Approaches to Water Planning

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Abstract
This paper attempts to summarize and organize the various technical approaches often seen or discussed for water planning. The basic approach to rational planning is presented, followed by brief reviews of Requirements-based, Benefit-Cost-based, Multi-objective, Conflict Resolution, Market-based, and Muddling Through approaches to planning. Each approach has its particular advantages and disadvantages for specific situations. Each approach also tends to have somewhat different analytical requirements. These approaches are discussed in terms of practical contributions to solving long-term water problems.

Introduction
Water resources planning is an ancient problem, dating back to the flood control and water supply activities of the earliest civilizations. The success of most civilizations has rested, in part, on their ability to manage water (China, Indus, Europe, S. and Central America). The demise of several civilizations has been traced directly to failed management of their regional water problems (Peru, Mesopotamia). In the United States, water resources planning has had a long historical development (Shad 1979). Quantitative analysis and even economic thinking in water planning date at least to the Roman times (Frontinus 97 AD; Leveau 1993) and has been vital to successful water management in modern times (Kelley 1989; Morgan 1950). Lack of planning or poor planning often is blamed for continued controversies, expense, and inefficiencies in water management. The complexity and controversy of water problems should lead water planners and decision makers to seek fundamental principles and approaches for organizing the technical aspects of preparing for their solution. This paper attempts to summarize and organize the wide range of planning approaches often seen or advocated for water planning.

The paper begins with a review of rational planning, the fundamental process aspired to by most planning efforts. This is followed by a review of various technical approaches common or commonly discussed for water resources planning. Practical problems for effectively completing planning processes are then reviewed. In light of these practical problems of water management, some realistic but limited objectives are suggested for water resources planning. Finally, analytical aspects for each planning approach are compared and some tentative conclusions are suggested.

Rational Planning

Rational planning is a systematic procedure to resolving problems in the future. Many have written about how rational planning should be done for water resource problems (Orth and Yoe 1997; Yoe and Orth 1996; US Water Resources Council 1983; White 1966). The ideas of rational planning also have been employed in some of history's most innovative water projects (Morgan 1951). These thoughts on planning are closely related to work on other urban, regional, landscape, and environmental planning problems (Meyerson and Banfield 1955; Briassoulis 1989; Johnson 1988) as well as more general rational or "smart" decision-making (Simon 1947; Hammond et al. 1999). While there are substantial differences in the methods and approaches suggested by these authors, there is an essential procedural similarity. This similarity of approach is a largely sequential rational planning thought process, outlined below.

All forms of rational planning take some variant of the rough series of steps summarized in Table 1. These steps are not always sequential; often steps are re-visited as a result of technical or stakeholder feedback, new information, or changing events. However, the general direction of the planning effort remains the same. The special importance of Steps 4, 5, and 7 should be noted. Statement of Objectives, followed by Identification of Solution Alternatives and Evaluation of Alternatives on Stated Objectives are the core of rational planning. This reduced set of steps parallels more formal and mathematical definitions of rationality and mathematical optimization (Von Neumann and Morgenstern 1944; Tribus 1969; Hillier and Lieberman 1995).

Table 1: An Outline of Rational Planning (* = most fundamental steps)

Step 1. Statement of Problem: John Dewey said, "A problem well stated is a problem half solved." Early in rational planning, it is desirable to firmly define the problem, stating people's concerns and what motivates the planning exercise.

Step 2. Inventory/Background: What do we know about the problem and the problem-setting? What has been learned already? How have earlier attempts to solve similar problems fared?

Step 3. Forecasting: The lifetime of most water problems and solutions is very long, far longer than the careers of individual decision-makers, engineers, and planners. Forecasts of demands and related conditions estimate how the problem and problem-setting are likely to change over the life of proposed solutions. Uncertainty in forecasts is unavoidable.

*Step 4. Statement of Performance Objectives: What makes a proposed solution "good" or desirable? Performance objectives can be economic, financial, environmental, social, or in terms of the reliability of achieving technical standards. Both planners and stakeholder representatives typically define performance objectives.

*Step 5. Identification of Alternative Solutions: What different actions might be taken to solve the problem (including doing nothing)? Alternatives should be mostly reasonable, represent a wide range of approaches to solving the problem, and selected from a variety of sources. Past experience with similar problems is very helpful, as is more academic and creative thinking. Public participation and preliminary modeling often aid planners in identifying alternatives.

Step 6. Development of Alternatives: Time and resources prohibit examining “all possible alternatives.” A limited number of promising alternatives are developed in sufficient detail for evaluation on performance objectives (the next step). Discussions with stakeholders and preliminary modeling often help screen, narrow, and refine alternatives.

*Step 7. Evaluation of Alternatives on Stated Objectives: Each developed alternative is evaluated in terms of expected performance on each stated objective (e.g., economic, financial, environmental, social, risk, technical standards, etc.) This is typically the most analytical step and may include consideration of reliability and uncertainties. Interpretation and sensitivity analysis are desirable components of the evaluation.

Step 8. Selection of a "Best" Alternative(s).
The "best" alternative is selected based on the evaluation in Step 7 and relevant stakeholder and public consultations. "The plan" consists of the write-up of steps 1-8, with particular emphasis on presenting the selected alternative(s). Selection often involves multiple objectives and decision-makers.

