Deciding to Recharge

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DECIDING TO RECHARGE

by

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STATEMENT BY AUTHOR

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LIST OF ACRONYMS

ADEQ : Arizona Department of Environmental Quality
ADWR : Arizona Department of Water Resources
AMA : Active Management Area
APP : Aquifer Protection Permit
AWBA : Arizona Water Banking Authority
AWS : Assured Water Supply
CAGRD : Central Arizona Groundwater Replenishment District
CAP : Central Arizona Project
CAVSARP : Central Avra Valley Storage and Recovery Project
CAWCD : Central Arizona Water Conservancy District
EU : Expected Utility
FAA : Federal Aviation Administration
GDSS : Group Decision Support Systems
GMA : Groundwater Management Act
GSF : Groundwater Savings Facility
GUAC : Groundwater Users Advisory Council
IPAG : Institutional and Policy Advisory Group
M&I : municipal and industrial
Metro Water : Metropolitan Domestic Water Improvement District
NPDES : National Pollution Discharge Elimination System
NRP : Northwest Replenishment Program
ppm : parts per million
RRC : Regional Recharge Committee
RRP : Regional Recharge Plan
SAT : Soil Aquifer Treatment
SAWARA : Southern Arizona Water Resources Association
SAWRSA : Southern Arizona Water Rights Settlement Act
SJT : Social Judgment Theory
TAMA : Tucson Active Management Area
TDS : total dissolved solids
THM : trihalomethane
TRWC : Tucson Regional Water Council
USCWUG : Upper Santa Cruz Water Users Group
USF : Underground Storage Facility
USGS : United States Geologic Survey
WCPA : Water Consumer Protection Act
ABSTRACT

Public water policy decision making tends to be too complex and dynamic to be described fully by traditional, rational models. Information intended to improve decisions often is rendered ineffective by a failure to understand the process. An alternative, holistic description of how such decisions actually are made is presented here and illustrated with a case study. The role of information in the process is highlighted. Development of a Regional Recharge Plan for Tucson, Arizona is analyzed as the case study.

The description of how decisions are made is based on an image of public water policy decision making as 1) a structured, nested network of individuals and groups with connections to their environment through their senses, mediated by their knowledge; and 2) a nonlinear process in which decisions feed back to affect the preferences and intentions of the people involved, the structure of their interactions, and the environment in which they operate. The analytical components of this image are 1) the decision makers, 2) the relevant features of their environment, 3) the structure of their interactions, and 4) the products or outputs of their deliberations. Policy decisions analyzed by these components, in contrast to the traditional analysis, disclose a new set of relationships and suggest a new view of the uses of information.

In context of information use, perhaps the most important output of the decision process is a shared interpretation of the policy issue. This interpretation sets the boundaries of the issue and the nature of issue-relevant information. Participants are unlikely to attend to information incompatible with the shared interpretation. Information is effective when used to shape the issue interpretation, fill specific gaps identified as issue-relevant during the process, rationalize choices, and reshape the issue interpretation as the issue environment evolves.
INTRODUCTION

PROBLEM STATEMENT

Water planning and policy making is a messy business. It tends to be contentious because of competing interests and conflicting values. In addition, the issues it grapples with tend to be technically complex and burdened with large measures of uncertainty. They require expertise in multiple disciplines, including hydrologic sciences, engineering, economics, law, and increasingly, social and cultural sciences. Policy making for such issues is beyond the abilities of any single person and is frequently politically infeasible, if not practically impossible, for any single organization. Thus water resources planning and policy making is frequently a process that involves winning the support of the affected public, and water resources planners and policy makers must answer to important publics that may have limited or weak understanding of the technical bases of decisions.

Individual planning and policy making initiatives meet with variable success in resolving important issues, and students are challenged to identify why some efforts appear more successful than others. An understanding of the process is needed to suggest interventions that will improve results. Contributions from single disciplines such as economics and systems engineering can, and often do, lead to better policies, but at least as often, experts representing single disciplines are dismayed at the way self-evident truths seem to be ignored in policy decisions. A more global approach is necessary to understand how water resources policy decisions are actually made. This paper draws upon research from a wide range of approaches to decision making rather than focusing on a single procedural analysis. It shines light on the process from research on decision making to see what picture emerges.
The purpose of the dissertation is to present a description of how water policy decision are actually made and illustrate it with a case study, along the way pointing out how information is/was used. It presents a case study to illustrate concretely how the global conceptualization applies to a real world example. My premise is that looking at the process in a global way permits insights into the role of information in the process. This paper indicates both what kinds of interventions have the best chance of being adopted and the limits on the use of information in the process.

SOURCE MATERIAL AND CONCEPTUAL FORMULATION

Although I have drawn heavily upon these authors and others, the particular shape and content of the image used in this analysis are my own. The image of decision making this paper proposes is

(1) a nonlinear process in which decisions feed back to affect the preferences and intentions of the people involved, the structure of their interactions, and the environment in which they operate;

(2) a structured, nested network of individuals and groups with connection to their environment through their senses, mediated by their knowledge. Through these connections information from the accumulated knowledge of their society and the ideas of others are available to them.

Where traditional, rational decision analyses proceed in a linear fashion from problem identification to choice, the analysis presented here emphasizes the holistic nature of decision making by focusing on four major analytical components: 1) the decision makers, 2) the relevant features of their environment, 3) the structure of their interactions, and 4) the products or outputs of their deliberations.

Policy decisions are made by people; they are the intentional choices of particular individuals with individual motives, preferences, competencies, experiences, and relationships. Yet choices are constrained by external circumstances, including natural and man-made laws, resource limits, technological limits, and the behavior of others. These constraints are defined by the environment. When people interact for the purpose of jointly deciding a policy issue, their interactions have an observable structure that will affect their decisions. Some of this structure is derived from their environment and some is designed by the decision participants.

Because decisions occur over time, they involve experience, learning, and change. People can change; their environments can change; and the structure of their interactions
can change. Some of this change will be exogenous to the process, but much of it will result from the process itself. Interim outputs of the process can be identified and their purposes and impacts described.

CASE STUDY

In Tucson, as elsewhere, people labor within constraints imposed by the natural environment and their society to create and maintain a comfortable and secure home. Because Tucson is a desert city, its citizens are perhaps more aware than others of the importance of water to their well-being. Unlike many other cities in more humid environments, in Tucson water policy is the subject of intense debate among the general public as well as a policy elite. Other public policy issues, such as environmental quality, economic growth, and governance frequently are linked with water.

In Tucson, as elsewhere, people are confronted with choices of policy direction under conditions of great uncertainty. Elected officials and their appointees, career bureaucrats, and other representatives of the people empowered to make choices on their behalf are subject individually to human fallibility. Apart from any more sensational failings of character and morality, they are handicapped by cognitive limitations explored in the literature of bounded rationality (Simon, 1955), heuristic reasoning (Tversky and Kahneman, 1974), and cognitive illusions (Chapman, 1967; Langer, 1975). In groups, they are subject to additional constraints associated with group decision processes, including problems of communication, inconsistent preferences, and interpersonal conflict (March, 1994; Kleindorfer, Kunreuther, and Schoemaker, 1994). The quality of Tucson's water policy decisions will depend, at least in part, on the ability of these policy makers to work effectively within their constraints. The Regional Recharge Plan (RRP) was one such attempt.
My case study data consists of documents produced during the course of the RRP process and observations of the process made during its central year. These I analyzed for evidence for my image of such decision processes. The analysis resorted the data from the components of the tradition decision model to components and sub-components of my image of the process.

The RRP process took place between August, 1995, and August, 1998, when the Plan was published. Activities after publication of the Plan are not included in this analysis. A technical committee met regularly for one year until publication of its Report in October, 1996. A policy committee took up the task of developing a plan after the technical report was completed. One joint meeting of the two committees was held on August 22, 1996. For approximately nine months, the policy committee met monthly. A draft plan was completed August of 1997. Between that time and the following August, the committee and staff were concerned mainly with revising and approving the Plan (and related activities not covered here). They met only intermittently during this period.

Much of the data used in the case study analysis was collected while I was a participant observer. I was employed by the Tucson Active Management Area of the Arizona Department of Water Resources as staff for the RRP committee tasked with developing the Plan. I was present at all committee meetings and was responsible for communication and coordination of data collection and analysis. I performed many of these tasks myself and reported to the committee.

The year previous to my involvement, another TAMA staff member held a similar position for the separate committee tasked with resolving technical issues. He produced and collect working documents, including notes, meeting minutes, and draft reports that were available to me and that I drew on to reconstruct that committee’s activities.
In addition, the technical committee produced a published report (RRC, 1996a) that is referred to extensively in the case study sections of this paper. Its contents are described there in some detail.

One of my first tasks was to perform a needs assessment. To do this, I personally interviewed potential recharge participants as to their goals, intentions, and concerns regarding their water supply situation in general and recharge in particular. The interview form used is appended (Appendix C). All but a few of the interviews were taped. The tapes were used to develop interview summaries and then erased. The needs assessment interviews were the source of statements about the goals, beliefs, and intentions of participants. Interview summaries were left on file at the TAMA offices.

The Plan produced by the RRP’s policy committee included background material and a planning process description, along with a plan and recommendations for implementation. These also are given detailed descriptions in the case study.

I left TAMA employment after I had compiled a draft of the Plan that was subsequently revised and published in 1998. I was in contact with TAMA staff intermittently during the revision period and had access to meeting minutes, Plan revisions, and some additional materials. These I used to reconstruct the activities of that committee after my departure.

My participation in the process necessarily affected my observations; no one can avoid bias in the circumstances. However, I viewed my role as one requiring detachment and neutrality, and therefore endeavored not to form opinions on decisions. Yet, many of the procedural, methodological decisions fell to me as staff. I tried to make these transparent to the committee so that the members might object if they chose, and occasionally they did. I expressed no personal opinions overtly and limited my
participation in discussions to explanations of staff work and checking my interpretations of the opinions of others.

In addition, the period of observation occurred prior to development of my conceptual formulation of the decision making process. Therefore, I was not observing the process with a well-structured preconception of how decisions would be reached and my interpretation of the case is objective. As another participant observer has stated, "The objective interpretation is objective in the sense that it is from the outside, not in the sense that it is absolute or value-neutral. It is the way an observer understands the behavior and available features of the context" (Feldman, 1989:33).

My observations were not ethnological; that is, I did not record them formally in field notes. Therefore, I have tried to base my interpretations primarily on analysis of the written record. Inevitably, however, many of my interpretations depend on the personal impressions I received. In addition, I lived in Tucson for many years, paid attention to media accounts and took part in discussions with diverse groups on the issues described here. The knowledge accumulated in this way, also, inevitably found its way into this paper.

ORGANIZATION AND CONTENT

The paper is organized in five chapters. The first chapter introduces the concept of complexity, the complex nature of the water policy environment, and its implications for decision making. In that chapter I canvass the complexities of the physical and institutional settings for public water policy decision making and their cultural context. The discussion highlights unique features of water as a subject for public policy.

In the second chapter I review a sampling of the vast literature on decision making. Following the common practice, I examine in order the decisions of individuals, groups,
organizations, and public policy. In this review I have emphasized the aspects of decision making with implications for my analysis.

Chapter Three contains a brief description of the image of public water policy decision making upon which the case study analysis is based. It lays out the four basic components used to analyze the public water policy decision making process. The chapter describes the interactions of these four conceptual categories and sketches subcomponents for each major component.

The fourth chapter presents the analysis of a case study. The case study is Tucson’s Regional Recharge Plan (RRP). It is analyzed according to the four components: (1) Participants are described in terms of decision relevant features, including training, experience, and organizational affiliation. (2) The relevant features of the physical and institutional environment are described, and the cultural context is provided by a chronicle of events leading to the formation of the RRP’s committees. (3) A section on structure describes the rules for participant interaction within the process and suggests how structure affected the nature of decisions. (4) A detailed description of process outputs establishes the dynamic relationship in which interim products influenced deliberation.

The RRP is a good example because it was successful; that is, it was completed, at least to the point of publishing a plan (decision) and beyond (some implementation) without blowing up or fading out. It also accomplished the primary goals that set the process in motion. I intentionally did not deal with evaluating the success of this or any decision process in other terms because the issues would carry me too far into the realm of ethics and philosophy. Others, with convictions about the nature of good policy, will be better able to make an impact on the process and its outcomes with the fuller understanding provided in this paper.
To this end, the fifth chapter contains conclusions that highlight notable features of the process with implications for information use. Specifically, it focuses on the concept of a socially constructed interpretation of the policy issue, one of the principal outputs of policy decision processes. It links the uses of information in decision making to the construction, elaboration, communication, and reinforcement of this interpretation.
CHAPTER 1. COMPLEXITY OF THE WATER POLICY ENVIRONMENT

At least five characteristics constitute a complex environment with sufficient complexity to compromise prediction and control. The water policy environment contains all five. The first is interconnectedness. Individual components of the environment are linked in multiple ways, to multiple others, directly and in a hierarchy of nested relationships. Thus, the behavior of any one component may affect others both directly and indirectly in multiple ways. In addition, relationships are interactive, which means that behavior of any component may have a feedback effect. Thus, effects not only spread through the systems, they also rebound.

Related characteristics of complexity are path dependence and sensitivity to initial conditions. All organic and many physical processes are path dependent. Current conditions depend on a historical progress of chance-like branching from past conditions (Gleick, 1987). The current situation can be explained by past events, but could not have been predicted. Initial conditions, that is, conditions at the point from which a prediction is attempted, will nudge the process along one branch rather than another. Very small influences potentially make enormous differences in results at a future time. These are characteristics of chaotic systems and, highly interconnected and interactive systems tend to be chaotic in this sense.

In addition, human systems at least, tend to contain inconsistency. Individuals want different things at different times; they want different things from each other; they understand and interpret their environment and each other differently. As a consequence, the rules, laws, and institutions they create are inconsistent. How these inconsistencies are perceived, interpreted, and resolved for any choice at any location and time is specific to that time and place (Blomquist, 1992).
These complicating factors increase uncertainty; thus uncertainty is a central concept for decisions in complex environments. Uncertainty in this context takes many forms. There is the uncertainty of predicting a specific instance when the possible outcomes of apparently stochastic processes have a known probability distribution (e.g., tossing a fair coin). There is uncertainty caused by lack of knowledge (e.g., choosing the prize behind curtain 1, 2, or 3). In most real world situations, this lack of knowledge results in what has been called "vagueness" or imprecise uncertainty (Wallsten, 1990). And there is uncertainty that is a combination of these (e.g., picking a red ball out of a bowl with an unknown distribution of red and white balls). Guesses about the probability distribution are supported by guesses about how good the first set of guesses are. Two additional forms of uncertainty are characteristic of human systems. Indeterminacy has been used to identify the inability to predict what a person will do in certain kinds of choice situations where the number of choices is large (Radner, 1997). In addition, humans perceive ambiguity, the possibility that two or more inconsistent interpretations of available evidence may be true, such as when two or more experts provide different estimates of the probability of an event (Kleindorfer, Kunreuther, and Schoemaker, 1993). These are special cases of combination uncertainty, which are particularly uncomfortable for people.

PHYSICAL REALITY

Water has a physical character and behaves according to physical laws that are known or can be discovered. The nature of its movement above and below ground level under natural conditions of temperature and pressure are generally understood. Specific description and prediction, however, depend on many location specific variables. For example, groundwater flow has been related to the shape, packing, porosity, and average
pore size of the flow medium and the specific weight and viscosity of the water (Linsley, Kohler, and Paulhus, 1982). Thus, a large proportion of the investment in water engineering and science is used for monitoring and testing at specific locations. The USGS National Streamgaging Program maintains a network of roughly 7,000 stream gaging stations, for example, at a cost of $85 million per year (USGS, 1997). Even so, much of the existing predictive capability depends on assumption and gross simplification. Groundwater flow models assume large areas of homogeneity in the subsurface media, for example, although heterogeneity is much more likely.

Many locations subject to policy have not been monitored or tested at all, and assumptions about water in these areas rest on incidental knowledge acquired in other contexts, like commercial drillers’ logs, and on additional assumptions about the similarity and proximity of an unknown location to a better known one. The Avra Valley recharge project in Tucson provides an excellent example of the range of error these assumptions permit. The project consists of four essentially identical two to three acre basins within an eleven-acre area. The average rates of recharge for the basins as of June 1997 ranged from 0.5 feet per day in one basin to 4.5 feet per day in the adjacent basin (Neal, 1997).

The chemistry of water, processes by which it takes on and loses constituents, also is generally known. Detailed knowledge is not comprehensive, however, as the number of possible constituents and the effects of their interactions under various conditions of temperature and pressure are astronomical. These processes and results are theoretically knowable through laboratory research, at least for a limited number of combinations of constituents in stable conditions. Laboratory-based knowledge may be used to predict water chemistry in natural systems, but only subject to the same context dependency.
found in predictions of physical systems. In addition, characteristics of physical and chemical systems interact.

Predictions about the movement and chemistry of atmospheric water depend, additionally, on areas of knowledge that, despite enormous recent efforts, remain incompletely understood even at a general level. For example, policy making and planning to deal with acid rain and the threat of global climate change have run into a science still debating basic evidence. The complexity of the processes is cited as the reason such a large effort has yielded so little predictive capability (Gleick, 1987).

Biological and ecological water are relatively young subjects of study. Organisms are adapted to physical (e.g., flow), chemical, and distributional (e.g., seasonal) characteristics of water. Their responses to changes in the characteristics are various, complex, and uncertain. In living organisms, responses to specific levels of chemical constituents, for example, will depend to some extent on the life history of the specific organism and possibly on a genetic predisposition that varies within a species. Some living organisms, that may not have direct responses to changes in water characteristics, depend on other organisms that do. Thus, second and third order effects are the rule rather than the exception in ecological systems. At the current state of knowledge, these effects remain largely unpredictable.

The history of water development and management abounds with examples of unintended consequences to biological and ecological systems. A few examples should suffice. Decades of timing releases of water from Glen Canyon Dam on the Colorado River to meet the demands of electric power generation caused degeneration of beaches in the Grand Canyon and associated destruction of the riverine ecology. An experimental release of dammed water to simulate natural flooding has partially restored beaches, leading to hope for ecological recovery, provided dam operation includes carefully
managed flood releases in the future (Department of Geology, Northern Arizona University, 1998). A humanitarian program of tube-well development in Bangladesh was successful in significantly reducing cases of water-borne disease in the area, but natural arsenic levels in the groundwater have resulted in an epidemic of arsenic poisoning (Bearak, Barry, 1998). The relatively stable water levels maintained in Lake Meade, the reservoir behind Hoover Dam, have enabled the development of habitat for the desert flycatcher; a suit filed by the Southwest Center for Biodiversity claims Lake Meade must now be managed to maintain that habitat because of the endangered status of the flycatcher. The results of this lawsuit can have an important impact on the operation of the CAP system (ADWR, 1998).

INSTITUTIONAL SETTING

A history of capture, use, development, and management of water has led to the creation of laws, organizations, and institutions that set limits on what is done by whom with or to water. Because of their history as responses to specific water problems, these laws, organizations, and institutions are inconsistent, overlapping, and incompletely specified with respect to authority, responsibility, and relationships (Eden, 1990). People create institutions to reduce indeterminacy in their relations with others (Blomquist, 1992). Institutions provide stability of expectations, so changes to institutions usually are resisted by vested interests. When conditions change, this resistance can create tensions that bring hitherto benign inconsistencies to the surface. Water related institutions developed over centuries of increasing knowledge about the physical (i.e., real world) system. Their embrace of this knowledge lags behind understanding because change would upset their pattern of dependencies. For example, the vested rights of groundwater and surface water users may directly conflict. Attempts to integrate the separate systems
of law to reflect knowledge about the interdependence of the physical systems may
subjugate one set of rights to another. That is, there will be losers.

Eventually, pressures for change will be irresistible. If a particular organization or
rule cannot be changed by direct assault, people may seek change through other avenues.
A nested and networked system of institutions provides flexibility by enabling changes to
be initiated in many places. A “new” judicial interpretation of existing law, for example,
can produce changes in an agency’s priorities that direct petition failed to produce. New
institutions may be created where the authority and responsibility of existing institutional
structures fails to resolve important problems. For example, after the authority of the
Arizona Health Department to regulate groundwater quality was challenged, a new
organization, the Department of Environmental Quality, was created (Eden, 1990).

Many different kinds of institutions have developed to fulfill different purposes.
Organizations formed to develop common water supplies are nested within systems of
laws developed to facilitate, record, and regulate individuals’ efforts to develop supplies.
These organizations stand alongside others that regulate how individuals and collectives
may affect the chemistry of certain categories of water.

Separate rule systems and organizations developed for different categories of water.
Surface water institutions have only recently and incompletely been integrated with
ground water institutions. Water that has been used and then treated before being used
again or returned to the natural system is subject to an entirely distinct set of institutional
rules from other water, as is water transported over natural barriers by artificial means.

Different institutions developed for separate uses of water and for distinct categories
of users. Irrigation districts distribute irrigation water under one set of rules, municipal
water providers distribute water under another set. In Arizona, within the category of
municipal water providers, private providers and public providers are subject to different but overlapping sets of rules.

Institutions similar in other ways exist at different levels of government. Thus, water quality protection units exist at federal, state, regional, and local levels. How they apportion authority and responsibility varies with locality.

The relationships among these institutions reflect the history of their development. Some were created to act autonomously; others were intentionally fitted into existing institutional niches. As conditions evolve, actions within one create effects in others. Groundwater pumping depleted river flow. Waste disposal made water unfit for domestic or industrial uses. At some point their inconsistencies become problematic for the institutions. In Arizona, the organization established to protect consumers--the Arizona Corporation Commission--and the organization mandated to ensure sustainable management of water supply and use--the Arizona Department of Water Resources--have been trying to adjust inconsistent regulations. DWR requires conservation programs and use of renewable supplies (i.e., CAP), both of which are costly. The costs are not directly related to supplying water at a minimum price on demand to customers, and therefore, charging these costs to customers may violate water consumer protection standards.

The network of water institutions includes links with organizations, individuals, and institutions whose interests in water is partial or incidental to other interests. Health departments typically have regulations affecting the operation of organizations that treat and distribute drinking water. Universities and other organizations whose purpose is development and application of knowledge are linked to the network of water institutions in several ways. Individuals move back and forth between them and share professional and educational backgrounds, professional organizations, and conferences. Specific studies and general expertise provided by knowledge institutions support policy making
in water institutions, which, in turn, can be a major source of support for university departments and profit making firms.

The regulated community also is part of the institutional network. Irrigation districts, water providers, and wastewater treatment organizations have obvious connections within the institutional environment. Others with less obvious links also are involved. Real estate developers and metal miners, for example, participate in and attempt to control the development of rules for water management and regulation.

Finally, public interest and community organizations, even without water user status, are part of the network. Organizations and individuals who perceive their interests affected in important ways can create and have created connections within the institutional environment. The Southwest Center for Biological Diversity has interested itself in water management and policy decisions because of the potential impact such decisions have on native fish species and birds. The Unified Community Advisory Board was formed from neighborhood groups concerned about local community health issues following the revelation of TCE contamination in some of Tucson’s water supply wells. It acts as representative of the affected communities with respect to cleanup activities by responsible agencies and organizations.

Water institutions also are nested in a hierarchy of governance that includes city, county, state, and federal legislative, judicial, and administrative bodies. Water related issues may be taken up in any of these arenas, and decisions will have an impact that propagates throughout the institutional environment. In addition, changes initiated by organizations nested at lower levels will have an impact at higher levels as affected parties look for pressure points to influence the process in their favor. Consequently, lower level changes frequently must be ratified and almost as frequently modified at higher levels.
Individuals frequently move around within the network of institutions, changing roles. They gain experience looking at issues from different perspectives and they bring new perspectives to different roles. These individuals form relationships with organizations as well as with other individuals. When they move within the network, they bring their relationships with them. Thus, whole networks of relationships shift as individuals move around.

SOCIO-CULTURAL CONTEXT

People share beliefs about water that are connected with other beliefs about what is and what ought to be. Because all of what we know about the world is subjective interpretation of sensory data, what we believe shapes the meaning of reality for us. That is, beliefs affect how physical reality is perceived, understood, and acted upon. Much of what we believe is provided by the culture in which we live.

The culture of the United States is diverse. Competing systems of beliefs coexist between regions, status and income classes, occupational groups, religions, and political parties. They also exist between neighborhoods, friends, family, and even within individuals (Elster, 1986). These competing beliefs guide and reinforce assertions of interests and rights to the use and control of water. Beliefs about the legitimate uses and control of water are at the center of most public conflicts over water policy decisions.

Brown and Ingram (1987) identified two major competing belief systems about water: the commodity value of water and the community value of water. Beliefs in both these systems reflect an instrumental view of water, but there also exist beliefs about the intrinsic and natural values of water. Many people incorporate beliefs from all these systems to different degrees. Which set of beliefs is evoked in the various decision settings will influence outcomes.
The dominant viewpoint in shaping water policy in the U.S. has been utilitarian; water has value only in service to people. The origins of this viewpoint have been traced to the Judeo-Christian tradition of human domain over nature (Smith, 1967). The value of water is related to its use in production, and water that is not used by man in some form of production is wasted.

This viewpoint is distinguishable from Brown and Ingram’s commodity value of water in several ways. Commodity water, like other commodities, derives it value from the market. It may be owned, bought, sold, and moved around like other commodities. Because it can be owned, the owner has rights that cannot be legitimately denied. Thus, for example, to limit use of groundwater by its owner has been considered theft, or in legal terms “a taking of property.” Commodity water is reallocated by the market. Uses with low market value are replaced by uses with higher market value in exchanges between willing buyers and sellers. For some at the extreme position, market value is essentially equivalent to value as an ideal (Anderson, 1983).

Utilitarians may accept the commodity value of water, but they may equally believe in the public ownership of water. Public ownership creates problems for determining market value, so the determination of low and high value water use usually is made legitimately through political processes. A belief in the public nature of water permits limitation of use rights. Water lost by inefficient irrigation systems may legitimately be considered “wasted” and therefore the irrigator may be required to use less by converting to a more water efficient technology. Even in strongly free-market centered times and places, law limited water use: malicious use of water has never been permitted (Sax and Abrams, 1986).

Brown and Ingram’s community value of water contained a large utilitarian component. The value derived from the productive use of water, however, emphasizes
the benefits to the collective. Within this system, it is assumed that collective benefits follow from the provision of benefits to individuals, such as the healthy society said to develop in communities of prosperous, small farms (Eden, 1990). Collective benefits are not captured in free market exchanges between individuals and are therefore the legitimate concern of extra-market, political valuation. These beliefs continue to support publicly subsidized development in many areas.

On the other hand, some non-utilitarians have come to accept the relationship between markets and value, at least metaphorically. Both believers in water as commodity and environmentalist may say that water should be priced to reflect its real value; that is, the price should not be subsidized. The real value for environmentalists, however, is more likely to be an ideal that includes non-market values (Bates, et al., 1993).

The community value of water contains other beliefs relating to the concept of water as central to community life. The organizing importance of water derives from the sense of identity, history and tradition of communities organized around the use and control of water. For Brown and Ingram, these were poor communities, principally of Hispanics and native Americans in the four corners states. In these communities, traditions of privilege and responsibility for water have entered myth. Maass and Anderson (1978) also commented on the organizing importance of water for irrigation communities in Spain and in southern California. The southern California farmers, from the individualistic Anglo-American tradition, were impassioned by issues of local self-governance and opposition to control by distant, hierarchically superior others.

Closely linked with organizing importance is the opportunity importance of water to communities. Continuing control over local water resources reinforces, both in political/economic terms and symbolically, the power of the community to control its
destiny. Despite studies that have demonstrated only a weak link between water and economic development (e.g., Lord, 1982), belief in the opportunity importance of water is widespread and deeply held in the southwestern United States. Political hostility to the idea of inter-basin water transfers is an illustration of these beliefs. The fate of the Owen’s Valley farming communities after Los Angeles acquired their water rights remains an emotionally potent argument against unregulated market transfers of water that take the water permanently beyond the control of the local community (see Kahril, 1982).

The Owens Valley story has other powerful symbolic content. Loss of water meant loss of the natural landscape and destruction of ecosystems. The literature of Mary Austin, which evokes beliefs about the spiritual connection of humans to landscape, is cited as a warning against the unresisted force of utilitarian and commodity value systems (Bates, et al., 1993). When people come to identify with a place, as Navajo do with the homes where they and their children were born or farm families do with the family land, then the things associated with the place take on special value as sources of personal identity (Brown and Perkins, 1992). The loss of water can mean a loss of subjectively important features of identity.

An emotional response to water may be part of being human. It has been demonstrated that people prefer paintings and slides in which water is depicted (Russell and Snodgrass, 1987; Komar, et al., 1999). Literature, especially from arid regions, has traditionally stressed the soothing and refreshing power of water: the sound and the sight of water flowing in natural and artificial channels, in ponds and fountains. It has even been speculated that a strong positive response to a landscape with water is adaptive in an organism (human) that seeks out ideal landscapes for survival (Pinker, 1997).
Natural water has additional values associated with ecological beliefs. Recently, such beliefs as that humans are part of a "web of life" have taken hold in the popular culture. In this belief system, depleting or damming water flowing in natural channels is likely to upset the natural balance of the web, with potentially severe consequences. The intrinsic value of natural things has always been found among people's beliefs. Although it has conflicted directly with the more dominant western economic and utilitarian perspectives, some economists have identified existence value as a legitimate source of market value. The Audobon Society and others fought in the courts for decades to mitigate the ecological damage done to Mono Lake by Los Angeles diversions from the Owens river system. They were able to carry on such a fight and eventually prevail in important ways because of commonly held beliefs about value priorities that allow non-use or non-human use the superior claim in some circumstances. In addition, the basic importance of water to survival has been described throughout history and is associated with the belief that water is priceless and should be free to everyone (Brown and Ingram, 1987). This conviction competes with beliefs based on economic models. In a diverse society, diverse beliefs and the cultural rules and institutions with which they are associated complicate the water policy environment.
CHAPTER 2. DECISION MAKING

Any broad reading of decision-related research quickly uncovers the theme of complexity. Living in the real world appears to require the ability to maintain a dynamic balance of inconsistent and even contradictory goals under ambiguous circumstances. The demands of decision-making may defy optimization in all but the most contrived situations. From the level of the individual through global institutional relationships, decision problems involve the tensions of irreconcilable demands and irreducible uncertainty.

