 (evaluate alternatives) correlates with USACE Steps 4 and 5, to evaluate and compare alternative plans. This step entails trade-offs analysis among competing needs and solutions. Once the alternatives that fit the evaluation criteria are identified, a look at the overall system is needed to determine whether solving one problem at one location is not creating larger problems elsewhere.

USBR process Step 8 and 9 (select the alternative and implement the decision, respectively) are similar to USACE Step 6, selecting the plan. Step 10 of the Reclamation process provides feedback through monitoring and adapting to changes. Progress is monitored closely, and problems are reviewed and addressed. This is an important step that USACE could also use to focus attention on what does work and what continues to work and then, to carry the lessons learned into the future.

5.2 Natural Resources Conservation Service

The NRCS is part of the U.S. Department of Agriculture.[1] The NRCS has current involvements in water resources planning and management for its specific projects. Additionally, it provides assistance to state and local agencies who are primary sponsors of flood risk-reduction projects and small dam and impoundment projects. The process used for NRCS projects is based on the USACE six-step planning process.

Examples of assistance to state and local governments are related to rapid watershed assessments (RWAs) and watershed and dam rehabilitation planning. Support for RWAs includes, but is not limited to, technical guidance and direct work related to HUC (Hydrologic Unit Code) profiling within watersheds, and technical assistance and direct work on sub-basin water-related needs and risk assessments. Direct assistance to state and local agencies includes the areas listed below (NRCS 2010):

- Resource inventory and methods selection

[1] NRCS was earlier known as the Soil Conservation Service.

- HUC (hydrologic unit code) profiling and GIS (geographic information systems) applications
- Resource analysis (watersheds and river basins)
- Archeological and cultural resources investigations
- Project/dam site investigations
- Development of alternatives
- Environmental compliance for project and alternatives
- Economic analysis of project and alternatives

The above areas are all in consonance with one or more of the six steps in the NRCS planning process. RWAs are quick and inexpensive for setting priorities and taking action. They provide a level of detail that is sufficient for identifying actions that can be taken without further watershed level studies or analyses. RWAs address multiple objectives and concerns of landowners and communities. They include a full array of conservation program tools (e.g., cost-share practices, easements, and technical assistance). The RWA process entails: collecting quantitative and qualitative data, organizing data using GIS technology, analyzing data to allow resource concerns to become apparent, and generating maps and information to help make better decisions about conservation needs and programs. The RWA process develops matrices that summarize current resource conditions, conservation practices, and related maintenance costs. It also summarizes desired resource conditions, conservation opportunities, installation and maintenance costs and potential funding sources for conservation implementation.

Finally, NRCS also provides peer reviews of state and local studies and planning documents. Examples of these reviews are related to watershed assessments, rehabilitation plans and projects, new water-related projects, and associated environmental assessments or environmental impact statements.

5.3 Tennessee Valley Authority

The TVA was formed in 1933 to manage water resources and generate electricity within the Tennessee River basin (Miller and Reidinger 1998). The TVA river basin lies in a seven-state area in the southeastern United States. The primary functions of TVA have related to flood risk reduction, waterway navigation, and production of cost-effective electricity, recreation and water quality. The TVA has planned, constructed, and operated control structures such as dams and reservoirs, levees, and locks.

The comprehensive water resources planning process used by TVA (Figure 6) includes each of the six steps in the USACE planning process. Further, attention is given to collaboration with agencies and other stakeholders throughout the process. Establishing objectives, conducting scoping meetings, determining issues to be addressed, identifying full range of alternatives, evaluating alternative plans, and selecting a preferred alternative are the same as the USACE planning steps.

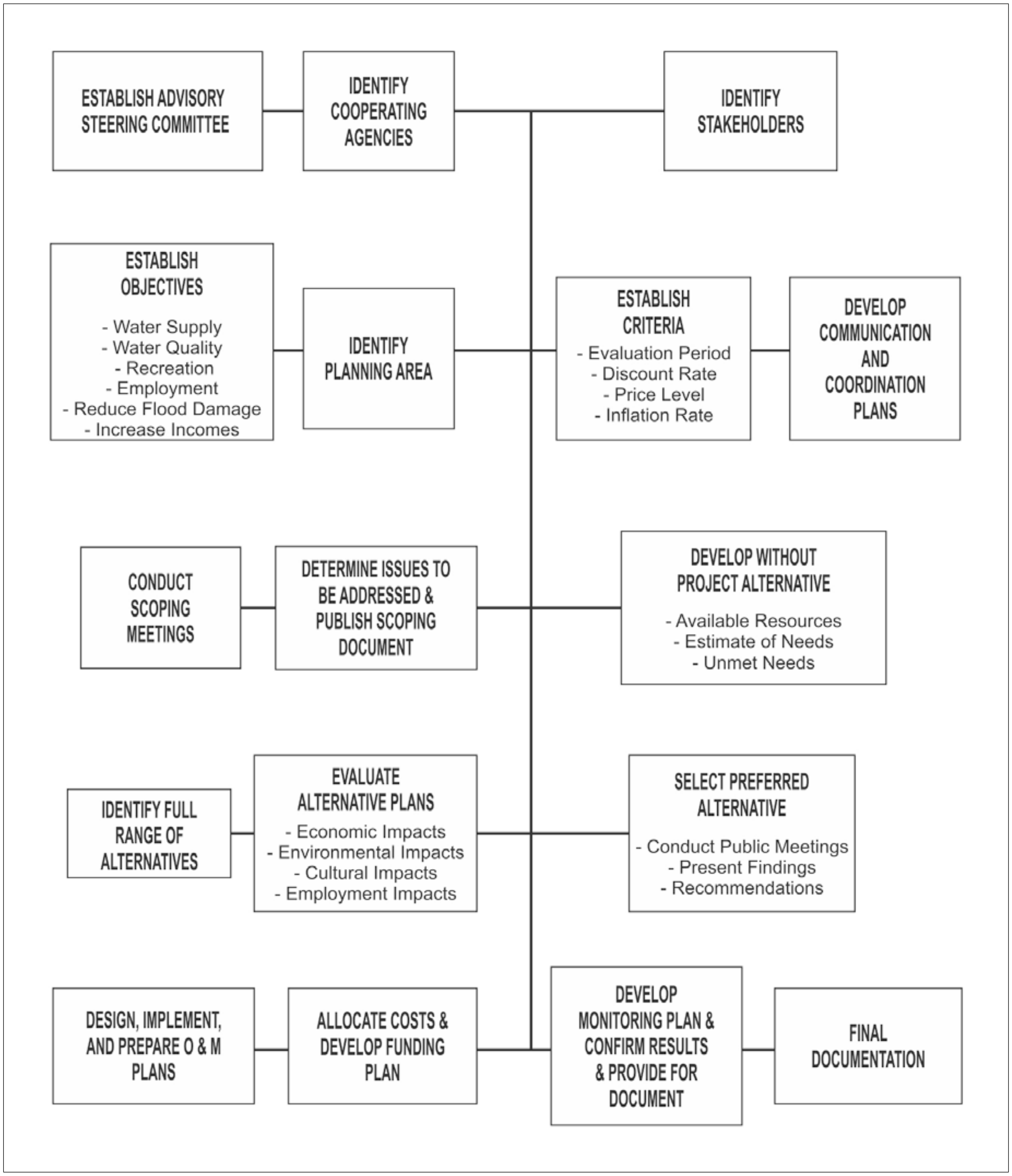
Figure 6 depicts the TVA's planning process for water resources projects. A total of 17 boxes are depicted; however, these represent and encompass focused steps and activities used in the planning and management of water resources projects in the Tennessee Valley watershed. The final box in Figure 6 (Final Documentation) encompasses feasibility studies, NEPA-related environmental compliance documents (EAs and EISs), and specific project operation and maintenance plans.

TVA attributes success of its water resources programs to its commitment to working cooperatively with other federal, state, and local agencies and with residents of the Valley. As an example, TVA works closely with the Corps of Engineers in the areas of navigation and flood control under formal cooperative agreements.

5.4 Observations

The 10-step decision process guide by the USBR is similar to the six steps used by USACE because the 10 steps encompass the USACE six-step process. The process used by the NRCS is similar in style to the Bureau's 10-step process and the USACE six-step process. Further, it should be noted that NRCS projects are often smaller in size than larger-scale dams and reservoirs and flood-control levees. Also, the NRCS frequently conducts RWAs in conjunction with local or regional state-level programs.

Figure 6. TVA water resources planning process (after Miller and Reidinger 1998).



6 Summary, Conclusions, and Recommendations

6.1 Summary

This report reviewed and examined AFs from several federal agencies, including the USACE six-step planning process. The report focused on the use of comprehensive and topic-specific AFs for addressing PSI changes within USACE water resources planning and management. An AF denotes a planning framework or process, characterized by listed steps which include both analytical and synthesis features. The USACE six-step water resources planning process represents a comprehensive AF. Examples of PSI changes that can occur over time and that need to be incorporated into planning include: modifications in water or environmental policies, land-use changes in urbanizing watersheds, land-use changes and development projects in watersheds and river basins, and climate variations. These types of changes can have consequences on hydrology, terrestrial and aquatic ecology, water demands, and local-to-regional economic and social conditions. Numerous topic-specific AFs have been described herein to address individual types of PSI changes; these frameworks can also be used as supporting tools within the USACE six-step comprehensive AF.