Step 9. Implementation and Pragmatic Revisions of the Selected Alternative(s). Implementation often requires substantial modification of a selected alternative. Practical considerations arise regarding political and institutional support, financial support, construction, operation, and ultimately closure or replacement over an alternative’s lifespan.

Step 10. Periodic Re-Examination: For the next problem, did we learn anything from this experience? How could we have improved our work?

Limitations of rational planning are evident (Banfield 1959; Simon 1947; Braybrooke and Lindblom 1970). It is often difficult or impossible for decision-makers and stakeholders to clearly state their objectives in quantifiable ways, particularly for objectives involving reliability and risks. In its idealized form, the identification and comparison of "all possible alternatives" on all relevant objectives is clearly impossible in practice. Only a limited number of alternatives can ever be identified, much less developed into a form that allows comparison of alternatives. In analysis, evaluations contain uncertain assumptions and unavoidable simplifications. Ultimately, any analysis must serve an institutional or political framework that works, however slowly, to make decisions regarding the "best" solution.

The strengths of rational planning are its transparency, logic, and the considerable lack of effective technical alternatives. Many variations for implementing rational planning have arisen, particularly in light of limitations under specific circumstances. Often, planning's greatest contribution to problem-solving is the structure and systematic approach it imposes on information-gathering and decision-making. Both rational planning variations and non-rational alternatives to planning should be compared based on how well they might satisfy the objectives of planning.

Approaches to Water Planning

This section reviews six major approaches for water planning, most of which are variations on rational planning. Each approach addresses technical aspects of water problems within a decision-making context. These six basic approaches are presented in a rough order of their historical formalization for modern applications:

1. Requirements-based Planning,
2. Benefit-Cost-based Planning,
3. Multi-objective Planning,
4. Conflict Resolution Planning,
5. Market-based Planning, and
6. Muddling Through.

For each approach to planning, the following aspects are discussed, a) history, b) methods, analysis, use of models, c) data and computational requirements, d) role of public participation, e) how it helps decision-makers, f) circumstances when it seems to succeed, and g) circumstances when it seems to fail.

Requirements-based Planning

Sometimes referred to as “project and provide,” requirements-based planning reflects a traditional approach to formulating engineering problems. First, define the load the system must bear to fulfill specified functions or requirements, with appropriate factors of safety. Then, design (plan), build, and operate the system to bear this load, or meet these requirements, at the lowest cost or with the greatest reliability for a given budget. An outstanding characteristic of requirements-based planning is that it assumes given and fixed demands, restricting or focusing planning efforts to "supply-side" options. This can be advantageous when demands are outside the control of the planner or of such great importance that the costs of meeting demands are relatively unimportant.

The history, practicality, and method of requirements-based water resources planning are exemplified by the classical Rippl method (1883) for reservoir sizing. Here, the demand for water is estimated through a forecasting method and is assumed fixed. The size of the supply is then determined by finding the reservoir size or combination of sources that would allow this demand to be met with a repeat of the historical streamflow record. The sum of supplies must always meet or exceed forecast demand. This so-called "firm yield" approach to water planning has dominated water planning until very recently, when the costs of providing such high levels of supply have been seen as often exceeding the costs of reducing or otherwise managing water demands.

Requirements-based planning is very effective and appropriate for many components of water systems (pump stations, distribution lines, local drainage, etc.). For these components performance expectations are relatively fixed and standardized, and more detailed planning analysis might be too expensive relative to potential resulting improvements. But for large components and system planning, it has often been inadequate.