The central image of dynamic balance is adaptation as used in evolutionary biology. The unceasing competition for adaptive advantage is the primary motive force preventing stasis. There appears to be an adaptive advantage to making sense of one’s environment. The development of various perceptual systems that detect and interpret aspects of the environment in relevant ways has improved the survivability and fecundity of species (Pinker, 1997). But apprehension of the environment is a tricky problem, characterized frequently as ill-defined; that is, it has too many unknowns. In order to find the value of one variable, the organism must act as though it knows the value of other unknown variables (Holyoak, 1990). A first guess, if it is adaptive, usually will be the one most likely to be presented by the environment. Under other possible but less likely circumstances, the first guess and subsequent inferences will be wrong. Then the biases that provide adaptive advantage in some situations are disadvantageous in others. (An organism that wants to fool you would then be well advised to capitalize on the first guess biases that advantage you in normal situations.) This is precisely what appears to occur in human decision making (Pinker, 1997).

Research suggests that the human brain is adapted to solving problems by recourse to various strategies; choice of strategy is dependent on the nature of the problem as
perceived by the individual (Pinker, 1997). These strategies work well on average over
the normal range of problems encountered by individuals. They also can be shown,
under certain circumstances, to violate formal rules of logical and probabilistic reasoning
and lead to problematic decisions (Hammond, 1996).

The traditional view of decision making is linear. People identify a problem; that is,
they notice an obstacle between the present situation and the desired state. They then
figure out a way to overcome the obstacle. The ability to conceive the world in these
terms has been called the definition of intelligence (Pinker, 1997:62). But a great deal
more is going on in decision making, and much of the research and theorizing of the past
few decades has been aimed at disclosing the layers of complications below the surface
of such a seemingly straight forward process. The task of disclosure has been undertaken
with many different tools from many different directions. As a result, the field is
extremely disorderly. For every general theory, there is contrary evidence; and for
experimental evidence there are competing theories. Therefore, to write of an emerging
picture really means to try to animate a Frankenstein’s monster of diverse components.

The particular monster described in this paper is constructed from evidence on four
categories of components. (1) People (individuals, groups, organizations, and
institutional entities) acting within and on their (2) environment, which includes other
people, their organizations, institutions, and cultures. Their interactions are (3) structured
in ways that affect (4) outcomes. Because decisions occur over time, they involve a
history of experience, learning, and change; that is, outcomes are not only endpoints, but
affect the people, their environment, and the structure of their interactions during the
decision process.

Public water policy decisions are made by people. The decision literature presents
evidence and proposes theories on how they make them. The literature addresses
questions about how decisions are affected by the way the human mind works. It explores what aspects of the environment influence decisions and how. It examines how groups of people make decisions, including decisions in organizations and decisions made on behalf of a diverse public. It addresses the structure of interactions and the impact of process structure on decisions. In this regard, decision literature looks at communication, coordination, and resolution of conflicts. It also examines feedback mechanisms like learning and experience.

The following sections will highlight some of the relevant theories and evidence in the literature at four progressive levels from decisions of individuals through groups and organizations to public policy decisions. Insights at lower levels will provide a foundation upon which to build toward an image of public policy decision making and the particular case of public water policy.

INDIVIDUAL DECISION MAKING

The constraints on public decision making have their roots in the individual. Most work developing explanations of how decisions are made has focused on the individual, and much of the recent work has been done by cognitive psychologists. Cognitive psychology is relevant to public policy making because people perceive, identify, define, analyze, communicate, and evaluate the problem and its alternative solutions. Without this cognitive participation by people, there is no policy problem. The way the individual’s mind works will help explain how public water policy is made, not just because a single person sometimes makes the decision, but also because individual human tendencies affect group processes, organizational structures, and institution building.
Traditional Models and Their Variants

The traditional model of individual decision making involves several conceptual steps usually thought of as occurring in sequence. The individual is dissatisfied and identifies the source of dissatisfaction. The individual defines his/her situation as a problem for which there is at least one solution. The individual identifies one or more alternative actions to resolve the problem. The individual evaluates the alternatives on the basis of his/her schedule of preferences and chooses the most preferred alternative.

In this scenario the decision maker is a rational actor. Rational actor models of choice are based on assumptions engrained in everyday conceptions of decision making. They assume fundamentally that choices are made on the basis of beliefs about the future consequences of current actions, which include how the decision maker will feel about those consequences (March, 1994). This implies that thought precedes action (Connolly, 1997) and that information influences decisions (Feldman, 1989). Even if human decision making frequently violates these assumptions, it is assumed that the best decisions are made by anticipating consequences (Baron, 1998).

Within this tradition various theoretical systems have been developed to describe decision making. The one most closely associated with the rational, consequential tradition is Expected Utility Theory (EU).

Expected Utility (EU) concerns itself with how choices are made among known alternatives. In EU individuals apply a probability calculus to choose among alternatives the course of action most likely to achieve the most pleasing combination of their choice-relevant desires. In its purest form, EU assumes that the individual has a stable and consistent set of desires (a utility preference function), knows all possible alternatives and associated probabilities, and chooses among the alternatives so as to obtain maximum expected utility. Research within this tradition demonstrates that people violate all these
assumptions. Utility preferences are inconsistent, context dependent, and changeable; only a few of the possible alternatives are considered and these are incompletely understood; and many strategies other than maximization of expected utility are employed (Slovic, 1990; March, 1994). This result has led to the characterization of human rational capabilities as limited and biased.

The theory of human cognitive limits has been called bounded rationality. The term, attributed to Herbert Simon, originally was applied to limits on mental resources for perception and cognition (Hammond, 1996), but has come to include limits on all information processing resources, including time (Radner, 1997). The theory proposes that because of these limits and the complexity and uncertainty surrounding decisions, decision makers simplify their choice problems. Simon proposed a strategy he called *satisficing*. Rather than attempt to maximize a utility function, the individual searches through the available alternatives only until he/she finds one that satisfies his/her choice criteria. This strategy requires less mental work (Slovic, 1990). Many decision strategies have been proposed that reduce the amount of mental work required to reach a decision from the often overwhelming demands of optimization. Some evidence has been found for the use of each of these in certain circumstances (Hammond, 1996).

The EU model accommodates satisficing and other choice simplifying strategies by assigning utility to the resources required for mental work. For example, they may be assigned value as transactions costs (Radner, 1997). Minimizing mental work as appropriate to the importance of a decision may be a simultaneous goal of utility maximizers and lead to satisficing behavior. A similar logic permits incorporation of strategies that minimize regret; that is, they assign a positive utility to regret avoidance (Plous, 1993). However, there is at least one aspect of bounded rationality that cannot be accommodated by EU, and that is the ultimate impossibility of "knowing the implications
of everything that one knows” (Radner, 1997). Humans must at some point fall back on feelings of rightness (common sense) to determine what is choice-relevant information and what it means.

Resorting to less taxing choice strategies than maximization is one way to simplify decisions. Another is to use more intuitive methods for evaluating alternatives. A large group of scholars within the EU tradition have found evidence that individuals use simple intuitive rules or heuristics as substitutes for formal reasoning.

The use of these heuristics is said to produce numerous systematic errors or biases. For example, the availability heuristic (Tversky and Kahneman, 1974), equates the ease with which instances are recalled with their frequency of occurrence. This heuristic may be used to solve relative frequency problems like “which causes more deaths annually, automobile accidents or diabetes?” Another heuristic is proposed to explain the results of experiments in which subjects seem to “anchor” their responses to cues provided in the questions and/or response scales (Tversky and Kahneman, 1981). These results mirror those of attitude survey researchers who have identified many context elements that affect expressed attitudes of respondents. These include question wording, question order, type of response, and response scale (Stipak, 1983).

Other biases result from “irrational” human tendencies such as a preference for certainty and a greater tolerance for risk when payoffs are expressed as gains rather than losses (Kahneman and Tversky, 1979). Related economic experiments found that individuals assigned greater value to an item they possessed than the identical item they did not possess (Lowenstein, 1987; Kahneman, Knetsch, and Thaler, 1990), and different discount rates to large and small amounts of money (Lowenstein, 1987).

The catalog of decision biases indicates that humans are poor at probabilistic reasoning, a significant handicap when anticipation of consequences involves likelihood
predictions. On the other hand, heuristics may have evolved as efficient solutions to a range of commonly encountered problems. For example, it has been argued that availability may be a relatively good surrogate for probability of occurrence (Pinker, 1997). If so, heuristics may be "hard-wired" into human brains and triggered automatically when the appropriate situation is perceived. This may account for the sense of rightness or comfort that signals the best decision, even when the solution or choice may be normatively incorrect (Denes-Raj and Epstein, 1994).

Social Judgment Theory (SJT) concerns itself with the process of evaluating (ranking, rating, or categorizing). It begins with the assumption that "humans function in a world that is indirectly observable and only partly predictable" and proposes that people make social judgments "by combining overlapping imperfect cues" (Hammond, 1996). Judgment problems that have been studied in this context include interpretation of x-rays, medical and psychological diagnoses, predictions of success in school or job, classifying soils, and rating livestock (Arkes and Hammond, 1986). Subjects are often experts whose use of cues (judgment protocols) are elicited through verbal report and through repeated trials.

Research in SJT has determined that individuals tend to combine cues linearly, even when they believe they are using a more complex calculus. They tend to use only a few cues, even when they believe they are considering many; and they tend to assign more importance to major cue and less to minor cues than they think. Furthermore, they can be poor at detecting correlations among cues and so will give too much weight to highly correlated cues (Kleindorfer, Kunreuther, and Schoemaker, 1993). These research results suggest that individuals may be aware of the complexity of the decision problems they face, but tend to simplify them implicitly in order to solve them. Individuals also tend to be inconsistent in their use of cues and their inconsistencies appear to be unbiased, that is,
"random error" (Kleindorfer, Kunreuther, and Schoemaker, 1993). SJT has been used to develop decision aids, such as expert systems, that automate expert judgment protocols and eliminate inconsistencies, but the systems rely mainly on the human experts to indicate which cues are relevant and what they mean (Hammond, 1996).

In comparing the approaches of EU and SJT, Hammond (1996) perceived that EU is concerned with the coherence of decision processes; that is, their internal consistency. SJT, on the other hand, is concerned with congruence, or the match between subjective experience and external cues. Individuals appear to be concerned with both kinds of consistency. The primary experience of their choices may be through interpreting the evidence of their senses, but they also make use of coherence strategies, especially when their choices are complex, important, and provide sufficient time.

Information Processing Models

A third approach to individual decision making employs an information processing model. Where EU focuses on choice and SJT focuses on evaluating, information processing theories focus on problem solving. Research in this area suggests also that two or more separate information processing systems share responsibility for individual problem solving. One calls on rational processes and an alternative system draws on intuitive processes (Epstein, 1994).

Humans may be able to make inferences because they have innate mental categories of things (Pinker, 1997); that is, humans can draw inferences about the characteristics of a thing by virtue of its membership in a category. Categories are nested, inter-connected, and may overlap. Category membership is the basis for relationships among things, such as the relationship of this rabbit in the category rabbits within the category of animals and also possibly the category of pets. There is some evidence that the human mind
constructs some mental classes of objects by the similarity of their features and another set of mental classes based on underlying rules, such as kinship systems. Similarity-based categories are fuzzy, while rule-based categories are relatively crisp (Pinker, 1997). Congruence processes may correspond to mental functions that recognize and classify instances of similarity-based categories and coherence processes may correspond to mental functions that develop systems of rules for assigning instances to rule-based categories.

Which system dominates depends on many factors, including the nature of the problem, stable and transitory characteristics of the individual, and contextual factors. Various specific strategies have been associated with both systems. Individuals appear to use a large set of reasoning strategies, including formal logical or probabilistic choice rules. Experimental evidence suggests that choice of decision strategy varies with the complexity of the task and individuals may be successful or unsuccessful using either rational or intuitive strategies (Epstein, 1994; Klein, 1998).

From this perspective, studies suggest that becoming an expert may involve shifting information processing from the rational to intuitive system, which is faster and less effortful. The choices of expert fire fighters appear “choiceless” or automatic in this sense (Klein, 1998). In observations made over a wide range of natural decision situations, Klein and his colleagues found that novices were more likely to use rational strategies than experts. Using chess expertise as a model, researchers theorize that experts create mental categories with inferential power similar to more normally intuitive categories. Instead of rationally comparing alternative choices of action, expert chess players, for example, recognize patterns of play that automatically suggest a candidate for the best move (Holyoak, 1990). Chess experts then can respond to particular board
patterns as intuitively as most people respond to patterns of facial expressions and tones of voice in their friends. \(^1\)

Alternative Theories

In contrast to rational, consequential theories of decision, a host of newer theories assume that decision processes are based on mental patterns, images, scenarios, or narratives that make sense of the decision environment for the decision maker. Although different in detail, these theories share the view that individuals experience choices not as discrete opportunities for rational or intuitive problem solving, but as events in a narrative. Choice of action may precede thought, and consequences may be used to explore the external world and the self (Connolly, 1997). Rather than a logic of consequences, individuals may use a logic of appropriateness. Choice of appropriate action depends on accurate matching of the decision maker’s identity, the situation, and the rules (March 1994). The central concern of the decision maker may be maintenance of a consistent image of him or herself and a coherent conception of the world. Several theories propose that people are concerned with elaborating believable explanations or justifications for their behavior, the behavior of others, and the evidence of their senses (Connolly, 1997).

The theory of arguments (Toulmin, 1958) proposes, for example, that underlying the decision process is “the individual’s desire to paint of coherent picture of the world. People want of provide a plausible set of arguments to justify what they are doing and want to be able to explain why they took certain steps or drew certain conclusions. One

\(^1\) Conversely, anecdotal evidence on autism suggests that austistic individuals must apply a learned rational strategy to infer emotional states (Sacks, 1995).
aspect of coherence seeking is the tendency to provide causal explanations where they might not exist, or make uncertain situations more certain through the use of deterministic rules or heuristics” (Kleindorfer, Kunreuther, and Schoemaker, 1993:85).

Some theorists reject a consequentialist explanation of choice. Their viewpoint is shared by self-perception theorists, who propose that individuals learn about themselves by observing and interpreting their own behaviors (Bem, 1972). Research demonstrates that individuals who are induced to behave contrary to their expressed attitudes subsequently change their attitudes, especially if they were not coerced or well-paid for the behavior (Plous, 1993; Eagly and Chaiken, 1993; Olson and Zanna, 1993). Theoretically, they explain their behavior to themselves by adjusting their beliefs. Interesting support for self-perception theory comes from attribution research. In experiments where a subject sat next to one person and across from another while observing a discussion, the external visual cues appeared to influence whose behavior was perceived as another’s and whose was identified with self (Taylor and Fisk, 1975).

Theories of decision making that reject consequential reasoning focus on identity. Evidence indicating that people use decisions to explore their own identities includes post-choice information search, escalation of commitment, and hindsight bias. People tend to find more reasons to be happy with a choice once made, in many cases rationalizing an intuitive choice, and they are more likely to commit themselves to important actions when they are first induced to perform a minor related action. When this escalation of commitment is observed, people also are likely to remember being more positive toward the action prior to taking it than they actually were (Plous, 1993). Misremembering is common to individuals, and memory research indicates that recall is subject to a number of biases. In fact, emotional state, mood, setting, problem type, and many other contextual factors affect memory.
People understand themselves as coherent beings. They have a set of responses appropriate to an on-going series of choices. Rules of behavior attached to identities provide standards of appropriateness. To make choices or solve problems, the individual invokes an identity, recognizes the situation, and recalls and interprets the appropriate rules for that identity in that situation (March, 1994, 1997). A professional water resources manager, for example, could use his/her identity as a mid-level manager in a public utility organization in a routine work situation to apply the organization’s rules for resolving priority conflicts among assigned tasks.

Any of several identities may be used, as when the same water resources manager is also a concerned public citizen, an environmentalist, and a professional engineer. The appropriate rules of these various identities may conflict in some situations; for example, the manager may ignore his/her environmentalist identity when making decisions as a professional engineer. To the extent that the individual is aware of the identity conflicts, he/she may revise his/her concept of self (March, 1994). In this way people can come more and more to identify with the point of view of their employer. In an extended look at the concept of fairness in the U.S., J. Hochschild (1981) accounted for the simultaneous conflicting definitions of fairness supported by middle Americans by the multiple identities of individuals.

Narrative theories of decision making may help interpret results from research on superstition. Individuals have a tendency to perceive patterns in a series of events regardless of whether a pattern exists. Conversely, individuals’ sense of randomness has been shown to have more alternations than truly random events (Plous, 1993). Certain relationships are more likely to be observed than others. They are relationships that are relatively close together in time and place; and they are relationships for which a narrative, possibly a socially or culturally derived narrative, exists. The existence of such
a narrative not only induces individuals to detect relationships that do not exist, but also prevents individuals from detecting relationships that do exist.

Recognizing patterns, especially causally determined patterns, enables prediction and control. People tend to believe they have more control over events than they do. Individuals may explain their ability to control uncontrolled events (e.g., rolling sevens on dice) as luck or some other power by substituting causality for probability (Langer, 1975). Like other biases, this tendency can be counteracted to some extent by training, but there is a suggestion that this predisposition may be adaptive. When coupled with an equally well-documented human tendency to over-confidence, it creates a narrative in which appropriate actions (e.g., blowing on dice), when properly performed, will cause desired outcomes. In other words, causal narratives motivate active participation in choice by emphasizing the possibility of control.

The illusion of control has a counterpart in how individuals perceive others. In general, people explain to themselves the actions of others by attributing motivations to them. The fundamental attribution error is the tendency of people to attribute behavior to fixed traits, such as personality or character. In fact, many experiments have demonstrated that more of behavior is determined by external factors, such as task structure, time pressures, and the behavior of others (Plous, 1993). Comparative studies suggest that culture influences what proportion of individual choice behavior is determined by internal versus external factors. For example, subjects in the U.S. appear to be less influenced by external factors than do Chinese subjects. Chinese subjects are more likely to attribute behavior of others to external factors, but even they underestimate external influence.
Knowledge and Information

Information is key to decision making whether it is used in the rational comparison of alternative consequences, in recognizing situations, justifying or explaining previous actions, or exploring the implications of past actions. Information is the opposite of uncertainty (Grauman, 1985). Many situations encountered in the real world are ambiguous; that is, they do not automatically identify themselves and may equally represent any of several multiple meanings. Information provides a means of discriminating among the possibilities. Yet research within social psychology indicates that individuals interpret information with reference to a cognitive representation or theoretical formulation of the observed phenomenon. A goal is assumed to activate a set of relevant concepts and procedures that, in order to permit conclusions to be drawn, must include at least a vague theoretical formulation of the phenomena observed (Wyer and Srull, 1988). The novice may try out a series of general purpose procedures and concepts before choosing one, while an expert may immediately activate a highly structured model. The formulation may be a causal narrative that includes superstitious beliefs and illusions or it may be a scientifically validated knowledge structure.

Knowledge is defined as a product of information processing, encoded and stored in persons’ memories (Grauman, 1988). This individual view of knowledge ignores the role that social interactions play in certifying interpretations of information. March (1994) observed that knowledge is a social construction, “valid in the sense that it portrays reality correctly and reliable in the sense that it is shared and reproduced among knowledgeable people.” The next sections will address how an individual’s processing of information into knowledge and decisions is affected by social interactions.
GROUP DECISION MAKING

Social interactions affect individual decision making, and group decisions are not simple aggregations of individual preferences. The interactions of group decision-making are incompletely understood, but research indicates that outcomes of group processes are less predictable than suggested by traditional models. Many a priori assumptions about group problem solving, judgment, and choice do not capture actual behavior.

Social Influences on Individuals

At the most basic level, individuals are aroused by the presence of others (Russell and Snodgrass, 1987). Their behavior reflects their awareness that others are present. The presence of many others (crowding) may be stressful or stimulating depending on the expectations of the individual (Freedman, 1975). Thus, the bare existence of a group indicates that the emotional state of the individuals has been altered, and the emotional state of the individual affects his/her decisions.

There is experimental evidence that the presence of others affects individual capability. Performance on simple tasks and the performance of experts on mastered tasks tend to be enhanced by the presence of an audience. Performance of complex and unmastered tasks tends to be impaired under the same circumstances. Recent research distinguishes the influence of supportive versus non-supportive audiences (Noble, 1998).

The existence of a group means a decision is made in a social environment composed of others. Social influences affect the behavior of individuals, possibly because the actions and demeanor of others provide a standard of comparison against which individuals can evaluate themselves. Social comparison theory (Festinger, 1954) proposes that in order to make choices, individuals must compare themselves to
something, either an internalized or externally evident, objective standard, or to others. This theory explains evidence from social psychology that individuals are less likely to offer help or take other situation appropriate actions in the presence of others (Plous, 1993). Indeed, the likelihood that help will be offered declines as the number of people increases. An alternate or complementary theory proposes that the individual’s sense of responsibility for an outcome motivates his/her effort. The existence of a group presupposes diffuse responsibility, so each individual’s effort decreases. It is well-established that individuals work less hard when they believe others share their task (Plous, 1993). Perhaps, when the situation is ambiguous, individuals determine both the existence and level of their responsibility with reference to others.

The judgment of individuals also is affected by others. It will tend to conform to the opinion of other group members. When individuals’ pre and post group decisions are compared following a group discussion, post-group decisions show movement toward the group decision but generally are not identical to it (Kleindorfer, Kunreuther, and Schoemaker, 1993). Individuals’ opinions will tend to conform if the group’s opinion is unanimous, even when it directly contradicts the evidence of their senses. This tendency also increases as the size of the group increases. When the individual’s viewpoint is reinforced by the presence of even one other person, however, this tendency to conformity can be reduced significantly. When the minority is consistent, it can affect the judgment of members of the majority (Plous, 1993; Kleindorfer, Kunreuther, and Schoemaker, 1993).

It is well-known that group interactions are not concerned entirely with the problem at hand. Much of the behavior of group members has the effect of reinforcing self-concepts, establishing and affirming social order, creating relationships, and interpreting events (March, 1994). As evidence of these effects, research demonstrates that members
of groups tend to see themselves as more similar to other group members than contrasting
groups, engage in more cooperation with the group and competition with contrasting
groups, express more positive attitudes toward in-group and more negative attitudes
toward out-group members, and describe in-group behavior as more justifiable than out-
group actions (Plous, 1993). These kinds of adjustments to identity, attitude, and
judgment have been observed even in ad hoc groups (Turner and Oakes, 1989).

Social Influences on Group Choice

Group choices are consistently different from what would be predicted from a simple
aggregation of individual choices. Contrary to expectations, group choices usually do not
reflect a central position among the various preferences of its individual members, but
may take any of the possible range of alternatives available to the group. The
composition of the group, the nature of the decision problem, the distribution of initial
preferences, and the existence of a contrast group may each affect the final choice (Davis,
1973).

When groups are asked to make joint decisions or tackle joint problems, they exhibit
a stronger tendency to rely on heuristics than individuals do and they amplify individual
biases. In particular, group interaction appears to have a polarizing effect on such
problematic individual behaviors as attribution and risk taking. In general, in a contest of
viewpoints, the group decision tends to move farther in the direction of the majority
opinion than the average of individual viewpoints would predict (Doise, 1969).

It is not surprising, therefore, that one of the most troubling aspects of group
decision-making arises in groups that are highly cohesive, in decisions that are insulated
from outside influence. Individuals in groups strongly influenced by forces of social
cohesion are more apt to ignore evidence contrary to the dominant group opinions, self-
censor and suppress dissenting opinions in other group members, and maintain beliefs in the infallibility of the group, leading to excessive risk taking. This pathology of group decision making has been called "group think" (Janis, 1972, 1982). Prescriptions for combating group think include encouraging conflict of ideas through a devil's advocate, role playing, subgroup formation, and active search for disconfirming evidence. In addition, leaders are cautioned to exercise restraint in expressing their opinions so as not to influence followers. (Kleindorfer, Kunreuther, and Schoemaker, 1993; Plous, 1993)

In other situations, however, the same social influences that create group think may support the efficient coordination of decisions, spirit of cooperation, and commitment necessary for action (see Brunsson, 1989). Thus, the anti-group think prescriptions may be destructive of the same features of groups that make concerted effort possible. It may be very difficult, if not impossible, to determine a priori whether group cohesion tendencies have reached problematic levels.

As problem solvers, groups tend to perform better than individuals (Hill, 1982); but this effect does not appear to result from unstructured group interactions, which tend to impair performance. Instead, the advantages of groups can be attributed to the increased probability that the group will contain one or more members with the necessary competence(s) to solve the problem. This result follows from research on solving problems for which a correct solution is known. In laboratory experiments of this kind, groups tended to do better than the average individual but no better, and sometimes worse, than the best individual. Research involving problems requiring creativity found similarly that group brainstorming was worse at generating usable ideas than a process that compiled ideas generated by individuals working alone (Plous, 1993).
Influence of Group Structure

The structure of the decision-making group affects the quality of group decisions. In one experiment, a structure in which a “leader” encouraged participation by all members outperformed groups that operated without such a structure, as well as the individuals acting independently. In another experiment, a group structure in which the group chose a single member whose judgments represented the group outperformed all other group decision structures, including discussion to consensus, dialectic argument, and Delphi approaches (Sniezek, 1989). Apparently, in these situations groups were better at recognizing solutions and/or people capable of generating them than they were at solving problems. However, the extremely limited number and range of such experiments precludes generalization. Features of the experimental situation minimized the likelihood that factors such as conflicting motives and distrust would influence decisions. Other structures may be more effective when such factors are important.

The relations of decision process structure and outcome have been studied also by Decision Scheme theorists, who propose that rules of the decision process affect the likelihood of particular outcomes. These researchers found that the decisions of unstructured groups tend to conform to an equiprobability model in which the initial positions of each group member had an equal probability of being the group decision. They propose that when groups have explicit decision rules, such as majority voting rules, the equiprobability model will give way to other models. Majority voting, for example, tends to lead to polarization. Unstructured groups may have implicit decision rules (e.g., consensus without voting) which remain implicit in the interest of group survival. For groups characterized by mutual trust and strong norms of decorum, minimizing the appearance of conflict may be at least as important as the content of a particular decision. When these researchers looked at the decisions of mock juries, they
found that the equiprobability model also fit the jury data, but a more complex model based on the proportion of initial positions appeared to fit it better (Davis, 1973).

The basic rules structuring jury decision making are exogenous; they are provided by law. Juries deliberate in seclusion, their information on the facts of the case is limited to that provided them during trial, and their information on matters of law is limited to that provided by the judge. In criminal cases, they vote individually either guilty or not guilty and, typically in the juries studied, a final guilty or not guilty vote must be unanimous. Otherwise the process ends in a failure to reach a decision, i.e., a hung jury. The first task of many juries is to select a foreman, who leads subsequent deliberations and conducts votes. Within this structure there is room for various styles of deliberation and various methods for achieving consensus.

Research suggests that the way juries arrive at verdicts reflects a dual strategy model of decisions (Hastie and Pennington, 1991). Individuals first develop a single dominant narrative that accounts for the evidence and then may or may not make a determination of guilt prior to group deliberations. Usually, the individual juror believes that the other jurors share the same interpretation of the evidence; that is, they express surprise when others offer different interpretations. The style of deliberations tends to conform to the style of the foreman, either "evidence-driven" or "verdict-driven." Evidence-driven jurors seek first to agree on a narrative that fits the evidence presented at trial, then apply the legal rules to that narrative. Verdict driven jurors seek to establish positions on guilt and justify their positions with reference to the evidence. Generalizing from experiments with mock juries, Hastie and Pennington (1991) concluded that deliberation on events produces more consensus in evidence-driven juries than in verdict-driven juries. During deliberations jurors use exchange of information, appeals to moral values, and various social rewards and punishments like disapproval, appeals to reason, and the like, to
influence the opinions of others. Such efforts are less likely to effect changes in an individual’s narrative of events than on his/her interpretation of how to apply legal categories, especially in verdict driven juries. When juries reach consensus, it is often because they agreed that regardless of differences in their understanding of events, the law requires a certain verdict.

Dealing with Intra-Group Conflict

Frequently, group decision making is characterized as a two-stage process: one dealing with decision process rules, the other with facts. Typically, the agreement on rules for resolving conflicts of interests or interpretation is conceived of as occurring first in a kind of meta-decision. After these rules are established, the judgment or choice involves only collecting, analyzing, and applying information to the problem (Ostrom, 1990). Stage-one rules are imbedded in the structured decision processes of institutions such as courts of law and representative democratic governments. In juries, for example, they are provided in the judge’s instructions. In unstructured groups, early discussions are often concerned with exploring communication and consensus techniques to resolve, minimize, reinterpret, or avoid conflict (Davis, 1973). Group members socialize each other, evoking and interpreting each others’ identities in ways that reduce conflict (March, 1994). For example, a group may try to reach agreement on the problem definition and objectives, and evoke rational decision maker identities in the expectation that a solution, arrived at through rational means, must be agreeable to the group.

Most of decision engineering concerns itself with the second stage, where the various information processing limitations of boundedly rational individuals tend to be amplified in groups. Partly, this is a result of social effects, such as those described above, but groups also are plagued by problems of communication and coordination.
Decision support systems are designed to provide an orderly and understandable process for group members to coordinate the analysis of information and share relevant information with each other. When conflict is low and/or methods for resolving conflict are established and accepted, decision support systems can reduce the costs of decision making by making communication and coordination more efficient. Thus, the centerpiece of decision support systems is often some means, typically technological, of performing complex, abstruse, or time-consuming analyses. In addition, most decision support processes use a series of communication sessions that may or may not include face-to-face discussions, but provide all participants with the same information. It appears to be important that there also be a record of the group's activities to connect the sessions (Kleindorfer, Kunreuther, and Schoemaker, 1993).

Other features that appear to be important include, a facilitator who administers an accepted set of process rules, which may include anonymous communication and voting; and a segmented process with recognizable outputs that serve as inputs to the next segment. The more contentious the problem, the more anonymity and segmentation may be useful. Anonymity may help participants separate interpersonal problems from issue-specific problems. Segmenting the process into stages with separate outputs can change the focus of participants from preferred outcome to the process of solving a joint problem and thus build commitment to the final decision. Segmented processes are less effective when outputs of early segments obviously determine the ultimate outcome. Participants are aware that the decision process affects the outcome and strategic manipulation at early stages can predetermine winners and losers. This awareness places stringent limits on the efficacy of decision support systems (Kleindorfer, Kunreuther, and Schoemaker, 1993).
Coordination and Cooperation - Game Theory

The contributions of Game Theory to group decision making research come from illuminating factors affecting coordination and cooperation. For the most part, it ignores the influences of group interaction and looks instead at the problem of aggregating individual preferences of rational, self-interested individuals, when individual outcomes depend on the actions of the group. From this perspective, the group's decision results directly from each member's choice of play. The payoff structure of games is a simplified simulation of realistic choice situations (Camerer and Knez, 1997). The most famous of the games studied is the two-player prisoners' dilemma (PD), in which two prisoners, isolated from each other, must decide whether to cooperate (remain silent) or defect (confess, implicating the other). In this game, the best payoff typically is available to the player who defects when the other cooperates. The best joint payoff rewards cooperative play. Because the players are isolated, they cannot influence each other directly, and both defect is the most common solution. Even so, many players want to reciprocate "niceness" and seem to have "an internal representation of the game as coordinating levels of cooperation and niceness" (Camerer and Knez, 1997:166). That is, many players see the game as a problem of signaling one's intentions and understanding the intentions of the other player.