6.2 Conclusions

The conclusions from this report are listed below.

- There are a large number of PSI-related AFs which are already being used in water resources planning and management. Additional PSI-related AFs are being generated and integrated into the USACE six-step process. Accordingly, there is no current need to develop a comprehensive AF that is focused specifically on PSI changes. Rather, the subject of PSI changes can be addressed within the current USACE six-step planning process and supported within that process by PSI-related AFs. This approach provides flexibility and adaptability as new PSI changes are identified and evaluated.
- Numerous other types of topic-specific AFs already exist. Examples include AFs for policy evaluations, EIAs, and cumulative effects assessment and management (CEAM) studies for NEPA compliance, biodiversity assessments, environmental and watershed sustainability,

climate change and adaptation, ecological flows, ecological risk assessments, adaptive management, collaboration in planning, and shared vision planning. As appropriate, these AFs can be used in support of the comprehensive USACE six-step process.

6.3 Recommendation

A recommendation from this review of AFs is that one or more pilot studies be conducted to demonstrate how PSI changes can actually be addressed and evaluated within the USACE six-step process. These studies could be used by environmental practitioners within USACE to demonstrate how PSI-focused AFs could support the comprehensive USACE framework. Such pilot studies could range from small-scale (sub-watershed), to watershed-level, or river basin use. In addition, the findings from these pilot studies could be compiled and used in subsequent water resources planning and evaluation, which will result in projects that are more adaptable to future demands and conditions.

Appendix A: Analytical Frameworks Used in Environmental Compliance Activities

Introduction

Numerous federal laws and their associated regulations or guidance require proponent agencies to provide specific compliance documentation for new or modified projects, plans, or programs. Such documentation is typically accomplished by completing specified processes and reporting requirements. The processes are typically AFs which include agency discussions and interactions. Examples of such AFs include the Section 7 Process of the Endangered Species Act of 1973 (16 U.S.C 1531-1544), as amended; the Section 106 Process of the National Historic Preservation Act (Advisory Council on Historic Preservation 2004); and the Section 404 (b)(1) Process of the Clean Water Act (USEPA 2009). Other related laws which have generated procedural requirements include the Coastal Zone Management Act (U.S. Congress 1972b), the Migratory Bird Treaty Act (U.S. Congress 1918), and the Fish and Wildlife Coordination Act (U.S. Congress 1934).

A major environmental compliance act which incorporates a broad range of laws and issues is the National Environmental Policy Act (NEPA). Compliance documentation under NEPA includes the preparation of Environmental Assessments (EAs) or Environmental Impact Statements (EISs). Attention is focused on addressing direct, indirect, and cumulative effects in EISs for water resources projects individually or in conjunction with regional areas and strategic studies.

Analytical framework related to EIA studies for individual water resources projects

Water resources projects focused on dams and reservoirs, and flood risk reduction measures have been frequently studied relative to their direct and indirect effects. Accordingly, robust literature now exists on such effects. For example, Brown, et al. (2009) delineated three categories of such effects which are included in Table A1. Numerous other examples could be cited from the literature. As appropriate, EAs and EISs on new projects, as well as modifications to existing ones, should address these types of effects.

Table A1. Direct and indirect effects of dam projects (Brown et al. 2009, S305–S306).

Category	Label*	Effect	Description
Biophysical	BP1	Water retention time	Time water is stored in reservoir as indicator of ecological impact
	BP2	Natural value	Potential gain or loss associated with dam activity
	BP3	Downstream tributaries	Number of tributaries for supplying sediment and organic material, buffering hydrology, and providing habitat
	BP4	Biodiversity	Threatened/endangered plants and animals
	BP5	Distance of river left dry downstream of dam	In scenarios where flow is diverted for irrigation
	BP6	CO_2 equivalent to coal	Benefit of producing hydropower as opposed to coal as alternative energy source
	BP7	Flood protection	The magnitude of flooding event captured by the dam in Return Year Interval (RYI)
	BP8	Site stability	Presence of geologic hazards, e.g. landslides, site stability, distance to faults, and reservoir-induced seismicity
	BP9	Reservoir surface	Surface area of reservoir at full storage
Socioeconomics	SE1	Social cohesion	Change in social networks and perceived social cohesion
	SE2	Cultural change	Sites of cultural significance
	SE3	Non-agricultural economic activity	Aggregate change in total income, less government transfers
	SE4	Health	Frequency and severity of contamination
	SE5	Agricultural economic activity	Aggregate change in total income, less government transfers
	SE6	Displacement	Relocation costs associated with changing water levels
	SE7	Hydropower/infrastructure	Value of hydropower consumed locally or sold
	SE8	Housing values	Hedonic value of recreation and landscape
	SE9	Transportation	Value of change in economic activity

Category	Label*	Effect	Description
Geopolitical	GP1	Downstream riparian population	People in downstream communities potentially affected by upstream dams
	GP2	Downstream irrigation	Downstream irrigated area potentially affected by upstream dams
	GP3	Political boundaries	Number of national and sub-national political boundaries crossed by waterway
	GP4	Existing dams	Regulatory/storage capacity of existing dams on waterway
	GP5	Agreements/ institutions	Number of inter-governmental institutions devoted to management of shared waterway
	GP6	Political participation	Plurality of decision-making processes in country where dam will be sited
	GP7	Historical stability/tensions	Degree of interstate and intra-state stability versus tension among riparian countries
	GP8	Domestic governance	“Durability” of state government, including its ability to anticipate and, where necessary, appropriately respond to domestic challenges
	GP9	Socio-economic impacts for non-constituents	Estimate of the magnitude of impacts for non-constituents (e.g. downstream communities in other riparian countries)

* BP = Biophysical factor
SE = Socioeconomic factor
GP = Geopolitical factor

The effects addressed in the three categories in Table A1 encompass PSI changes. These effects can be used as an objective evaluation of the magnitude of the effects of dam construction and a subjective evaluation of its biophysical, socioeconomic, or geopolitical effects.

Analytical frameworks for addressing direct and indirect effects within environmental compliance under NEPA

NEPA incorporates a broad range of laws and issues. Compliance documentation under NEPA includes the preparation of EAs, EISs, or Programmatic EAs or EISs. Attention here is focused on addressing direct, indirect, and cumulative effects in EISs for water resources projects individually, or in conjunction with regional areas and strategic studies.

Table A2 demonstrates relationships between the USACE six-step process and examples of activities conducted in response to NEPA requirements, including direct and indirect effects. The NEPA process should proceed in parallel with the USACE six-step planning process. In fact, mutual benefits can accrue to both processes. To accomplish such benefits, the plan formulation team and the environmental team must exchange information with and provide feedback to their corollary team.

Table A2. Relationships between the USACE six-step planning process and activities in the traditional NEPA compliance process focused on direct and indirect effects.

Steps in USACE Planning Process	Examples of Associated Activities in the NEPA Process
Step 1 – Identifying problems and opportunities*	• Establishing environmentally-related need for proposed action and alternatives (if applicable) • Formulating environmentally-related goals or objectives, along with economics-related and socially-related goals or objectives • Identifying Valued Environmental Components (VECs)
Step 2 – Inventorying and forecasting conditions*	• Assembling information on the environmental setting (includes historical conditions to forecasted future conditions). Also includes consideration of environmental and natural resources standards and thresholds. • Defining direct and indirect impact issues via intra-agency and public scoping • Delineating future without project conditions (No Action alternative)
Step 3 – Formulating alternative plans (including a plan for the proposed action)	• Formulating alternatives with a perspective toward their environmental acceptability and sustainability
Step 4 – Evaluating alternative plans	• Predicting impacts (direct and indirect effects) and assessment (assessment is primarily related to determining the significance of predicted direct and indirect impacts on physical-chemical, biological, cultural, and socio-economic components of the environment) for each studied alternative ** • Identifying and evaluating mitigation measures to avoid or minimize adverse impacts (effects)
Step 5 – Comparing alternative plans	• Evaluating environmental impact trade-offs among the alternatives • Decision making associated with selecting the proposed action • Preparing written documentation of the NEPA process • Requiring project construction and operational measures to be environmentally-based, including the incorporation of mitigation measures to avoid, minimize, and/or compensate for negative environmental impacts
Step 6 – Selecting a plan	• Displaying comparative environmental impacts, mitigation requirements, and summaries of economics- related features and social impact features of each alternative plan • Monitoring and adaptive management to ensure the project is operated in an environmentally-responsible manner

* Public participation activities are assumed to occur throughout this step.

** Of particular importance for addressing cumulative effects is to initially focus on direct and indirect effects to VECs (direct and indirect effects are noted in Step 2).