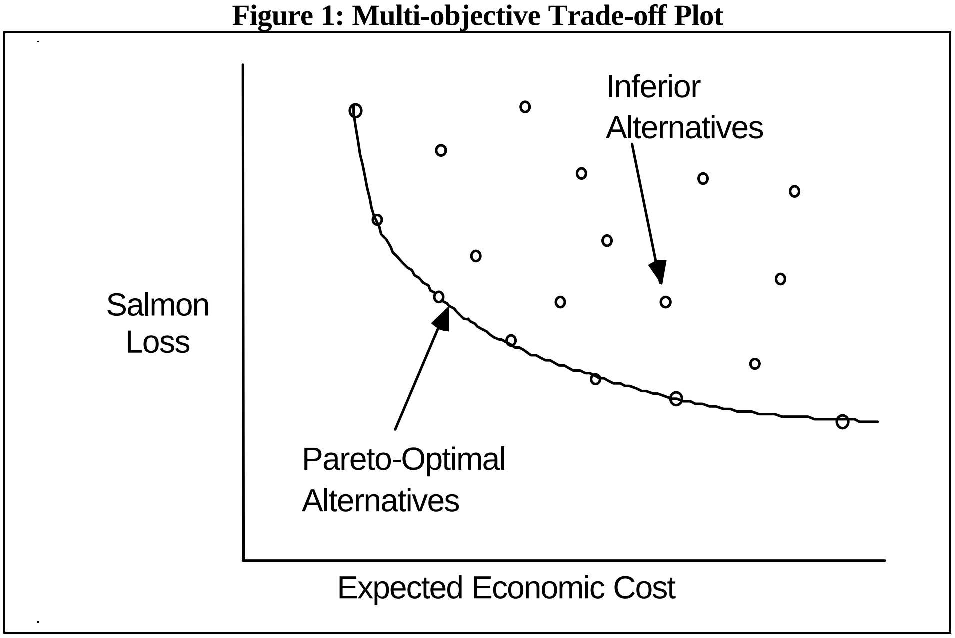
Benefit-Cost-based Planning

Benefit-cost analysis attempts to consolidate the many impacts of each alternative into monetary benefits and costs. The 1936 federal Flood Control Act neatly summarizes the basic germ of benefit-cost analysis, that a proposed project should have "… benefits to whomsoever they may accrue … in excess of the
-cost analysis has expanded steadily to include greater varieties of water uses and impacts (Griffin 1998; Russell et al 1970; Howe 1971; James and Lee 1971; Lund 1987; US Water Resources Council 1983; Boardman et al 1996). Flood control, navigation, water supply, hydropower, recreation, and even some environmental water uses have been usefully incorporated into benefit-cost analyses (Loomis 1987). While the limitations of benefit-cost analysis are well known, its application has helped eliminate unworthy projects, justify worthy ones, and raise the quality of discussion for ambiguous cases. The ability to incorporate risk, reliability, and uncertainty, either as mean economic values or probability distributions of net economic value, is among the strongest technical features of benefit-cost analysis.

Multi-objective Planning

Partially arising from the perceived one-dimensional nature of benefit-cost evaluations, multi-objective approaches to planning attempt to display to decision-makers the trade-offs inherent in selecting alternatives where not all objectives can be measured in the same units (Cohon 1978; Cohon and Marks 1975). Such a trade-off display appears in Figure 1. Some authors attempt to go beyond this objective to develop rational bases for making decisions with these trade-offs (Keeney and Raiffa 1976; Haimes and Hall 1974).

Figure 1: Multi-objective Trade-off Plot



While the analysis approach of multi-objective planning is technically attractive, it typically lacks a formal institutional mechanism to establish the trade-offs needed to identify a most desirable alternative from a large field of "Pareto-optimal" solutions (Figure 1). Thus, in practice for multiple stakeholder problems, multi-objective planning has limited itself to informing decision-makers or stake-holders on the relevant trade-offs involved in their decisions or to helping identify promising solution alternatives that satisfy a wide range of likely objective weights (Brill et al 1982). It is also often difficult to visualize or communicate trade-offs among more than a few objectives.

Planning to Resolve Conflicts

Planning to resolve conflicts is fundamentally different from other planning settings. The objective is to reconcile individuals or groups with conflicting objectives for water management. Such planning occurs in a political environment with parties having alternatives to participating in a formal planning process. Responding to the common difficulties of planning in many real institutional and political situations, several forms of conflict resolution-based planning have emerged (Viessman and Smerton 1990; Delli Priscoli 1990). These various approaches typically emphasize the need of various parties or stakeholders to communicate, understand, and negotiate as necessary conditions for any solution to be accepted politically. Two general categories of these still-emerging planning approaches are summarized below.

Conflict resolution-based planning typically gages its success based on how well a "consensus" solution is achieved, and may not be as concerned with the Pareto-optimal rationality of a solution. Any plan agreed upon by the diverse stakeholders is generally thought to be a good plan. While consensus-based conflict-resolution processes appear to be useful, they have been far from universally successful, perhaps because such problems are tremendously messy and difficult (Walters 1997). Three approaches to planning in this setting are discussed.

<u>Adaptive Management and Shared Vision Modeling</u>
Adaptive environmental management was first proposed in the late 1970s by a group of ecologists (Holling 1978; Walters 1997). The objective was to support ongoing environmental management with consideration of uncertainties and incorporating an ability to change management of the system as more was learned of the system's behavior and response to management. A central tenet of this school of thought is that computer modeling has a central role for synthesizing knowledge of the environmental problems, integrating new knowledge of the problem, and developing promising management strategies. In adaptive management, the development of computer models is a collaborative exercise among different disciplines and stakeholders, with the intent of aiding development and negotiation of management alternatives, with management and model-represented understanding adapting to new information over long periods of time.

A similar approach has taken hold recently among water resources engineers called "shared vision modeling" (Palmer, et al. 1999; Keyes and Palmer 1995; Werrick and Whipple 1994; Reitsma et al 1996). This approach also uses the development by a group of stakeholders and technical experts to develop a common understanding of the problem and develop, quantitatively compare, and negotiate potential solutions.

<u>Experimental Management</u>
Experimental Management is sometimes also called “adaptive management” and consists of performing a series of carefully-monitored “experiments” on design or operations which lead to improved understanding of their effectiveness. While some element of experimentation is unavoidable in water and environmental management, the costs of experiments and failed experiments are large. The variability and lack of control of such field experiments also often leads to the need for experiments to run for many years before reliable conclusions can be made. Artificial flood releases for channel restoration on the Colorado River are an

apparently successful example of experimental management (Collier et al. 1997). [Kai Lee (1993)??? – does this sub-section fall better as a subset of "watershed planning" below?]