Research suggests that in many games where cooperative play produces the most efficient (jointly favorable) outcome for participants, it still is very difficult to achieve unless participants are permitted to communicate (Schelling, 1984; Camerer and Knez, 1997). When players are permitted to communicate their intentions, each player still has the problem of trust; for the self-interested player, there will be an incentive to deceive the other into cooperative play. Even so, communication increases cooperation. It is interesting to note that face-to-face contact by itself promotes cooperative behavior. That
is, contact without overt communication and communication without contact have independent effects on promoting cooperation. (Kleindorfer, Kunreuther, and Schoemaker, 1993)

In iterative play, cooperation is more frequently achieved even if communication between players is not permitted (Axelrod, 1984). This probably is because players are able to learn from experience the consequences of defection or cooperation (Kleindorfer, Kunreuther, and Schoemaker, 1993). The best strategy for iterative play is tit-for-tat, in which the signal for cooperative play is cooperation on the first play, and any defection is punished on the next play. Believable intentions to cooperate and punish defection appear to be important in achieving stable cooperative play (Axelrod, 1984).

The payoff structure of the game affects the development of cooperation. The best joint outcome may still provide larger payoffs to one player than the other. The greater the difference, the fewer times experimental play resulted in a cooperative solution. In addition, as the degree of risk increases, if losses to cooperative players are very large when the other defects, subjects are less likely to play cooperatively (Kleindorfer, Kunreuther, and Schoemaker, 1993).

The number of players also affects the development of cooperation. As group size increases, cooperation decreases, even in games where the defector does better only relative to the group: the lower the total group payoff, the lower the defector's payoff (Kleindorfer, Kunreuther, and Schoemaker, 1993). Cooperation in larger groups may be more difficult to achieve because the problems of communication and enforcement are greater.

Games can model many situations in which communication is limited or suspect and coordination of play is desirable. Situations occur every day in which any decision is preferable to no decision yet individuals are uncertain about the positions of other group
members and there is incentive for strategic deception. Common pool resource situations (e.g., groundwater management) can be modeled by such a game. Called coordination games, players in these games appear to get stuck in low payoff positions. Research on such games has identified some factors that encourage more cooperative play. These include announcing to all players the location of the efficient solution, offering additional incentives (side payments) to the group for reaching the efficient solution, and training (Camerer and Knez, 1997).

Experiments with large numbers of players (up to 16) in a coordination game called the weakest link game, found that groups rarely played the most efficient solution. In fact, in iterative play, solutions tended to decrease in efficiency quickly until play stabilized at the least efficient level. The researchers inferred that the group was unable to intuit the necessary conditions for efficient play. Experiments with training two- and three-player groups led the researchers to speculate that once an n-player group had established a history of efficient play, they would be able to maintain it, even when group membership changed, as long as new members were added slowly enough to permit indoctrination by the rest of the group (Camerer and Knez, 1997).

Trust

These results suggest that the ability of groups to arrive at jointly beneficial solutions, or avoid catastrophic outcomes, may depend on the beliefs of each member about the future actions of all others. Beliefs that support cooperative strategies include trust, and trust related issues are at the center of group decision making. Trust, communication and cooperation are mutually reinforcing. Trust is easily destroyed and relatively difficult to reestablish. Lack of trust leads to defensive behavior. (Kleindorfer, Kunreuther, and Schoemaker, 1993) Individuals may have innate psychological
apparatus for engendering trust and detecting fraud (Pinker, 1998). These may be at work whenever people meet, and therefore would be expected influence face-to-face group interactions. Activities that build trust, therefore, may be an important component of group decision processes.

ORGANIZATIONAL DECISION MAKING

Organizational Design

Organizations are generally numerous, structured, rule-ordered groups. Organizations can be considered social constructions whose purpose is coordinating the specialized and interrelated activities of many people toward common goals. They tend to be hierarchical and systematized. Classical organizational design theory proposes that hierarchical organization and explicit systematization are the best means for establishing common goals and achieving efficient coordination (Kleindorfer, Kunreuther, and Schoemaker, 1993). At the extreme rationalist position dominant in the 1940s, organizational designers posited the existence of universal design principles for incentive systems, rules, operating procedures and policies to create “frictionless, unitary, mechanistic organizations” (Kleindorfer, Kunreuther, and Schoemaker, 1993:323).

How well the classical design of organizations functions in the real world appears to depend on a number of factors, including size, task complexity, and technology. What limited empirical evidence exists suggests that medium sized organizations, engaged in mass production, using standard technologies fair best using the classical model. Both large and small firms and firms using new and/or highly complex technologies appeared to fair better with decentralized “organic” structures (Kleindorfer, Kunreuther, and Schoemaker, 1993).
An underlying source for this difference may be information processing demands. The information processing view focuses on the coordinative function of organization. As organizations become more complex by growth or technological change, their demands for information processing increase. Organizations can deal with the increased demand by increasing information processing capacity (e.g., installing automated systems), or increasing unit autonomy and thus decreasing the need for hierarchical communication (e.g., decentralization and/or lateral communication) (Galbraith, 1973). In fact, decentralization may be the inevitable result of increasing information processing demands, given "costly and bounded rationality" (Radner, 1997). Decentralization means that "different decisions - or groups of decisions - are made by different decision makers on the basis of different information" (Radner, 1997).

When individuals and sub-units of organizations have divergent goals, a decentralized structure creates problems of control. The classical model, with its formal hierarchical structure and clear lines of authority, was supposed to achieve control through central authority and supervision. In decentralized organizations, control may be achieved theoretically by designing structures that align incentives of decision makers with the central goals of the organization (Kleindorfer, Kunreuther, and Schoemaker, 1993). Any mechanism designed to induce a specific set of behaviors, however, must be based on expectations about the external environment and the choices people will make given a set of potential rewards and punishments. Under any set of realistic assumptions, this is an impossible task (Radner, 1997). That decentralized organizations can function effectively indicates the existence of rules of conduct, explicit and/or implicit, that shape the expectations and choices of autonomous groups and individuals.

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2Costly rationality assumes that all information processing, including observation, storage, communication, and computation, have some irreducible cost.
Rules as substitutes for direct supervision have been observed in association with highly routinized work. In this context, they appear to function both to protect managers from deviant choices of employees and to protect employees from arbitrary actions of managers. Many of the choices made within and by organizations are routine and engaging in a rational choice calculus for each instance would waste time and resources. Once successful strategies are devised for dealing with routine situations, they may become rules that are more or less automatically invoked when the appropriate situation is recognized. This is the basic notion underlying theories of the development of rules in organizations: they embody the knowledge that accumulates over time (Zhou, 1997).

Much of the knowledge accumulated in organizations derives from experience, and therefore rule changes tend to be incremental and path dependent. Rules change to accommodate new knowledge, but much of this change takes the form of reinterpreting or forgetting out-dated or inconvenient rules. "Organizations are constrained by the structure and knowledge that are built up in their history" (Zhou, 1997). Thus constrained, organizations may consider only a limited range of possible options.

When the organization encounters a new problematic situation, it may apply a rational choice process to the problem. However, observation of choice behavior under conditions of varying uncertainty suggests that people's behavior is more stable and predictable, i.e., rule-ordered, under high uncertainty. Thus, organizations may fail to respond when a changed situation calls for deviation from rules. When the failure of existing rules is recognized, the disruption engendered by deliberate decision-making frequently destabilizes the rule-based order, and the response of the organization is likely to be creation of new routines (March, 1994, 1997; Zhou, 1997).
Social Identity Theory

The choices of individuals in organizations shape the interpretation, reinterpretation, and evolution of its structural and procedural rules; at the same time individual identities are shaped by such rules. Social identity theory holds that an individual’s social identity is constructed on the basis of externally created social categories; that is, people behave according to the interpersonal expectations and cultural norms associated with particular roles. In organizations, these roles largely are defined by their position within the hierarchy. The powerful socializing influence of organizational roles supplements formal rules to stabilize interpersonal expectations with respect to behavior and thereby facilitate organizational coordination (March, 1994, 1997; Zhou, 1997).

Various factors may go into assembling the particular set of expectations and norms, including professional training, stereotypes, popular cultural images, and the history of incumbent behavior. Social role has been shown to affect confidence, risk taking, use of heuristics, biases in decision making and risk estimation, and personal standards. According to this theory, then, individuals will tend to exhibit significantly different approaches to decisions when they change their positions (March, 1994). Conversely, changes in the structure of organizations that increase the number, status, prestige, and/or authority of individuals from different professional backgrounds or other recognizable social categories will alter significantly the approach to organizational decisions (Pfeffer, 1992).

When the preferences and identities of organizational actors are consistent, it may make very little difference who participates in making a decision. The organization may be viewed as an unitary actor, rather than a collection of individuals. Such organizations may be considered to have identities that bias decisions in the direction of expectations and cultural norms associated with particular identities. For example, organizations that
are considered leaders and internalize that characterization tend to be bolder and more innovative (March, 1994). An identity or organizational ideology may come to dominate decision-making to the extent that the ideology will dictate most decisions. One might look at the mid-century decisions of the Los Angeles water company to promote growth by acquiring and developing distant water supplies as a manifestation of this tendency (Ostrom, 1953).

To say that roles within the organizational structure shape preferences and identities is not to say, however, that those preferences and identities will be consistent with each other. In fact, individuals who conform to the behavioral expectations associated with a position are distinguishing themselves from individuals in other positions. In a hierarchical structure, executives and mid-level managers face different expectations and will see themselves as fulfilling different identities. Hierarchical subunits will develop distinctive sub-cultures based on personal interactions and the sharing of common resources and common functions within the organization. This tendency toward differentiation may be exacerbated in decentralized organizations (March, 1994).

Participation

When the preferences and identities of potential participants are inconsistent, participation will determine the outcome of decision processes. A key determinant of participation is attention. “If everyone could attend to everything, and did so, the possibilities for irreconcilable conflict, that is for the failure of decision procedures to achieve acceptable choices, would be greater than they are” (March, 1994:230). Potential participants have multiple demands on their attention. In addition, structural features of the organization and/or the decision process may encourage the attention of some and
discourage the attention of others. Successful organizations manage internal inconsistencies through the allocation of attention.

Organizations can allocate attention by designating who makes which decisions. The inconsistencies between levels of hierarchy will have less effect when certain decisions are made only by vice-presidents, and inconsistencies among departments will be less evident in departmental decisions. Thus, organizations may sacrifice global consistency for local consistency (March, 1994). When the time comes for implementation of vice-presidential decisions, the multiple interpretations and decisions needed to put a policy into action will be made by others with potentially different preferences and identities. Vice-presidential inattention may simultaneously facilitate and undermine implementation. That is, the policy that is effectively implemented may be significantly different from the understanding of the original decision-makers.

Organized Anarchy

The attention of potential participants may be diverted at any time during the decision process. In addition, decision problems seem to rise and fall from salience in cycles of attention (Downs, 1980). Frequently, problems are addressed but left unresolved. Certain kinds of solutions may be available only at certain times, their availability dependent on serendipity, technological innovations, fads, and professional biases of decision participants. Occasionally, solutions become available when no matching problem is on the decision agenda. For these reasons, decisions often display evidence of temporal sorting; that is, they appear to result from a chance co-occurrence of people, problem, and solution. Such situations are characterized by ambiguity about preferences, uncertainty about means and ends, and fluid participation. When they have been observed, the situations have been called “organized anarchy” (March, 1994).
The "garbage can model" of choice was developed to simulate decision making in organized anarchies (Cohen, March, and Olsen, 1972, 1997). In this model, people, problems, solutions, and choice opportunities are assumed to arrive independently at exogenously determined intervals. Problems and solutions are linked when they are both attached to the same choice opportunity. Problems are solved when enough people attend to a choice opportunity to which at least one problem and one solution are attached. Choices also can be made that do not resolve problems: when a solution is attached to a choice with no problem, or when the unresolved problems attached to one choice opportunity have "fled" to another choice opportunity. The numbers, timing of entry, access structure, and problem solving power can be varied in simulations to test the results of temporal sorting under various conditions. For example, more problems are resolved when the system contains fewer problems relative to the problem solving energy of the decision makers or when the access structure severely limits the ability of people, problems, and solutions to switch choice opportunities. In general, "As problems become more difficult relative to the competencies of decision makers and the solutions available, the system faces increasing problems. Decisions become more difficult. The overall likelihood of solving any given problem drops, it takes longer to make choices, and decision makers spend more time moving from one choice opportunity to another" (March, 1994:203).

The model has three measures of evaluation: (1) the amount of time problems are attached to choice opportunities but remain unresolved, (2) the amount of time problems float in the system unattached to choice opportunities, and (3) the amount of time choice opportunities are active before some choice is made. The access structure of the model is meant to simulate organizational structure. A good organizational structure should minimize the time consumed in studying and discussing problems, the amount of time
problems are ignored, and the time it takes to make decisions; measures (1), (2) and (3) above. Unfortunately, most changes in the access structure will improve some measures at the expense of others. Generalizations from simulation results are difficult because the responses of the system to incremental changes in parameters are not strictly linear and there are strong interactive effects among parameters. In this sense, the model captures the behavior of organized anarchy fairly well (Cohen, March, and Olsen, 1972, 1997).

Not all organizations are plagued with garbage can decision processes. Public water policy making of the kind examined in this paper, however, may be well-characterized as organized anarchy. Decisions, when they are made, frequently bear the marks of temporal sorting. The next section describes the factors that work against consistent and orderly policy making at the public level.

PUBLIC DECISION MAKING

In moving from the organizational level to the level of public decisions, it is necessary to abandon the concept of the unitary actor. As has been shown, that concept has limited usefulness even at the level of the individual. The convenient fiction of a single decision maker basing decisions on an objective evaluation of the public welfare is too limited for most water resource policy problems, even if it could be defended for other kinds of public decisions.

Aggregating Preferences

A key flaw in the notion that a decision maker can evaluate public welfare objectively, even accepting the problematic assumption of stable, consistent individual preference functions, was identified by Kenneth Arrow in 1951. Called the "impossibility theorem," it states that there is no way to aggregate the preferences of
multiple individuals in a way that preserves the few minimum conditions of consistency assumed by expected utility theory, unless you make interpersonal comparisons of utility. That is, in order to aggregate utility functions, you have to be able to decide whose utility is worth more. Obviously, that can be done, but (1) it can not be done "objectively", and (2) people do not like to do it, at least not explicitly (Kleindorfer, Kunreuther, and Schoemaker, 1993). Hierarchies, rules, and procedures assign comparative utilities implicitly, but when the allocative effect of such constructs is understood explicitly, someone is likely to object, especially at the level of public decisions. For example, agitation for environmental justice indicates increased understanding of the effects of certain decision systems on the allocation of environmental risks (e.g., R. Bullard's comments in Center for Risk Management, 1993).

One can imagine a unitary actor aggregating utilities by assigning values to them on the basis of some ethical system, but he/she would be a dictator, benevolent or otherwise. In a society whose institutions are steeped in the ideologies of democracy, equality of opportunity, and freedom from tyranny, such an arrangement would be acceptable only in a severely limited number of setting (e.g., certain families and owner-operated businesses). To explain decisions in other settings, models must account for the participation of multiple parties.

Models of group decision making within the rational tradition typically emphasize processes for aggregating preferences for well-understood alternatives, while models of individual decision making emphasize methods for choosing the alternative most likely to achieve an individual's well-understood preferences. Models of public policy decision making that assume a single decision maker subsume a public preference aggregation process within an individual decision model. Their method is value-oriented. Models that assume multiple decision makers subsume the individuals' alternative selection
strategies within a group process such as bargaining. Their method is goal-oriented. (Goicoechea, et al., 1982)

Krzysztofowicz (1979) described the difference between goal-oriented and value-oriented decision making: Goal-oriented decision making first establishes a goal, makes a decision on how to achieve the goal, then accepts, rejects, or modifies the decision. Value-oriented decision making first solicits value judgments, obtains a set of group values, and then uses the group value set as the decision rule. Value oriented decision making is used in the rational expert decision process model historically associated with water management decisions. Goal oriented decision making is used in regulatory negotiations, where a group goal set is given.

Multiple Participant Decision Making

Neither orientation provides for decisions when goals and values of multiple individuals differ. When goals and values diverge, one or more of the following techniques may advance decisions: (1) obscure diversity through ambiguity and barriers to communication, (2) invoke rules that allow decisions without consensus (e.g., majority vote and adjudication), and (3) engage in activities such as information search and communication that may reduce conflicts (March, 1994). All three occur in most public decision processes, and context will determine which is dominant.

The discussion of organizational decision making described how the allocation of attention is used to manage participation in decisions. Attention allocation creates barriers to communication. Decentralization and autonomy decrease hierarchical communication, while centralization and hierarchical authority tend to decrease interdepartmental communication (March, 1994).
The mass media also can direct public attention to certain policy decisions away from others. When it replaces communication within and among individuals, groups and communities, the essentially unilateral communication of mass media hampers development of independent preferences for public policy (Lindbloom, 1990).

There are, in addition, communications that describe policy options as capable of meeting incompatible preferences, such as the promises of candidates for political office. Such over optimistic or deceptive communications can be distinguished from ambiguity, although they have similar effects.

Ambiguity hides differences by permitting simultaneous inconsistent interpretations. Some ambiguity is inherent in all public decisions because the medium of communication, language, contains inherent ambiguities and must be interpreted by individuals to yield meaning. On the other hand, most public decisions are expressed in ambiguous language intentionally to allow for selective interpretation by supporters who may agree in principle but not in detail. This strategy defers details to a later time when changes in participation may make consensus more likely, for example, when the attention of the public has shifted to other policy issues (March, 1994; Brunsson, 1989).

Sometimes conflicts arise from insufficient understanding of the problem. In water resource policy, increasing the general level of knowledge about physical reality may facilitate agreement. Communication about the intentions and expectations of participants, examination of preferences, development of alternatives, and other explorations may disclose possibilities for agreement. These kinds of inquiries seldom lead all the way to agreement or solution, but they can bring enough parties close enough so that residual differences may be resolved by other means.

When inconsistent policy preferences cannot be reconciled, hidden or disguised, decisions are made through rule systems that provide choice without consensus. Within
these rule systems, participants deploy traditional political tools: persuasion, power, and exchange. These tools are closely related. Power and exchange are persuasive. Persuasive ability is a source of power and a resource in exchange. Power can be well described by a model of exchange in which the resources include money, status, affection, knowledge, followers, moral leadership, among others (March, 1994).

In a power as exchange model, three factors determine power: the distribution of resources, the distribution of desires, and the rules of exchange. It is obvious that the more decision-relevant resources participants control, the more influence they are likely to have over the decision. Conversely, participants who do not desire the resources controlled by others are less likely to be influenced by them. The rules of decision making, such as who participates, what desires may be considered, how the agenda is determined, and what constitutes a decision, advantage some and disadvantage others (March, 1994).

In complex social settings, multiple sets of rules may govern, and they may offer differential advantages to different participants. Decision problems may move around among different institutions, existing rules may be changed, and alternative institutions created, when participants sense they lack sufficient control over decisions under one rule set. Thus, the existence of alternative rule sets indirectly influences power exchanges (Ingram, 1980).

Bargaining, log-rolling, and coalition formation are strategies in exchange relations, intended to give participants power over the salient aspects of decisions. Bargaining may occur when desires are incompatible, each party is perceived as capable of preventing the others from obtaining the thing desired; and therefore, the parties must make some accommodation with each other. Coalition formation is the process by which participants join together to overcome opposition. They are frequently united by an understanding
that a favorable decision will provide all coalition members with something desired. Natural coalitions are formed by partners who want the same or complementary things. Members usually come from a shared network of relationships. Such coalitions are relatively easily formed and stable (March, 1994).

Logrolling is a method of coalition formation in which the desires of participants are independent: members of the coalition are indifferent to the desires of other members. The decision package is created to include a little something for everyone. Logrolls are relatively difficult to form because potential partners usually are not part of the same network of relationships, and so partners may be hard to find and risky to trust. Logroll-based coalitions also are unstable over time, as other potential partners may be offering better deals. Winning coalitions typically are part natural coalitions and part logrolls (March, 1994).

Legitimacy

Decision rules define winner and losers. Losers may be compelled to submit to a decision contrary to their preferences. In majoritarian institutions, as few as 50 percent plus one of the participants may be in the winning coalition; yet, as long as the coalition holds, they can compel the acquiescence of the rest. In an orderly society, they are able to do so because the participants accept the rules. They may accept the rules because they accept the rules for making and changing rules. They accept the higher order, or constititional, rules because they accept the way they were made and can be changed. Thus lowest level rules are supported by an institutional hierarchy (Ostrom, 1990). According to generally accepted social norms, as long as the rules are accepted and the decision process follows the rules, the losers are obliged to accept the decision. In this way a decision that appears rule-based derives legitimacy.
With legitimacy, the winners can count on support from the system of nested and networked institutions in which they are embedded to enforce decisions on losers. Public opinion, specific constituencies, professional and social associations, and laws and their adjudication all are mechanisms of enforcement. Without legitimacy, support may be lacking, and the winning coalition may win nothing. Thus, legitimacy becomes a source of power in the exchange model.

Most of the rules upon which legitimacy is based are not specified in law or constitutions. They are the normative systems that have evolved within a continuous cultural context (March, 1994, 1997; Zhou, 1997). Decisions have legitimacy when they were arrived at through legitimate processes. In Western democracies, processes may be legitimated on the basis of multiple, frequently inconsistent norms, including, rationality and scientific method, participation, openness, and professionalism. A myth of public policy making holds that the conflicting demands of the various norms can be reconciled. Concern for legitimacy leads decision makers to seemingly contradictory behavior, such as soliciting public participation and failing to incorporate expressed public preferences or requesting scientific studies and failing to use them. In some instances, these are deceptive tactics, in others they are honest attempts to respond to conflicting demands.

In the traditional model of public decision making, decision makers control outcomes through decisions. Choices are translated into intentions, and intentions are translated into actions. The process of translating choices to actions is implementation, and many scholars have remarked that the translation is not automatic (Edwards, 1980). The "problem of implementation" can be illuminated by examining the divergent requirements for decision and action.

Action requires consensus. Actors need to share a common purpose in order to effectively coordinate their actions. The more cohesive the group, the more efficient the
coordination. Communication, coordination, and cooperation are facilitated by forces of social cohesion that also align preferences and simplify judgments. "The action organization makes people narrower and stupider than they were before they joined it" (Brunsson, 1989:11). The choices made in the service of action tend to be automatic expressions of a common ideology. Organizational structure and processes reflect an emphasis on efficiency and outcome.

When decisions require legitimacy, decision makers must demonstrate to their support constituency that decision processes and structures meet socially relevant norms. The more diverse the constituency, the more complicated the decision, the larger the stakes, the more uncertain the outcome, the more decision makers will rely on socially constructed rules. Rationality has been the dominant set of behavior rules associated with the role of decision maker in Western culture since the Enlightenment. The more decision making is based on these external rules, the greater the emphasis on procedural rationality (Zhou, 1997:267).

Rational decision rules require that knowledge be sought through exploration to reduce uncertainty and increase understanding of alternatives and consequences. Yet, because of the interconnectedness of things, the second and third-order effects of simple actions, "knowledge seems to increase questions at a faster rate than it increases answers." As a result, "decisive action comes more easily from the ignorant than from the wise, more easily from the short-sighted than from those who anticipate the long run" (March, 1994:265). Interest groups can use demands to increase the rationality of and participation in the decision process to stop or impede organizational action" (Brunsson, 1989:231). Demands for Environmental Impact Statements are a good example because they are often employed to impede progress on a project until political forces can be marshalled to cancel it.
Public organizations and agencies may have both action and decision functions. State legislatures and city councils are concerned almost exclusively with decisions and consequently have well-elaborated and documented procedural rules. Public works, transportation, and sanitation departments are more action oriented. Only occasionally is there conflict over the decisions of such department (e.g., siting a hazardous waste facility) and they seldom attract public scrutiny. Typically public water utilities have been primarily action organizations. Decisions were considered technical and were left to the implicit decision processes of experts. In recent years, this action autonomy has eroded and utilities have had to expand their decision functions (Gottlieb and Wiley, 1982; Martin, et al., 1988). Tucson Water, for example, faced the evaluation of consumers relating to quality, reliability, and cost of service, at the same time it faced a community increasingly concerned with fairness, scientific justifiability, economic rationality, and environmental sensitivity of policy decisions. One consequence has been a commitment to greater community participation in planning (Johnson, 1996).

The Hypocrisy Model

An organization dependent on support from conflicting interests will have difficulty maintaining the unity of purpose necessary for action. The stresses in such a situation will result in a functional breakdown: the organization may avoid decisions, it may avoid action, or it may separate the functions of decision and action. When an action organization makes decisions in its normal way, without demonstrating the use of legitimating processes, it loses public support and decisions may be impossible to implement. When decisions are separated from action, the result has been called "hypocrisy." As defined by Brunsson (1989), hypocrisy is the inconsistency that results from decoupling talk and decisions from action. Decoupling separates the two domains
in time, subject matter, audience, and organizational unit. With hypocrisy, decision makers can maintain legitimacy by making decisions according to legitimate processes, while other organizational units continue to act. For example, an elected board may take public comment, consider the claims of conflicting interests, hear expert testimony, and evaluate policy options by rational processes before making a decision, and administrative agency staff can interpret the decision and implement it on the basis of the exigencies of administration.

The decision and action are not necessarily inconsistent, they are simply the products of distinct structures and processes. Consistency among talk, decision, and action legitimates action. They are more likely to be inconsistent when the audience for decisions requires that goals reflect superordinate moral values while the audience for actions focuses on practical effects. When talk and decisions are central functions of organizations, they are likely to make inconsistent decisions. Typically, when action is a central function of organizations, inconsistent decisions are avoided, and thus it becomes extremely difficult to make any decision at all (Brunsson, 1989).

The Arizona Department of Water Resources (ADWR) is committed to the goal of safe yield by the year 2025. The goal expresses the important community value of sustainability. Yet, by the department’s own projections, this goal will not be reached, even granted 100 percent compliance with its own regulations. Through public committees and stakeholder participation, complemented with scientific studies and rational analysis, ADWR develops plans that form the basis of enforceable regulations, meant ostensibly to create conditions for safe yield. Through participation, the regulated community ensures that the idealistic public goal is tempered by practical considerations. Promulgation of regulations and regulatory compliance actions are normally negotiated. Apparent consistency between decisions and actions is maintained by permitting
inconsistency between two sets of decisions: value supporting decisions and action supporting decisions.

In a smoothly functioning decoupled organization, that is, one in which decisions are made and actions are taken, policy making is a bottom-up process. Issues are identified and developed by the staff, who educate the decision makers. Staff often suggest the agenda of issues to be considered, make preliminary studies and initial proposals, and generally guide leaders toward preferred decisions. Leaders may act independently of staff by introducing their own agendas and advocating their own policy preferences, but such activities tend to be rare because they are difficult, risk exposing the officials' lack of expertise, are usually met with resistance and result in frustration, and, if successful, can be extremely destructive of staff morale and productivity (Brunsson, 1989).

Decision makers in functioning decoupled systems maintain the illusion of control by taking responsibility for decisions. This means they justify decisions to the public and accept the blame for bad outcomes. When leaders do not to take responsibility for decisions, the system may cease to function (Brunsson, 1989). Contrast the situations of Tucson Water and the Tucson City Council when the water rate structure was changed in 1979 and when CAP was delivered in 1993. In the first case, the Tucson City Council took responsibility for the decision and lost their positions, yet the new rates remained in place and there was no breakdown in the utility's ability to develop policy (Martin, et al., 1984). In 1993, the Council disavowed responsibility for problems with CAP delivery. The utility was forced to take responsibility, experienced managers were lost, along with staff morale and unity of purpose. The disruption or lack thereof may be considered negative or positive depending on one's point of view.

Brunsson observed that "morality is not always on the side of action. . . . Those without . . . hypocrisy are those who pursue or advocate realizable goals, trading in their
morality in exchange” (1989:233-234). When decision makers address problems characterized by unresolved value conflicts, any action may have unacceptable effects for important values. Decision processes can fulfill essential purposes other than directing action. Societies create and maintain an inconsistent set of unattainable moral standards that frame the rules for social behavior and identity. Processes productive mainly of talk sustain belief in these moral standards.

When the hypocrisy model of decision making is contrasted with the traditional model, several fundamental differences are evident. In the traditional model, decisions have no intrinsic value, their value resides in action: decisions cause actions. In the hypocrisy model, decisions and the talk generated in the course of decision making have their own value as outputs. Talk, decisions, and actions may be inconsistent. Where decisions and actions are consistent, they have developed in parallel or the decision was taken subsequent to the action in order to justify it (Brunsson, 1989).

Decisions and Meaning

Decisions create meaning. Many of the situations encountered in the real world are ambiguous; that is, they require interpretation because they may equally represent any of several meanings. When the source of the ambiguity is ignorance of relationships in the physical world, science can offer fairly reliable interpretations; but science has its limits. It is costly and time consuming. Scientists are frequently no better than others at interpreting ambiguous situations. The interpretations of science have to be communicated to humans, usually through the distorting medium of language. When the source of the ambiguity is the behavior of humans, interpretations are socially determined.
Most commonly in water resources policy, ambiguity results from both the physical and social realms and their interaction. Thus, in policy making, interpretations of reality are frequently negotiated, and "decisions become vehicles for constructing meaningful interpretations of fundamentally confusing worlds" (March, 1994:180). Decisions represent general agreement on what is known and what is true.

The process of making sense involves selecting, ordering, and relating events. Any narrative of this kind is literary, that is, conveys meaning through structure, word use, and ellipses that presuppose shared assumptions about the world being described (Agger, 1991). The meaning does not have objective existence but data must be interpreted, and may be interpreted in many ways. Much of the meaning is covert, and may be hidden equally from the creator of the narrative and the interpreters. Pervasive cultural assumption, such as gender roles, are likely to be hidden in the most purportedly objective communications (O'Connor, 1997: 311).

Cultural norms, like gender roles, that underpin identity and guide identity-appropriate behavior are created by "millions of individuals trying to make sense of how to act in day-by-day concrete situations" (March, 1994:191). Values, goals, wants, and other conceptions of the self emerge from the process of making decisions (March, 1994:261). Attitudes, perceptions, and choices are compared with those held by others, particularly others who are similar and who are in close proximity. Beliefs and judgments, therefore, become socially anchored and reality becomes a consensual social construction (Pfeffer, 1992:208). Once social consensus begins to develop, it is difficult to change that consensus, not only because people become committed to their positions, but because the fact of agreement makes each individual believe that his or her own position is probably correct (Pfeffer, 1992: 212).
Features of human inference, in combination with plausible features of historical processes are likely, however, to lead humans to misinterpret their experiences and perceptions. False beliefs are formed, transmitted, and reinforced by the same processes as true beliefs; individuals cannot infer much about validity from universality (March, 1994:182).