Council on Environmental Quality

Another AF for EISs that addresses water resources projects is the generic topical outline from the Council on Environmental Quality's (CEQ's) NEPA regulations. Table A3 contains these topics and associated comments (CEQ 1986). Direct, indirect, and cumulative effects can be addressed within these sections. USACE's NEPA Regulations (ER 200-2-2) indicated that CEQ's topical contents should be used for EISs (USACE 1988).

Table A3. Analytical framework based on an EIS topical outline (CEQ 1986).

Section	Comments
Cover sheet	The cover sheet must not exceed one page. It must include a list of the responsible agencies including the lead agency and any cooperating agencies; the title of the proposed action; the name, address, and telephone number of the person at the agency who can supply further information; a designation of the statement as a draft, final, or supplement; a one-paragraph abstract of the statement; and the date by which comments must be received.
Summary	Each EIS must contain an adequate and accurate summary. The summary must stress the major conclusions, areas of controversy (including issues raised by agencies and the public), and the issues to be resolved (including the choice among alternatives). It will normally not exceed 15 pages.
Purpose and need	The EIS shall briefly specify the underlying purpose and need to which the agency is responding in proposing the action and any alternatives.
Alternatives, including the proposed action	This section is the heart of the EIS. Based on the information and analysis presented in the sections "Affected Environment" and "Environmental Consequences," it presents the environmental impacts of the proposal and the alternatives in comparative form. Therefore, this section sharply defines the issues and provides a clear basis for choice among options by the decision maker and the public.
Affected environment	The EIS must succinctly describe the environment of the area(s) to be affected or created by the action and any alternatives under consideration. These descriptions are to be no longer than is necessary to ensure understanding of the effects of the alternatives. Data and analyses in a statement must be commensurate with the importance of the impact, with less-important material summarized, consolidated, or simply referenced. Useless bulk in statements is to be avoided, and effort and attention must be concentrated on important issues. Verbosity does not enhance the adequacy of an EIS.
Environmental consequences	This section forms the scientific and analytical basis for the comparisons of action and alternatives. The discussion is to include the direct, indirect, and cumulative effects; any adverse environmental effects which cannot be avoided should the proposal be implemented; the relationship between short-term uses of humans' environment and the maintenance and enhancement of long-term productivity; and any irreversible or irretrievable commitments of resources which would be involved in the proposal.

Section	Comments
List of preparers	The EIS must list the names and qualifications (expertise, experience, professional disciplines) of the persons who were primarily responsible for preparing the document or any significant background papers including basic components of the statement. Where possible, the persons who are responsible for each particular analysis, including analyses in background papers, should be identified. Normally, the list will not exceed two pages.
Appendices	If an agency prepares an appendix to an EIS, the appendix must consist of material prepared in connection with the EIS and material which substantiates any analysis fundamental to the statement. It must be analytical and relevant to the decision to be made and must be circulated with the EIS or be readily available on request.

Analytical frameworks related to cumulative effects and management studies

Cumulative Effects Assessment and Management (CEAM) studies within EISs tend to be more challenging than addressing direct and indirect effects. Such studies need to be focused on compliance with the following quoted definition of cumulative impacts, as found in Section 1508.7 of the CEQ's NEPA Regulations (CEQ 1986).

> Cumulative impact is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertake such other actions. Cumulative impacts can result from individually minor, but collectively significant, actions taking place over a period of time.

CEQ's 11-Step analytical framework

Because the definition of cumulative effects is complex, CEQ issued guidance in 1997 on how to address CEAM in NEPA compliance activities (CEQ 1997). The key feature of this guidance was an 11-step process (or AF) for addressing CEAM (Table A4). Four EIA components provide a context for the 11 steps. A key phrase in Steps 4 through 8 is "resources, ecosystems, and human communities." Earlier EIA terminology referred to physical-chemical, biological, cultural, and socioeconomic components of the environment. A Canadian term, "valued ecosystem (or environmental) component" (VEC), is being increasingly used to encompass the phrase "resources, ecosystems and human communities," and the term is used in this report.

This example AF can be used to address new issues in water resources planning. One example is related to giving historical, current, and future attention to PSI changes within the planning process.

Table A4. An 11-step analytical framework for addressing CEAM component of NEPA compliance studies (after CEQ 1997).

EIA Components	CEAM Steps
Scoping	1. Identify the significant cumulative effects issues associated with the proposed action and define the assessment goals. 2. Establish the geographic scope for the analysis. 3. Establish the time frame for the analysis. 4. Identify other actions affecting the resources, ecosystems, and human communities of concern.
Describing the Affected Environment	5. Characterize the resources, ecosystems, and human communities identified in scoping in terms of their response to change and capacity to withstand stresses. 6. Characterize the stresses affecting these resources, ecosystems, and human communities and their relation to regulatory thresholds. 7. Define a historical reference for the resources, ecosystems, and human communities.
Determining the Environmental Consequences	8. Identify the important cause-and-effect relationships among human activities and resources, ecosystems, and human communities. 9. Determine the magnitude and significance of cumulative effects on specific VECs.
Mitigation and Management	10. Modify or add alternatives to avoid, minimize, or mitigate significant cumulative effects. 11. Monitor the cumulative effects of the selected alternative and adapt management.

Canadian 12-step analytical framework

In 1999, the Canadian Environmental Assessment Agency (CEAA) issued a practitioner's guide for CEAM (Hegmann et al. 1999). Table A5 shows the 12 steps in the CEAA AF, which is similar to the CEQ's 11-step AF in Table A4.

The CEAA assessed incremental additive effects of proposed actions on VECs. Similar to the CEAM (for U.S.), total effects are compared to thresholds or policies, and their implications regarding the VECs are assessed. Basically in CEAA, a key task is examining the effects on a VEC until the incremental contribution of all actions on the VEC is understood. It is important to note that an assessment of a single project must determine if that project is incrementally responsible for adversely affecting a VEC beyond an acceptable point (i.e., threshold). The total effect on the VEC may be due to many actions; thus the CEAA must make clear to what degree the project under review is alone in contributing to that total effect.

Table A5. Analytical framework for CEAM compliance studies in Canada (Hegmann et al. 1999, 9).

EIA Components	CEAM Steps (Tasks)
Scoping	1. Identify regional issues of concern. 2. Select appropriate regional VECs. 3. Identify spatial and temporal boundaries. 4. Identify other actions that may affect the same VECs. 5. Identify potential impacts due to actions and possible effects.
Analysis of effects	6. Complete the collection of regional baseline data. 7. Assess effects of the proposed action on selected VECs. 8. Assess effects of all pertinent actions on selected VECs.
Identification of mitigation	9. Recommend mitigation measures.
Evaluation of significance	10. Evaluate the significance of residual effects. 11. Compare results against thresholds or land use objectives and trends.
Follow-up	12. Recommend regional monitoring and effects management.

Example of using multiple AFs in a CEAM study

USACE conducted the Ohio River Mainstem System Study (ORMSS) to develop a system investment plan (SIP) for maintaining safe, environmentally sustainable, and reliable navigation on the 981-mile Ohio River over the period 2010–2070. This plan is intended to serve as a long-term planning tool for decision makers in the budgeting and asset/infrastructure management processes. This study evaluated system-wide impacts through a Programmatic Environmental Impact Statement (PEIS). Navigation investment alternatives were formulated based on five possible navigation traffic scenarios associated with utility coal use, air-quality compliance policy, and economic growth. The overall study involved using the USACE six-step planning process along with several more-focused AFs related to direct, indirect, and cumulative effects.

The purpose of this example is to demonstrate the use of multiple AFs within a planning and modernization project for inland navigation. More detailed information is included in the February 2011 plan documents (USACE 2011) that can be obtained from the Pittsburgh District.

Analytical frameworks for economic, engineering, and environmental issues

As stated above, the study addressed economic, engineering, and environmental issues via AFs to develop the plans for navigation infrastructure to the year 2070 (USACE 2011). Economic issues were derived from a range of projections of navigation traffic increases and cost inefficiencies that occur due to barge queuing when main locks are subjected to either scheduled or unscheduled maintenance or repair. Addressing economic issues included an evaluation of traffic scenarios, use of existing navigation traffic and habitat models, and development of the new Ohio River Navigation Investment Model (ORNIM).

As an adaptive management strategy for the Ohio River main-stem, ORNIM (including all input data) is a flexible tool that can be used in a variety of future applications. ORNIM could be used to determine how a new transportation-related scenario would affect system-wide priorities for federal investments in navigation infrastructure. For example, PSI changes might include modification of planning assumptions utilized in the ORMSS such as assuming that all previously authorized projects would be completed as planned or other fundamental changes affecting system-wide priorities. Re-examination of system results in such a manner would be a cost-effective means of determining revised priorities due to significant PSI changes and could be considered an AF for managing future unanticipated PSI changes. Major PSI changes would require further efforts beyond ORNIM, including economic and environmental analyses.

Engineering issues encompassed the possibility of constructing larger auxiliary locks at several locations and developing risk functions and consequences of component failures that were used to proactively schedule major repairs, rehabilitations, and replacements at existing facilities. These risk-based considerations and related event trees comprised the AFs for engineering evaluations. Environmental issues were addressed in a CEAM study of the entire mainstem navigation system.