"Watershed" Planning

"Watershed planning" has been widely advocated by federal, state, and local agencies, though there is little clear guidance of how it should be done (Kenney 1999; Gelt 1998). This concept differs fundamentally from long-standing concept of relatively centralized planning for water at a watershed scale (White 1969; Goodman 1984). The most common tenets of current usage of "watershed planning" are that all stakeholders in the watershed should be involved in discussions regarding its management, all aspects of water quality and quantity in the watershed should be considered, and that the parties should have great flexibility in arriving at a consensus solution (USEPA 1996). The emphasis is on developing consensus-based water plans, involving all major stakeholders and agencies. As with adaptive management, considerable mutual education among parties and stakeholders is seen as a major aspect of watershed planning. Consensus aspects of watershed planning seem to be more successful for small watersheds, where stakeholders are relatively few in number.

A common problem with consensus-based planning, especially its adaptive management and experimental management forms, is the need for extended studies, funding, and attention from parties involved. While the exchange of ideas of these processes can produce valuable results, the long time-frame often causes many good efforts to lapse due to budgetary variability, management and personnel transitions, and short attention spans at managerial and political levels.

Market-Based Planning

Markets are a decentralized form of planning, and under some circumstances can accomplish planning objectives very effectively (von Hayek 1945). Markets and negotiated contracts have long been important components of water planning. In recent years, the use of markets in water planning and management has received increased interest and use (Lund and Israel 1995). Market-based planning often includes water contracts, markets for spot, dry-year, or permanent water transfers, transferable discharge permits, or privatization of facilities or operations. Often the markets are exclusively among public agencies or districts.

There are obvious limits and disadvantages of market-based solutions to public resource problems. Nevertheless, markets have been shown to be effective and efficient components of water and environmental management under some circumstances (Anon. 1995; Howe, et al. 1986; Eheart and Lyon 1983).

Practical "Muddling Through"

Political and economic circumstances often do not support long-term planning, particularly plans that recommend major changes to the current situation. Under these conditions, it is often more effective for planning efforts to take a short-term view of making small improvements in a direction which is desirable for the long term. This approach is sometimes called disjoint incrementalism or "muddling through" (Lindblom 1959, 1979; Braybrooke and Lindblom 1970). Often, plans developed with the intent of following other planning approaches end up merely contributing to "muddling through." Numerous advantages have been ascribed to incremental alternative evaluations and actions in a pluralistic political environment (Braybrooke and Lindblom 1970), including improvements responsiveness to perceived problems, ability to identify important consequences, and diffusion of decision and evaluation responsibilities. In this way incremental decisions in a political context are seen as being superior in some ways to more formal planning decisions undertaken using formal decision-making calculations (such as benefit-cost analysis).

Actual planning often reflects several of the approaches described above.

Water Planning Approaches and Rational Planning

Table 2 is a summary comparison of the water planning approaches discussed above in terms of the three most fundamental steps of Rational Planning.

Table 2: Rational Aspects of Common Water Planning Approaches

Planning Approach	Performance Objectives	Alternative Identification	Performance Evaluation
1. Requirements-based	Cost and simple technical performance standards (e.g., meet forecast water demands in 95% of years)	Alternatives suggested by experts, stakeholders, and sometimes model results	Cost-effectiveness
2. Benefit-Cost-based	Maximize net economic or financial benefits for owner, region, or nation	Alternatives suggested by experts, stakeholders, or model results	Benefit-cost analysis, perhaps including uncertainty & variability
3. Multi-objective	Quantifiable objectives specified by decision-makers or stakeholders	Alternatives suggested by experts, stakeholders, and model results	Reduce alternatives to the Pareto-optimal set
4a. Conflict Resolution: Adaptive Management (Holling 1978)	Quantifiable objectives specified by decision-makers or stakeholders	Alternatives suggested by experts, stakeholders, and model results	Reduce alternatives to the Pareto-optimal set, including long-term efforts to adapt and narrow uncertainties
4b. Conflict Resolution: "Watershed Planning"	Objectives stated by decision-makers or stakeholders	Alternatives suggested by stakeholders and sometimes by experts	Little or no formal evaluation
5. Market-based	Each party has its own objective(s), not necessarily revealed	Alternatives limited to those supported by the market	Each party evaluates alternatives individually and privately
6. Muddling Through	Only limited objectives and expectations	Only easily implemented alternatives considered	Only very simple and expedient evaluation of alternatives

Practical Problems

The many practical limitations of planning often govern which approach to planning can or should be taken for a particular situation.

Conflicting Water Uses and Objectives

Conflict among uses and users of water is the dominant characteristic of contemporary water planning. Agricultural water supply, environmental water uses, urban water supply, flood control, hydropower, recreation and other uses all compete in economic, legal, and political forums over the management of water, at local, regional, state, and federal levels. Even within a common water use, one often finds conflict among different individual users or user groups for allocation of water, financial costs, and environmental impacts. Table 3 compares how each planning approach addresses conflicts over water use objectives.

Table 3: Planning approaches and conflict, authority, and integration

Planning Approach	Conflicting Uses, Users and Objectives	Limited Authority to Implement Plans	Integrating Local, Regional, & State Plans
1. Requirements-based	Requirements must be established first.	Rests on consensus over defined "requirements."	Difficult
2. Benefit-Cost-based	Economic valuation mediates conflicts	Requires consensus on economic basis for evaluation.	Explicit
3. Multi-objective	Conflicts presented as trade-offs	Authority to complete planning is lacking.	Difficult
4. Conflict Resolution	Negotiating conflicts is central to the planning process	Recognized as part of planning process.	Difficult
5. Market-based	Market mediates conflicts	Market forces overcome limited authorities.	Implicit, relatively easy
6. Muddling Through	Conflicts avoided whenever possible	Only limited plans attempted.	Usually not attempted

Limited Authority to Implement Options

Regional water planners have very limited ability to directly affect the vast majority of water management decisions, because most water management decisions being made locally. The effectiveness of regional water plans will be greater if they can be integrated with local water management efforts and activities.