Information, Knowledge, and Policy

Students of information use in policy decisions have reported consistent failure to identify instances in which information had a direct impact on policy (Innes, 1990; Feldman, 1989; March, 1994). A great deal of effort goes into the collection of information and the production of knowledge, but real world decision making usually precludes its direct use. On questions of policy, it is seldom immediately obvious which bits of information are relevant and what they mean.

Research within social psychology indicates that understanding information entails forming a cognitive representation or theoretical formulation of the observed phenomena. Once formed, a theoretical formulation “may constrain the types of information one subsequently seeks and the way that new information is interpreted” (Wyer and Srull, 1988:43). In other words, previously acquired knowledge of concepts and procedures influences what evidence is attended to and how it is used. The evidence and its interpretation then shape the representation, and so on. The cognitive representation thus formed may be remembered when the evidence for it is forgotten.

Cognitive representations are beliefs about the way the world works. Some beliefs, when they have been produced and verified by appropriate rules, can be classified as knowledge. Knowledge is a social construction, produced and verified by established rules. Scientific knowledge is produced and verified by the rules of science. Rules for
certifying knowledge make it inaccessible to unilateral manipulation, but knowledge can change. Old knowledge can be challenged by new knowledge (March, 1994:240).

An analogy can be drawn between the way people make everyday social judgments and the way scientists acquire and use information (Wyer and Srull, 1988). Using social psychology research, researchers illustrated the way theoretical assumptions underlying both interpretation of evidence and the procedures that generate evidence influence development of cognitive representations. They observed that expert scientists are likely to have specific and well-developed ideas about what evidence is important and what it means. March (1994) takes this observation a step further by suggesting that competence in a particular field may prevent experts from heeding important information or interpreting it in creative ways, because they tend to become blinded by a dominant paradigm or cognitive representation of the policy issue. They may be biased by its assumptions, of which they may be unaware, just as ordinary social judgments may be biased by implicit assumptions or intuitions.

Knowledge is not neutral politically. It frames approaches to problems and shapes decision possibilities in ways that favor some alternatives and interests over others. Because most knowledge is subject to strategic misrepresentation, it can become an instrument of power. Those without access to their own experts are justifiably skeptical of knowledge that supports the preferences of others with better access. Socially peripheral groups and individuals who feel estranged from prime sources of information may reject all external claims to knowledge or be highly selective, believing only what supports their value position (March, 1994).

Because the meaning of information is not self-evident, knowledge is constructed though interpretation. Interpretations vary and one may or may not be more valid and reliable than another. Knowledge is subject to manipulation; therefore claims for ones
preferred interpretation are suspect. It is no wonder, then, that knowledge that supports a policy decision is likely to be negotiated.

J.E. Innes (1990), whose focus is the creation and use of social indicators, argued that ordinary knowledge and scientific knowledge are inextricably linked components of issue relevant knowledge. Scientific knowledge is understood as a component of the issue relevant myth, or institutionalized understanding of the policy issue. For Innes, production of the kind of knowledge that influences policy results from discourse among content experts and policy makers. Participants in this discourse simultaneously develop a common way of seeing the issue, an acceptable methodology, and agreement on the basic principles of policy.

As part of this knowledge system, information producers continue to work within the rational, scientific tradition. The value of products of this tradition to decision making is not diminished because their effects usually are indirect. The scientific tradition is best adapted to produce information of technical interest; that is, understanding how things work for the purpose of solving problems (Habermas, 1984).

Baron (1998), whose perspective on public decisions is rooted in the rational, scientific model, acknowledges the importance of issue relevant myths, although he considers their influence mostly negative. He uses the term intuitions for certain kinds of cognitive representations. Baron’s intuitions are similar to heuristics in the heuristics-and-biases literature, but contain a component of moral judgment. They “appeal to some judgment other than consequences” and are followed as a kind of authority one accepts without knowing or remembering the reasons (Baron, 1998:5). In addition, intuitions tend to be linked in ways that defy logical rules, and they are seldom examined for their logical consistency. Thus, an intuition that nature knows best would influence people who routinely use antiseptics and pesticides to oppose contraceptives.
The concepts these terms describe are not identical in detail, but they envision a construct mediating the use of information in decisions. The creation, modification, and maintenance of this construct has been called interpretation (Feldman, 1989). According to Feldman, however, this process of interpretation cannot be done by an individual working alone, but develops within an organization or system through combining multiple perspectives. There are several ways of looking at any issue, and the way an issue is perceived determines "the properties of the problem and the appropriateness of different solutions" (Feldman, 1989:90). Feldman observed that policy analyses produced in the Department of Energy had little direct effect on policy decisions, but were part of a process that developed the definition of the policy issue. She generalized that producers of information who want to influence policy decisions do so by influencing the interpretation of issues; thus, the influence of information on policy usually is indirect and slow.

Decision makers acting within the constraints of their individual cognitive capacities and group interactions use information to confirm, elaborate, refine and revise a pattern, cognitive representation, myth or narrative interpretation of data from communication with others, cultural artifacts, and memory. The dominant or operating interpretation influences the search for additional information and that information's evaluation and interpretation, and is in turn modified as new information is incorporated. The use of information in policy making is mostly indirect, and increasing the impact of information on policy is more dependent on social discourse than on the nature or form of the information itself. Within this picture of decision making, "...a good information strategy is not so much one that removes uncertainty from a prestructured array of decision alternatives connected to a predetermined array of preferences, as it is one that moves the whole apparatus of information, desires, and options in a productive direction,
simultaneously developing ideas of what is ‘productive’ and instruments for achieving it” (March, 1989: 395).

Summary

Decision theories and models that focus on choice among well-developed alternatives or solutions to well-defined problems miss most of what is going on when public policy decisions are made. Multi-participant decision makers engage in activities that expand and explore the problem domain. They try to reduce uncertainty by collecting and analyzing information, referring to sources of knowledge, and negotiating meaning. Their decisions are framed by their understanding of the issues, which is circumscribed by their understanding of themselves, others and their environment. Rules, both explicit and implicit, direct the decision making process and shape its outcome. Decisions initiate or justify action. Actions may be determined by a series of incremental, almost automatic, decisions, and seemingly inconsequential decisions can have major impacts by starting the decision process down one path rather than another. Actions can change the physical environment, rules and institutions, relationships, and the interpretation of life in ways that feed back into the decision process.

Action is only one of its outcomes, however; and often not the most important one. Decisions relate intentions to consequences or situations to appropriate responses. They contribute to the evolution of meaning by elaborating narratives that make sense of the world. They help “mold and sustain a social order of friendships and antagonism, trust and distrust” (March, 1994:212). They demonstrate adherence to social values and in so doing affirm their importance and reinforce their influence.
CHAPTER 3. AN IMAGE OF DECISION MAKING FOR ANALYZING PUBLIC WATER POLICY DECISION PROCESSES

The analysis of the Tucson case study that follows in the next section will draw upon features of the water policy decision process as described in the foregoing section. The analysis is organized around four major conceptual components of the process: the participants, the environment framing the decision, the structure of the decision process, and the outputs of and feedback from the decision process. The decision domain can be visualized as a hierarchically nested network of participants interacting with each other and their environment through direct sensory perceptions, communication, and access to artifacts (e.g., research reports and newspapers). The decision process imposes a structure on their interactions and produces outputs that feed back to modify the preferences and understanding of participants, the nature of the environment, and the structure of the process.

PEOPLE

People make decisions. Historical analyses seem to divide into two camps over the importance of individuals in determining outcomes (Hammond, 1996). The Great Man theory of history focuses on the impact of individuals or elites; the opposing camp views outcomes as resulting from collective processes and trends. In complex, sensitive, path dependent systems, both viewpoints have merit in explaining aspects of the system. Social forces set the general trend, in that individuals can be said to reflect generally held preferences and beliefs about the world. Individuals are shaped by their experiences and their experiences occur within the context of social groups with evolved agreements about the meaning of raw experience. These agreements constantly are being
renegotiated within a culture. There is constant testing of the social milieu in aid of individual interpretation. This process shapes individuals and reshapes their culture.

Yet by acting at sensitive decision points, individuals have a chance to profoundly affect outcome. It is characteristic of complex processes that small and seemingly unimportant choices can prove to be major turning points that set the trajectory of subsequent decisions. Policy entrepreneurs are attentive to opportunities for influencing the direction of decisions. Their special contributions of such resources as technical competence, authority, influential relationships, creativity, and persuasiveness not only can affect a specific decision but also point the way for changes in beliefs and understanding.

Within the water policy decision process, personal influences people bring to bear on decisions include their cognitive strategy, choice of which can be based on competencies developed through training and professional experience; identity as derived from roles, including organizational ideology and position, profession, and training; resources available through organizational position and networks of relationships; and interpretations of experience and communication. People in policy making positions tend to reflect the roles they have assumed within organizations (March, 1994). Thus, when policy makers represent organizations in the decision process, the formal goals of organizations may be used as surrogates for the individuals' goals. In addition, the history of decision relevant interactions and interpretations accumulates in organizations. People in policy making positions in organizations tend to have adopted the organizational understanding of past events, at least when assuming the role of organizational representative (March, 1994).

The quality of group decisions can depend on the competence of group members (Plous, 1993). Some competencies are associated with organizational position, e.g.,
authority, control of resources, or constituent support. Others, such as technical expertise and reputation, result from professional training and experience, which are associated with organizational role.

The identities evoked in the decision context tend to be predominantly role defined (March, 1994). Water policy decision makers tend to observe rules of behavior based on professional and rational models, in which individuals are expected to represent the interests of their organization. Other behaviors, including emotionally charged or overtly political behavior, are regarded as suspect. Assignment of individual competencies and histories to organizationally defined roles relegates personality, individual differences in intellectual capacity, transient emotional states, and personal histories and motivations to insignificance in policy decisions. This is unrealistic but defensible.

ENVIRONMENT

The choices of individuals and groups are constrained by the operation of laws largely outside their control. Water flows downhill unless energy is expended to push it uphill. Man-made laws also constrain choice except when resources are spent to circumvent or change them. First approximations of policy decisions usually assume fixed physical and institutional laws to the extent that they are known. More in-depth understanding of laws is likely to reveal alternative strategies for overcoming physical or legal obstacles. Often these strategies require a new interpretation of the decision environment. For example, when a law requires that water be recharged to offset groundwater pumping in a specific area, the first policy impulse is to recharge in that area. However, the requirements of the law may be met by moving both pumping and recharge to other areas. The “success” of this strategy may depend on whether enough
others come to share the new interpretation. A great deal of flexibility is provided by ambiguity and reinterpretation.

A physical reality probably exists, but it cannot be known directly. Living organisms have developed ways of sensing relevant aspects of physical reality because their senses enhanced genetic reproduction (Pinker, 1997). Humans have eyes and ears. They also have common sense to help them interpret the signals from their senses in relevant ways. In addition, they have traditions of knowledge accumulated over generations and artifacts that aid in the accumulation, which expand enormously the ways in which physical reality can be understood. Biological relevance may be determined by survival and fecundity, but the relevance to a decision of sensory and other information depends on interpretation.

Some interpretations are more easily agreed upon than others. A shared culture solves many everyday problems of interpretation and guides less common ones. A diverse culture, such as in the United States, produces diverse interpretations. Decisions about natural resources are difficult when decision participants have diverse interpretations of the evidence of physical reality. Much of the work of public decision making involves trying to reach shared or compatible interpretations of data that may be called the factual basis for decision (Anderson, et al., 1981).

A social reality also probably exists, although it is likely to be less stable and have a wider range of relevant interpretations. Its form probably is more dependent of past agreements on interpretation. Public decisions are highly dependent also on the consonance of interpretations of social reality such as the motivations of the participants and the legitimacy of the process.
STRUCTURE

The two components of the decision system, people and their environment, respond to each other in ordered relationships characterized by structure. The structure of these relationships affects outcomes. Features of structure include the organizing rules of the decision process, the hierarchy of roles assumed by decision makers, and the network of communication among decision participants and their constituents.

Structural features are inherited from past time periods and created through the interaction of individuals and the environment. Particularly salient are structural features that affect how information about the decision domain is sought, collected, processed, interpreted, and remembered. The structure of these interactions is a major determinant of decision (March, 1994).

Group decision making in water resources is based on associations formed to share information (Blomquist, 1992). Communication does not just happen. Individuals must seek each other out, talk and listen, write and read, and process information. Who communicates with whom, what roles participants are filling, what responsibilities and authority they have for action, their friends and professional affiliations, the formal or informal nature of their communication, and similar factors are subsumed under the issue of interaction structures.

Existing networks of communication may tend to distort understanding of physical and social reality through polarization and simplification (Kasperson, et al., 1988). Creating new associations may offset these tendencies. New structures for decision relevant interactions may specifically evoke identities that promote agreement. Face-to-face interactions can encourage cooperation in the context of shared tasks (Kleindorfer, Kunreuther, and Schoemaker, 1993).
On the other hand, information processing work may best be accomplished by competent individuals working alone (Plous, 1993). Structure dictates who does what information processing, what kind of information is shared, and how it is shared. How completely specified, transparent, and rational the information processing methodology is will depend on trust relationships and the perceived level unresolvable uncertainty and ambiguity, as well as the size, diversity, and attentiveness of the decision’s audience (Kleindorfer, Kunreuther, and Schoemaker, 1993). Methods satisfactory to participants may need rationalization to satisfy the wider public.

The decision process will have formal and informal structures. Formal rules of participation, interaction, and decision are supplemented by informal social rules of behavior. Formal rules are relatively easily described, while informal rules may not even be evident to participants, unless they happen to be violated.

Records are kept of deliberations, especially when the participants’ opinions differ. Misremembering is so common that agreement among potential adversaries usually requires record keeping. A written record that captures the salient features of agreement or disagreement for all participants aids movement toward decision. Commitment at an early stage increases the likelihood individual participants will make future commitments (Kleindorfer, Kunreuther, and Schoemaker, 1993). Thus, a shared interpretation of decision relevant information emerges over time. Documentation reinforces this process by constraining divergent memories.

Records of agreement, a transparent, rational process, and interpersonal relationships characterized by shared understandings will not necessarily withstand external events. Structure does not determine decision. Constituents may reject utterly their representatives’ agreement; behind the scenes political machinations may effect significant changes in law; new opportunities may distract policy entrepreneurs from old
problems; unforeseen consequences of engineered solutions can create ecological disasters. Things change.

In addition, future uncertainties become present facts, as, for example, when a recharge project is completed and expenditures are totaled. Acute awareness that the nature of physical and social reality and understanding of them will change, leads sophisticated decision participants to build flexibility and contingency planning into decision processes.

OUTPUTS

The avowed objective of decision making is decision, although subsequent action is implied. The policy process involves a series of decisions about what to consider, how to analyze, and how to evaluate. These decisions direct the process by limiting its scope, assigning priorities, and introducing biases inherent in the chosen methodologies. Individuals who are aware of the potential consequences of decisions made within the process do not generally limit their participation in the problem domain to the decision process. Outside the process, they act on the environment and communicate with others. The relationship between individuals and the environment is dynamic. That is, not only are interpretations of relevant aspects of physical and social reality changed by individual communication, but actual physical and social reality are changed by their actions. Individuals know that they can affect the environment and, therefore, that their choices are not strictly constrained by existing conditions. Individuals and groups can dig ditches, influence legislators to change laws, and persuade large groups of others to vote for or against an initiative. These actions change the environment and therefore change the conditions for decision.
Thus the action implied by the decision process, implementation, is only one of many action outputs. Each sub-decision may lead to an action with direct or indirect effects on the decision process. Even if implementation of the decision is never achieved, the actions produced by the decision process may have important effects on the problem, if only to provoke a contrary reaction.

The process of group decision making can influence significantly the way a problem is understood. Shared meaning evolves through communication and discourse over the interpretation of experience. If the ultimate limit of bounded rationality is not knowing the significance of what we know (Radner, 1997), then developing a shared understanding of what, among all the things we know, is important and why bounds the decision. This shared understanding evolves with the decision process, and it can be as important a product as the decision itself.

Finally, the nested network of individuals in their environments is held together by relationships. These may be characterized in many ways. Some may be more conducive to policy agreement than others. The process of decision making creates and redefines connections among individuals in ways that affect outcomes. In addition, because individuals define themselves in relation to others, the relationships developed in the decision process will affect how people understand themselves and others. These understandings will affect future relationships and through them future decisions.
CHAPTER 4. CASE STUDY: TUCSON'S REGIONAL RECHARGE PLAN

PEOPLE

The decision literature suggests that group decisions are highly dependent on individuals and their interactions. Individuals are not the perfect decision makers of the rational model, but deviate in three major ways. They do not have static, well-ordered preference functions, they cannot know or keep in mind all the facts relevant to a decision, and they do not employ without error any single strategy for processing what they know about facts and preferences into decisions. Instead, individuals are dynamic systems that interpret their experiences in terms of their beliefs and make decisions by a repertoire of strategies that include unconscious instinct and computer-aided decision models designed to provide simultaneous optimization of multiple parameters. In groups, their interactions affect how they interpret experience, and their interactions are affected by socially relevant features of the individuals as well as the nature and environment of the group. Therefore, a realistic description of group policy decision making must include features of identity that are likely to have an impact on individual and group decision processes.

In this paper, it has been assumed that participants in the water resource policy decision process have significant impacts on the outcome. In addition, salient analytical features of participants, such as self-interest, competence, and experience have been assumed to derive from the individual’s role as representative of an organization, profession and/or interest group. On the basis of these assumptions, the following section will describe the participants in Tucson’s Regional Recharge Plan (RRP) process with reference to analytic features, including the organizations and interests represented, professional competencies, roles, and relationships.
The Regional Recharge Plan Initiators

The RRP process was initiated on the recommendation of the Groundwater Users Advisory Council (GUAC) to the Arizona Department of Water Resources (ADWR), Tucson Active Management Area (TAMA). The TAMA is the Tucson area’s regional component of ADWR, and its GUAC is a standing committee composed of five community members appointed by the Governor to advise on matters relating to water management in the AMA. The ADWR is a state level government agency responsible for regulation and management of Arizona’s water resources. In 1980, passage of the Groundwater Management Act (GMA) created Active Management Areas where programs intended to end groundwater mining by the year 2025 would be enforced. The TAMA is the second most populous active management area in the state and contains the City of Tucson, most of Pima County, parts of the Tohono O’odham reservation, and a small areas in Pinal and Santa Cruz Counties.

The ADWR maintains an office in the TAMA responsible for developing and implementing groundwater management programs with specific reference to local conditions. The TAMA hosts monthly meetings of its GUAC where local management issues are discussed and recommendations made. GUAC members tend to be community leaders, representatives of the business community, large water users, and individuals with established interests in local water-related issues. They are not necessarily knowledgeable about the technical aspects of water management. The TAMA staff provide technical information and explanations to the GUAC within the scope of their responsibilities and up-date the council on TAMA activities.

TAMA personnel publicly maintain studious neutrality in local water policy debates and speak publicly only to clarify technical questions and describe ADWR programs and
policies. While accepted as part of the water establishment, they are considered largely objective in local conflicts, and therefore qualified to act as honest brokers on contentious issues.

TAMA personnel, in general, come from educational and professional backgrounds in planning, public administration, geography and regional development, water resources administration, agriculture, and engineering. They maintain links with the water community through regular meetings with local water user groups and regulatory consultations. They maintain contact with other water professionals through participation in conferences and professional associations. They monitor regional political activities with relevance to water and frequently represent the agency on local councils and committees, such as the Tucson Regional Water Council and the Pima Association of Governments. As a result, they are in a position to know most of the individuals active in local water issues.

A history of regional intergovernmental contentiousness and recent public controversy over water management and related issues prompted the GUAC to propose that the TAMA take the lead in initiating community-wide talks on groundwater recharge. On the advice of its GUAC, TAMA personnel proposed a general structure for the Regional Recharge Plan process. Previous experience suggested that separate processes should be developed to deal with technical versus policy aspects of recharge. There were a number of technical issues relevant to recharge site selection that were openly debated in the community. It was hoped that agreement among a cross-section of technical experts on these issues would facilitate the more political process of region-wide recharge planning. In consequence, two committees were created: the Regional Recharge Committee (RRC) and the Institutional and Policy Advisory Group (IPAG).
The Regional Recharge Plan Committees

Participation on these two committees was determined in one of three ways. Most members were invited individually. The initial list of invitations was generated by the TAMA and its GUAC. Invited organizations, for internal reasons, sometimes chose to name their own representatives. Some organizations and individuals participated on their own initiative. There were approximately 20 members on each committee.

Those individuals initially invited to participate were members of a community of interest centered on Tucson area water management; they were individuals who knew each other from having worked or come in contact with each other on water related matters. Impressions of competence, centrality, interest, and the like had been developed in these previous encounters and were the basis for invitations. Those who were not known personally were generally known by reputation.

They have been referred to as the "water industry" (Gottlieb, 1988) or "water elite" (Martin, et al., 1988), terms with negative connotations that derive from assumptions of exclusivity and associations with power politics. Gottlieb describes the water industry as "an overlap of public agencies and private interests," controlled mainly by middle-aged white males with "engineering and development-oriented biases." The elite described in Martin, et al. are dominated by the few with direct stakes in policy decisions, including developers and large water users. Individuals with access to this elite trace their influence to technical and political expertise and are reluctant to jeopardize their access by raising divisive issues. In 1988, Tucson's water elite still was biased toward growth and development. The technical language of water policy discussions prevented wider public participation.
In this paper, the term "water establishment" is used instead to refer to a group of people who occupy responsible or advisory positions in local organizations with interests in water policy. These include large water users, government agency personnel, consultants, managers of water providers, both private and public, and members and staff of interest organizations. Their self-interests are as different as their roles and the perspectives they represent. Membership is largely determined by vocation, education, and professional relationships. The extent to which this community matches the descriptions of water industry and water elite is an open question. There currently is greater effort to understand and respond to public preferences than in the past and a somewhat wider range of participating interests. At the same time, there remains a general reluctance to pursue divisive issues, such as limiting growth, and a belief that the technical complexities of water management issues make broad public participation in decisions problematic (Wilson, Matlock, and Jacobs, 1998).

The RRC was composed of individuals with professional competence in hydrogeology, water engineering, and related technical fields. They represented the range of organizations with an interest in the construction and operation of recharge facilities. These included the City of Tucson and other large water providers in the area, consulting engineering firms, government agencies such as the U.S. Geological Survey and Bureau of Reclamation, the Tohono O'odham Nation, and individuals whose reputations for expertise were established during their association with the University of Arizona. The membership criterion of technical expertise was explicit and acknowledged. In an effort to avoid real or apparent bias, individuals were invited who had expressed themselves at variance with established opinion, provided they met the expertise criterion.
The formation of a separate committee of technical experts solved three problems for the RRP. First, the in-depth understanding of physical systems necessary to resolving some of the outstanding factual issues was most efficiently available in appropriately educated and experienced individuals. Second, a committee with members of similar educational and professional backgrounds would likely be comfortable with the same assumptions on which to base judgments. That is, they were likely to share a language and cognitive framework to facilitate agreement on the meaning of available data. Third, any agreement reached through information gathering and analysis by objective experts is legitimated and thus difficult to dispute at a later point in the process.

Several consulting firms with offices in the area sent qualified representatives. In doing so they established and reinforced relationships with contracting organizations, enhanced their reputations in the water community, and collected information of potential future value in the competitive consulting environment. They also fulfilled civic responsibilities in accord with personal and professional identities. In general, the interests of these consultants were associated with past or potential clients, but their organizational independence lent credibility to and enhanced the legitimacy of the RRC’s conclusions. The presence of experts from the University of Arizona also served this function.

One active member of the RRC was associated with positions on CAP use, water treatment, and related issues directly at variance with those generally espoused by the water establishment. Because of his reputation for expertise and intellectual honesty, his participation was welcomed. There was hope that technical conclusions with which he concurred would be more readily accepted by the public he represented.

The Institutional and Policy Advisory Group (IPAG) consisted of policy oriented individuals from an overlapping range of organizations and interests. Most participants
also had a working familiarity with the technical aspects of the policy issues. The
different focus of the IPAG from the RRC was reflected in the absence of consulting firm
and university associated representatives and the greater representation of recharge
stakeholders, including agriculture, mining, and real estate development interests.

The primary participating organizations were those perceived to be indispensable for
acceptance and implementation of a plan. That is, organizations were invited and urged
to participate if their failure to participate was likely to undermine implementation. This
meant that organizations with historical and on-going conflicts in other arenas
participated together. Broad representation was sought on the model of stakeholder
participation in regulatory negotiations. This model was both well-established within
ADWR and the TAMA and generally accepted in resource policy development. It avoids
both real and apparent bias, enlists the broadest possible resource base, and facilitates
implementation.

On the other hand, participants did not represent the full range of publicly expressed
opinion. Anti-establishment sentiment was not directly represented. Prominent
"outsiders" and activists were not invited. To the extent that this decision was openly
discussed, it was rationalized on the basis that (1) previous experience had caused some
participants to distrust the motives of certain individuals and interest groups and to
suspect them of seeking only to disrupt, and (2) meetings were public, although not
widely publicized. Theoretically, anyone with an interest could attend any meeting; and,
in fact, a few interested observers did attend some meetings.

The Participants

The largest group of represented interests was municipal water providers. Their
goals were similar: real "wet" water storage for future use and "paper" water storage
credits to meet state regulatory requirements (IPAG, 1997a). Their interests, therefore, were somewhat competitive, to the extent that the type and location of recharge projects would have different cost and benefit implications for them. Not surprisingly, individual providers tended to favor specific sites and projects and disfavor others.

A second category of participants was government agencies with policy and/or statutory commitments to participation in recharge. For example, the Bureau of Reclamation administers several federal programs to support various stages of recharge planning and project development. The Central Arizona Water Conservation District (CAWCD), besides operating the Central Arizona Project, has responsibility for constructing recharge projects under the State’s Demonstration Project program. The Pima County Flood Control District has a policy of providing technical assistance for recharge project planning and development and has been a partner in several recharge initiatives. Government agency participation in the RRP was governed by their interpretation of statutory directives and authorities. They tended to advocate for sites and projects in which they had invested time, resources, and/or other support.

Farms and irrigation districts were represented on the IPAG mainly because State law allows some rigidly defined categories of water (principally CAP water), substituted for ground water on farm crops under specified conditions, to be considered recharge for the purpose of generating “paper” water storage credits. The cooperation of farmers and irrigation districts is essential for entities that want to earn credits through this program, which simultaneously provides a source of low-cost water to farmers. The future existence and extent of the program could be affected by how it was characterized in the RRP.

The two major copper mines in the TAMA are also major water users. They were invited to participate because, like farms and irrigation districts, they may be able to
generate water storage credits by substituting CAP water for the groundwater they currently pump. In addition, mining use of groundwater is a subject of public controversy because it is commonly believed that mining is using up high quality groundwater that would otherwise be available for domestic use, while people are expected to drink lower quality CAP water. Groundwater contamination allegations against the mines also had been debated publicly. Mining’s express goal in participating was to change negative perceptions about their role in the community (IPAG, 1997a). Thus, by participating they demonstrated their willingness to consider CAP water use, provided that the additional risks and costs were not beyond reasonable bounds, and at the same time kept an ear open to discussions with potential to affect them directly.

Real estate development interests were represented indirectly through some water providers and more directly through attorneys. Rules administered by the ADWR link permission to develop land to assured provision of water for 100 years. Rules generally preclude sole reliance on ground water to meet the 100-year water supply requirement. Thus, real estate developers and the water providers who will supply their developments have an interest in the opportunities recharge provides within this rule set. Real estate developers are commonly perceived to be powerful political forces in Arizona. They demonstrate more interest in participation at state and national policy levels and more overtly political avenues of influence than in local forums like the RRP. Their participation in the RRP process did not reflect an overt desire to influence its outcome.

Although at the initiation of the RRP very little water had been recharged in the TAMA, several entities and groups were engaged in project development. The RRP participants whose organizations were committed to particular projects or plans tended to participate more consistently and forcefully than those with less at stake in the outcome. Coalitions that formed around projects and plans tended to be based on geographical
location. The northwest area interests had organized within the Northwest Water Alliance and developed the Northwest Replenishment Program, which included the towns of Marana and Oro Valley and the largest municipal water provider in their area, the Metropolitan Water Conservation District (Metro Water), along with cotton farmers and irrigation districts, and the Pima County Flood Control District. The southern end of the basin was slower to organize, but created the Upper Santa Cruz Water Users Group (USCWUG) during the course of the RRP. Their first goal in forming the association was to obtain state assistance in investigations of potential facilities south of the terminus of the CAP canal. A large pecan farm, rapidly growing residential areas, the Tohono O’odham, and the mines shared interest in this area. The City of Tucson was involved from the start and encouraged the Association’s efforts.

The central area of the TAMA is occupied by the City. Tucson has the largest CAP water subcontract and its municipal water provider, Tucson Water, serves the vast majority of water users in the TAMA. Thus, it has sufficient resources to pursue recharge independent of its neighbors. The City shared costs with CAWCD for development of a state demonstration project near the CAP terminus. In addition, it had investigated several other sites and was engaged in developing a large project on the west side of the TAMA in the central Avra Valley. The City also maintained talks with the Tohono O’odham (and San Xavier District) about potential cooperation on recharge projects.

Indian tribes in the TAMA nominally were represented in the RRP by members on both the RRC and IPAG. The Tohono O’odham and San Xavier District representatives participated on the RRC but not on the IPAG. The Pasqua Yaqui were represented unofficially and indirectly by others when the RRC was active and participated in IPAG meetings directly relatively late in the process. The Tohono O’odham were to receive an
allotment of CAP water and additional exchange water under the terms of the Southern Arizona Water Resources Settlement Act (SAWRSA), for which uses had not been fully determined. Potential existed for recharge of tribal water off the reservation, recharge of tribal water on the reservation, and recharge of non-tribal water on the reservation. The U.S. Bureau of Reclamation was required to secure and deliver the exchange water and provide technical assistance to the Tribe. The San Xavier District was pursuing and eventually received a Water Conservation Fund grant to study recharge, among other things. The Pasqua Yaquis also are entitled to an allotment of CAP water and were engaged in developing a water resources plan for their community.

Tribal representation is sensitive for several reasons. Inclusion of tribes as stakeholders has become a generally accepted rule of public water policy decision making in Arizona and recruitment of participants is a valued activity of decision process organizers. On the other hand, these efforts often fail to produce effective or committed participation. One possible explanation is cultural: the different decision culture of the tribes in the Tucson area and the relative inexperience of representatives with the unstated rules of discourse in the dominant culture. Individual experience can be particularly important. Pasqua Yaqui participation in IPAG, for example, was largely the result of the interest and experience of an individual within the community’s government administration.