Lessons learned about analytical frameworks from ORMSS

The ORMSS was planned within a comprehensive AF and supported by several complementary frameworks. Numerous lessons were articulated about using AFs in the ORMSS, including those listed below.

- The CEQ's 11-step CEAM process provided a useful comprehensive framework that was easily modified during the continued planning and implementation of the CEAM study.
- A CEAM study for a large-scale water resources plan requires both a holistic approach and systematic thinking. Multiple AFs can be utilized.
- Educational efforts related to CEAM were important; such efforts were directed toward the CEAM Central Planning Team, an Oversight Board, the Interagency Working Group, and attendees at agency and public scoping meetings. AFs can provide useful concepts for explanation.
- Collaboration efforts were vital to planning and conducting the CEAM study. The Interagency Working Group (IWG) utilized multiple AFs in their discussions.
- For large-scale planning efforts, special studies and research efforts may be needed to answer fundamental questions related to selected VECs, cumulative effects on such VECs, and interactions between and among VECs. Such studies and efforts can be framed within supplementary AFs.
- An important conceptual perspective is that cumulative effects must be addressed on selected VECs. In doing this, it is important for the central planning team and stakeholder groups to "think from the perspective of the VECs." Such thinking requires a mind-shift from focusing on the proposed action to focusing on the VEC recipients of the contributed effects. This mind-shift itself represents an AF.
- It is unlikely that quantified predictions of future cumulative effects can be achieved for all VECs; however, the use of relative contribution categories and scenarios of alternative futures can be aids in conducting a CEAM study.
- The environmental sustainability of selected VECs can serve as an integrator of cumulative effects and as a basis for VEC prioritization and establishment of the significance of such effects (Canter and Rieger 2005). Further, sustainability enhancement can be a useful basis and serve as an AF for planning and implementing proposed action mitigation and cumulative effects management efforts, including the initiation and use of an adaptive management program.

Observations on analytical frameworks within environmental compliance activities

This appendix includes referrals to several AFs (compliance processes) for meeting the environmental requirements of multiple federal laws. Particular attention is given to AFs for satisfying documentation requirements associated with addressing direct, indirect, and cumulative effects of water resources projects. Of particular note is an 11-step CEAM process (AF) developed by the CEQ and the 12-step “Cumulative Effects Assessment Practitioners Guide” prepared for the CEAA (Hegmann et al. 1999). Examples of topic-specific AFs within the 12-step AF are also mentioned. Accordingly, the primary point of this appendix is to demonstrate that several environmental compliance AFs already exist, and they can be used as supporting frameworks to the USACE six-step planning process.

Appendix B: Analytical Frameworks for Water Resources Planning and Management

Introduction

An Institute for Water Resources (IWR) report includes an excellent review of watershed planning issues and constraints (Cole, Feather, and Letting 2002). Examples used in the report relate to information on fragmented authorities and missions of federal water resources agencies, and analytical challenges within existing water resources planning frameworks (AFs). This IWR report also reviews a watershed planning AF from the USEPA, an adaptive management AF from the U.S. Forest Service, and the USACE six-step AF for water resources planning and management. Possibilities for integrating the three AFs were also described.

The IWR report indicates that fragmentation of government authority may be the primary constraint influencing the efficiency, effectiveness and completeness of the watershed planning process. Because water-related government entities have grown so large and complex, coordination and communication across agency authorities and missions have become one of the fundamental, operational challenges.

Within the 21st century, several newer issues and their associated AFs have been included in water resources planning and management. For example, several newer issues are grouped below in accordance with Steps 2, 4, and/or 6 of the USACE process.

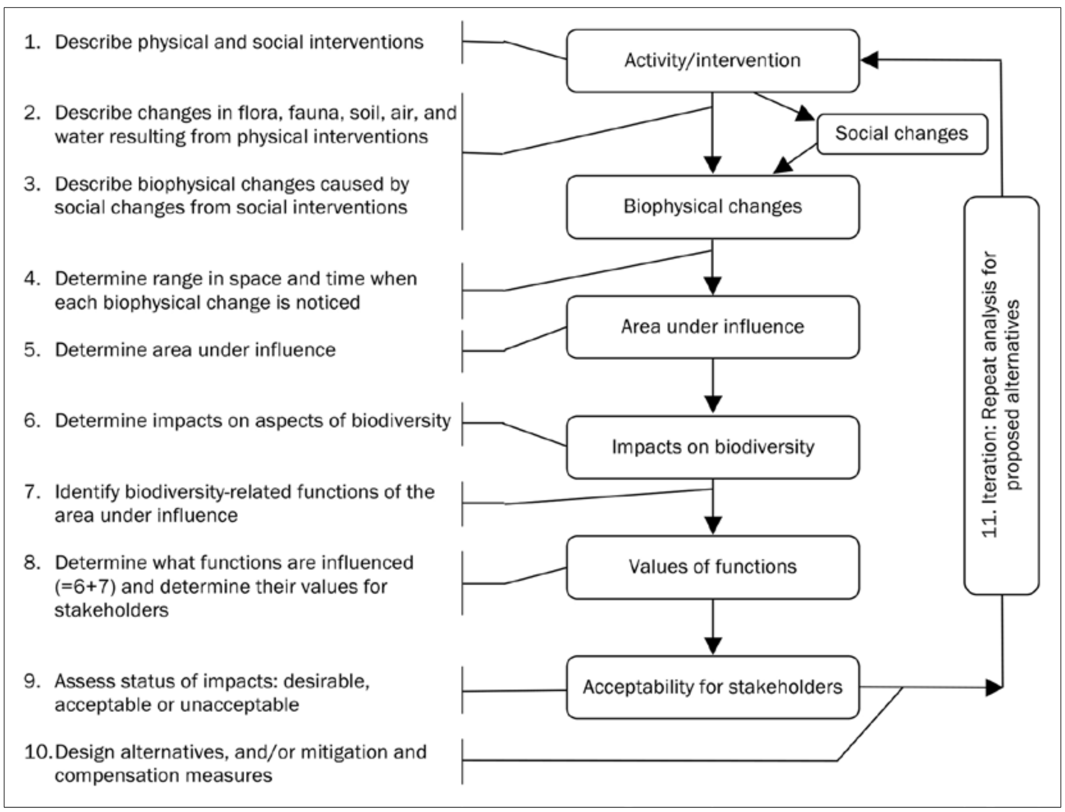
- **Step 2** (Inventorying and forecast alternatives) – issues related to biodiversity assessment, water supply protection, environmental and watershed sustainability, and climate change.
- **Step 4** (Evaluating alternative plans) – issues related to watershed-level conceptual modeling, ecological flows, ecological risk assessment, and risk management.
- **Step 6** (Select a plan) – issues related to ecological restoration and adaptive project and environmental management (including monitoring).

Analytical Frameworks Related to Inventorying and Forecasting

Biodiversity assessment

Biodiversity assessment was highlighted in 2002 by the Convention on Biological Diversity's (CBD's) issuance of guidelines related to incorporating biodiversity assessments in environmental impact studies (CBD 2002). Figure B1 displays an 11-step AF which can be used in planning and conducting biodiversity assessments (Slootweg 2005). Steps 1–10 encompass features of Steps 2 and 4 of the USACE six-step water resources planning process. Step 11 involves "iteration." The framework is intended to be used iteratively, so identification of alternatives and mitigation is not postponed until the end. These 11 steps could also serve as a useful AF for examining cumulative effects from multiple other projects and actions on biodiversity.

Figure B1. Analytical framework for biodiversity assessment (after Slootweg 2005.)



Landscape ecological assessment

Another example related to biodiversity assessment involves the use of landscape ecological assessment (LEA) as a tool for integrating biodiversity considerations in larger scale SEA. In this case, landscape ecology was used to develop a conceptual framework for assessing the consequences of long-term developments under several scenarios (Mortborg, Balfors, and Knol 2007). A case study using LEA was conducted in the region encompassing Stockholm, Sweden. The integration of biodiversity issues in LEA requires prediction tools that employ relevant knowledge on the impact of land-use changes on the fauna and flora inhabiting the area. Loss and fragmentation of natural habitats can be major causes for the decline of biodiversity. The magnitude and significance of impacts on biodiversity are not easy to determine, as they depend on various aspects such as the landscape context of the study area, the scope of the proposed development, and the vulnerability of a species to external influences.

The LEA AF used systematic steps and GIS to evaluate scenarios of development. A central feature of LEA is using indicators of habitat type and quality along with their spatial distributions. LEA can be a tool for integration of biodiversity issues in planning; such planning is based on landscape ecological knowledge, which facilitates quantification and visualization of biodiversity effects in the assessment process. The resultant maps of habitat networks can be used for decision support. Accordingly, LEA would support the USACE planning process in evaluating and comparing alternative plans. This tool could also be further explored relative to its use for CEAM within regional-scale and strategic-level studies.