In the past, State and Federal governments often intervened in water problems to facilitate regional solutions. In recent times, this has become difficult due to reduced State and Federal ability and willingness to fund regional options, particularly in the face of controversy. Each approach's treatment of limited planning authority is summarized in Table 3.

The need for centralized authority for water management has long been debated, and is really central to political theories of water management. The classical work by Wittfogel (1957) argued that the origin of central governments and indeed dictators arose from the need for a central authority to develop and manage irrigation and flood control in early Mesopotamian civilizations (so-called hydraulic civilizations). However, others point to the high effectiveness and efficiency of many highly decentralized water management systems, such as Bish's (1982) work on the Puget Sound region and Blomquist's (1992) work on Southern California groundwater management. The decentralization theorists point to the greater potential for decentralized management for utilizing local knowledge, maintaining local and decentralized accountability and performance objectives, widening the range of options considered, and ensuring widespread review and comment on intermediate and final policy and planning products. Effective decentralized management requires coordinating mechanisms that can be informal or formal, such as coordinating committees, agreements and contracts, a regional agency of local agency members, or the courts. A water plan for a region with decentralized water management is likely to be more educational and define a framework or direction for common activity, and less a direct plan of action.

Integrating Local, Regional, State, And National Plans and Policies

Most water management decisions are local. For every State or Federal water planner, there are dozens of local water utility planners. And for each local water planner, there are thousands of agricultural, residential, commercial, and industrial water users, each making long and short-term water management decisions. Integrating these local and user decisions with regional and state water management decisions is both difficult and essential for effective regional water management plans. Some summary thoughts on how each approach pursues this function appear in Table 3.

Water planning can rarely be undertaken with the precision and comprehensiveness of an industrial or military enterprise. More commonly, regional water planning must take into account policies and plans already existing at local, regional, state, and federal scales. Thus, plans often take a certain resemblance to the "exquisite corpse" of early 20th century surrealist art circles, as illustrated by quote below from an early housing study.

> "The process by which a housing program for Chicago was formulated resembled somewhat the parlor game in which each player adds a word to a sentence which is passed around the circle of players: the player acts as if the words that are handed to him express some intention (i.e., as if the sentence that comes to him were planned) and he does his part to sustain the illusion. In playing this game the staff of the Authority was bound by the previous moves. The sentence was already largely formed when it was handed to it; Congress had written the first words, the Public Housing Administration had written the next several, and then the Illinois Legislature, the State Housing Board, the Mayor and City Council, and the CHA Board of Commissioners had each in turn written a few. It was up to the staff to finish the sentence in a way that would seem to be rational, but this may have been an impossibility." Meyerson and Banfield (1955), p. 269.

Data

Technically, most planning analysis is limited by the quantity and quality of data available. Moreover, some types of data, such as future water demands, exist reliably only after their quantities are irrelevant to planning. Large amounts of data do not necessarily contain useful information. Poorly or unsystematically collected or estimated data often contain less useful planning information than simple logical estimation.

Data problems are compounded if there is fundamental scientific controversy over how empirical data should be assembled or interpreted. This is often the case with biological problems, where there is both significant variability in empirical data and fundamental questions of how particular biological and ecological systems work.

The lack of data, or useful data, tends to encourage various forms of planning relative to others. These are summarized in Table 4. Given the cost and time required for collection, data will always place technical limits on how planning can be done.

Variability and Uncertainty

Many aspects of real water problems are highly uncertain or variable, particularly over planning time-frames. Many fundamental uncertainties exist regarding how water management specifically affects environmental resources. Hydrologic uncertainty, from "usual" variations between drought and flood to prospects for climate change; water demand uncertainty, from changes in population and wealth, changes in water use efficiency, and changes in weather; and changes in water quality and demands for water quality all are central to regional water planning.

The formal understanding and analysis of such uncertainties involves the use of probabilities. Probabilities are a very powerful, rigorous, and essentially unavoidable analysis tool for such problems. However, the use and results of studies using probabilities are difficult to explain to many decision-makers, the public, and even most technical people. The treatment of variability and uncertainty for the six planning approaches are compared in Table 4.

Table 4: Planning approaches and data, variability, and assessment

Planning Approach	Data Requirements	Variability and Uncertainty	Assessing Performance on Each Use Objective
1. Requirements-based	Limited	Reliability indices or targets	Usually simple. Are "requirements" met?
2. Benefit-Cost-based	Great	Can be explicit	Performance estimated in economic terms. Often controversial or difficult.
3. Multi-objective	Moderate to Great	Difficult to present	Often difficult.
4. Conflict Resolution	Minimal to Great	Difficult	Done by relevant stakeholders; may conflict.
5. Market-based	Minimal	Implicit, relatively easy	Implicit. Performed by parties in market.
6. Muddling Through	Modest	Usually not attempted	Only attempted in limited ways.