A less culture-sensitive explanation is a preference for using more familiar channels of influence. Like real estate developers, the Tohono O’odham appeared to prefer other forums for recharge discussions. In addition, internal organizational affairs may have directed their attention to other problems and decision opportunities.

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3A Tohono O’odham representative privately expressed dissatisfaction with the practice of assuming concurrence with the RRC report if members made no formal objections, because he was not authorized to concur on behalf of the Tribe.
Some individuals were self-motivated to participate and took advantage of the open nature of the process. One such individual joined the RRP to promote his concept for resolving community conflict over CAP water use. Another joined to advocate consideration of a new potential recharge site. Neither had a direct impact on the outcome.

The public interest was represented by the Tucson Regional Water Council (TRWC). The TRWC provides a forum for discussion of regional water issues. It organizes regular meetings and takes positions from a public interest perspective. Like its predecessor organization, the Southern Arizona Water Resources Association (SAWARA), it provides a platform for individuals with an interest in water policy unassociated with benefit to a particular organization to have a personal impact on policy through the power of information. SAWARA was formed specifically to lobby for construction of the CAP to Tucson but expanded its mission to include consideration of a wide range of water problems. After the arrival of the CAP canal, a reorganization of SAWARA narrowed its activities and produced the TRWC to carry on its advocacy functions. The TRWC tends to reflect water establishment biases, and anti-establishment activists have questioned its public interest identity, characterizing it instead as a tool of business and development interests. Participation in its study groups is substantially more diverse and its positions more independent than that characterization implies, however.

The RRP and the CAP

The State of Arizona is deeply committed to use of its full entitlement to Colorado River water. State agencies, and the Department of Water Resources in particular, have adopted the goal of maximum use of CAP. It is believed that future supplies of water from the Colorado River will decline and that maximum storage now is needed to offset
future shortfalls. ADWR policy and regulations encourage, first, the substitution of renewable (CAP) water for groundwater uses, and second, recharge of groundwater aquifers. In consequence, RRP discussions assumed the maximum use goal, constrained only by existing legal requirements and principles of responsible water management.

An unanticipated consequence of completing the CAP canal to Tucson has been exacerbation of a latent division in the community. Before Tucson was assured that the canal would reach it, community consensus in its favor was nearly unanimous. As Ingram (Martin, et al., 1988) wrote, no community leaders opposed it, and majority public sentiment also favored it. This consensus was achieved by deferring decisions about who would use it for what. Only after the water began to flow was the community forced to face the divisive questions about its use.

Most of the RRP participants' organizations shared a commitment to the CAP, having participated in the consensus that facilitated its extension to Tucson. In addition, most considered recharge part of the solution to divisive community issues about the use of Colorado River water. Some held CAP subcontracts, some did not. Of the latter, some wanted to acquire CAP water under other arrangements. Subcontract holders must pay capital repayment costs for the canal and a portion of the operations and maintenance costs regardless of whether or not they take any water. Other arrangements do not entail the same level of financial commitment but lack the security of supply provided by subcontracts.

Municipal water providers, like Tucson Water, Green Valley Water Company, and Flowing Wells Irrigation District saw in recharge planning an opportunity to create benefits from their CAP water subcontracts; however, the benefits they hoped for varied with their situation. Tucson Water had made very large investments in treatment and distribution of CAP water to its customers, but delivery had been halted indefinitely after
problems resulting from water chemistry and distribution system changes with CAP water caused massive public complaint. A subsequent citizens’ initiative was passed by a majority of Tucson’s voters that limited Tucson Water’s choices for CAP use. During roughly the same period, Metro Water was formed, partly as a consequence of the rancorous disputes of its predecessor organization with Tucson Water. Metro Water’s customers were to have received water from Tucson Water. Metro Water, thus, did not have its own CAP subcontract. The Green Valley Water Company is a private company that serves real estate developments in the rapidly growing Green Valley area south of Tucson along Interstate 19. At a minimum distance of ten miles from the CAP terminus, it was unable to take any CAP water for direct use or recharge within its service area. Flowing Wells Irrigation District serves a fully developed area within urban Tucson. It could not deliver CAP water to its customers (if it wanted to) because it lacked the necessary treatment facilities; and, because no further development was planned within its service area, Assured Water Supply rules did not affect it. Thus, it foresaw no benefit from retaining its subcontract, unless recharge policy or other regulations changed (IPAG, 1997a).

Developers of land outside the service area planning boundaries of water providers that met Assured Water Supply requirement would have to gain access to renewable supplies in other ways. Water storage credits (paper water) were available, as long as excess CAP water was available to them or if a water storage credit market were developed.4

Although CAP water was originally intended to supply both agriculture and mining, all potential Tucson area users in these sectors declined subcontracts. Costs associated with taking CAP water was the main reason. In addition, the mines had concerns about

4 See more at Environment.
reliability of supply. Large farms and irrigation districts consider their long-term survival linked with access to renewable supplies. Current regulations encourage a mutually beneficial arrangement whereby farms use subsidized water to generate water storage credits for the CAP subcontractor or eligible purchaser of excess CAP water.

Roles, Professional Norms, and Group Decision Skills

The people who represented the interests of these organizations were, in general, mid-level managers, consultants, or directors of small organizations. According to Brunsson (1989), such individuals are "organizational intermediators," who develop skills in bridging the gap between political actors (those who talk) and operational actors (those who do). Their world includes elements of both modes of operation, and they function in "two contradictory norm systems" (Brunsson, 1989:226). Brunsson suggests that they may succumb to confusion, frustration, and depression, if they have a low level of tolerance for situations that require them "to sustain double standards and double talk and produce hypocrisy." They may escape by choosing sides: identifying with one system or the other; but frequently they evolve a role of their own based on professional norms. Although Brunsson had in mind the norm set of specific professions within an organization, e.g., accountants, the concept can be extended to people whose roles are based on general norms of professional conduct.

Members of the RRC most clearly identified with professional norms. As engineers, scientists, and operational actors within their organizations, they were familiar with and practiced the accepted method for producing facts. Their perspectives incorporated the principles of the rational actor model that actions should be controlled by decisions based on facts. Their circumscribed roles insulated them from the political sphere, although they were aware that the questions they addressed had important political implications.
Many members of the IPAG, on the other hand, were accomplished "intermediators". They occupied the middle ground where broad policy goals are interpreted in the context of specific conditions. Members displayed all of the responses Brunsson observed of people in the intermediary position. Most expressed professional identities appropriate to water resources managers and administrators. They represented, more overtly than RRC members, the interests of the organizations they represented, and the opinions they expressed were, in general, predictably favorable to the interests of their organizations. They were not, however, political. The identities evoked by the process were those first of professional decision makers and water policy experts, and second, as stake holders. Professional norms of rationality, fact seeking, and convergence on consensus dominated. That is, IPAG interactions all but eliminated overt political behavior such as bargaining, coalition formation, and log rolling. Members identified themselves as working in the public interest. At the same time most represented organizations and groups with specific interests in the outcome of the process. This implies that they would advocate perspectives that reconciled public good with their own interests. This reconciliation requires some facility with hypocrisy, as defined by Brunsson, which also was evident in IPAG deliberations.

A focus on people highlights the importance of highly effective individuals on outcomes. Blomquist (1992) calls such individuals "policy entrepreneurs". He describes entrepreneurship as involving "the development over time of skills in collective problem solving, based on experience in particular situations where time and place specifics apply" (Blomquist, 1992:349). Policy entrepreneurs are local insiders who have earned their status by long tenure in the water policy arena and display knowledge of local conditions. They are generally associated with a power base--an organization, agency or public interest group, and represent an identifiable perspective. Their command of facts
allows them to define or redefine issues in ways that suggest solutions compatible with their perspectives.

The Tucson water establishment contains several such individuals. They formed a working core on RRP activities and constituted important nodes in the network of relationships that connected water interests. Such individuals facilitate communication among the broad range of individuals and organizations with potential interest in the policy issue (Laumann and Pappi, 1976). Therefore, they were in a position to provide the RRP with up-to-date information on activities, ideas, and opportunities with potential impact on the deliberations.

Nested Networks of Relationships

The RRP process was nested within a policy and governance system with multiple avenues for influence. Most participating organizations had established connections with ADWR officials in the central administration in Phoenix. They had direct dealings with CAWCD and other State and federal agencies. They maintained these connections independent of the RRP throughout the process. They also continued to meet with each other on recharge and related matters in separate forums, including their subregional coalitions, advisory committees, and regional organizations.

Organizers of the RRP needed concurrence of participants that the process should provide their main avenue for influencing future regional recharge decisions. This entailed convincing them that cooperating in the RRP was likely to produce greater benefits than other activities and evoking their local civic leadership identities. Courtesy visits were made to elected officials of the City of Tucson and Pima County to inform them about the process and elicit at least passive support for it. Such a visit was also made to the Legislative Water Council of the Tohono O’odham Nation and Tucson’s City
Manager. These visits, which highlighted the personal involvement of the TAMA director, sent the message that participation in the RRP should be considered an important and high priority activity.

In gaining the cooperation of most rechargers, the RRP's organizers were assisted by some existing professional and institutional relationships. Most participants were regulated by ADWR. Regulatory decisions on recharge projects were completely unaffected by participation in the RRP, but information about the progress of recharge projects was communicated freely between the regulatory and planning functions. Perhaps more important were ADWR linked funding programs, including Augmentation Grants and the State Demonstration Project Fund. There was competition for the attention of funders among the recharge project sponsors. This competition was not normally part of RRP discussions, but occasionally was evident. Annual additions to the fund for Augmentation Grants to support preliminary research and site evaluations were significantly diminished when the State Legislature diverted them to the Arizona Water Banking Authority (AWBA). The AWBA received $2.50 of the $3.00/af withdrawal fee that had gone to AMA augmentation funds. The State Demonstration Project Fund became fixed when the entire annual funding source was transferred to the Water Bank. Thus, entities competed to protect monies committed to them from these funds or identified monies they believed had been wrongly encumbered, so as to have some transferred to their projects. In addition, projects that received State Demonstration Project funding were perceived to have an advantage in attracting AWBA and CAWCD recharge.

From the point of view of the Tucson water establishment, a core impetus for initiating the RPP was creation of the Arizona Water Banking Authority in 1996. The AWBA presented an opportunity for recharge project developers to capture resources at
the same time enhancing the Tucson area’s regional water storage position. The Water Bank would control, at least for the short term, a large quantity of surplus Colorado River water. It was required by law to recharge the water for the benefit of taxpayers within the three CAP counties. Where the Bank chose to recharge became locally important because the water could be stored underfoot and therefore easily recoverable or it could be recharged elsewhere, making recovery more costly and possibly insecure. In addition, the Bank would pay for recharge in storage projects. A paying customer is a desirable partner for a project and a contract with a paying customer provides leverage for project financing. It was assumed that any project endorsed by the RRP would have an advantage in the competition for AWBA involvement.

The AWBA’s decisions were autonomous, but its position vis à vis ADWR created an avenue of influence. If the TAMA gained cooperation of most or all recharge facility developers, they could have substantial influence on AWBA decisions. In addition, the Water Bank operated under a tight schedule. The more timely and responsive RRP participation in Bank planning, the more likely participants were to influence decisions in their favor. Because of the statutory linkage between the Bank and ADWR, the Department sponsored RRP represented a potentially better avenue of influence than direct lobbying, although a combination strategy of RRP cooperation and direct lobbying probably was most effective.

A fuller description of organizational relationships will be presented in the following section on the decision environment.
ENVIRONMENT

Decisions are affected by the environment in which they occur. As part of the decision process, decision makers must select which aspects and manifestations of the environment are relevant to the decision and interpret their significance. The elements of the decision environment that RRP participants believed were relevant to their decision were described in their reports. In addition, opinions on decision relevant issues of potential recharge project participants were aired in a needs assessment, which was carried out as part of the RRP process. These documents referred not only to physical and institutional decision constraints, but also alluded to a history of interactions that influenced decision making.

Participants in the RRP were familiar with basic facts about their environment. At a minimum, they knew that the area was a desert with insufficient rainfall to sustain its population and therefore dependent on ground water, which was ample but ultimately exhaustible. Their understanding of basic conditions determined the boundaries of the problems that groundwater recharge was intended to ameliorate.

This understanding was summarized in the RRC Report in the section titled Demand and Supply Conditions (RRC, 1996a:II.1-II.8). It established that more than half of the water used in the TAMA is mined ground water (water pumped in excess of recharge) and that significant groundwater level declines have occurred as a result. In addition, the risk of subsidence from aquifer dewatering was severe in some areas. The Report noted, as well, that the governing institutional frame, the Groundwater Management Code, included incentives for the use of renewable supplies, including CAP water and effluent. With respect to these supplies, it was stated that, in addition to producing a growing supply of effluent, entities in the area had contracts for large quantities of CAP water that were then unused, and that future shortages of CAP water were expected. Finally, the
Report described the specific incentives for recharge contained in the citizens’ initiative passed by Tucson’s voters late in 1995: the Water Consumer Protection Act (commonly known as Prop. 200). The brief recapitulation of groundwater conditions and negative effects of groundwater mining served as a justification for its focus on recharge of renewable water supplies and an introduction to the water management goals of the RRP. General agreement about these basic facts framed subsequent discussions.

Physical Setting

The RRP concerned the land area contained within the TAMA. The TAMA boundaries were drawn to encompass two major groundwater basins, the Upper Santa Cruz sub-basin on the east and the Avra and Altar sub-basins on the west. The geologic setting is denominated basin and range, meaning valleys sandwiched between mountain ranges. The broad gently-sloping valleys and confining mountain ranges of the TAMA are oriented north-northwest (Figure 1). The principal sources of natural recharge to ground water are mountain front runoff and streambed infiltration. Groundwater flow trends toward the north-northwest along the axes of the sub-basins. Groundwater flows into the TAMA from the south and exits to the north-northwest.

The subsurface of the intermontane valleys is filled with alluvial sediments that are deeper than 11,000 feet in some areas (ADWR, 1998). Geologists have identified separate formations within the fill on the basis of their distinct characteristics. The upper formations, to about 1,000 feet, are the source of most of the ground water used in the TAMA. (Figure 2.) The alluvial material ranges from unconsolidated silts, sands, and gravels near the surface to consolidated conglomerate, sand, silt, and mudstone at depths. Depth to the water table varies, but is generally greater than 100 feet. Lenses of silt and
clay that impede downward movement of water through the vadose zone (sediments above the water table) occur at various locations throughout the basins.

Figure 1. SCHEMATIC ILLUSTRATION OF GEOLOGIC UNITS, UPPER SANTA CRUZ SUB-BASIN from Regional Recharge Committee Technical Report (1996) p. II-3.

The Santa Cruz River channel and its major local tributaries, the Rillito and Cañada del Oro, run through the Upper Santa Cruz sub-basin. The Santa Cruz is ephemeral in the TAMA and flows only in response to rainfall, except immediately downstream of the two regional wastewater treatment plants. Brawley Wash runs through the Avra/Altar sub-basins to join the Santa Cruz northwest of Marana. The Cañada del Oro and a few other creeks in the TAMA have small perennial reaches, but most streams, like the Santa Cruz, are ephemeral. Major rivers and washes generally channel storm runoff from the south to the north-northwest, although water in the Cañada del Oro valley flows southwest toward the Santa Cruz River.
Metropolitan Tucson straddles the Santa Cruz River, predominantly on the east side, and extends east-southeast and north-northwest to cover the valleys up to the foothills of the Santa Catalina, Rincon, and Tortolita Mountains. Suburban development links Tucson with smaller towns, such as Oro Valley to the north, but substantial areas of undeveloped desert and farm fields still lie between Tucson and Marana to the northwest and Sahuarita/Green Valley to the south. The San Xavier District of the Tohono O'odham Reservation separates South Tucson from Sahuarita. The Avra Valley is sparsely populated and contains a portion of the Schuk Toak District of the Tohono O'odham Reservation.

The CAP canal carries Colorado River water east across the State of Arizona to Phoenix and thence south through Pinal County to Tucson. In the TAMA, it runs along the west side of the Tucson mountains in the Avra Valley, avoiding more populous portions of the TAMA. CAP water is pumped uphill through a series of pumping stations to its terminus near the juncture of I-19 and Pima Mine Road within the San Xavier District, near its southern boundary. Tucson Water’s Hayden-Udall water treatment plant is located near the canal, also on the west side of the Tucson mountains. (Figure 3.)

Groundwater pumping over the years has resulted in depression of water levels in areas influenced by wells. The greatest long-term declines were in the City of Tucson’s Central Wellfield and in the area of copper mining wells, where levels fell 200 feet and 160 feet respectively since 1940 (ADWR, 1998). Other areas of significant decline are under City of Tucson wells in the south Avra Valley, the agricultural irrigation wells northwest of Marana, and the municipal wells in the lower Cañada del Oro. Localized water level rises also have occurred as a result of increased recharge and decreased pumpage, principally decreased agricultural irrigation.
The most obvious effects of long-term groundwater mining in the TAMA are decreased well productivity and increased pumping costs. The quality of pumped groundwater is expected to degrade because salinity increases with depth. Local water table declines have had the effect of lowering stream levels and reducing stream flows with resultant destruction of riparian ecosystems. In addition, evidence of subsidence has been observed in several areas. A program to monitor subsidence at specific stations in the Upper Santa Cruz and Avra sub-basins measured aquifer compaction since 1980 from as little as 0.01 feet to as much as 0.18 feet (ADWR, 1998). The greatest anxiety about subsidence concerns the area over the City of Tucson’s Central Wellfield, which includes a large part of urban and suburban Tucson.

Technical Factors Relevant to Recharge

The RRC identified eight recharge methods appropriate to the Tucson area. The methods and their descriptions are reproduced from the RRC Report as Table 1. Differences among the recharge methods were highlighted in discussions. Some participants expressed aesthetic preferences for methods that used natural stream channels and would support or enhance existing streamside habitat (IPAG, 1997a). From the recharger’s point of view, however, support of vegetation may be undesirable. Injection wells can be placed in urbanized areas where land costs and availability is a problem, because their space requirements are minimal. Well-injection also may be better suited to subsidence prevention. Injection wells require treated source water, however, because clogging caused by sediment and organic material in the source water and incompatible water chemistry can occur in the aquifer, where it is difficult and costly to remedy. These factors represent less of a problem for spreading methods, because clogging occurs near the surface where relatively simple remedies can be used. Sediment

<table>
<thead>
<tr>
<th>Method</th>
<th>Observations</th>
</tr>
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<tbody>
<tr>
<td>Off-Channel Constructed</td>
<td><strong>Shallow Spreading Basins</strong></td>
</tr>
<tr>
<td>Spreading basins are designed to be operated in a wet-dry cyclic mode to maintain high infiltration rates. The dry cycle is used to control the development of a biological film at the surface which impedes the movement of water. The water depth during the wet cycle is not more than 5 feet.</td>
<td>The existing Sweetwater Recharge Project (which recharges treated effluent), the Avra Valley Pilot Recharge Project and the proposed Central Avra Valley Storage and Recovery Project for CAP recharge are examples of this recharge method.</td>
</tr>
<tr>
<td>In-channel Constructed Facilities</td>
<td>A facility designed to function within the active floodplain of a watercourse. These may include: inflatable dams, gated structures, levees and basins, compound channels, etc.</td>
</tr>
<tr>
<td>Managed In-channel Recharge</td>
<td>This type of facility involves no construction (other than monitoring devices). The natural stream channel is used for &quot;passive&quot; recharge.</td>
</tr>
<tr>
<td>Injection Wells</td>
<td>Use of wells to inject water directly into the water-bearing unit of the aquifer.</td>
</tr>
</tbody>
</table>
Table 1 continued. RECHARGE METHODS FOR THE TUCSON AREA

<table>
<thead>
<tr>
<th>Method</th>
<th>Observations</th>
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</thead>
<tbody>
<tr>
<td><strong>Groundwater Savings Facilities</strong></td>
<td>Although the construction costs for this type of recharge are limited to delivery pipelines, such facilities may have a limited lifespan. As agricultural land is taken out of production due to urbanization or other factors, this will decrease the acreage available for such projects. There are two in-lieu projects permitted in the Tucson area, BKW Farms and Cortaro-Marana Irrigation District.</td>
</tr>
<tr>
<td>Also called “in-lieu” recharge. Credits are accrued when a permit holder (such as a municipal provider) provides a renewable water supply to a facility which would otherwise have used groundwater (such as a farmer). Groundwater credits are accrued by the permit holder.</td>
<td></td>
</tr>
<tr>
<td><strong>Induced Recharge</strong></td>
<td>In the Tucson basin, this method would have the greatest chance for success along portions of the Rillito Creek, and upper Tanque Verde Creek.</td>
</tr>
<tr>
<td>This method uses extraction wells along side a river channel to draw down groundwater levels, thereby preventing the water table from intercepting the land surface and sustaining favorable infiltration rates. This method is only applicable in areas where the permeability and transmissivity of subsurface soils are favorable.</td>
<td></td>
</tr>
<tr>
<td><strong>Vadose Zone Recharge Wells</strong></td>
<td>Vadose Zone Recharge Wells differ in design and construction from stormwater drywells which are commonly used to drain urban runoff into the vadose zone to comply with local detention/retention ordinances. The Scottsdale Water Campus is an application of this technique for recharge purposes.</td>
</tr>
<tr>
<td>Wells are designed to promote recharge by introducing water into permeable, unsaturated strata above the water table.</td>
<td></td>
</tr>
<tr>
<td><strong>Deep Basins or Pits</strong></td>
<td>Pits are constructed to expose coarse-grained sediments of the vadose zone when fine grained overburden precludes use of shallow spreading basins. An example of a proposed deep basin site is the Tanner Gravel Pit (which has not yet been evaluated for viability).</td>
</tr>
<tr>
<td>Recharge pits differ from drywells in size and shape; unlike wells, they are typically much wider than they are deep.</td>
<td></td>
</tr>
</tbody>
</table>
and most organic matter are removed from the water by biodegradation and sorption as it passes through the vadose zone. On the other hand, contaminants in the vadose zone, such as nitrate and pesticides, can be flushed into the ground water by surface methods.

Such technical problems are not relevant to Groundwater Savings Facilities (GSFs), which are not recharge projects in the physical sense. The concept of GSFs as recharge projects is a regulatory fiction established in 1990 to encourage the use of renewable water. Ground water is saved because it is left in the ground. GSFs have the advantage of being inexpensive; the only costs for the typical GSF are conveyance facilities and power required to move CAP water from the canal to existing irrigation works.

Besides recharge technology, several other technical factors were considered relevant to recharge project siting. Principal among these was infiltration rate, the rate at which water enters the soil. The instantaneous rate, measured by short-term infiltration tests, is relatively easy to obtain, but it tends to be faster than the long-term rate, which is difficult to estimate without long-term field testing. The long-term rate should be used, along with surface area and the schedule of wet/dry cycles to calculate average annual recharge rate for surface basin recharge projects.

The presence of impermeable layers in the vadose zone will affect the operation of recharge projects. Impermeable layers will impede the downward movement of recharge water and cause perched groundwater mounds and lateral groundwater movement that will have to be accommodated in the project design. It may be necessary to create deep basins by digging through such layers to areas of greater permeability.

Projects intended to store water beneath the site require greater depths to the water table than projects designed to augment the lateral flow of groundwater. The best sites for projects intended to mitigate historical groundwater level declines may be up gradient of areas of greatest declines.
Groundwater chemistry can affect the operation of a recharge project by clogging soil pores and reducing aquifer permeability if groundwater and source water are incompatible. The quality of the source water will affect the quality of the groundwater. Thus a particular recharge project site may be desirable or undesirable because it dilutes poor quality groundwater with high quality source water or it dilutes poor quality source water with high quality groundwater, depending on the goal of the project. It may be important to avoid areas of contamination because a project can mobilize contaminants in the soil and affect the movement of plumes of contaminated groundwater. This same ability of recharge to affect plume movement can be used to advantage, however, to manage or contain the flow of contaminated groundwater.

The project’s specific objectives influence how site characteristics are evaluated and incorporated into the project’s design. Factors that affect site evaluations and project design are related interactively to cost considerations.

Technical Factors Affecting Recharge Costs

The RRC reported the key cost factors to consider for recharge projects include: (1) long-term average recharge rates, (2) land acquisition costs, (3) proximity to source water (e.g., distance from the CAP canal), (4) ability to utilize existing infrastructure, and (5) regulatory considerations. Recharge rates control how much water can be recharged annually in a facility of a given size. The more water is recharged, the lower the cost per acre-foot. If land acquisition is not a problem, however, a spreading facility can be enlarged at relatively low cost to increase the total amount recharged annually to offset a slow infiltration rate.

Distance from the source is important because the single greatest component of construction costs is frequently the water conveyance system. In addition, the greater the
uphill distance the greater the power costs for moving the water. If conveyance infrastructure already exists, or the project employs gravity (or CAP system head) to move water, distance from the source may not be too great a cost disadvantage.

The infrastructure needed to recover and distribute the recharged water also was considered a cost factor. Recharged water may be recovered from the recharge site or its immediate vicinity, in which case water quality will be very close to that of the source water. If extraction wells and distribution lines do not exist, they will have to be built. In this case, aquifer transmissivity and depth to ground water are factors in recovery cost calculations. If the water is for potable supply, it may have to be treated to federal drinking water standards and possibly demineralized. Treatment facilities that did not already exist would have to be constructed.

Recharged water also may be recovered from permitted recovery wells anywhere in the TAMA. In this case, water treatment usually is not an issue. Existing extraction wells may be permitted as recovery wells, thus recovery costs may be ignored. In the TAMA, GSFs are located close to the CAP canal, but most storers intend to recover potable ground water from wells in their service areas. Water also may be recharged without the intention of ever recovering it.

Regulatory considerations can be costly both in time and for construction of compliance features. Several federal, state, and local agencies may be involved in permitting a facility. The RRC Report contained a summary of permitting considerations reproduced here as Table 2. The studies and documentation required for permit applications may be costly and time consuming. The regulating agencies may require more studies and documentation after the application has been reviewed. If there are objections, there may be consultations and negotiations. A small demonstration project may be required. There may be monitoring and harm mitigation provisions attached to

<table>
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<tr>
<th>PERMIT</th>
<th>CONDITIONS WHERE REQUIRED</th>
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<tr>
<td>ADWR-Underground Storage Facility Permit (A.R.S. § 45-811.01)</td>
<td>An underground storage facility permit is required prior to construction of a &quot;constructed&quot; facility, or prior to operation of a &quot;managed&quot; facility. Groundwater storage can also be accrued in groundwater savings facilities by delivering an alternate supply of renewable water, called in-lieu to a recipient who agrees to replace groundwater use with in-lieu water. Recharge credits can only be accrued within a permitted facility.</td>
</tr>
<tr>
<td>ADWR-Water Storage Permit (A.R.S. § 45-831.01)</td>
<td>Water storage permits allow the permit holder to store water at a facility. The applicant must have a right to use the source water, must ensure that the storage occurs at a permitted facility, and must have applied for all necessary water quality permits.</td>
</tr>
<tr>
<td>ADWR-Recovery Well Permit (A.R.S. § 45-834.01)</td>
<td>A recovery well permit is required to allow recharged water to be withdrawn, either inside or outside the area of impact of the recharge project.</td>
</tr>
<tr>
<td>ADEQ-Wastewater Reuse Permits (A.C.C.R. 18-9-701 et seq.)</td>
<td>A permit is required for the use of reclaimed wastewater transported from the point of treatment to the point of use.</td>
</tr>
<tr>
<td>EPA-National Pollution Discharge Elimination System Permit, Section 402 of Clean Water Act (33 U.S.C. § 1251 et seq.)</td>
<td>This permit is required for any private or public entity who discharges pollutants from a point source into navigable waters of the U.S. Although this is a federal permit, ADEQ processes the applications.</td>
</tr>
<tr>
<td>Corps of Engineers/EPA Section 404 of Clean Water Act (Dredge and Fill)</td>
<td>Required for any project that will result in the discharge of dredged or fill material into navigable streambeds at specified disposal sites. All 404 Permits must have ADEQ approval under Section 401.</td>
</tr>
<tr>
<td>Section 7 of the Endangered Species Act, (166 U.S.C. §§ 1531 et seq.)</td>
<td>A biological opinion is required from the Fish and Wildlife Service regarding the likelihood of any action proposed to be taken by or funded by a federal agency which would jeopardize the continued existence of any endangered species or result in the destruction or modification of the species' critical habitat. The ESA also prohibits the &quot;taking&quot; of an endangered species even if there is no federal action. Section 9 of the ESA comes into play if a non-Federal entity &quot;takes&quot; an endangered species.</td>
</tr>
<tr>
<td>Local Flood Control District Floodplain Use Permit (A.R.S. § 48-3609)</td>
<td>Required for doing almost any type of work within the designated 100 year floodplain as defined by ADWR. ADWR maintains a list of floodplain administrators for local areas.</td>
</tr>
<tr>
<td>State Historic Preservation Act (A.R.S. § 41-844)</td>
<td>If a project involves the potential to disturb the surface and/or subsurface of the ground it must be ensured that no prehistoric and/or historic archaeological sites will be disturbed.</td>
</tr>
</tbody>
</table>
the permit. A rule of thumb used in the RRP was the more agencies likely to be involved in permitting, the greater the amount of time and resources likely to be consumed in the process.

Institutional Setting

Permitting

The ADWR has primary responsibility for permitting recharge projects. Since 1986, a number of programs were passed into law by the state legislature to resolve legal uncertainties, and provide incentives and regulatory guidelines for groundwater recharge. The Underground Water Storage, Savings and Replenishment Program, passed in 1994, organized the various recharge statutes into a coherent program. ADWR administers the program and issues the permits required to operate a recharge facility, store water in such a facility, or recover stored water.

From a regulatory standpoint, there are two main types of facilities: Underground Storage Facilities (USFs) and Groundwater Savings Facilities (GSFs). USFs are recharge projects that add water to the ground. GSFs save groundwater by substituting water from a renewable source (e.g. CAP water) for groundwater that would otherwise have been pumped. Both USFs and GSFs allow water storers to accrue groundwater credits.

To obtain a USF permit the operator must demonstrate to the satisfaction of the department that (1) the operator is technically and financially capable of constructing and operating the facility, (2) the project is hydrologically feasible, (3) it will not cause unreasonable harm to land and water users, and (4) any required floodplain use permits have been obtained. The hydrologic feasibility determination includes examination of project efficiency factors to ensure that recharge is the facility's primary purpose (Swieckowski, Swanson, and Mocarski, 1997). A basin project that is not designed to
operate on wet/dry cycles and undergo bottom scraping to improve infiltration would be suspect as an attempt to circumvent artificial lake regulations. These provisions do not preclude multipurpose projects that include environmental enhancement, but they do make such projects technically challenging to document for permit review.