Watershed-level prioritization model

Randhir et al. (2001) described the development of a watershed-level prioritization model and its use in a water-supply protection program for the Ware River watershed in Massachusetts. The model was composed of GIS-derived spatial information on watershed land uses, relationships between land uses and surface runoff, water quality, and the travel time of the runoff water from the watershed. An expert elicitation process was used along with the analytical hierarchy process (AHP) in the development of the prioritization model. The model results were then used to plan land acquisition and land cover management programs. The AF was composed of a conceptual model, information assemblage, prioritization of factors related to land use and time of travel, and the development of priority indices and protection measures for subwatersheds in the study area.

U.S. Army's Sustainable Installations Regional Resource Assessment (SIRRA)

The determination of both water demand sustainability and water quality sustainability conditions over time and spatial areas requires AFs, and USACE's six-step planning process can be used as the basis for such sustainability-related studies. The Army's Sustainable Installations Regional Resource Assessment (SIRRA) methodology was used to characterize U.S. watersheds by using a subset of indicators. The work involved the development of a methodology aimed to identify watersheds with potential sustainment problems and to rank 2,250 HUC8 watersheds by their relative vulnerability to such problems (Jenicek et al. 2005). For each watershed, 23 indicators were used to develop a composite score that indicated the vulnerability of the watershed or the stress that it had incurred from development. The SIRRA methodology could be used in the early steps of water resources planning (USACE Steps 1 and 2) and in formulating, evaluating, comparing, and selecting a plan (Steps 3–6).

Jenicek et al. (2009) described a refinement and extension of the 2005 SIRRA method that included 24 indicators with the potential for measuring HUC8 watershed sustainability in terms of water supply and demand. Indicators were rated on a red-amber-green rating scale, and the results were graphically portrayed as a first-cut evaluation of watershed health using national data sets. The document contains a web-based decision support framework as an aid to improved system-wide decision making and communication with stakeholders. This tool can be used to support watershed planning and management.

Climate change

In 2009, four federal agencies jointly released an interagency report that explores strategies for improving water management by tracking, anticipating, and responding to climate change (Brekke et al. 2009). The agencies included the U.S. Geological Survey (USGS), USACE, USBR, and the National Oceanic and Atmospheric Administration (NOAA).

Selected issues about climate change that could be used within an AF for watershed management are listed below (Brekke et al. 2009).

- Climate change could affect all sectors of water resources management since it may require changed design and operational assumptions about resource supplies, system demands or performance requirements, and operational constraints.

- Long-term monitoring networks are critical for detecting and quantifying climate change and its impacts. Continued improvement in the understanding of climate change, its impacts, and the effectiveness of adaptation or mitigation actions requires continued operation of existing long-term monitoring networks and improved sensors deployed in space, in the atmosphere, in the oceans, and on the Earth's surface.
- Monitoring needs to focus on locations that describe the climate signal (e.g., upstream and downstream from major water-management infrastructure or in vulnerable ecological reaches).
- Paleoclimate information and stochastic modeling can be useful for developing climate scenarios that include a wide range of potential hydroclimatic conditions. The expanded variability may allow a more robust evaluation of planning alternatives, particularly when there is concern that study outcomes and decisions may be sensitive to climate assumptions.
- Adopting alternatives that perform well over a wide range of future scenarios (PSI changes) could improve system flexibility. Water resources planning and management requires recognition of existing and potential future uses of water resources, particularly when public health and safety are involved.
- Adaptive management involves an approach where decisions are made sequentially over time, thus allowing adjustments to be made as more information becomes known. This approach may be useful in dealing with the additional uncertainty which can be introduced by potential climate change.
- Adaptive options in response to climate change can include operational changes in reservoirs, water demand management, infrastructure modifications, and climate-influenced designs.

Adaptive management traditionally focuses on a framework where robust decision criteria may be considered. It is based on an iterative process of six steps: (1) assess the problem, (2) design, (3) implement, (4) monitor, (5) evaluate, and (6) adjust (Williams and others, 2007). Several of the USACE six planning steps are related to this framework. Adaptive management is more suited to guiding operational or institutional changes rather than construction of new water-related facilities. There is considerable on-going research designed to address effects of climate change on water resources, including quantity and quality. More research is still needed to identify and address knowledge gaps to evaluate uncertainties and risks required for more informed decision making.

Climate change and environmental impact assessment

Table B1 shows an AF composed of five steps for addressing climate change effects created by Canada's The Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment (CEAA 2003). These steps provide a useful AF for planning and implementing a CEAM-related study of climate change effects. The framework provided a unique initiative in Canada's response to climate change and it provides a consistent methodology for practitioners.

Table B1. Analytical Framework for assessing climate change effects on water resources and associated plans and projects (after CEAA 2003).

Step	Guidance
Step 1 – Preliminary Scope for Impacts Considerations	• Focus on general considerations and readily accessible information. • Are there likely to be impact considerations associated with the project that should be addressed in greater detail? • Document a rationale as to why or why not impacts should be addressed. • If there are no likely impact considerations that should be addressed in greater detail, no further analysis is required. • Proceed to Step 2 if further analysis is required.
Step 2 – Identify Impacts Considerations	• Identify project and environmental sensitivity to possible changing climatic parameters. • Conduct more detailed collection of regional climate change and project-specific information. • Clarify changing climatic parameters (magnitude, distribution and rate of changes).
Step 3 – Assess Impacts Considerations	• Assess range of possible changes to climatic parameters. • Determine the range and extent of possible impacts on the water resources project. • Assess the potential risks to the public or environment. • Based on the risks to the public or environment resulting from the effects of climate change on the water resources project, determine whether impact management is required. • Proceed to Step 4 if further action is required.

Step	Guidance
Step 4 – Impacts Management Plans	If the water resources project is likely to pose risks to the public or environment resulting from the effects of climate change: • Clarify mitigation measures to reduce project vulnerability. • Clarify adaptive management plan to reduce risks associated with climate change. • Incorporate ongoing information gathering and risk-assessment. • Distinguish between public and private sector risks and responsibilities.
Step 5 – Monitoring, Follow-up, and Adaptive Management	• Monitor status of water resources project and effectiveness of mitigation measures. • Implement remedial action as necessary. • Incorporate "lessons learned" into normal procedures. • Address evolving project and climate change knowledge, technology, policy and legislation

National Research Council

The National Research Council (NRC) published the results of a study on adapting to the impacts of climate change (NRC 2010). As part of this study, the panel described a multiple-activity planning process (AF) for developing and implementing an adaptation strategy. The adaptation planning process includes the activities listed below.

- **Activity 1** – Identify current and anticipated future climate changes and their potential effects that are relevant to the system being studied (e.g., river reach, lakes, public water system, coastal area). This identification is particularly relevant for determining the "future without project condition" and, ultimately, the "future with project condition" under various scenarios or alternative plans.
- **Activity 2** – Assess the vulnerabilities and risks to the water resources associated with the system being studied.
- **Activity 3** – Develop an adaptation strategy using risk-based prioritization schemes applied to an array of options (note that the array could range from one option to various combinations of multiple options).
- **Activity 4** – Identify opportunities for resources-related co-benefits and synergies resulting from combinations of multiple options.
- **Activity 5** – Implement adaptation options within the system.
- **Activity 6** – Monitor, re-evaluate, and adjust (if necessary) implemented adaptation options.

These six activities can be envisioned as a linear process or as one that includes specific feedback loops. One example of a loop would be to use the monitoring results (Activity 6) to refine future climate changes (Activity 1). Results could also be used to adjust prioritization schemes (Activity 3) and implement adaptation options (Activity 5).