Limited Range of Alternatives

It is possible to develop, refine, and evaluate only a limited number of alternatives. Each new alternative, particularly creative or novel ones, requires a great deal of development and education of stakeholders. It is often difficult to develop promising alternatives in an atmosphere of controversy. Stakeholders often perceive an interest in limiting the range of alternatives to be considered.

Assessing Performance For Each Use Objective

In planning, we would like to be able to quantitatively evaluate proposed alternatives on each performance objective. There are several common difficulties in doing this: 1) Stakeholders often find it difficult to specify their performance objectives, sometimes for political reasons, but also because it is a difficult intellectual and technical problem. 2) Given reasonable verbal statements of performance objectives, it is often difficult to derive quantitative mathematical analogs. 3) Fundamental uncertainties often exist in knowing how a particular performance objective (such as salmon populations) will be affected by specific water management decisions.

The assessment of performance is made more difficult by the variability in hydrologic conditions and operations. How well can a particular water use tolerate or benefit from variability in flows? How should various probability distributions of water availability for specific uses be compared? Table 4 summarizes each planning approach's performance assessment problems.

Transparency: Can We Understand And Communicate It All?

Even among the most experienced water planners and managers, few individuals have both broad and detailed knowledge of a particular large regional water system. One career usually cannot encompass complete and up-to-date detailed knowledge of a system and deep thinking about how to improve the system's operation over the long term. Even the water wonk cannot understand it all. This problem is compounded by the employment transience at technical, managerial, and political levels; in any planning meeting, there are usually several who must be “brought up to speed.”

With the diverse audiences and objectives of regional water planning, can we ever make our thinking and analysis understood? Given the real limitations and realistic expectations of planning, a simplified analysis that more clearly communicates water management guidance might more effectively improve a region's water management than presentation of sophisticated methods. (However, more sophisticated and detailed analyses are likely to be essential for developing and detailing much of a regional plan.) A plan that cannot be understood is unlikely to attract the kind of confidence or readership needed for implementation.

Some Realistic Objectives for Regional Water Planning

We all have ideas of what a water plan should accomplish. Popularly, many think a water plan always leads to the solution of a region's water problems. Alas, the world is complex and this is often not the case. In reality, water plans serve a variety of related and important functions, only some of which lead directly to resolution of water problems.

1. Education. Regional and statewide water plans are important for educating the public, political leadership, and water policy professional staff and leadership about water problems and options. Regional water plans provide a regularly-updated practical and authoritative overview of a region's water problems, with some directions for improving this situation. Each individual party concerned with a region's water problem will have a much narrower view of the subject, and so cannot provide the integrated perspective of a regional plan.

a. Public education. Water policy is central to the growth and stability of many regional and state economies and water management is often prominent in public policy debates at state, regional, and local levels. To improve the quality of public decisions and improve the accuracy of public perceptions, the public, the media, and "opinion leaders" need a reasoned and readable perspective on regional and statewide water problems.

b. Educating political leadership. The political leadership of both general and water-related governmental units is tremendously distracted by other issues and their own internal political dynamics. It is difficult for even the best people in politics to devote a great deal of time to understanding the technical aspects of decisions they are called upon to make. Thus, political leaders must rely on advice from others and authoritative accounts of the problem. Regional water plans provide specific and contextual information on water problems and options. By providing a regional or statewide perspective, a plan can inform water decision-making on relevant aspects of water problems and provide some assurance to statewide, regional, and local water managers that their problems have been fairly presented for consideration.

c. Educating the professional water community. Local, regional, and statewide water plans are probably the primary documents available to new water professionals to orient them to the practice and the context of their work. For these people, regional and local plans provide an authoritative view of the context of their activities as well as perspectives on the overall direction of water management activities and examples of accepted planning methods.

2. A reference document. Regional and statewide water plans are vital reference documents for many statewide and regional water management and planning activities and decisions. In one location, a regional plan provides authoritative estimates of water demands and forecasts (dissaggregated by use type), information on storage, conveyance, and water supply availability, an inventory of water distribution systems and their organization, an authoritative inventory of water problems, and a wealth of other information, including where additional information can be found. These estimates, data, and discussions provided have every-day use for local, regional, statewide, and private water management and use activities.

3. Leadership in water management. Although most regional water plans are conducted by entities with only limited financial and jurisdictional powers for water management, such plans are significant in terms of "leadership". The options and objectives considered and the methods used in the plan constitute leadership by example for other local and regional planning efforts. Such leadership must be responsible.

It's leadership rests on neither lagging too far behind the advanced state of practice, nor being so far ahead of advanced practice as to risk being mis-understood or ignored.

a. Leadership in content. The options and objectives considered in regional water planning have relevance for smaller jurisdictions. A regional or statewide plan providing detailed consideration of water conservation and environmental water demands sets some precedence that these items are considered legitimate and establishes expectations that these should be considered in local planning and management efforts. An example of irresponsible exercise of leadership would be a regional plan that gives undue attention on wacky or pre-mature water management options, such as iceberg towing or re-routing major rivers from other states.

b. Leadership in method. At regional and statewide scales, and for federal agencies, planning practices set precedence and expectations for lower levels of government that are more active and have more resources and jurisdiction to implement water management options. This leadership in method has great potential to help integrate and improve the planning efforts of lower units of government, increasing the number of promising alternatives examined and solidifying their evaluations of alternatives.

c. Leadership in learning. In many areas of water and environmental planning, we must make management decisions and plans without a clear understanding of long-term performance and trade-offs. A plan which realistically identifies knowledge shortcomings and includes research efforts to overcome these limits, as well as sensitivity studies to examine contingencies is desirable for improving management effectiveness over the long term.