GSF permit requirements seek to ensure that projects do not undermine conservation programs. Farmers must prove to the satisfaction of ADWR that groundwater would have been used if GSF water were not available. In addition, they must demonstrate that they would not have purchased CAP water or effluent on their own. That means, they must show that renewable water was too expensive but groundwater was not. In the TAMA, this is generally fairly easy to demonstrate.

GSF water tends to be highly subsidized by storers. GSFs are perceived by some local water interests as only postponing groundwater level declines. The GSF operator typically has an undiminished grandfathered irrigation water right, which can be exercised in future years when GSF water is not used.

A typical storer would be a municipal water provider that purchases CAP water but because its location is distant from the canal, it is unable to use the water directly. The storer may store its CAP water in a USF or GSF and obtain groundwater credits. The number of credits granted is calculated by ADWR according to a formula specified in the permit. Water credits represent an amount of water that the storer may pump from recovery wells. The storer may use the water credits either in the same calendar year in which water is stored (Annual Storage and Recovery) or in subsequent years (Long-term Storage). It may recover the water from a properly permitted recovery well anywhere inside the same AMA as the recharge project.

Under regulations current during the RRP discussions, there was only one significant requirement for recovery well permitting. No recovery well would be permitted in an
area experiencing four feet or more groundwater level decline annually. Tucson Water obtained recovery well permits for most of its existing wells, but a few were denied permits on the basis of the four-foot rule. RRP participants agreed that the current recovery rules were neither effective as water management tools, nor equitable in their effect on the distribution of the costs and benefits of recharge.

The Arizona Department of Environmental Quality (ADEQ) also reviews recharge facility permit applications. They may recommend additional provisions to be appended to a permit. The purpose of these additional provisions it to satisfy permiters that the project will not contribute to the migration of a contaminant plume or poor quality groundwater, or leaching of pollutants to the groundwater table, so as to cause unreasonable harm (ADWR, 1998).

The ADWR/ADEQ permitting process may be technically demanding and time consuming. Recharge facility sponsors expressed some dissatisfaction with the time lags and lapses in communication between applicants and reviewers. In addition, applicants suspected that permiters were being over cautious in their monitoring requirements (IPAG, 1997a).

Effluent projects have a greater level of ADEQ involvement than CAP projects, because recharge of CAP water is exempt from the State’s Aquifer Protection Permit (APP) program. Effluent USF projects, on the other hand, must obtain APPs, and any project in stream channels must also obtain a National Pollution Discharge Elimination System (NPDES) permit. Effluent GSF projects require Wastewater Reuse Permits to use reclaimed wastewater, transported from the point of treatment to the point of use, for agricultural irrigation (IPAG, 1998).

Although CAP water does not require an APP for recharge, its quality for potable use is regulated as surface water. The ADEQ in it role as administrator of the Federal
Safe Drinking Water Act has been developing rules for determining if recovered CAP recharge water should be considered "groundwater under the influence of surface water." If recovered CAP recharge is determined to be under the influence of surface water, the recovered water may have to be filtered and disinfected before it can be delivered to potable water customers.\(^5\) If public water system wells are within 500 feet of a surface water body, which would include a recharge facility using CAP water, draft rules state that ADEQ will require a determination. If existing hydrogeologic and well construction data are insufficient to make this determination, recovery well water will have to be tested. The test currently preferred by ADEQ is a Microscopic Particulate Analysis, which looks for leaf and insect fragments and similar indicators that have not been filtered out by aquifer materials. This test would have to be made only twice for a determination to be made and would not be an on-going monitoring requirement (IPAG, 1998).

Recharge projects also may have to obtain a number of other permits or clearances. Local floodplain use permits are required if the recharge facility will place structures within the 100-year floodplain. Both Pima County and Marana have floodplain permit ordinances. Recent heavy flooding in the Marana area has made that jurisdiction particularly sensitive to flood hazards.

In-channel projects would have to obtain Clean Water Act, Section 404 permits from the U.S. Army Corps of Engineers and U.S. EPA for alterations to the channel. Dredge and fill material must be handled so as not to damage wetlands. Under Section 401, ADEQ must review Section 404 permits and certify that federal water quality standards will be met.

\(^5\) Groundwater currently does not require this kind of treatment, although a contemplated national groundwater disinfection rule may change that.
Projects would require consultation with the U.S. Fish and Wildlife Service if (1) they include a federal component, such as right-of-way over federal land or funding from a federal agency, and (2) a risk exists that the project will harm endangered species. Mitigation and prevention of harm to endangered species, such as fish barriers, may be required.

The Federal Aviation Administration (FAA) published guidelines (FAA Advisory Circular AC 150/5200-33) recommend that facilities attractive to population of “hazardous wildlife” (e.g., birds) not be sited within 1 to 2 miles of an airport, and five miles for approach and departure airspace. The FAA may request a bird abatement plan and mitigation measures if the project is near an airport and is likely to attract birds.

Recharge project sites where the land surface will be excavated and/or inundated must be surveyed to ensure that no archaeological sites will be disturbed. Notifications must be made pursuant to requirements of the State Historic Preservation Act if archeological, paleontological, or funerary items are found. Local preservation offices also may have to be notified.

Augmentation

Conservation and augmentation are the two water management strategies promoted by the Groundwater Management Act for achieving safe yield by 2025. Augmentation received less attention that conservation in 1980, but since the construction of the CAP, the state has developed its institutional apparatus to coerce and encourage municipal water users to use renewable rather then mined water and to store excess water in the present against future shortages.

When the GMA was negotiated by Arizona’s dominant water users in 1980, rights to use ground water were grandfathered in an amount more than sufficient to supply the
demand that existed then in all sectors. Because the Code prohibited expansion of
irrigated farmland in the TAMA, the demand in this sector was unlikely to grow beyond
the grandfathered rights. The Code also limited the amount of water available through
new industrial use permits, but because grandfathered non-irrigation rights (water rights
available for industrial use) greatly exceed demand, the limit on new permits has not
constrained the growth in industrial water use (ADWR, 1998). In fact, in the years
since 1980, very few ground water users in the TAMA have been limited in their water
use by water rights. Conservation requirements for industry and agriculture force
efficient water use, but do not provide incentives for a switch to renewable supplies.
Only the municipal sector is required to use renewable water supplies, and only those
providers that must accommodate growth on subdivided land.

Assured and Adequate Water Supply Rules (AWS), adopted in February of 1995,
require that new subdivisions prove to the satisfaction of ADWR that they have a
sufficient supply of water to meet the demands of the subdivision for 100 years. If the
subdivision is within the service area of a supplier, the supplier must have secured an
AWS designation from the Department, or the subdivider must obtain an AWS
certificate. The water accounting rules are somewhat different for designations and
certificates, but both require that a major portion of the demonstrated supply be from
renewable sources. Applicants are allocated a specified amount of ground water, which
may be used at the discretion of the applicant, but any ground water used in excess of its
allocation must be replenished from a renewable source. If an applicant does not have
access to a renewable water supply, it may join the Central Arizona Groundwater
Replenishment District.

2 A large volume of unused groundwater right and permit allocations is associated with
the industrial sector--out of nearly 193,000 acre-feet per year total rights, 132,000 acre-
feet were unused in 1995.
The Central Arizona Groundwater Replenishment District (CAGRD) is an organization created in 1993 within CAWCD and tasked with recharging mined groundwater for AWS certificated lands and designated providers. Applicants for CAGRD membership also must have applied for an AWS designation or certificate.

The CAGRD may construct and operate recharge projects as well as recharge for its members in projects constructed by others. The CAGRD may use various sources of renewable water for replenishment. Its main source, however, is CAP water. Members must pay for replenishment services. The price of services is set by the CAGRD. The CAGRD maintains a replenishment account for each member. Members’ accounts are balanced annually. The amount of excess ground water pumped is debited, and members must pay the CAGRD to bring the balance at least to zero. Members also may pay into the account to build a limited credit balance (IPAG, 1998).

The CAGRD is obligated to replenish mined ground water for its members within their AMA within three years. However, legislation provided the CAGRD with a gradual start-up schedule for construction of recharge projects. Thus, replenishment in the early years would be only a small fraction of the groundwater pumped by members.

All the designated suppliers in the TAMA joined the CAGRD. The collective bargaining power of the district and other economies of scale may make CAGRD services less costly than alternatives (ADWR, 1998). Even so, the largest water providers preferred not to relinquish control of recharge costs. An important reason for involving themselves in recharge projects was their greater control over expenditures (IPAG, 1997a).

A very restricted credit market can be maintained in transferred CAGRD storage credits. Approval of the Director of ADWR must be obtained to transfer credits, and the entity to which credits are transferred must have been eligible to have originally accrued
the credits. There was some support expressed among participants for an expanded market in water credits (IPAG, 1997a).

The Central Arizona Water Conservation District (CAWCD) operates the CAP and repays the federal construction debt for the project. Additional recharge related responsibilities include construction and operation of State Demonstration Projects and administration of the State Demonstration Projects fund.

The CAWCD estimates annually the amount of water that will be available to customers. It accepts orders from subcontractors, and as long as there is excess water, CAWCD will schedule orders from eligible others. In 1998, the capital charge, which all municipal and industrial (M & I) subcontractors were required to pay for subcontracted water regardless of the amount of water ordered, was $48.00 per acre-foot. The annual operating charge, which they were required to pay for water ordered was $29.00 per acre-foot, and the pumping energy charge, which was required for water actually delivered, was $36.00 per acre-foot. Subcontractors could purchase specially priced excess CAP water under an incentive program if that water was to be used to accrue long term storage credits. In 1998, the price for that water was $41.00 per acre-foot. M & I users without subcontracts were permitted to purchase excess water for the same total price as delivered M & I subcontract water--$113.00 per acre-foot (IPAG, 1998).

The CAWCD charges a single "postage stamp" rate to all CAP water users within the same category, regardless of their location. This policy makes CAP water more attractive to Tucson area water users than if conveyance costs for distance and lift were included in the price. Maintenance of this policy is important to local water users.

Annual priority for deliveries of CAP water was established by law; Indian and M & I subcontract deliveries share the highest priority, non-Indian agriculture has the lowest. On a day-to-day basis, however, non-Indian agriculture may receive water withheld from
municipal rechargers; the CAWCD administrators reason that failure to irrigate crops has a more substantial impact than recharge project operating delays. This scheduling policy disturbed some TAMA rechargers because design and operation of recharge facilities is affected by the likelihood of delivery delays and interruptions (IPAG, 1998). There has been no shortage of Colorado River water for the CAP, but water delivery has been curtailed because of problems in the system.

The State Demonstration Project program was created to encourage development of recharge facilities. The CAWCD can provide some reliability of supply by storing water in State Demonstration Fund projects. If a significant canal outage or Colorado River shortage occurs, the CAWCD may deliver water it has stored to its customers. The customer must pay CAWCD recovery and conveyance costs, but not construction or operation and maintenance costs for the recharge facility.

Funds were provided for State Demonstration Projects by ad valorem taxes on property in Maricopa and Pima Counties at the rate of four cents per $100 secondary assessed valuation. CAWCD collected these taxes between 1991 and 1996 specifically for State Demonstration Projects or recharge of excess CAP water. By 1997, most of the fund for the Tucson AMA had been expended or encumbered. Three recharge projects in Pima County received State Demonstration Project funds. Since 1996, monies raised from the tax were to be provided to the Arizona Water Banking Authority (AWBA), unless CAWCD determined that they were needed to fulfill CAWCD’s repayment obligation to the federal government (ADWR, 1998).

Creation of the AWBA in 1996 was a significant event for groundwater recharge in Arizona. With its creation, the State assumed responsibility for storing annually all the CAP water that otherwise would have gone unused, up to Arizona’s full entitlement of 2.8 million acre-feet. Founding legislation provided a rapid timetable for policy
development and implementation and required storage of 360,000 acre-feet of water within its first year of operation.

Legislation provided the AWBA with five specific goals: (1) increase utilization of Arizona’s Colorado River entitlement, (2) enhance reliability of municipal CAP deliveries, (3) help meet water management objectives, (4) facilitate Indian water rights settlements, and (5) provide a mechanism for Arizona to participate in interstate water banking with Nevada and California. In its first years, however, its primary goal was to store as much Colorado River water in Arizona as possible. Other goals were likely to become more important in the future, thus AWBA plans had to balance short-term expediencies against long-term optimization.

The AWBA received funding from four sources, each with its specific obligations. The most important sources during the RRP period were taxes and withdrawal fees. The \textit{ad valorem} property tax of four cents per $100, previously assigned to the CAWCD, was to be used for the benefit of the county in which the funds were collected. Groundwater storage credits accrued using these funds must be transferred to the CAWCD for recovery and delivery to M&I subcontractors during times of shortage. A withdrawal fee allocation of $2.50 per acre-foot could be used only for the benefit of the AMA where the fees were collected. AMA benefits for which accrued credits might be used included Indian water rights settlements and water management objectives of the State’s Groundwater Management Code. Other actual or potential sources of monies were general fund appropriation and the proceeds of interstate banking activities (ADWR, 1998).

Recharge participants recognized the opportunities created by AWBA cooperation. The AWBA was expected to bring CAP water into the AMA that otherwise would have gone elsewhere. In addition, participants expected the AWBA to participate in
developing water storage projects. Although the AWBA could not construct or operate a facility, its participation in a project constructed and operated by others would facilitate financing and economic stability of the project.

AWBA start-up and the IPAG phase of the RRP occurred concurrently. The AWBA’s schedule required it to develop an annual plan of operation, a Storage Facilities Inventory and a Facilities Plan for each of the Phoenix, Pinal, and Tucson AMAs. The RRP made advising the AWBA one of its goals, and the AWBA, as a matter of policy, relied on input from the RRP in developing those portions of its plans dealing with the TAMA.

This relationship was facilitated by the linkage between the AWBA and ADWR. The Director of ADWR serves as chair of the AWBA Commission and coordinates with the AWBA to ensure that the Bank’s water storage and recovery activities serve the water management objectives of the groundwater code. Statute also specifies that ADWR make recommendations to the AWBA on the location of water storage to advance AMA water management goals, and the AWBA is required to consider the Department’s recommendations. The TAMA, as sponsor of the RRP, was in the position to connect the plans of the Bank and Tucson region rechargers. In fact, the AWBA explicitly acknowledged its intention to coordinate its TAMA plans with the RRP (AWBA, 1998).

Indian Water and SAWRSA

Indian water rights settlements hold a prominent place in Arizona’s water policy environment. One of the specified goals of the AWBA is assisting in the settlement of Indian water rights claims. Indian Tribes received an initial allocation of CAP water from the U.S. Secretary of the Interior that the CAWCD is obligated to deliver, on demand, with a priority equal to municipal supply.
In the TAMA, the Tohono O'odham Nation was allocated 37,800 acre-feet of CAP water annually. In addition, settlement of the claims of the Nation under the Southern Arizona Water Rights Settlement Act (SAWRSA) obligated the U.S. Bureau of Reclamation to exchange 28,200 acre-feet of effluent from Pima County wastewater treatment plants for other water to be delivered to the designated recipients within the Nation. The Pascua Yaquis also have a smaller annual allocation of 500 acre-feet.

Initially, SAWRSA water was intended to support agricultural development, but the 1982 Act was not implemented as expected. Disputes regarding the internal distribution of settlement assets and other problems delayed implementation. Although plans for agricultural use of the water have not been abandoned, the San Xavier District has been exploring opportunities for recharge to restore groundwater levels, riparian vegetation, and wildlife habitat.

Additional recharge related opportunities existed on reservations. For example, projects developed to store non-Indian water for non-Indian users could expand recharge capacity in the AMA, and recharge of large quantities of Indian water could improve the AMA-wide water balance significantly (ADWR, 1998).

Tribal governments have jurisdiction over recharge projects located on tribal land, thus regulation of such projects may differ from projects elsewhere in the AMA. In order for non-Indians to accrue groundwater storage credits recognized by the State of Arizona, however, there would have to be an intergovernmental agreement between the State and the Tribe. The Water Resources Committee of the Tohono O'odham Nation's Legislative Council deals with water resources policy issues and a Water Projects Office provides technical expertise. The Pascua Yaquis have a Community Planning Office that deals with water resources issues and makes recommendations to the governing body.
Throughout the RRP process, neither tribe had formal rules governing recharge and no intergovernmental agreements on recharge or groundwater storage credits existed.

Historical Setting

The RRC Report also contained references to the social and political history of recharge in the TAMA. These references alluded to the shared experiences of participants in the broader debate over regional water policy, especially with respect to CAP water.

The arrival of the CAP canal system and water from the Colorado River meant that issues that had been deferred in the interest of community consensus had to be addressed. Although support for CAP was broad, understanding of how the water would be used and how water quality problems would be resolved remained vague. The CAP project had been conceived initially to rescue irrigated agriculture in Arizona, but by the time it was constructed, municipal users had long since become its principal beneficiaries. In the Tucson AMA, farmers, irrigation districts, and copper mines had joined the coalition of CAP supporters and had requested allocations from the system, along with Tucson Water and other municipal users, including developers. When subcontracts were offered, however, only municipal sector entities signed them. Subcontracts were declined by all mining and agricultural users in the TAMA because of cost. Actual subcontract prices were substantially higher than initial estimates, and the additional costs for constructing conveyance from the canal to the point of use were prohibitive (ADWR, 1998). The water that would have come to the AMA through these subcontracts was returned to a statewide pool for reallocation.

The groundwater code did not provide sufficient incentives for agriculture or industry to use renewable supplies. Groundwater continued to be available to them at
relatively low cost in the Tucson area. Thus, the financial burden of supporting the CAP fell more heavily on municipal subcontractors.

A vocal sector of the public was hostile to the idea that agriculture and industry should profit from their grandfathered groundwater rights at the expense of municipal water consumers, and believed farms, mines, and golf courses should be compelled to use non-potable water (ADWR, 1998). Although legal means for compelling CAP water use were not available within the existing institutional structure, municipal water users regarded subsidizing CAP water use in other sectors as unfair.

The GMA prevented most municipal providers from declining CAP subcontracts because of AWS rules. Entities with CAP subcontracts were deemed to have met AWS supply requirements for the first five years of the program. Major municipal suppliers, including Tucson, and large real estate developers never entertained the possibility of failure to meet AWS requirements. For these suppliers, a CAP subcontract was unavoidable.

After the five-year period had elapsed, a revised AWS program required that, to maintain their designations, entities had to demonstrate how they intended to use their CAP water. Entities without credible plans for using their CAP subcontracts or lacking subcontracts, could join the CAGRD. All municipal suppliers that anticipated the need to support growth joined the CAGRD. Tucson Water did not join at first, but was forced to negotiate a CAGRD contract in 1996, when intervening events undermined their original water management plans.

It had been Tucson’s intention from the beginning to supply CAP water directly to its customers. Before the CAP was completed, Tucson Water embarked on a multi-year study of treatment systems. Their major concerns were the fluctuating, but generally

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6 Golf course watering is considered an industrial water use under the groundwater code.
high, mineral content of CAP water, disease causing microorganisms, and organic material that transforms to cancer-linked disinfection by-products such as chloroform. Tucson Water, like most potable water suppliers, took federal drinking water standards as it benchmark for acceptable quality (Table 3). By these standards, the mineral content of untreated CAP water was not a problem. Indicators of the possible presence of microbial pathogens had to be eliminated in more than 95 percent of monthly samples. The standard for trihalomethanes (THMs), the only category of disinfection by-products for which a federal standard existed, was 100 parts per million (ppm). The standard for THMs was expected to be tightened to 20 ppm (RRC, 1996a).

Tucson chose not to demineralize CAP water because it was not required by federal or state standards and they believed that the substantial additional cost to rate payers would be unacceptable. They rejected simple chlorination because of its THM formation potential. They chose, instead, to construct a “high-tech” ozonation-chloramination treatment plant because it gave the same protection against disease causing microorganisms as chlorination and would produce water that exceeded the anticipated federal water quality standards for THMs (Tucson Water, n.d.).

The decision makers at Tucson Water also rejected a proposal, from outside the water establishment, to avoid construction of a large surface water treatment plant by using all the CAP water to recharge the aquifers and to continue supplying groundwater to customers. The argument of all-recharge proponents was that the Soil Aquifer Treatment (SAT) provided by recharge would remove hazardous impurities, and people could continue to receive water of accustomed quality.

At that time (1987), recharge was only beginning to be used in Arizona. The City and its prime contractor were in the middle of a multi-year study of the technical and economic feasibility of recharge (1985-1989). Legal questions regarding the

<table>
<thead>
<tr>
<th>Water Quality Constituent</th>
<th>Existing Tucson Water AV Supply Wells</th>
<th>Existing Tucson Water Production Wells</th>
<th>Treated CAP Water</th>
<th>Raw CAP Water</th>
<th>Secondary Effluent</th>
<th>Reclaimed Wastewater</th>
<th>EPA Drinking Water Standard</th>
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<tbody>
<tr>
<td>Sodium (mg/l)</td>
<td>41.0</td>
<td>40.1</td>
<td>97.7</td>
<td>96.7</td>
<td>112</td>
<td>122</td>
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<tr>
<td>Total Nitrogen (mg/l)</td>
<td>No Data</td>
<td>No Data</td>
<td>&lt;1.4</td>
<td>No Data</td>
<td>22.7</td>
<td>No Data</td>
<td>NO STD</td>
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<tr>
<td>Nitrate (mg/l as N)</td>
<td>2.4</td>
<td>1.9</td>
<td>&lt;0.556</td>
<td>&lt;0.542</td>
<td>4.6</td>
<td>5.2</td>
<td>10 MCL</td>
</tr>
<tr>
<td>Ammonia (mg/l as N)</td>
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<td>No Data</td>
<td>&lt;0.75</td>
<td>&lt;0.19</td>
<td>12.6</td>
<td>No Data</td>
<td>NO STD</td>
</tr>
<tr>
<td>Sulfate (mg/l)</td>
<td>12</td>
<td>52</td>
<td>262</td>
<td>242</td>
<td>100</td>
<td>134</td>
<td>250 SMCL</td>
</tr>
<tr>
<td>Chloride (mg/l)</td>
<td>24.0</td>
<td>19.9</td>
<td>97.5</td>
<td>87.6</td>
<td>90.6</td>
<td>109</td>
<td>250 SMCL</td>
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<td>Fluoride (mg/l)</td>
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<td>0.36</td>
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<td>0.425</td>
<td>0.80</td>
<td>0.93</td>
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<td>210</td>
<td>282</td>
<td>633</td>
<td>611</td>
<td>547</td>
<td>655*</td>
<td>500 SMCL</td>
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<tr>
<td>Hardness (as CaCO3) (mg/l)</td>
<td>84</td>
<td>129</td>
<td>261</td>
<td>266</td>
<td>141</td>
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</tr>
<tr>
<td>Alkalinity (as CaCO3) (mg/l)</td>
<td>124</td>
<td>129</td>
<td>98.8</td>
<td>105</td>
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<td>222</td>
<td>NO STD</td>
</tr>
<tr>
<td>pH</td>
<td>8.1</td>
<td>8.0</td>
<td>7.43</td>
<td>8.12</td>
<td>7.35</td>
<td>7.0</td>
<td>6.5-8.5 SMCL</td>
</tr>
<tr>
<td>Arsenic (mg/l)</td>
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<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>&lt;0.0074</td>
<td>&lt;0.0075</td>
<td>0.05 MCL</td>
</tr>
<tr>
<td>Barium (mg/l)</td>
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<td>&lt;0.2</td>
<td>&lt;0.2</td>
<td>&lt;0.357</td>
<td>&lt;0.36</td>
<td>2.0 MCL</td>
</tr>
<tr>
<td>Copper (mg/l)</td>
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<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.0237</td>
<td>&lt;0.03</td>
<td>1.0 SMCL</td>
</tr>
<tr>
<td>Total Trihalomethanes (ug/l)</td>
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<td>&lt; 1.83</td>
<td>&lt; 3.24</td>
<td>&lt; 11.4</td>
<td>100 MCL</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
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<td>No Data</td>
<td>0.251</td>
<td>1.28</td>
<td>16.9</td>
<td>4.3</td>
<td>1.0 MCL</td>
</tr>
<tr>
<td>Total Coliform (CFU/100ml)</td>
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<td>No Data</td>
<td>&lt; 2</td>
<td>No Data</td>
<td>&gt; 1227</td>
<td>&lt; 4.9</td>
<td>0**</td>
</tr>
</tbody>
</table>

*Reclaimed water includes groundwater recovered from the Sweetwater US&R Facility. Ambient groundwater is high in TDS.*
**Positive total coliform test requires repeat sampling. Second positive test results, or > 5% of monthly samples positive violates MCL.*
responsibilities of rechargers and the ownership rights to recharged water were the subject of state levels legislation in 1986 and 1987, and experience with large-scale recharge projects was lacking. When proponents of the all-recharge option put an initiative on the ballot in Tucson in 1987, the water establishment campaigned against it. They argued that too little was known about the technology and that an all-recharge mandate would rob the City of the flexibility it needed to make efficient use of its water supplies. The initiative was defeated when voters appeared to trust the cautions of a united establishment over the statements of the initiative's promoters.

Quality became the main water issue concerning the community once the CAP had resolved the issue of insufficient long-term water supply. The public was aware to some extent that CAP water was harder than Tucson's groundwater (Eden, 1993). Because of its higher concentration of total dissolved solids (TDS), consumers believed it would taste worse. Dealing with the higher TDS would add to household expenses for detergent, in-home softeners, bottled water, more frequent replacement of water using appliances, and the like. Because Tucson's treatment plant was not designed to reduce TDS, these inconveniences were to be born by individual householders.

The treatment system, itself, introduced concerns. Residual chloramine, needed to keep microorganisms from growing in the distribution system, would be toxic to fish and the treated CAP water could not be used in kidney dialysis machines. Public warning about these limits on use appeared to reinforce latent fears about the dangers of "chemically treated" surface water. The link between cancer and chlorination by-products was in the news and part of the public debate about the safety of the national water supply. The sense of security provided by federal drinking water standards was eroded by the national debate over those standards, which included expert opinion that it may be impossible to determine a "safe" level of carcinogens. The experiences of the
Tucson community with TCE contamination of ground water and federal involvement in its remediation tended to reinforce public skepticism.

Public trust in Tucson Water remained high, however, through the first deliveries of treated CAP water to Tucson homes in 1993 (Eden, 1993).

This trust quickly eroded when problems occurred. Water users experienced a range of problems from cloudy and discolored tap water to sudden failure of boilers, hot water heaters and other fixtures. Problems were especially acute in areas served by the oldest distribution lines and in neighborhoods of older homes. The immediate responses of the utility were inadequate to deal with complaints and public hostility. Significantly, Tucson Water management lost its political support in the City Council. The Council voted in 1994 to return the City to ground water (while unrelated repairs were made to the CAP system upstream of Tucson) and in 1995 to keep the City on ground water until problems could be solved (ADWR, 1998).

Investigations revealed that most of the problems could be attributed to corrosion of accumulated mineral coatings in old water mains and household plumbing caused by changes in pH and other inorganic chemical factors and a reversal in the direction of flow through portions of the distribution system (ADWR, 1998). Several million dollars were allocated to replace aging distribution lines, and corrosion issues were addressed from the water treatment perspective. During the hiatus, however, proponents of the all-recharge initiative placed a revised version on the City ballot. With the change in public sentiment, their proposal to prohibit direct use of CAP water for five years won voter approval, even with an essentially united water establishment against it.

The recharge initiative became law in November 1995 as the Water Consumer Protection Act (WCPA). Its main effect was to prohibit the City from delivering CAP water to its potable water customers unless the water is treated to meet or exceed the
quality of ground water from Tucson’s Avra Valley Wellfield in salinity, hardness, and dissolved organic material. Instead of direct use, the act specified that Tucson’s CAP water should be sold, exchanged, or applied to nonpotable uses including agriculture, mining, and turf irrigation. It also required basin and streambed recharge to prevent subsidence within the City’s Central Wellfield, specifically stating that all withdrawal there, measured over a five-year period, shall be replenished. However, water could not be recharged in an area containing or adversely affected by toxic landfills. Furthermore, CAP water could not be recharged by well-injection unless treated to the same quality as for potable delivery and free of disinfection by-products (WCPA, 1995). A copy of the WPCA is appended (Appendix A).

Several consequences following from this series of events were relevant to the RRP process. Groundwater recharge gained priority as a water supply strategy. The water establishment developed a new understanding of the public’s attitude toward CAP water. The City of Tucson was weakened politically in the water policy arena, and other jurisdictions became more assertive of local control.

Although WPCA only applies to the City of Tucson, others potable water suppliers in the area were reluctant to risk rate-payer disapproval and, in the words of TAMA planners, “appear likely to use CAP water primarily through storage and recovery in the near term.” (ADWR, 1998: 8-9) The Metropolitan Water District, for example, determined that its customers “were strongly opposed to the direct service of treated CAP water.” (Megdal and Myers, 1995:100) Thus, direct potable use of CAP in the TAMA had been ruled out because of the public’s perceived antipathy to CAP water quality. Most municipal rechargers assume, furthermore, that unless there were a major change in public opinion, recovered recharge eventually would have to be demineralized. Soil Aquifer Treatment through recharge was not considered a treatment alternative, and
municipal rechargers were willing to wait and see how public opinion and drinking water quality regulations play out (IPAG, 1997a).

A major consequence of the failure of CAP deliveries in Tucson was loss of experienced city water management and staff. The Director and many top managers were fired or resigned as a result of the events. City Council members dissociated themselves from responsibility for previous water policy decisions and blamed the utility management yet were unable to articulate an alternative. As the RRP was being discussed, the City was in retreat in the face of a hostile, distrustful public and political leadership vacuum.

While the City was still the largest water user in the region, it was a convenient time for other jurisdictions and interests to take advantage of Tucson’s relative political weakness. Thus, a second casualty was Tucson Water’s dominance of regional water policy. Interjurisdictional conflict was identified by TAMA planners as “one of the greatest obstacles to developing a rational water policy for the Tucson community.” The principal conflicts referred to by the planners existed among the City, Pima County, smaller water providers, and water users “over effluent, CAP utilization, assignment of costs and benefits of [the] reclaimed water system, management of Tucson Water and Pima County Wastewater” (ADWR, 1998:12-5).

A needs assessment, performed at the request of the IPAG, included questions about obstacles to cooperation. Many respondents aired grievances and reported negative perceptions about the City of Tucson. These included beliefs that the City was (1) determined to annex it way to total dominance of the basin, (2) a bully in group activities with other jurisdictions within the basin, (3) unpredictable and would reverse policies with out warning, (4) committed to a policy of non-cooperation with entities with whom it is in litigation, and (5) listens only to its own voters/rate payers on policies that have
basin-wide effects. Needs assessment respondents also accused the mines of suspiciousness, mines and developers of environmental irresponsibility, and farmers of receiving unfair subsidies (IPAG, 1997a).