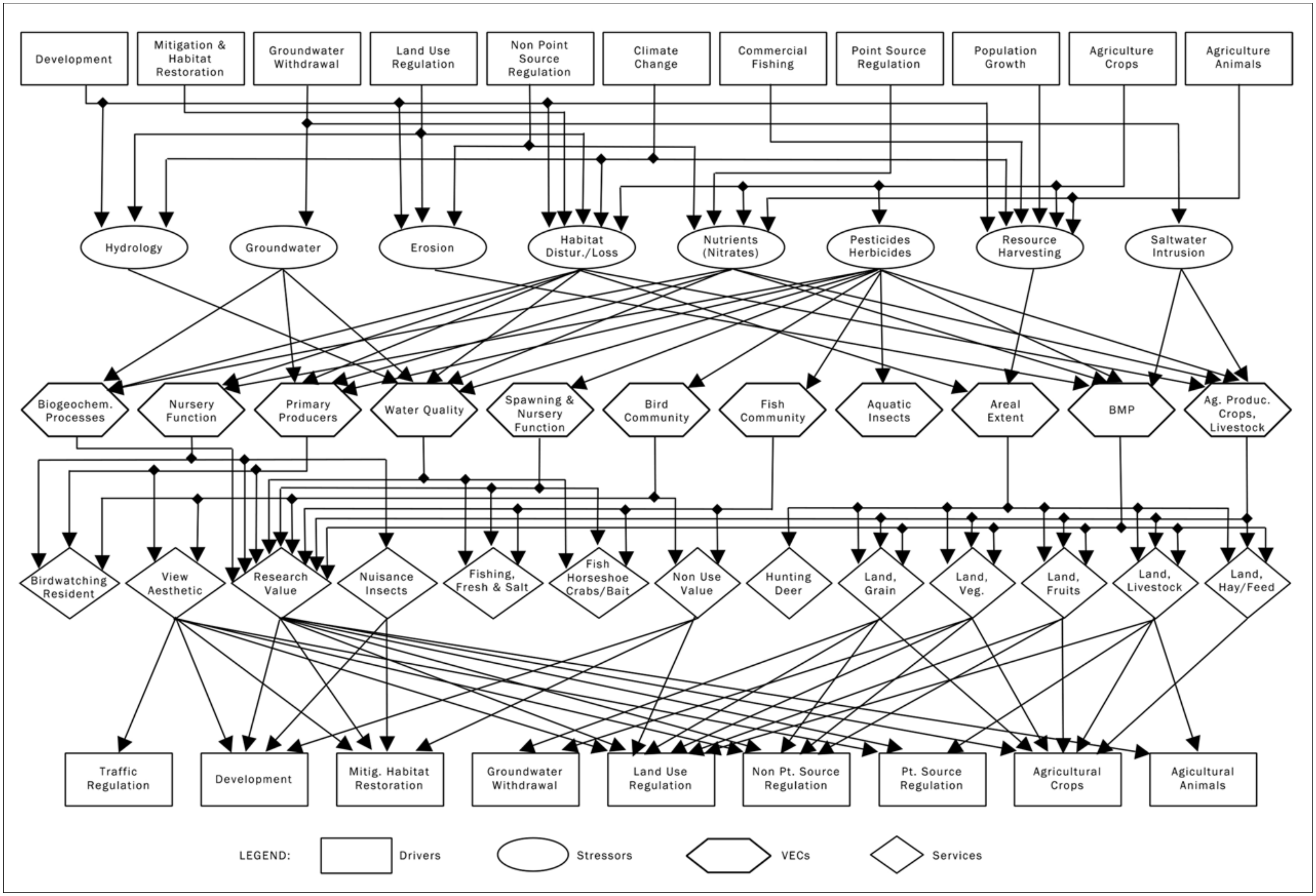
The NRC process is compatible with the USACE six-step planning process for water resources plans and projects. Further, the six activities also relate to eight of the 11 steps in the CEQ's CEAM process (CEQ 1997). Steps 4–11 in the CEQ's AF have direct relevance to incorporating climate change in CEAM. Steps 10 and 11 are specifically focused on mitigation and cumulative effects management. Adaptation considerations are primarily related to Step 11.

Analytical frameworks for issues related to evaluating alternative plans

Watershed conceptual model

Watershed-based planning is returning to importance within the six-step USACE water resources planning process. Watershed planning requires a holistic approach in terms of problem identification, inventorying and forecasting conditions, and evaluating alternative plans. A watershed-scale conceptual model could provide the basis for a holistic approach. Figure B2 depicts a GIS-based, watershed-scale, conceptual model developed for the St. Jones River watershed (84 sq mi) in Delaware (Reiter et al. 2009, 3260). The model was developed from habitat and land-use information. The model can be used both to enhance understanding of watershed ecological, social, political, and economic considerations and to facilitate quantitative calculations of the consequences of future watershed changes.

Figure B2. St. Jones River watershed conceptual model (after Reiter et al. 2009).



Analytical frameworks for ecological flows

Recent attention has also been directed toward managing downstream flows from impounded waters. This is done to maintain an ecologically sustainable water management program associated with either single dams in a watershed or multiple dams in a river basin. Implied in this attention is the need to expand typical project purposes from water supply, flood risk reduction, and/or navigation to also include attention to minimum flows for maintaining or enhancing downstream aquatic ecological conditions. Richter et al. (2003) described an AF for determining necessary ecological (environmental) flows (Figure B3). The relevant AF includes the six steps listed below.

- **Step 1: Estimate ecosystem flow requirements** – develop initial numerical estimates of key aspects of river flow necessary to sustain native species and natural ecosystem functions.
- **Step 2: Determine influence of human activities** – account for human uses of water, both current and future, through development of a computerized hydrologic simulation model that facilitates examination of human-induced alterations to river flow regimes.
- **Step 3: Identify areas of potential incompatibility** – assess incompatibilities between human and ecosystem needs with particular attention to their spatial and temporal character.
- **Step 4: Foster collaborative dialogue to search for solutions** – collaborate with other agencies and stakeholder groups, search for solutions to resolve incompatibilities.
- **Step 5: Conduct water management experiments to resolve uncertainty** – use water management experiments to resolve critical uncertainties that hamper efforts to integrate human and ecosystem needs.
- **Step 6: Design and implement an adaptive management plan** – use this plan (program) to facilitate short- and long-term decision making relative to ecologically justifiable water management.

In another publication, Richter et al. (2006) described a systematic process (AF) for planning a specific adaptive management program for developing environmental flow recommendations. The five-step AF (Figure B4) includes: (1) an orientation meeting; (2) a literature review and summary of existing knowledge about flow-dependent biota and ecological processes of concern; (3) a workshop to develop ecological objectives and initial flow recommendations and identify key information gaps; (4) implementation of the flow recommendations on a trial basis to test hypotheses and reduce uncertainties; and (5) monitoring of the system response and further research as warranted. Further, and depending on locale, recommended monthly low flows can be developed along with periodic annual flow pulses and floods with targeted inter-annual frequencies. This AF was applied to the Thurmond Dam and Reservoir in South Carolina, and the resulting flow recommendations were included by the USACE within a comprehensive river-basin planning process.

Figure B3. Analytical framework for ecologically sustainable water management (after Richter, et al. 2003, 209).