4. Specific recommended actions and their implementation. We normally think of water plans as recommending particular thought-through actions for improving a region's water management. However, practically, this is often not the functional case. The specifics of a regional water plan usually are most relevant at the local level, where agencies tend to have greater financial resources and more independent implementation authority. As one moves higher in regional authority, including to state authority, the actual financial, jurisdictional, and political wherewithal to implement plan specifics drops steadily. Historically, State and Federal agencies have dominated water development only for short periods. In California, for example, Federal water projects dominated regional water development from the 1940s until1982 and State projects from 1967-1982. This occurred despite Federal and State planning studies dating from 1873 (Pisani 1984). Before and since these periods, almost all major water supply projects in California have been instigated, financed, owned, and operated locally or sometimes regionally. Now and for the foreseeable future, regional water plans are likely to be effective only where they can integrate the activities and options of water management across jurisdictions and users. This is likely to be a difficult and prolonged process.

5. Following the Law. Much of the time, planning processes exist and are tailored to meet relevant state or federal legislation, such as the federal National Environmental Policy Act (NEPA) or state acts, such as the California Environmental Quality Act (CEQA). Such legislation requires various procedures for involving different units of government and the public, specification of objectives and identification and evaluation of alternatives. These forms of legislation provide some standardization of planning across many types of planning problems. In addition, there is also often more specific legislation for particular water problems, such as federal Clean Water Act or Endangered Species Act and their state variants. Any water management or development proposal or project will be expected to comply with relevant legal requirements; these requirements often explicitly or implicitly require a planning process (add citations)

In terms of rational decision-making, the purpose of the plan is to convince a broad audience of decision-makers and publics that:
1) the problem is well understood,
2) a wide range of potentially promising alternatives has been identified with reasonable thoroughness,

3) unreasonable alternatives have been reasonably eliminated,
4) each remaining alternatives has been developed in such a way as to provide the most desirable performance, and
5) that the final plan is the best of these best-performing alternatives.
For long term water problems, contributions to any of these aspects of addressing water problems can represent a valuable accomplishment of a plan.

Analytical Approaches

Water planning is a complex business, and almost all regional water planning and management activities have a heavily technical component. (We are, after all, talking about moving and storing millions of tons of liquid every day with substantial economic impacts and financial costs.) Lund and Palmer (1997) present a more detailed overview of the roles of computer modeling in planning and conflict resolution in water resources. Table 5 summarizes common forms of analysis for each planning approach.

Table 5: Planning Approaches with Common Forms of Analysis

Planning Approach	Common Forms of Analysis
1. Requirements-based	Supply modeling constrained by satisfaction of projected demand quantities. Reliability of satisfying demand projection often is estimated.
2. Benefit-Cost-based	Benefit-cost analysis: Explicit valuation of economics of supply and demand, often with explicit integration of some major uncertainties.
3. Multi-objective	Identification of trade-offs in major objectives across major alternatives. Optimization can suggest promising alternatives for a range of objective weights.
4. Conflict Resolution	Models are used to consolidate scientific understanding of the system; the resulting models are used to develop promising alternatives and estimate tradeoffs; bring decision-makers into modeling early and use models as part of stakeholder negotiations. However, some forms of conflict resolution avoid modeling entirely.
5. Market-based	Buyers and sellers largely do their own market calculations in private.
6. Muddling Through	Modest analysis. Since only small decisions are taken, less extensive analysis is needed.

The purpose of analysis is usually not numbers, but insight (Geoffrion, 197?). Under practical conditions, it is often difficult to perform such analysis. In many cases, strategic analytical insight can be better achieved through the more independent analysis of internal agency "skunk works", universities, or similar settings with diminished political accountability.

When to Plan How

Considerable public and professional controversy exists regarding how water planning should be done. Each planning approach presented has been successfully applied in some situations, and has failed in others. No single planning approach will succeed in all circumstances. In developing regional and statewide plans, often it will be necessary to integrate plans developed under different planning philosophies.

For discussion, three broad sets of planning circumstances are used to illustrate the likely suitability of different planning approaches. The first circumstance is where only rapid and inexpensive studies are possible. There may be few resources for conducting the study, the pace of political events may limit the time available for planning, or the problem might not merit much attention. The second set of circumstances is where planning resources are far less limited and a single formal decision-making process exists to adopt and implement a plan. In the third set of circumstances, multi-party decision-making occurs without a very formal planning process in the midst of considerable controversy. Table 6 presents some hypothetical ideas on the suitability of each approach for each set of circumstances.

In an era when federal and state governments lack the funding and will to impose or persuade formal planning procedures on stakeholders, conflict resolution, marketing, and muddling through approaches to planning are all that remain for stakeholders wishing to solve regional water problems. However, even within this less formalized and more pluralistic setting, requirements-based, benefit-cost-based, and multi-objective planning and techniques can be informative and useful.