These criticisms referred obliquely to specific events. For example, the City participated in the development of a regional water augmentation authority, the Santa Cruz Valley Water District. At a critical meeting of the District’s board in 1993, Tucson voted, against all the other Board members, to dissolve the Authority. Because the City had veto power, its vote ended the District. It was believed generally that the City had feared it would have insufficient control over governance of the District.

Most future growth was expected to occur outside Tucson Water’s service area. Growth areas organized resistance to Tucson’s annexation plans and to incorporation within Tucson Water’s service area. The IPAG’s needs assessment revealed a change in the desires and capabilities of entities outside the urban core to do their own water management (IPAG, 1997a). More public entities wanted to involve themselves in water management, witness the purchase of private water companies by public entities in the Northwest (e.g., Marana). The Metropolitan Domestic Water Improvement District (Metro Water) organized to purchase and manage the private Metropolitan Water Company. Metro Water subsequently was able to purchase a CAP subcontract from Tucson, instead of taking the treated CAP water its predecessor entity had contracted for. Other privately organized companies considered converting themselves to public entities to gain control over management choices. Respondents expressed the belief that subregions were in a position to solve their own renewable supply problems, and articulated some support for water management by sub-basin.

7 The City’s respondents declined to comment, except in very general terms, on the possibility that distrust among jurisdictions was an obstacle to recharge planning.
The current institutional regulatory structure focused on an AMA-wide water balance and was by and large incapable of dealing with sub-basin issues, which became the responsibility of individual entities. The only regulatory tool for sub-basin management was recovery well permitting. But sub-basin balance was embraced as a long-term water management goal (ADWR, 1998).

Subregional organizations were formed to develop locally responsive water supply strategies. The Northwest Replenishment Program (NRP) was developed collaboratively by the major water users and public jurisdictions with interests in the Cañada del Oro and Lower Santa Cruz watersheds, including Metro Water, the Towns of Oro Valley and Marana, BKW Farms, and Pima County Flood Control District. It consisted of three recharge projects, two of which were designed to include flood control, environmental enhancement, and recreation components (Megdal and Myers, 1997:100). At the southern end of the TAMA, the Upper Santa Cruz Water Users Group (USCWUG) formed to discuss development of a water augmentation program for their sub-region. ADWR supported a CAP water use feasibility analysis and delivery system optimization study for USCWUG. Groups members were interested in the opportunities for groundwater savings and recharge that direct access to CAP water would bring them.

Tucson Water managers focused on compliance with the WCPA. In response to the WCPA, Tucson expanded its recharge plans to accommodate at least 60,000 acre-feet of raw CAP water. It interpreted the provisions of the Act as encompassing construction of a large-scale recharge and recovery project in the Central Avra Valley. Water mining in the Central Wellfield would cease, permitting natural recharge to replenish the aquifer in that area, thus preventing subsidence. Well-injection recharge with treated CAP water in the Central Wellfield, begun in January of 1993 and in abeyance since October of that year, was discontinued. At the same time, the City undertook several major studies to
determine public preferences and investigate the technical and economic feasibility of alternatives for complying with them.

These activities did not satisfy WCPA proponents, however. Although the actual provisions of the Act are sufficiently vague to admit several interpretations, initiative proponent have described the Tucson’s Central Avra Valley project as a ruse to avoid compliance with the wishes of voters as expressed by the Act. These proponents interpret the Act as directing the City to immediately begin recharging CAP water into the stream channels and other selected sites within the Central Wellfield (Makasson and Devine, 1998a).

An anti-CAP ticket of WPCA proponents ran for the CAWCD Board in 1996. The CAWCD is governed by an elected board that determines CAP policy. The Board is composed of 15 members elected from Maricopa, Pinal, and Pima Counties. Pima County has four members. Pima County voters split their delegation among establishment, anti-establishment, and independent candidates. Because the Board is dominated by Maricopa County, this vote had little impact on Board policies. Its significance was mainly as a measure of the unpredictability of public sentiment.

If the representations about public sentiment of WPCA proponents were to be believed, there was an important gap between the beliefs and objectives of the general public and those of the Arizona water establishment regarding CAP water use. Although the notion of rethinking support for CAP might receive public airing, it has not represented a serious policy option among decisions makers. The State regulatory apparatus is designed to promote use of CAP water. “Full utilization of the state’s Colorado River entitlement has been the key to Arizona’s water management policy for decades” (Henley and Jayne, 1997:223). The state’s long battle for “its share” of the Colorado River still set the tone for state level water policy, with important implications
for Tucson. Before direct delivery of CAP water to Tucson customers was halted indefinitely, area water managers' two major concerns were maximizing the TAMA's portion of CAP water allocations and having a terminal storage facility constructed. Both of these goals were jeopardized by the failure of direct delivery.

As long as Tucson area subcontractors took only a small fraction of their allocation, the region would be disadvantaged in attempts to retain relinquished subcontract water or acquire additional CAP water by reallocation. It could be argued rationally that CAP water should be allocated where need is demonstrated by use, i.e., in other regions of Arizona.

Tucson continued to demand the construction of a terminal storage facility as a fixed commitment of the CAP project. The purpose of terminal storage, to provide security in case of failures on the system, was more difficult to justify if municipal supply did not depend on direct delivery. Realistically, plans for a terminal storage lake would not materialize as long as Tucsonans refused to take direct delivery. The water establishment did not falter in its support of CAP, but as long as the State continued pushing direct use of renewable supplies, Tucson's water policy makers would be caught between institutional exigencies and public sentiment.

As the RRP process was underway, an attempt was made by supporters of a terminal storage lake to change some of the requirements of the WCPA. Tucson Water sedulously refused to comment of the initiative, but the Tucson Regional Water Council endorsed it with reservations as a step in the right direction (TRWC, 1998). The initiative failed, however, which was interpreted by WCPA proponents as overwhelming community antipathy to potable direct uses of CAP.

Significant anti-CAP sentiments distinguished Tucson from most of the rest of the state, where cost, not quality, was the primary impediment to its use. From the opening
of the canal, statewide demand for CAP water was lower than anticipated. While there were more than enough entities with long-term interest in control of a CAP water allocation, economical uses did not develop rapidly enough. The basic cost of a subcontract was much higher than estimates. Furthermore, infrastructure costs to take the water from the canal were prohibitive. In an effort to stimulate CAP water demand, the CAWCD attempted to develop price incentives for short-term use of water without creating disincentives for subcontractors. Although municipal supply is the long-term priority of the system, concerns about short-term under use have led to policies designed to keep agriculture as a participant (ADWR, 1998). The fairly complex price, eligibility, and priority rules for various categories of potential customers resulted. Incentive pricing had little effect on agricultural use of CAP water in the TAMA because groundwater pumping costs to farmers were still lower. On the other hand, the GSF program was embraced.

Public antipathy to subsidizing agricultural and mining water use may have been eroding, as the institutional situation became better understood. Because farms and mines could not, under current law, be forced to take CAP water, heavy subsidies might be the only way to “save” groundwater for potable consumers. Even heavily subsidized “recharge” in GSFs tended to be less expensive than storing in USFs, because USF storers must defray the project’s capital and operating costs in addition to purchasing the water (Makasson and Devine, 1998b).

STRUCTURE

The structure of a decision process influences its outcome because rules may favor some interests at the expense of others; they trigger one set of assumptions rather than others; and they make one set of problems and solutions easier to perceive than others.
Water policy decisions result from an interaction of particular people within a particular context according to a specific set of rules. The set of rules or structure of the interaction is partly provided by the historical process and partly invented or chosen by the participants. The concept is not new. Blomquist described the process of developing groundwater management institutions in southern California in essentially the same way (Blomquist, 1992).

The RRP can be thought of as a decision opportunity within a Garbage Can process of regional water policy; that is, there is evidence of temporal sorting in the timely meeting of problem, solution, and decision maker commitment within an appropriate access structure. Whether a decision would be made that resolved a problem depended on the number and timing of entry of problems and decision resources, and the access of decision makers, problems, and solutions to decision opportunities (Cohen, March and Olsen, 1979, 1997). Creation of the RRP forum occurred fortuitously at a time when interest in problem resolution was high and solutions were well-understood, yet only certain decision makers and solutions were available.

Although Tucson’s water policy environment may have fit the model of a Garbage Can process, the RRP itself was intentional problem solving. It was designed by its sponsors and developed by its participants through a series of choices that were in part reasoned and in part automatic. The rules specified the form the process would take, who should participate, and how decisions should be made. The goals of sponsors and participants in choosing these particular rules were to maximize chances for reaching agreement by employing a process likely to produce consistent participant preferences, and achieve public legitimacy by adhering to dominant social values.

The basic design of the RRP was modeled on stakeholder participation processes that had proved effective in the past in the water policy arena for developing legislation
and regulations. The advantages of this model are now assumed almost automatically, within that arena at least. According to this model, representative stakeholders would meet at intervals until a decision was reached. All identified stakeholders would be represented and representatives would be authorized to speak for the interests they represented. Meetings would be facilitated by a respected neutral party. Provision would be made to supply the information needed by the participants to make their decision, and the information would come from a neutral source. A final report would document and publish their decision. Designers of the RRP process added to the basic model a feature of decision engineering with a history of some success in resolving policy issues with technical, scientific components. They separated resolution of technical questions from the more overtly political issues.

Conditions for the RRP process differed in an important way from legislative and regulatory negotiations, because no enforcement actions were contemplated. Implementation of the plan would depend on the voluntary compliance of participants and others. To maintain commitment, the process had to be structured, like voluntary organizations, to gain compliance through intrinsic incentives.

As it developed, the structure of the RRP came to resemble a model of Group Decision Support Systems (GDSS) (Kleindorfer, Kunreuther, and Schoemaker, 1993). Although at the beginning it lacked a detailed map of decision tasks, it came to include the key features of (1) shared information, (2) a mechanism for analysis and display of results, (3) leader/facilitator, (4) a segmented process with outputs in one segment to serve as inputs to next, and (5) a record kept of proceedings.

The basic model was so well understood by the participants that very few of its structural rules were ever stated explicitly. The innovation of a separate technical committee, however, was featured in RRP documentation. Aspects of the structure
were important to the legitimacy of the process also were documented. These included promoting cooperation, efficiency, and equitable access in the development of recharge facilities (IPAG, 1996).

Formal Versus Informal Structure

Formal structure is the rules agreed upon or accepted explicitly (e.g., Robert's Rules of Order). They may include participation, voting rules, discussion rules (such as who may speak), notification, and record keeping. Informal rules are rules left unstated but followed nonetheless. These usually include meeting etiquette, status, and deference. Groups in which unity (or its appearance) is important will often leave decision rules unstated and rely on relationships of trust and social norms to guide behavior (Davis, 1973). The need for explicit rules may be interpreted as evidence of distrust, which elicits reciprocal suspicions, but norms may break down as the differential value of outcomes becomes more important to participants than group solidarity. When this happens, formal rules may be negotiated to regulate behavior. Thus an informal consensus voting rule may be replaced by a more formal demonstration of consensus or other voting rule.

Social norms are associated with roles, and the roles of participants stabilize interpersonal expectations of behavior. Different behaviors are expected of professional scientists, rational decision makers, and political operatives. An invitation to participate in the RRC and IPAG carried expectations of behavior that were enforced informally by other participants. Individuals were familiar with each other from similar settings. New members were indoctrinated with group norms. Yet open committee membership and the implicit nature of most rules created the possibility that a shift in the balance of
membership, e.g., different professional backgrounds, could alter the approach to decisions.

Forum

The RRP was structured as a series of monthly face-to-face meetings approximately two to three hours in length. The purpose of bringing people together for discussions was to share knowledge and information about preferences and intentions. Communication and coordination are enhanced by providing all participants with the same information.

Face-to-face meeting may not be advisable when animosity exists between the participants, "when there is reason to believe that some group members may be 'gaming' the facts or that social interaction may lead to polarization and conformity rather than learning and open discussion...." (Kleindorfer, Kunreuther, and Schoemaker, 1993:235). However, face-to-face interaction tends to build cooperation and a sense of common purpose. Through a process of social comparison, individuals accept group assigned identities or standards of behavior. Group identification can lead to a convergence of opinion. Groups of individuals with generally consistent opinions usually move any divergent opinions of individuals toward the majority. When the RRC included a single representative of anti-establishment opinion, the individual was more likely to alter his opinion than to change the opinions of the majority. Had he been supported by a consistent minority, anti-establishment opinions might have had more impact. On the other hand, the existence of a consistent minority also would likely have polarized the process.
Participation

The access of decision makers to decision opportunities may be managed by participation rules (March, 1994, 1997). In addition, interaction rules can make participation more or less attractive to potential participants. Changes in the environment may draw participants away or add them to the decision making process in the midst of deliberations. Participation rules can facilitate or impede these changes and render them more or less disruptive.

In the RRP, criteria for participation were distinct for the two committees. Technical expertise was required of RRC members. Affiliation with an organization or entity with demonstrated policy interest in recharge was required for IPAG. All RRC members were invited to IPAG meetings and received meeting summaries. A few individuals attended regularly throughout the process, i.e., were members of the RRC and continued participating by attending IPAG meetings. They combined technical and policy expertise, were the single designated recharge participant for their organizations, or were deeply committed to the process. For example, the U.S. Bureau of Reclamation and CAWCD did not have separate IPAG representation, but RRC representatives attended IPAG meetings. Their participation was offered mostly as sources of information rather than directors of opinion.

Meetings were open to the public. Public meeting notices were posted as required by law, but meetings were not publicized. Committee membership was by invitation, but no party requesting participation was denied an invitation. This policy permitted a fine distinction to be made between the demands of action (i.e., limited and homogeneous participation) and legitimacy (i.e., open and inclusive participation) (Brunsson, 1989). Meeting notices and agendas were mailed to everyone on the mailing list. This list
included non-members. Membership was somewhat fluid. Individuals who consistently attended meetings were added to the "official" membership list.

Not all participants were active. Some nominal committee members never attended meetings. Others attended occasionally. The amount of a member's participation at any particular meeting was not always related to how often that member attended meetings. Some attended regularly and said little, others attended intermittently and said much. The participation at any given meeting was significant. Strong statements with which everyone present seemed to concur influenced the direction of the project. ⁸

The core participants were self-selected. They tended to perceive a greater stake in the outcome and have a stronger idea of what the end product would look like than less active participants. The participants who had the most impact on the process attended most consistently. These individuals also had multiple links with ADWR and each other. They attended GUAC meetings and were on the informal list of stakeholder interest representatives consulted for advice on regulatory policy issues.

No individuals with avowed anti-establishment opinions were invited to join the IPAG and none attended IPAG meetings, although they were aware of the meetings. The reasons for their absence are unknown, as their interest in the process was never polled. In consequence of their absence, there was relatively little fundamental disagreement on the goals of the process and the interpretation of data.

⁸For example, a statement that focused the needs assessment on values determined that value identification was featured in the assessment, and the path of subsequent analysis was value oriented and employed methodologies for defining objectives in value terms. Value focused objectives then had to be assessed in terms of regional goals. An alternative strategy, to develop goal focused objectives and assess them is terms of values, was thus rejected automatically. (See page 67)
Facilitation

Meetings were chaired by the Director of the TAMA according to informal rules of order. Under normal circumstances, speakers were acknowledged by the Chair, although deviations from this rule were accepted within limits of polite conversation. Everyone present was entitled equally to speak, including observers. In general, observers did not participate actively in discussions. The Director of the TAMA (the Chair) functioned as leader and facilitator, making sure that everyone was given an opportunity to speak. She took an active role in keeping discussions on track and pressing for decisions. She frequently counteracted the tendency of large groups to avoid decisions that involve work or resolving conflict. She reminded participants of past agreements and the need to meet external deadlines, such as for AWBA recommendations.

Voting Rules

No formal votes were taken. Consensus was the basis of decisions and decisions were not made as long as an objection remained. Active agreement was not required, but acquiescence was necessary. Thus, in essence, everyone present had an equal vote that amounted to veto power. No attempt was made to obtain the vote (opinion) of absent participants, although some participants did convey informal proxies of absent others. Absentees were provided opportunities to dissent at subsequent meetings. Effort was made to maintain forward momentum, but no decision was considered irrevocable and any discussion could be revisited. Social rules were relied on to discourage backtracking previous committee work.

Process structure was dictated by demands of voluntary compliance. In the language of Brunsson's hypocrisy model (1989), RRP was not an action organization, although some participants represented action organizations (e.g., BKW Farms) or organizations
with action components (e.g., Town of Oro Valley). The RRP committees functioned as a *decision organization* that left implementation to separate *(decoupled) action* components. To the extent that participant organizations implemented recharge projects and cooperated on other projects in accord with the plan, decisions would be consistent with action. The RRP’s linkage to the TAMA and its GUAC coupled its decisions with theirs to encumber funds and let contracts for activities related to development of the RRP and information gathering in support of its implementation. The stated intention of the AWBA to be guided by the recommendations of the RRP linked the decisions of those organizations. Thus non-coercive incentives for compliance with the Plan were built into its structure.

Coercion was impossible and cooperation was needed for implementation. Voting rules did not allow for decision without consensus. No one was willing to lose, and no one was capable of enforcing decisions on losers. Voting could have destroyed the process by alienating important minorities (Davis, 1973). The observation that majority voting tends to produce polarization may have been intuited by participants. Although some participants were more creative of solutions and/or more persuasive by reason of eloquence or technical competence than others, no single individual or group was able to dominate the process within these rules. It appeared that the general predictions of Decision Schemes theorists held: that an equiprobability model would fit the RRP decisions, meaning anyone at a meeting was equally likely to introduce the decision concept that was approved by the Committee.

When opinions differed, the RRP tried to reduce diversity by “information search and communication” (March, 1994). Obscuring diversity with vague and over optimistic statements was not evident. Various other methods for resolving conflicting preferences were not available to the participants. Rules and structure did not permit aggregation of
preferences. Attempts to use aggregating techniques failed to find a group preference function and it was impossible to make interpersonal comparisons of utility.

The differences of opinion that were not eliminated by increasing shared knowledge were negotiated. For example, a draft rating of recharge projects was based on a “rational” calculus developed by staff on the guidance of the IPAG. Individual ratings were reviewed in detail several times. The strong need and desire of the participants for a rational plan made negotiations and bargaining covert, and based on interpretations and fine tuning of criteria. After the initial rating was proposed, the stakeholder in any project was responsible for obtaining agreement of the group on the highest possible ranking for its projects. Arguments for raising a rating had to be based on perceived inconsistencies in the application of criteria, on the inappropriate weighting of criteria, or similar rationally defensible positions and not on any bargained exchange or overt exercise of power. Any residual disagreement over the “final” rating was deferred to a future when a change in situation could lead to a change in rating (IPAG, 1997c).

No final meeting was held. The process was left deliberately open-ended in order that future changes could be accommodated in the plan. Late in 1998, Committee discussions addressed under what conditions new projects would be added to the plan, and these structural proposals presupposed the continued existence of the Committees.

Work

The RRP was structured as a series of face-to-face meetings held monthly or as needed. Need was determined by the participants. The decision of when and where next to meet was made at each meeting by consensus of those present. Agenda items for the next meeting were suggested by participants at meetings and agenda items where
scheduled by committee staff. The TAMA Director and staff, functioning in the role of
decision support consultant, often added items to the agenda. Arrangements for outside
speakers and presentations also were made by staff.

The principal tasks of committee meetings were to communicate new information
(updates) and discuss it until a shared understanding/interpretation was reached and/or
the need for additional information identified. Committees determined what information

gathering and processing tasks should be done in the interval between meetings and who
should do them. They also reviewed work products and agreed to modify and accept

them.

Like jury discussion, the RRP committees listened to reports and discussed what
they learned, comparing their individually constructed interpretations. Also like juries,
consensus sometimes was reached despite disagreement about the narrative, because they
could agree on the next appropriate action. The meeting goals were understanding and
agreement, not work. Work (data collection, data processing, and summarizing results)
was done between meetings by individual participants, subcommittees, and staff.

Large meetings do not process information well. Groups tend to rely more on
heuristics than individuals and may also simplify complex features of their environment.
Each individual tends to contribute less effort to a project as a member of a group than
alone, and this tendency increases with the size of the group. Large groups solve
problems more effectively when they select representatives to work out group problems
(Plous, 1993; Kleindorfer, Kunreuther, and Schoemaker, 1993). These generalizations
appeared to hold true in RRP committee meetings. The decisions of the full committees
generally followed discussion of processed information presented by others, including
subcommittee reports. Subcommittees tended to be composed of participants especially
competent to solve specific problems.
The different goals, roles, and professional norms of the two committees manifested themselves in their somewhat different work structures. The RRC as a whole developed the list of potential recharge projects and recharge project criteria by brainstorming. Most participants were familiar with previous recharge studies (e.g., CH2M-Hill-Tucson Water, 1989). They also had the list of potential projects proposed by WCPA proponents.

RRC participants themselves did most of the inter-meeting work, individually and in subcommittees. Winnowing the brainstormed list of projects was done by subcommittee. Subcommittees were formed to apply criteria to listed projects; “each subcommittee member evaluated the sites based on one or more evaluation criteria in accordance with the member’s particular expertise” (Eden and Jacobs, 1997:168). The most active members wrote study papers on issues identified by the Committee. A committee member particularly interested in an issue might suggest that it be included and then write the report.

The study reports were provided to all committee members, reviewed, discussed, and revised on the basis of consensus opinion. Only one report inspired a dissenting opinion, which was noted in the published final report. The dissent was presented in the form of a written report distributed to all RRC members. In discussion, objections to the dissent were enumerated and the group rejected its conclusions. In the final report, the main points of the dissent were described along with the majority’s response. Specific research was recommended to resolve residual uncertainty.

Much of the inter-meeting work fell to staff. For example, RRC staff devised and carried out a method for calculating comparable project costs to be used for economic

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9 The author of the report happened to be absent from the meeting at which it was scheduled to be discussed.
criteria. This allowed conceptual projects to be compared on economic criteria with projects already under construction. Staff expertise, full-time commitment, and neutrality/objectivity made information collection and processing more efficient and acceptable to most committee members.

IPAG subcommittees were rarely formed. When they met, they were formed on an ad hoc basis: named at a committee meeting for a specific short-term purpose to be accomplished before the next meeting. For example, a subcommittee was formed to simplify and prioritize project evaluation criteria when it became clear that the full committee was an ineffective forum for the task.

One working meeting of the IPAG was scheduled to group project criteria into logical categories and rank or prioritize them. Group discussion never reached the stage of identifying a suitable grouping or addressing the relative importance of specific criteria. Although individual participants made reasonable suggestions, the rules of interaction that emphasized equality and diffused responsibility made it effectively impossible to adopt any single suggestion or work out a combined solution. Instead the IPAG gave general guidance to a subcommittee or staff and critiqued results.

In addition to the work done by sub-committees and staff, participants worked on RRP tasks between meetings, supplying review comments, making recommendations, or similar tasks as agreed upon at meetings. All participants had an equal opportunity to contribute to inter-meeting work products and were encouraged during meetings and between meetings, by mail and telephone, to do so. Generally, however, a core of the most active members did most inter-meeting work.

The pivotal role of the TAMA Director and staff caused some confusion among some participants as to whether the RRP products were ADWR or separate. It was the position of the Director that all RRP products were not ADWR products, except that the
Department published and distributed reports. That is, although primarily written by ADWR staff, all was done by the direction of the Committees and represented their opinions, which were not necessarily those of the Department.

Staff activities appeared to be subjected to more scrutiny by the committees than subcommittee activities. This distinction may have been linked to suspicions about a covert ADWR agenda or may have been reactions to staff as individuals, because of their perceived personal agendas or levels of competence. The RRP participants would be responsible to their constituents, in the model proposed by Brunsson (1989), even though they did not participate directly in the many information processing decisions of inter-meeting work products. They may have felt uncomfortable about their lack of control over decisions for which they would be responsible or lack of knowledge about decisions they would need to justify. Alternatively, the committees selected their sub-committees but did not choose staff, which was supplied by the TAMA. With subcommittees, they may have delegated decisions to individuals who represented their values, so they could more easily trust that their values were incorporated into decisions (Goicoechea, et al., 1982).

The complexity of the RRP’s tasks, along with the time constraints of the process, led inevitably to decentralized decision making. Large amounts of data had to be processed and interpreted for the committees. The decisions inherent in data processing and interpretation could not be made by the full committee. Delegation to staff and subcommittees provided one method of decentralized decision making. A second method employed was to accept, largely without question, the individual decisions of participating entities on the specific projects they were sponsoring. Decisions relating to public acceptance were left to sponsors when that meant, for example, the acceptability of a project sponsored by the Town of Oro Valley to its citizens. Also left to sponsors
(and ADWR regulators) were determinations of economic feasibility, positive benefit-cost ratio, technical factors affecting site selection, and project design. For example, if a project’s sponsors stated that hydrogeologic data and project design indicated their project would recharge 10,000 acre-feet annually, that number normally would not be challenged.

Decision Process Design

The RRP attempted to combine goal-oriented decision making by experts and value-oriented decision stakeholders. Their efforts resulted in a hybrid process in which neither a goal-oriented decision rule nor a value-oriented preference rule could be fully specified. Thus, an irreducible component of the decision remained intuitive.

The RRP’s task flow was not fixed at the beginning, but evolved as experience was gained. Early (meta-structure) rule making involved only agreement on objectives, time commitment, and the participant expertise requirement. This arrangement was consistent with research suggesting that organizations employing complex technologies in environments with large uncertainties do well when they have an “organic” form, which grows out of the demands of the task rather than being dictated from above (Kleindorfer, Kunreuther, and Schoemaker, 1993).

The RRC developed an initial list of objectives. The RRC’s objectives referred specifically to work products, and were to (1) achieve an understanding of the physical and institutional setting for recharge, (2) develop siting criteria, (3) apply sitting criteria to potential recharge sites, and (4) prepare a report (Eden and Jacobs, 1997). These goal oriented objectives shaped the content of later discussions.

A complete schedule of subtasks was not created, however, so work progressed as the demands of the task became better understood. For example, participants attempted
to list siting criteria first, on what proved to be the mistaken assumption that objective
criteria existed. They found, instead, that agreement on criteria depended on agreement
on a uniform set of project objectives for recharge. Because the objectives of the
participants varied, they could not agree on a single set of criteria applicable in equal
proportion to all project sites. The activity required value judgments, which were beyond
the scope of the RRC. As it occurred, the RRC was incapable of reaching consensus on
criteria under their mandate; therefore task expectations had to be revised.10

Unlike the RRC, IPAG did not develop goal oriented objectives, but focused initially
on developing a list of principles that captured the values shared by the participants.
These included (1) open participation, (2) unity to solicit outside resources, (3)
cooperating for mutual benefits, (4) costs shared in proportion to benefits, and (5) an
open-ended plan. Consequently, their workflow was less goal directed than the RRC’s.

There was no shared image of what a final RRP would look like. Participants
adjusted their expectations as the demands of their decision making work became better
understood. Figure 4 represents the task flow of the RRP. It was created, for
communication to participants and others, midway through IPAG deliberations. By this
time, the image of a plan consisting of multiple dispersed projects designed to meet the
particular needs of subregions had emerged as a solution with possibility for agreement.

10In a well-known application of Social Judgment Theory to public policy, technical
expertise and value judgments were separated in order for the city council to choose a
type of bullet for the Denver Police Department. The decision process was similar to the
RRP in broad outline, with a key difference. The three decision criteria (stopping
effectiveness, severity of injury, and threat to bystanders) were determined before and
apart from either the scientific judgment or value judgment phases. These criteria were
deﬁned in detail, e.g., the standard target was deﬁned as the torso of a 20- to 40-year-old
man of average height (5’10”) and weight (175 lbs.). The scientists dealt with the task of
judging 80 bullets on these criteria; a panel of community representatives provided
relative weights for the criteria. Then the weights and bullet ratings were combined using
a simple linear equation (Hammond and Adelman, 1976).
While essentially accurate as a conceptual model, Figure 4 was not used to guide the process, nor does it reflect actual chronology. It reduced confusion by depicting progress as orderly, rational, and understandable at a time when the process appeared to be wandering. It was modified slightly and used subsequently to describe the process.

Record Keeping

After the first meetings of the RRC, minutes were taken by the committee staff. However, meetings were not recorded. Written summaries of the meetings were prepared by staff and mailed to all committee members prior to the next scheduled meeting. Minutes were not formally approved at each meeting during most of the process, but changes were noted and minutes revised if objections were raised. Late in the process, when final decisions on the Plan and recommendations were required, adoption of the Minutes was incorporated into the formal structure of meetings. The TAMA Director requested both incremental adjustments to the formality of record keeping, in her role as process facilitator. Early progress was impeded because without a record of past accomplishments, participants lost time retracing previous discussions. As the process reached its final decision stage, informal review of minutes was too weak a commitment to bind participants to agreements. Levels of formality in record keeping appeared to correspond to levels of individual defection or commitment to group decisions.

Minutes were not kept of subcommittee meetings. These tended to be more working meetings than discussion meetings. The lack of minutes meant that no record was kept of the bases upon which decisions were made except broadly defined. For example, an RRC subcommittee “conducted an initial screening to eliminate from further consideration those sites with factors that rendered them unfavorable for implementation within the next 5 years” (Eden and Jacobs, 1997). No record was kept of what these
factors were. The reports of subcommittees were not prone to defection by subcommittee members, and their results generally were not questioned by the whole committee. Documentation of subcommittee proceedings did not appear to be necessary and could have changed the conditions of their meetings from action orientation to rationalization and talk.

The first RRP draft was written by staff on the basis of documents generated during the two years the committees had been meeting. All the data collection and processing activities of subcommittees and staff resulted in some form of documentation to display results. Several of these were modified for incorporation in the Plan. The Plan also included a summary of some of the studies reported by the RRC and a description of the institutional setting for recharge. Participating entities contributed support in creating maps and supplied additional documentation on projects, including illustrations. An iterative revision phase was needed to make everyone comfortable with what would be published. Members were aware of the potential importance of the document for institutional support and public relations, and therefore were sensitive to the nuances of its language.

OUTPUTS

The RRP took place over a period of approximately three years from the time the GUAC approved the effort in August 1995 until the Plan was published in August of 1998. During that period, the participants produced a series of “outputs” that served as inputs to later stages in the process. These outputs consisted primarily of two published reports, but they also included other documents such as study papers, lists of objectives, selection criteria and projects, a needs assessment, maps, charts and tables of information. These documents presented the information participants considered relevant to their
decisions and their understanding of the meaning of the information in the decision context. The documents also provided a paper trail by recording decisions and, in many cases, the bases for the decisions.