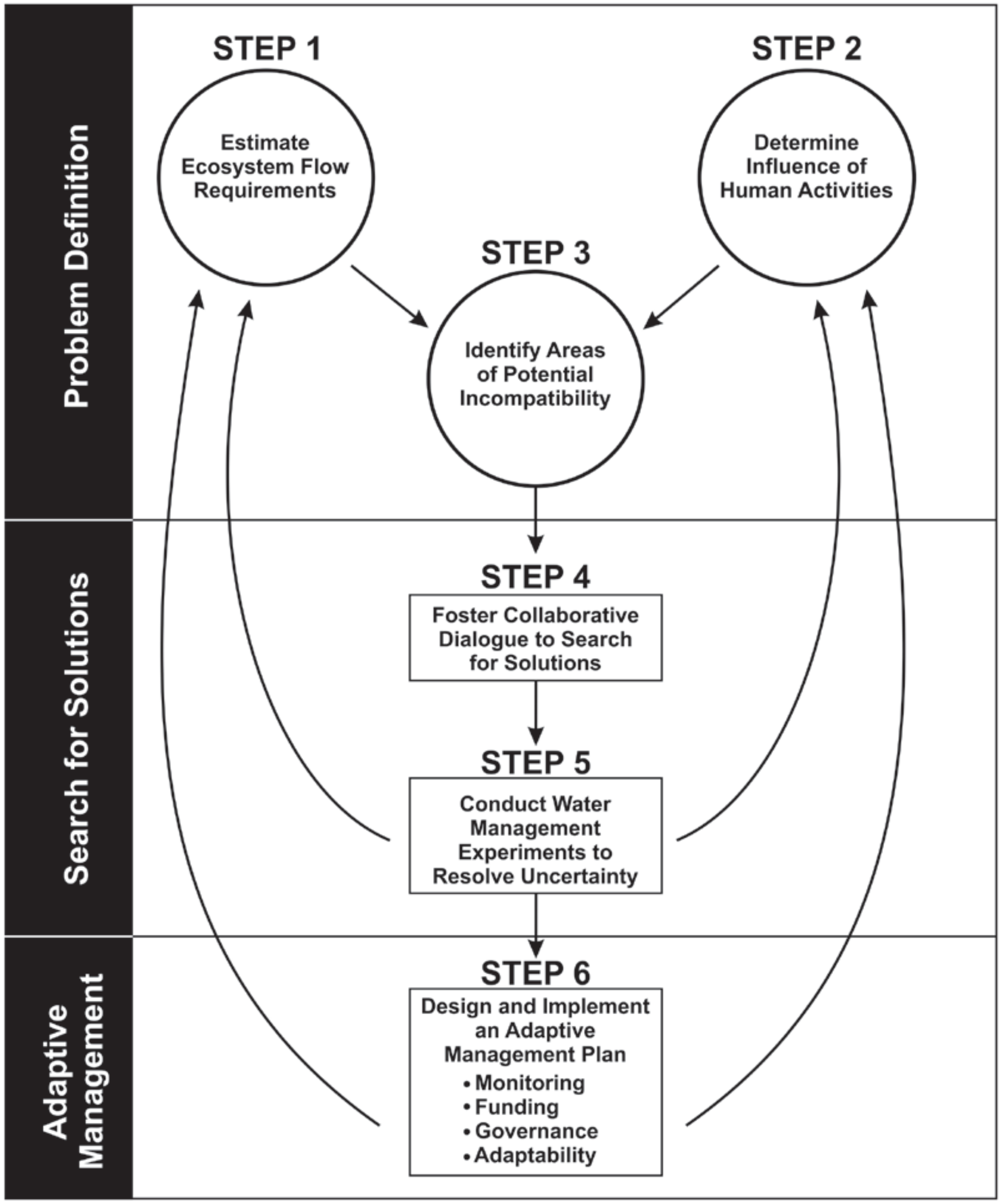
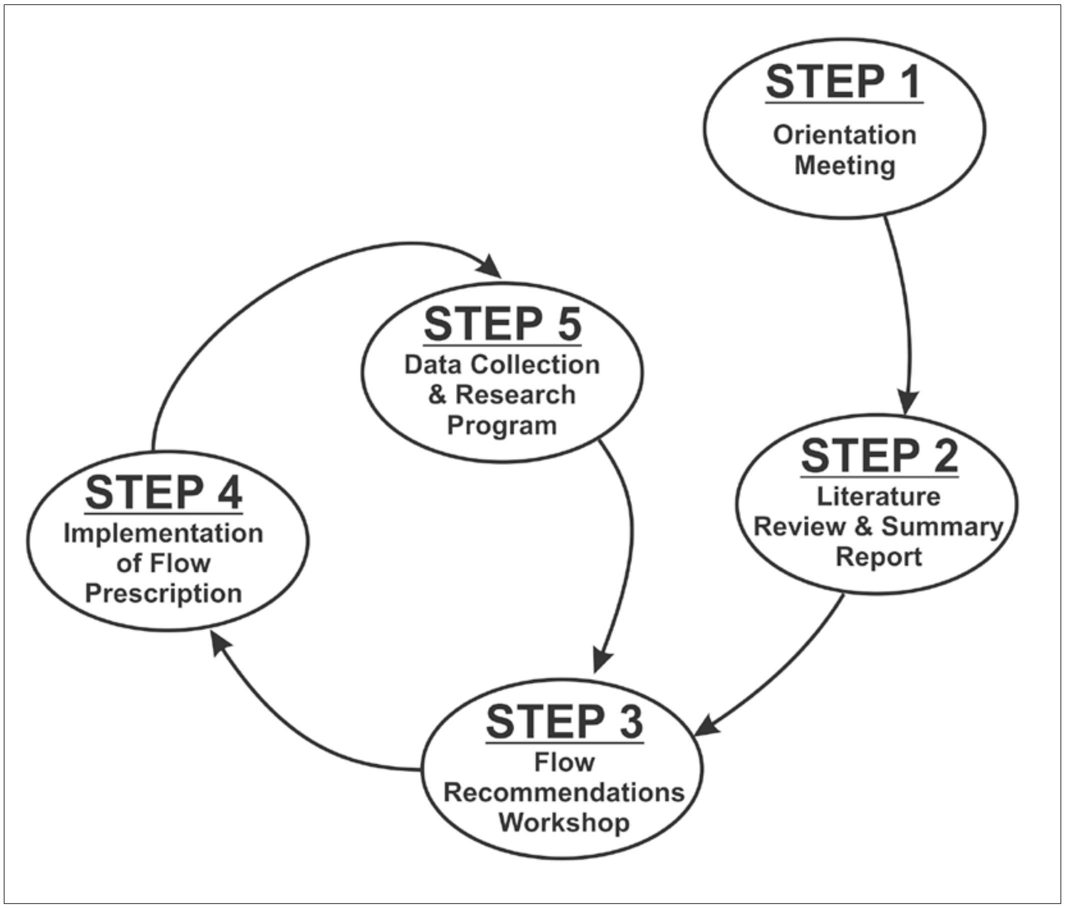


Figure B4. Analytical framework for developing environmental flow recommendations comprises five steps (after, Richter et al. 2006, 300).



Ecosystem management decision support system

The ecosystem management decision support (EMDS) system for watershed assessments was originally developed by the U.S. Forest Service and USEPA (Jensen et al. 2000). In general, this EMDS system integrates GIS and knowledge-based system technologies into an analytical tool for watershed environmental assessment and monitoring. The developed EMDS system was based on an AF that consisted of defining core topics and questions. The core topics for watersheds included erosion processes, hydrologic processes, vegetation patterns, stream channel features, water quality, species and habitats, and human uses. Indicators for each of these types are also specified. The core questions related to each of these seven topics are listed below (Jensen et al. 2000).

- What are the dominant or important patterns and processes within the watershed?
- What are the current conditions and trends?

- What were the historic conditions?
- What are the natural and human causes of change between historic and current conditions?
- What are the relationships between core topic patterns and processes?

The findings from the topic-specific core questions are then integrated based on the following sequential six-step analysis process (Jensen et al. 2000).

1. Characterization of the Watershed – This step involves identification of the dominant physical, biological, and human processes or features of the watershed that affect ecosystem functions or conditions;
2. Identification of Issues and Key Questions – This step is used to focus the analysis on the key elements of the ecosystems that are most relevant to the management questions and objectives, human values, or resource conditions within the watershed;
3. Description of Current Conditions
4. Description of Reference Conditions
5. Interpretation of Information – This step involves comparison of existing and reference conditions of specific ecosystem elements in the identification of significant differences, similarities or trends and their causes.
6. Recommendations – The purpose of this step is to bring the results of the previous steps to conclusion, focusing on management recommendations that are responsive to watershed processes identified in the analysis.

This six-step watershed assessment EMDS system is directly related to Step 1 (specify problems and opportunities) and Step 2 (inventory and forecast conditions) of USACE's six-step planning process.

Analytical frameworks related to plan selection

AFs for risk assessment in ecological restoration projects

Risk assessment can be a useful tool in water resources planning. Because of risks and uncertainties related to the potential effectiveness of ecosystem restoration projects, an AF for integrating risk analysis considerations within the USACE six-step planning process has been developed (Thom et al. 2004). The risk analysis AF includes, but is not limited to, identifying risk-related concerns (Step 1), development of one or more conceptual models (Step 2), use of ecological risk assessment concepts (Step 3), and evaluation, comparison, and selection of ecological restoration projects (Steps 4–6). This example is useful for two reasons: it demonstrates how newer issues can be incorporated into the planning process, and it also demonstrates how to factor risk considerations into planning. Thom et al. (2004, 2) lists the following benefits of incorporating risk analysis in the AF, which allow USACE planners to:

- identify the levels of uncertainty that are acceptable, at the start of the planning process;
- use conceptual and numerical models to communicate the planning team's understanding of the ecosystem to others, and reduce the risk of mis-specifying the system;
- consider the uncertainty associated with the variables chosen to measure project effects;
- examine alternative designs to manage identified uncertainty;
- explore risk information to eliminate alternatives with unacceptable risk from consideration;
- incorporate risk analysis into USACE's traditional four decision criteria of: effectiveness, efficiency, completeness, and acceptability;
- introduce an alternative's irreducible uncertainty as an attribute to be considered along with other attributes in the comparison of alternative plans; and
- include risk information in the final plan selection process.

One feature of integrating the risk analysis AF is the focus given to the development and use of one or more conceptual models. In addition, the report includes an example of the application of risk analysis to six planning steps associated with a project for restoring the functions of a degraded tidal wetland.

Another example from a different source is related to the restoration of aquatic ecosystems, and it involved the use of a watershed approach to establish restoration priorities (Bohn and Kershner 2002). This approach was used by the U.S. Forest Service to prioritize, plan, and implement restoration activities in the Whitefish Mountains of northwest Montana. A six-step watershed-based AF consisted of: characterization of environmental and social processes, delineation of key issues and questions to be addressed, documentation of current conditions, description of reference conditions, synthesis and interpretation of the assembled information, and development of prioritized recommendations.

Adaptive management for resource stewardship

Six fundamental elements in an AF for the adaptive management process include (NRC 2004):

- **Element 1** – Management objectives regularly revisited and accordingly revised
- **Element 2** – Model(s) of the system being managed
- **Element 3** – Range of management choices
- **Element 4** – Monitoring and evaluation of outcomes
- **Element 5** – Mechanism for incorporating learning into future decisions
- **Element 6** – Collaborative structure for stakeholder participation and learning

Further elements or sub-elements for consideration include the assemblage of information on historical and current conditions of key indicators for resources that are potentially subjected to effects from a plan, program, or project and other actions; and the quantitative prediction or qualitative description of these anticipated effects, along with impacts from other past, present, and reasonably foreseeable future actions (i.e., the cumulative effects) on the key indicators. Further, assembling information on organizations with responsibilities for resource management, resource-specific models and tools, and existing monitoring programs is also an important supporting foundational element (Canter and Hollins 2005; Canter, Hollins, and Harrell 2005).

Another element involves collaborative long-term agreements among pertinent federal, state, tribal, and local environmental agencies with a program management board (or steering committee) comprising representatives from these agencies. Another consideration includes adequate budgetary and personnel resources. Finally, a peer group of advisors with expertise in the science of the key resources, public policy analyses, the planning and conduct of environmental monitoring and research, and environmental decision making would be supportive of adaptive management programs.