Figure 2 attempts to place the theories discussed along two commonly relevant dimensions, degree of planning formality and degree of stakeholder inclusion. Other dimensions could have been used, and these placements are inexact, but the figure serves to illustrate how muddling through, doubtless the most common approach to planning in practice can often result from a collapse of formality in planning method and tends not to be very inclusive in its application, unless there exist multi-stakeholder venues for discussion and coordination. Even in the worst cases, attempts at more formal or inclusive planning can generate insights, alternatives, coalitions, and information useful to muddle through more effectively.

The rational selection of a planning approach should be based on the likely success of each alternative approach in achieving the practical objectives of the planning effort. This selection process itself illustrates many of the practical problems in regional water planning.

Table 6: Hypothetically Good Conditions for Different Planning Approaches

Planning Approach	Only Rapid and Inexpensive Studies Possible	Single Formal Decision-making Process	Controversial Multi-Party Decision-making
1. Requirements-based	Reasonable; especially effective for small, well understood, and non-controversial problems	May overly limit alternatives and evaluation	Usually unsuccessful
2. Benefit-Cost-based	Only limited analysis possible	Good, but usually requires interpretation	Informative, but politically insufficient
3. Multi-objective	Only limited analysis possible	Good, but requires interpretation and final judgment	Informative, but politically insufficient
4. Conflict Resolution	Usually inadequate time or resources	Not needed	Promising, but often politically futile
5. Market-based	Potentially good, if properly arranged	Sometimes good	Promising, if properly arranged
6. Muddling Through	Often the best possible approach for large problems	Probably not good	Often the only possible approach; success limited and incremental

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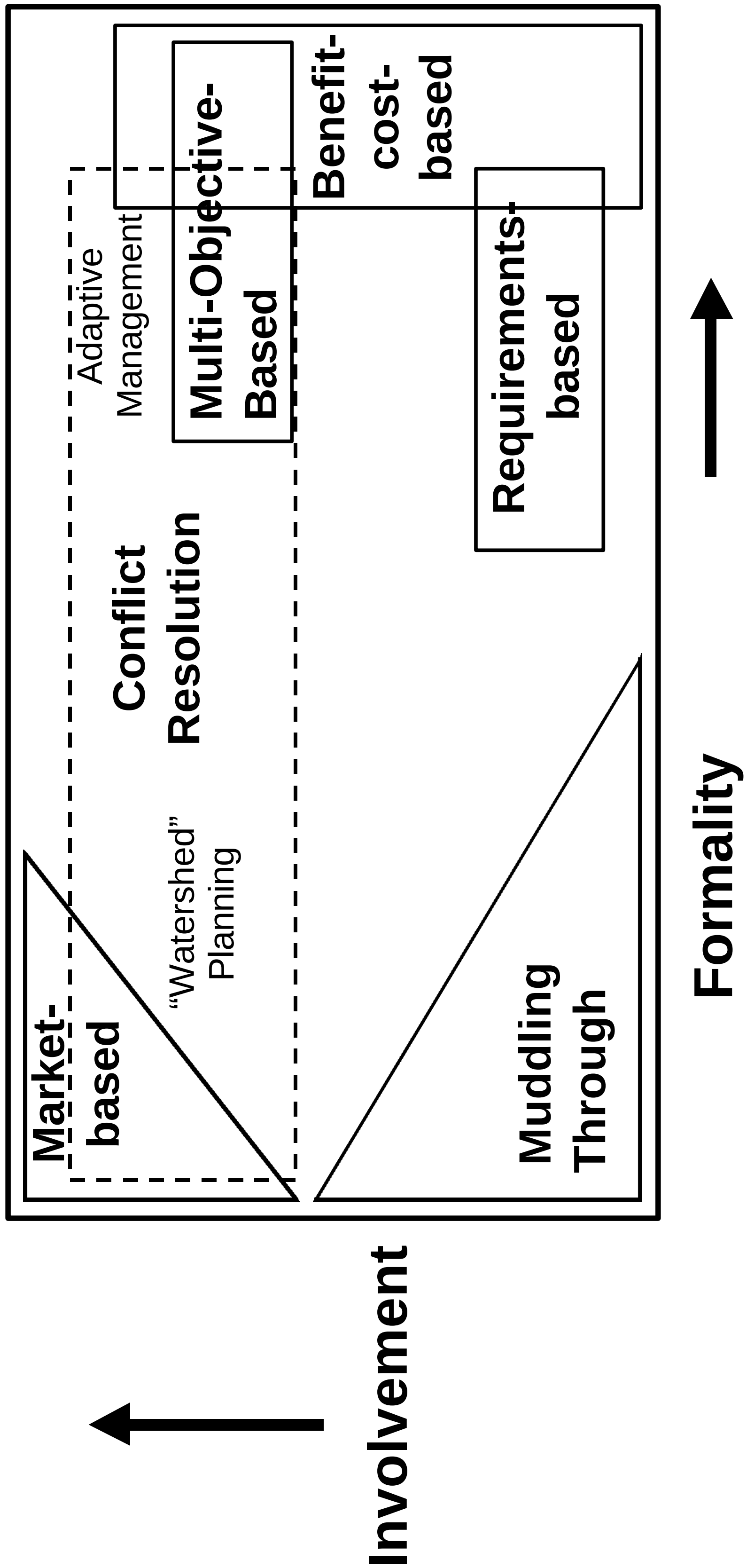

Figure 2: Approaches to Planning