Further, implementation guidance has been issued for monitoring ecosystem restoration projects (Section 2039 of Water Resources Development Act [WRDA] 2007; U.S. Congress 2007) and contingency (adaptive management) planning (Section 2036 of WRDA 2007; USACE Aug. 2009).

Appendix C: Background Reading Related to Analytical Frameworks for Addressing Physical, Social, and Institutional Changes and Associated Impacts

Introduction

This appendix contains summary information on two groups of reading lists which can support the use of AFs in water resources planning. The "background reading list" includes citations of 15 references for AFs that address general and specific types of PSI changes and their associated impacts (or consequences). These references are included to provide supporting information for practitioners involved in identifying and evaluating PSI changes in water resources planning. The second section includes additional references related to AFs for conducting CEAM studies within regional and strategic planning.

The types of documents cited in this appendix encompass peer-reviewed journal articles, government reports, and a book chapter. Each of the 20 references was procured and subjected to a brief review by the authors that ranged from reading the abstract to examining the contents of entire documents. Each citation includes a bolded parenthetical note of the topic it covers. The user of this background reading appendix could readily procure the majority of the listed documents via online downloads.

Background Reading List

Bruch, C., M. Nakayama, J. Troell, L. Goldman, and E. Maruma Mrema. 2008. "Assessing the Assessments: Improving Methodologies for Impact Assessment in Transboundary Watercourses." Impact Assessment and Project Appraisal 26(4): 239–251. **(Transboundary impacts)**

Hansen, S., and C. Fischenich. 2002. *An Assessment of Watershed Planning in Corps of Engineers Civil Works Projects*. ERDC TN-EMRRP-SR-34. Vicksburg, MS: U.S. Army Corps of Engineers, Engineer Research and Development Center – Environmental Laboratory. **(Watershed planning)**

Jenicek, Elisabeth M., Natalie R.D. Myers, Donald F. Fournier, Kevin Miller, MeLena Hessel, Rebecca Carroll, and Ryan Holmes. 2009.*Army Installations Water Sustainability Assessment*. ERDC/CERL TR-09-38. Champaign, IL: U.S. Army Corps of Engineers, Engineer Research and Development Center – Construction Engineering Research Laboratory. **(Watershed planning)**

Katz, D. 2006. "Going with the Flow: Preserving and Restoring Instream Water Allocations." Ch. 2 in *The Worlds Water – 2006-2007 – The Biennial Report on Freshwater Resources*, edited by G. Wolff, H. Cooley, M. Palaniappan, A. Samulon, E. Lee, J. Morrison, D. Katz, and P. Gleick, 29–49. Washington, DC: Island Press. **(Watershed management)**

Koehler, Brandi, and Tomas M. Koontz. 2008. "Citizen Participation in Collaborative Watershed Partnerships." Environmental Management 41: 143–154. **(Collaboration)**

Koontz, Thomas M., and Craig W. Thomas. 2006. "What Do We Know and Need to Know About the Environmental Outcomes of Collaborative Management?" Public Administration Review 66(Issue Supplement s1, Environmental Outcomes of Collaborative Management): 111–121. **(Collaboration)**

Lund, Jay R. 1996. "Developing Seasonal and Long-Term Reservoir System Operating Plans Using HEC-PRM." RD-40. Davis, CA: U.S. Army Corps of Engineers, Institute for Water Resources – Hydrologic Engineering Center. **(Models-operations)**

McDermaid, Karen K., and Daniel C. Barnstable. 2001. "Step-by-Step Guide to Conducting a Social Profile for Watershed Planning." Champaign, IL: University of Illinois at Urbana-Champaign, Department of Natural Resources and Environmental Sciences. **(Watershed planning)**

Morton, Lois Wright, and Steve Padgitt. 2005. "Selecting Socio-Economic Metrics for Watershed Management." Environmental Monitoring and Assessment 103: 83–98. **(Watershed planning)**

Orth, K.D., and Yoe, C.E. 1997. "Planning Primer." IWR Report No. 97-R-15. Alexandria, VA: Institute for Water Resources, Water Resources Support Center. **(Planning)**

Richards, L. 2006. "Protecting Water Resources with Higher-Density Development." EPA Publication No. 231-R-06-001. Washington, DC: U.S. Environmental Protection Agency. **(Land use)**

USACE. 2003. "Planning Civil Works Projects under the Environmental Operating Principles." EC 1105-2-404, May 1, 2003, Washington, DC: Headquarters, USACE. **(Collaboration)**

Wathern, P., S.N. Young, I.W. Brown, and D.A. Roberts. 1987. "Assessing the Impacts of Policy: A Framework and an Application." Landscape and Urban Planning Vol. 14:321–330. **(CEAM)**

Wiering, M., and Immink, I., "When Water Management Meets Spatial Planning: A Policy-Arrangements Perspective", Environment and Planning Part C: Government and Policy, Vol. 24, 2006, pp. 423-438. **(Incremental changes)**

Additional reading list for analytical frameworks for CEAM in Regional and Strategic Studies

AFs for CEAM studies were addressed in Appendix A. Five other AFs for addressing CEAM in regional Environmental Impact Assessments or Strategic Environmental Assessments have relevance for impact studies at large scales and could be relevant for individual watersheds to river basin planning (see “References” chapter that follows for publication details of resources listed below):

- Dube (2003) describes an AF for regional evaluations of CEAM for aquatic ecosystems in Canada.
- Noble (2008) presents an AF incorporates strategic approaches for addressing CEAM at the regional level. The AF is applied to the Great Sand Hills area in the Saskatchewan Province in Canada.
- Harriman and Noble (2009) describe the conceptual basis and an AF for Regional SEAs. These studies include attention to CEAM.
- Larsen and Kornov (2009) provide an AF for incorporating climate change in SEAs focused on river basin management plans.
- Cooper (2004) highlights an AF for addressing CEAM in plan-related SEAs. The primary focus is on applications in the United Kingdom, although such applications could encompass numerous countries.

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Abbreviations

AF = analytical framework

AHP = analytical hierarchy process

AIS = administrative and institutional system

CBD = Convention on Biological Diversity

CEAA = Canadian Environmental Assessment Agency

CEAM = cumulative effects assessment and management

CEQ = Council on Environmental Quality

CFR = Code of Federal Regulations

CWA = Clean Water Act

DOE = Department of Environment

EA = environmental assessment

EC = Engineer Circular

EIA = environmental impact assessment

EIS = environmental impact statement

EMDS = Ecosystem Management Decision Support

EO = Executive Order

EPMG = Environmental Policy and Management Group

ERDC = Engineer Research and Development Center

ER = Engineer Regulation

GIS = Geographic Information System

HEC = Hydrologic Engineering Center

HQUSACE = Headquarters U.S. Army Corps of Engineers

HUC = hydrologic unit code

IWG = interagency working group

IWR = Institute for Water Resources

LEA = landscape ecological assessment

NED = National Economic Development

NEPA = National Environmental Policy Act

NER = National Ecosystem Restoration

NOAA = National Oceanic and Atmospheric Administration

NRC = National Research Council

NRCS = Natural Resources Conservation Service

NRS = natural resources system

ORMSS = Ohio River Mainstem Systems Study

ORNIM = Ohio River Navigation Investment Model

PEIS = programmatic environmental impact statement

PGN = planning guidance notebook

PIA = policy impact assessment

PL = public law

PSI = physical, social, and institutional

RWA = rapid watershed assessment

SEA = strategic environmental assessment

SES = socioeconomic system

SIRRA = sustainable installations regional resource assessment

TVA = Tennessee Valley Authority

USACE = U.S. Army Corps of Engineers

USBR = U.S. Bureau of Reclamation

USEPA = U.S. Environmental Protection Agency

USGS = U.S. Geological Survey

VEC = valued ecosystem component

WRDA = Water Resources Development Act

WRS = water resources system

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14. ABSTRACT
The U.S. Army Corps of Engineers (USACE) incorporated lessons learned from Hurricanes Katrina and Rita into an "Actions for Change" initiative to transform planning, design, construction, operation and maintenance, and decision-making processes. Theme 1 has emphasized an integrated, comprehensive, and systems-based approach that shifts focus from individual projects to an interdependent system. In this report, the Incremental Changes to USACE Systems effort focused on using comprehensive and topic-specific analytical frameworks (AFs) for addressing physical, social, and institutional (PSI) changes within water resources planning and management. An AF denotes a planning framework or step-wise process with analytical and synthesis features. The existing USACE six-step planning process represents a comprehensive AF for water resources. Numerous other topic-specific AFs for addressing PSI changes were examined as supporting tools within the USACE six-step process. This report provides examples of AFs that could be immediately useful in planning and managing PSI changes as USACE adopts risk-based project planning, and it suggests additions to the six steps that would be useful in certain scenarios. The report concludes there is no need for USACE to develop a comprehensive AF specifically focused on PSI changes because topic-specific AFs can be used to support the existing USACE six-step process.

15. SUBJECT TERMS
project planning, analytical frameworks (AFs); planning processes; physical, social, and institutional (PSI) changes

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