Some of the process outputs were not captured in documents. Decisions were made throughout the process on matters great and small. Many of these flowed automatically from previous decisions about goals, concepts, and methods. These decisions were never discussed and can only be inferred. In addition, relationships were formed and changed. Better relations among recharge interests, and new associations and partnerships developed in conjunction with planning activities. Some new relationships had significant effects that were documented elsewhere (e.g., the CAP extension feasibility study and contract).

Objectives

The first process output was a list of overall objectives that established the goals of cooperative recharge planning. The goals, as listed in the RRC Report (1996), were

- Provide a forum for regional cooperation regarding recharge activities;
- Maximize the use of renewable water supplies in the Tucson AMA;
- Optimize the sharing of recharge, pumping, and transmission facilities;
- Expedite selection, testing and construction of groundwater recharge facilities;
- Provide a background document for the facilities plan required by the AWBA.

These objectives defined the scope of later activities. Agreement on the objectives demonstrated that participants shared an understanding of the direction recharge planning should take.
The first objective announced formation of an institution intended to change relationships through facilitated communication among recharge interests. A forum coordinates time and location for sharing information.

The maximization goal committed participants to the idea that more is better. It ruled out other ways of perceiving solutions to water supply and demand imbalance and identified recharge as a tool for increasing the use of renewable water. Citing the Tucson AMA limited the geographical extent of maximization efforts. Similarly, an expediting goal committed participants to the idea that faster is better. It implied that obstacles to speedy development of recharge projects should be removed. Ultimately, these two goals led to decisions that favored, at least in the short-term, projects that could be brought into operation quickly.

An optimizing goal allowed participants to balance competing objectives and did not commit them to the idea that more sharing of facilities is necessarily better. In practice, however, the objective was understood as a weaker way of saying maximize. It encouraged, but did not mandate sharing.

Formation of the AWBA was anticipated during the first year of the RRP. The opportunities the AWBA presented to local water interests could best be captured by early, concerted influence. The desire to make the most of this opportunity produced a sense of urgency that otherwise might not have existed. This objective acknowledged a specific time element to the RRP process that the Plan should be essentially completed before the AWBA’s facilities plan was due.

Special Issue Studies

Once consensus was reached on objectives, the RRP participants went on to improve their understanding of the recharge environment. By filling gaps in their own knowledge
and resolving publicly debated questions to their own satisfaction, they built a basis for future decisions. At the same time, they built a basis for convincing the public of the correctness of their judgments and the legitimacy of their decisions.

The water experts participating in the RRP were perturbed by what appeared to be basic misunderstandings implicit in the WCPA. Its proponents represented themselves as championing the public interest, and as such, set the terms of public discourse. Thus, the WCPA, as interpreted by its proponents, defined relevant issues for recharge. The special studies of issues related to recharge that the RRC produced provided an opportunity to place before the public the consensus opinion of experts refuting what were believed to be popular misconceptions.

RRP participants understood the position of WCPA proponents to represent several refutable assumptions. Principally,

1. Because of high infiltration rates in river beds, 60,000 to 70,000 acre-feet per year of CAP water could be recharged in the stream channels of the Central Wellfield area, even when areas that "contain or [are] adversely effected [sic] by toxic landfills" (WPCA, 1995) were avoided.

2. Stream channel and basin recharge are inexpensive, quick, and simple.

3. Stream channel and basin recharge are the best methods for relieving subsidence in the Central Wellfield.

4. Soil Aquifer Treatment will turn CAP water into water of a quality comparable to currently pumped ground water.

One of the first tasks the RRC set for themselves was to examine these assumptions. The participants produced a series of study papers based on existing research reports and other data. These papers were discussed at committee meetings and the consensus of the
committee was summarized in the RRC’s final report (RRC, 1996a). The studies examined each of the WPCA assumptions and a number of other participant concerns.

With respect to the amount of water that could be recharged in Central Wellfield stream channels, the RRC found that less than half of the 60,000 to 70,000 acre-feet per year required to replace groundwater pumpage could be recharged, if stream reaches near “toxic landfills” were avoided. The RRC found that proximity to toxic landfills might not be technically prohibitive, because design factors could minimize the risk of mobilizing contaminants; however, adding design features to deal with that risk would introduce additional costs. The prospect of additional costs induced the RRC to conclude that recharge projects should avoid areas of known contamination. Not all landfills are “toxic”, however; and it was a separate site investigation task to determine if a landfill represented a contamination risk.

The stream channel recharge estimate was disputed by a participant who argued that high infiltration rates observed after natural precipitation indicated that much more recharge was possible. The majority of the Committee maintained, however, that those infiltration rate observations would not be indicative of long-term recharge rates. Infiltration through the recent alluvium is more rapid than through the underlying Fort Lowell Formation. In consequence, mounds of recharged water would form at the interface between the formations. These groundwater mounds in the recent alluvium would result in rejected natural recharge. The Committee concluded that a project to recharge in the Central Wellfield stream reaches unaffected by landfills would have a capacity of only about 15,000 acre-feet per year. The RRC recommended a program of further study to determine more accurately the long-term recharge rate. In default of such a study, the RRC’s estimate was accepted by RRP participants and became the factual basis for subsequent discussions.
The RRC reported that costs for significant streambed or basin recharge in the Central Wellfield would be high under any water delivery scenario, although well within the range of normal recharge project costs. The committee wrote “Recharge is a complicated process that requires site-specific studies and pilot tests to assess effectiveness, cost and environmental impact” (RRC, 1996a:VIII-1). The RRC noted that cost components “often ignored” by the public included permitting and monitoring costs and conveyance costs for both recharge and recovery. In addition, time was usually underestimated, primarily because permitting and conflict introduce uncertainties: “unforeseen institutional, political, or regulatory constraints” (RRC, 1996a:III-8). They concluded that releasing water to river beds is inexpensive only if delivery infrastructure exists and there are no regulatory concerns.

The RRC also reported that rejected natural recharge would negate much of the value of CAP recharge in streambeds. Natural recharge in the beds of streams in the area of the Central Wellfield contributes a large proportion of the TAMA’s renewable water. The RRC became convinced that if a recharge project were operated in these stream channels to maximize CAP recharge, recharge from storm events would be forced to flow out of the area and possibly out of the AMA. Because the natural recharge is relatively pure water, such a project would be trading down in groundwater quality.

On the subject of subsidence, the RRC reported that although it was possible to mitigate subsidence through surface recharge methods, such methods introduced risks. Subsidence occurs when ground water is removed and the weight of the overlying material compresses the aquifer. The elevation of the land surface falls and the storage capacity of the aquifer is reduced. The additional pressure from the weight of recharge water over dewatered portions of the aquifer has the potential to increase compaction. To avoid this compaction, vertical permeability must allow recharge water to reach the
compacting interval in the desired time frame. Therefore, caution should be exercised in using surface recharge methods within an area where wells have created a cone of depression in the water table; areas like the Central Wellfield. The RRC concluded that well-injection recharge at the compacting interval of the aquifer is the surest method to combat subsidence. In addition, for the Central Wellfield, “well injection recharge...may be the most promising technique given the limited availability of suitable surface recharge sites and [recharge water] delivery systems to these sites” (ADWR, 1998).

On the subject of recharge as a demineralization treatment, the RRC was unanimous. Recharge will introduce salts into the aquifer. If and when the recharged water is recovered, the salts will be recovered with it. There is no recharge method that reduces TDS concentrations, except by dilution of high TDS source water with lower TDS ground water. The higher salinity of CAP water will affect the area regardless of how it is used. Use will affect only the distribution of salts.

The RRC participants identified a number of other issues they wanted to address with special studies. Some of these were part of the public discourse on water management, while others were the particular concern of individual participants. Flooding, for example, appeared to have been a concern for a segment of the water community. The section of the RRC Report on flooding hazards begins with the statement that “[s]everal applications for recharge in the Tucson area have been objected to on the basis that downstream flooding will result from the recharge project” (RRC, 1996a: V-7). The RRC was able to relieve most of these concerns. Generalizations from existing studies supported the idea that the flood effects of recharge projects would be minimal in storm events great enough to cause flooding. The main hazard would be from recharge-associated structures in the channel or floodplain. Both Pima County and
Marana require floodplain permits for any such construction in their jurisdictions, so the permitting process was assumed to handle any residual local flooding factors.

Several participants directed attention to infrastructure concerns, largely in relation to costs. Two rules of thumb received general agreement and were noted in the Report. Creating infrastructure for moving water was one of the largest costs of recharge. Thus use of existing infrastructure should be a major factor in siting projects. In addition, large operating cost savings were calculated for projects that made use of CAP system head to move water. Sharing the cost of construction and operation was important for projects where infrastructure did not already exit.

Environmental and recreational benefits had been associated with recharge projects in public discussions. Recharge, particularly stream bed recharge, was regarded as a way to provide water for environmental amenities, especially riparian habitat. Some enthusiasts thought that the tendency of artificial lakes to seep might be turned into a benefit as recharge. In this, recreationists and environmentalists were directly at odds with State water conservation law. The RRC Report was explicit about the problem. The design of recharge projects that will provide environmental and recreational benefits is substantially different from the design of recharge projects intended to maximize recharge. Inclusion of environmental and recreational benefits might broaden support for recharge facilities, but by State law all the water had to be accounted for. Thus, water allocated to vegetation had to be deducted from water counted as recharge. Recreational or ornamental lakes specifically could not be permitted as recharge projects. Recreational use and habitat enhancement required specific design features that had to be reckoned as costly, and the gain in public support for multiple purpose, multiple benefit projects should be weighed against the additional cost and diminished recharge benefit.
The RRC report pointed out, in addition, that the creation of habitat by recharge projects may restrict the recharger's future options. While the RRP process was under way, the Southwest Center for Biological Diversity filed lawsuits alleging that Hoover and Roosevelt Dams should be operated to protect the endangered willow flycatcher habitat along the margins of the reservoirs. Success of these suits could mean that, under the Endangered Species Act, creation of habitat for endangered species, whether intentional or unintentional, obligated rechargers to operate the project for habitat maintenance even after the project would have been closed and the water reallocated to other uses.

Another issue related to enforcement of the federal Endangered Species Act seemed to oppose the interests of environmentalists and rechargers. The CAP introduced the threat that non-native aquatic species could invade the habitat of endangered native species. The size and nature of this threat was disputed among the relevant agencies for several years. The unofficial opinion of the FWS was that escape of non-native aquatic species to the Santa Cruz River sub-basin was probable. The Biological Assessment produced by the Bureau of Reclamation, however, "concluded the operation of CAP would have no effect of endangered aquatic species" (RRC, 1996a: V-24). The FWS Biological Opinion previously issued on the Gila River sub-basin, which required various mitigation measures such as fish barriers, was to have been used as a model for the Santa Cruz. However, the CAWCD objected to that opinion and refused to pay for construction of mitigation features. The matter was in litigation. Meanwhile, there was uncertainty about whether in-channel and floodplain recharge projects using raw CAP water in the TAMA would be required to include mitigation features. This question remained unresolved.
Recharge Project Site Lists

The RRC participants "brainstormed" a long list of possible projects. Brainstorming "enables individuals in a group setting to suggest alternatives for consideration by others without being criticized as to their feasibility" (Kleindorfer, Kunreuther, and Schoemaker, 1993:59). Prescriptive models of alternative generation frequently include brainstorming as a method for stimulating creativity and expanding the set of alternatives. It is intended to counteract natural human tendencies to limit and simplify their options.

The brainstormed list included project sites investigated by the participants, suggested by WCPA proponents, and other likely candidate sites, like quarries, known to participants. A total of 116 sites were listed. Through a series of screening decisions, the original list was reduced first to 34 and then to 16 sites. Specific criteria were not stated in the report for choosing among the initial list of 116 projects the 34 to be evaluated, and from among these, the 16 to get complete descriptions.

It is worth noting that the list was not generated by searching the TAMA for sites that met explicit siting criteria. As a practical matter, it would have been infeasible to evaluate the entire AMA for recharge potential. Participants had a fairly good general sense of where recharge was desirable and feasible, and consulted earlier studies. At least some of the choice must be attributed to individual advocacy. For example, a large project to be sited on the west side of the CAP canal at Tangerine Road was purportedly included because of the enthusiastic endorsement of a single participant. Project sponsors had their own criteria of site selection, and presumably, had no incentive to choose patently inferior sites. It would not have "expedited" recharge to recommend that sponsors abandon existing plans (e.g., for sites with higher transmissivities).

The only screening criterion reported by the RRC was the likelihood that a project could be developed within three to five years (RRC, 1996a). It is conceivable that time
estimates were generated for all 34 long-list projects and these estimates were used to screen projects, but no paper trail exists in the ADWR, where most committee records were kept. Sites whose sponsors projected operation within three to five years were assumed to be implementable within the time frame, even when the project was ambitious and costly and implementation was likely to be complicated.

Recharge Project Siting Criteria

The RRC's next task was to develop siting criteria. Criteria, by definition, should provide tests for distinguishing between desirable and undesirable. Strictly speaking, the RRC did not produce criteria, but instead listed factors that should be considered when evaluating sites. The distinction is important, because the criteria they listed left IPAG with the problem of how to evaluate the technical merit of listed projects. The IPAG was not capable or desirous of resolving that problem, so very little of the information generated by the RRC on project evaluations was referred to explicitly in the IPAG's final project ratings.

In their working documents, the RRC listed several criteria that reflected the original objectives of the RRP. These original criteria were (1) long-term storage rate, (2) storage capacity, (3) need for additional conveyance systems, (4) annual cost for recharge, (5) annual cost for recovery, (6) annual cost for treatment, (7) regulatory considerations, (8) impact on groundwater quality, (9) impact on groundwater level decline, (10) extent of regional benefit, (11) potential for recreational use, and (12) time required to implement (RRC, 1995-96). This list was not communicated to the IPAG nor does it appear in the RRC's Report. Instead, what was published as recharge siting criteria consisted of descriptive characteristics listed within three categories: technical criteria, economic factors, and extent of regional benefits. Although the criteria did not distinguish
technical merit, they organized the available data, selected among the infinite possibilities those data that were relevant to the decision, and displayed them for the IPAG. Their value existed less in providing guidance for project selection than in informing and guiding decision makers to a common understanding of the technical aspects of their problem.

Each of the 16 projects selected for in-depth study was described in terms of these criteria. A sample Recharge Facility Description and Basic Assumptions is appended (Appendix B.). Although the RRC intended to provide comparable information on all the projects it described, large incomparables remained in the amount of data available for each project and the different interpretations of individual RRC evaluators.

The 16 sites that received full descriptions by the RRC shared a number of characteristics. First, they all used straight-forward surface recharge methods, either basin or in-channel. Five GSFs were included, but no well-injection, vadose zone, or induced recharge projects were listed. In fact, of the longer list of 34 projects receiving cursory evaluations, only one well-injection and three deep basin or pit sites diverged from the basic types. Justification for dropping all the pit projects was not included in the report. (This is not to say that the eliminations were not rational or justified.) Well-injection of treated CAP water was prohibited in Tucson for five years by the WCPA. The only existing well-injection projects in the AMA were in Tucson. No similar projects were planned outside the City limits.

Second, all projects would recharge CAP water. Effluent and storm water projects were not included. (One project had an effluent alternative, but was estimated as a CAP project.) Normatively, effluent would be integrated into a coherent conjunctive use
system. It was left out of consideration for several reasons:

(1) Another forum was dealing with effluent issues; as solutions were found in that forum, projects could be added to the Plan.

(2) The short-term availability of surplus Colorado River water diminished the immediate importance of effluent as a renewable water source.

(3) Effluent regulations were sufficiently different from CAP regulations that inclusion would have added a layer of additional complication to the process.

(4) Effluent problems were unlikely to be solved within the AWBA time frame and did not concern the AWBA. Entrenched animosities were part of this problem. Advocates for a “rational” policy of conjunctive uses of CAP, effluent, poor quality ground water, etc. were participants with long-term perspectives and lacked urgency in recharge development. Their political agendas were not damaged by temporizing and obstruction.

Third, all existing CAP surface recharge projects, including GSFs, were included. Projects only in the planning stage were listed if they had committed sponsorship. To this core were added conceptual projects with particularly strong water management features. For example, a conceptual project to recharge 15,000 acre-feet of CAP water into stream channel reaches in the Central Wellfield was listed. The in-channel project for the Central Wellfield was conceptualized and maintained throughout the process on the strength of public interest, as indicated by the WCPA. Two Tohono O’odham (San Xavier District) projects also were listed.

Several of the more speculative projects listed by the RRC were at the southern end of the TAMA. Two GSFs were listed, one for the pecan orchard owned by FICO and the other for the ASARACO copper mine. Both entities had representatives in the RRP and neither objected to the inclusion of these projects, even though they were not active
sponsors. They were willing to consider participating in these projects should other entities contribute to solving conveyance, reliability, and water quality problems. An association was formed to investigate the feasibility of extending the CAP so that these or other entities in the area could take raw CAP water.

Recommendations for Further Study

Finally, the RRC made a number of recommendations for further study. Further study of the fate of disinfection by-product precursors in spreading and vadose zone recharge was suggested, as RRC was not convinced that low weight fulvic compounds would be removed. With respect to in-channel recharge in the Central Wellfield, the RRC suggested research on long-term rates and stream channel underflow (related to rejected recharge). Studies to learn more about the location and extent of contamination, the threat posed by landfills, and their relation to recharge were recommended. Most of these unanswered questions were included in subsequent research.

Transfer of Responsibility

All of the major ingredients of the final Plan were evident in the RRC’s Report. The discussions and decisions that took place in the next two years essentially ratified the work of the technical committee’s project selection. The IPAG produced consensus among the entities, developed and elaborated a rationale for the projects, advanced relationships among the interests to facilitate project construction and use, and created a common narrative for recharge. The Plan’s conclusions and recommendations emerged from this common narrative as explicitly legitimized forms of ideas underlying the
original program. This gives the outcome an appearance of inevitability not experienced by the participants during the process.\footnote{Michelangelo is purported to have said that creating a sculpture was releasing the figure already in the marble. After a decision policy is made, if it was well rationalized, it will often seem to have released the policy hidden in the data. This is not the impression of the process as it unfolds.}

When the meetings of the RRC ceased and the IPAG began to function, the public relations aspects of the process were emphasized. Products immediately requested by the IPAG were an executive summary of the RRC Report and a one-page statement of objectives and principles. These were used to inform public officials of the expert’s conclusions and recommendations and to elicit political support for the process. The executive summary (RRC, 1996b) highlighted the conclusions of the various issue studies, restating them in simple, forceful language. The objectives and principles page emphasized voluntary cooperation, open participation, and equitable distribution of costs and benefits (IPAG, 1996). Both were used in visits with city, county, and tribal officials. Individual committee members were responsible for distributing copies and using them to advocate for the process.

Needs Assessment

The IPAG’s second order of business was to develop a common understanding of the preferences and intentions of potential recharge participants. The IPAG commissioned a needs assessment as the way to such an understanding. Staff prepared a questionnaire and personally interviewed representatives of organizations with potential interests in Tucson area recharge. Figure 5 contains the list of contacts generated by the
Figure 5. ENTITIES CONTACTED FOR NEEDS ASSESSMENT from Institutional and Policy Advisory Group, Regional Recharge Plan (1998) p. VIII-1.
IPAG at a meeting. Many of those interviewed were either members of IPAG or their colleagues in represented organizations. Interviews were conducted over three months. The interview format was open-ended to allow respondents to express opinions on as wide a range of topics as they wanted. Prompts suggested topics that were assumed to be of general concern. (Interview questions appended, Appendix C.)

Survey results were processed in two ways. The first method produced an unattributed summary of the issues and concerns raised by respondents (IPAG, 1997a). The issue opinion summaries were intended to display the range of values associated with recharge in the minds of participants. The summary was reviewed by all respondents and IPAG members, who recognized that their own statements of opinion had been fairly represented and believed they recognized the opinions of others. They requested changes to statements that misrepresented their opinions. A revised and approved copy was distributed to all RRP members. Thus, the needs assessment provided participants a way to understand each other without having to confront each other. Like the technical issues addressed by the RRC studies, the policy issues were potential obstacles to agreement. Unlike the technical issues, however, most of the policy issues did not require resolution within the RRP. Agreeing on a fair description of the issues allowed the IPAG to move forward, just as juries can disagree on their reconstruction of events but can still reach decisions on the basis of the law. The contents of this opinion summary were used as reference for parts of the IPAG report (the Plan) in sections describing the regulatory setting and potential participants (and as a reference for the People and Environment sections of this chapter).

The second product derived from the interviews was an attributed list of goals for participation in recharge. After reviews and revisions, it consisted of 17 separate goals, some with two or more sub-goals. The level of interest of each respondent on each
objective (strong, moderate, weak, or none) was displayed in a matrix, approved by all the respondents (Appendix D).

Staff grouped related goals and sub-goals to produce a smaller number of categories, then calculated interest in the groups using a point system, where strong=3, moderate=2, and weak=1 point, to sum responses. From this calculation, a shortened list of objectives and indication of their relative importance was derived.

Simple calculations like this have obvious biases. First, sums reflect the original distribution of respondents. Because committees prefer to use the equal vote rule and prefer not to make explicit interpersonal comparisons of utility, any discounting or weighting of responses had to be justified. Yet, there was no apparent justification for any particular weighting scheme. Equal weight, the default position, was not necessarily fair. Was it appropriate, for example, to give two equal votes to two departments of Pima County government (Parks and Recreation and Wastewater), which had little or no direct involvement in recharge projects, with Pima County Flood Control District, which had committed staff time and other resources to several projects? Was it appropriate to give an individual farm the same weight as a major public water supplier? Second, the sums were sensitive to the grouping of objectives and sub-objectives. Goal definitions were not self-evident. The specific goals of regional recharge participants could be defined in many different ways. Fine grained statements that contained individual nuances of meaning had to be combined into broader statements, and it was not always clear what broader categories were appropriate. The participants chose their goals from an extensive wish list, while RRP goals had to focus on those decisions within the scope of their responsibility. Yet the limits of their responsibility were not strictly defined. Thus, the transformations could not be mechanical.
The justification arrived at by staff and accepted by IPAG involved separating sub-regional goals from regional goals. It was assumed, based on existing conditions, that sub-regional entities and organizations were on track to achieve sub-regional and individual goals. Therefore, the preferences of participants whose responses indicated a regional focus could be given more weight (IPAG, 1997b).

When the consolidated list of recharge objectives was presented to IPAG along with its rationale, the committee members raised no objections to this process. They did, however, revise wording and reorder objectives. This process brought the list of objectives to ten, listed in order of importance (Figure 6).

Refining Objectives and Criteria

Between the Needs Assessment reports and the distribution of the first draft Plan, a series of working papers documented efforts to maintain a legitimate, rational process for selecting recharge projects. Recharge objectives were refined and selection criteria derived from them. Project information from the RRC Report's evaluations was applied to selection criteria in an attempt to rate each project on each criterion. Problems encountered in this exercise led to adjustments to the definitions of objectives and measures used for selection criteria.

A list of criteria was arrived at by asserting connections between the list of ten objectives and the categories and components of descriptive data provided by the RRC. The intention was to retain as much information as possible about goals, participant preferences, site conditions, project design, and project status, from previous process outputs. The list of objectives derived from the needs assessment pictured an ideal future state. Water management goals were emphasized. They did not account for the urgency felt by many RRP participants. As the process developed, participants perceived a
<table>
<thead>
<tr>
<th>Rank</th>
<th>Objective</th>
</tr>
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</table>
| 1    | Stored water available for future use  
|      | - at the desired location  
|      | - in the needed quantity  
|      | - at the needed time                                                                 |
| 2    | Most economical way to meet objectives  
|      | - at least cost  
|      | - at cost consistent with benefits                                                                |
| 3    | Storage credit to meet entity-specific needs  
|      | - with certainty  
|      | - with equal access to all entities willing to pay reasonable costs                                |
| 4    | Water quality protection  
|      | - from mobilization of contaminants                                                                |
|      | - from degradation due to long-term recharge of lower-quality water                               |
|      | - by phase-in of water chemistry changes in water delivered to consumers                           |
| 5    | Riparian and/or nature-based recreational amenities.  
|      | - along natural stream channels                                                                     |
|      | - as part of planned system of parks and/or trails                                                 |
| 6    | Groundwater level stabilization/restoration and subsidence prevention/mitigation.                  |
| 7    | Local influence on decisions that affect  
|      | - land use and development  
|      | - recovery of storage credits                                                                      |
| 8    | Increased use of CAP water within the Tucson AMA                                                    |
| 9    | Reduced groundwater mining                                                                         |
| 10   | Increased use of effluent                                                                           |

Figure 6. SURVEY RESULTS SUMMARY - PRIMARY OBJECTIVES OF INTERESTED PARTIES from Institutional and Policy Advisory Group, Regional Recharge Plan (1998) p. VIII-3.
tension between regional water management benefits and maximizing near-term CAP use. The criteria had to be revised to reflect an intention to balance these objectives. Thus, the list of criteria finally approved by the IPAG differentiated short-term from long-term goals (Figure 7).

This list of criteria was combined with project information from the RRC Report to create project assessments, similar in appearance to the project descriptions in the earlier report (Sample, Figure 8). These proved too cumbersome, still, to be used directly for project selection. An exercise in which committee members used the assessments to score projects resulted in very different scores, because individuals interpreted the available evidence differently.

The IPAG and staff went through several stages of semi-quantitative analysis, partly rationalized, to go from the table of objectives to project site selection. Decision literature describes several possible methods of moving from objectives to choice. Most, however, required fairly complicated calculations when the number of objectives is large. Decision literature also proposes that one factor in the effectiveness of any decision aiding strategy is its understandability to decision makers (Kleindorfer, Kunreuther, and Schoemaker, 1993). The committee agreed that the methods tried by staff were too complicated and too numerically dependent. In addition, deficiencies in the project descriptions and unresolved differences in the preferences of IPAG members impeded progress.

IPAG was reluctant to endorse a highly numeric method. Their reluctance encompassed the expenditure of time and effort to analyze the method for bias, to understand the results, and to commit to them. In addition, the IPAG preferred not to
Hydrologic Feasibility. The project site and design meet the technical criteria as described in the RRC Report.

Regulatory Compliance. The project has obtained or is likely to qualify for all applicable permits and can comply with all applicable laws and regulations including the Endangered Species Act.

Contaminant Isolation. The project will not mobilize contaminants or exacerbate groundwater contamination.

Acceptability. The project has been approved or is likely to be approved by the governing bodies with jurisdiction over land in the project’s area of impact. Local organizations and enterprises are unlikely to object to the project or the project is likely to mitigate local objections.

Speed. The project can be brought into operation within the next three years. (Short-term)

Water Storage Capacity. The project stores a large quantity of water relative to the short-term storage goal; the storage capacity exceeds the minimum, short-term requirements of its sponsors. (Short-term)

Low Cost. The project provides the most economical means to meet its sponsor(s)'s objectives. (Short-term)

Water Supply. The project stores water in the vicinity of future wellfields; the project stores a large quantity of water relative to the long-term storage goal; the project storage capacity exceeds the minimum, long-term requirements of its sponsors. (Long-term)

Storage Credits. The project generates storage credits that can be transferred, recovered or extinguished by the credit owner. Water stored at the project has a high probability of generating credits. (Long-term)

Environmental Enhancement. The project stores water in the vicinity of a riparian/environmental amenity so as to enhance the amenity; the project is designed for riparian/environmental enhancement; the project is accessible to the general public for recreation. (Long-term)

Water Quality Management. The project design provides mitigation/containment of plumes, per a specific remediation plan. The project minimizes any long-term negative water quality impacts of recharge on the aquifer and water customers. (Long-term)

Reduced Overdraft/Cones of Depression and Subsidence Prevention/Mitigation. The project stores water in the vicinity of overdraft and subsidence; the project is designed to mitigate subsidence effects. (Long-term)

Multiple Parties/Multiple Benefits. The project has the support of multiple cooperating sponsors; the project provides multiple benefits to identifiable beneficiaries. (Long-term)

Benefit/Cost. The project costs are appropriate relative to the benefits it provides, including intangible benefits. (Long-term)
Example of Recharge Project Evaluation
based on regional recharge project evaluation criteria

BRAWLEY WASH AT THREE POINTS
Off-Channel Recharge Basins
(RRC Site No. 11)

Hydrologic feasibility: Infiltration rate 3 ft/day; very favorable infiltration media; fine-grained layers in vadose zone can cause lateral movement. Water will be stored primarily in regional aquifer surrounding and down gradient from the recharge facility; depth to GW 150 ft at site, increasing rapidly to north.

Regulatory compliance: No special problems foreseen; may need flood protection.

CAP use: Yes.

Multiple parties: Unknown at this time; land and nearest existing well-field owned by Tucson.

Acceptable to governing jurisdictions: no problems identified based on incompatible land use plans or local opposition.

Credit security: No risks identified

Contaminant isolation: No problem with migration of contaminant plumes, no known landfills. Previously farmed but agricultural chemical residues not detected in pilot project

Low cost: Recharge unit costs of $58.55/AF are higher than projects closer to CAP canal. Recovery costs not estimated.

Speed: Not expected to be developed within the next 3 years.

Recoverability: Yes.

Figure 8. EXAMPLE OF RECHARGE PROJECT EVALUATION BASED ON REGIONAL RECHARGE PROJECT EVALUATION CRITERIA from Eden and Jacobs (1997) Regional Recharge Planning in the Active Management Area, slide presentation graphics.
**Water supply:** Estimated annual recharge volume 40,000 AF/yr; down gradient recovery in existing Avra Valley wellfield assumed, but existing City-owned wells are limited.

**Reduced overdraft/cones of depression:** Negligible historical groundwater level declines, but declines down gradient as much as 50 feet since 1980.

**Water quality management:** Not applicable. (Ambient water quality TDS=330 mg/L and N=3.8 to 8.0 mg/L; project likely to increase concentrations of TDS and decrease concentrations of nitrate.)

**Subsidence prevention/mitigation:** Not applicable

**Environmental enhancement:** Not planned under current proposal.

Multiple benefits: Unknown; potential water bank storage, potential storage for long-term storage and annual storage and recovery for credits with recovery at distant location.

**Benefit/Cost:** Undetermined.

**Equity:** Potential participants/customers unknown.

**Effluent use:** No.

(**Drinking water:** ADEQ has indicated that no treatment will be required for drinking water used by municipal providers if the water is recovered beyond a 500-ft radius from the recharge facility, but treatment may be provided on the users’ option, i.e., to decrease salinity or hardness.)

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Figure 8 continued. EXAMPLE OF RECHARGE PROJECT EVALUATION BASED ON REGIONAL RECHARGE PROJECT EVALUATION CRITERIA.
rank projects numerically. One reason for this preference was the belief that the precision implied by a numerical ranking could not be justified. Numerical ranks would imply greater certainty than the available information warranted. Different projects also were valuable for different reasons and numerical ranks would obscure that fact.

Members of IPAG wanted to develop a simpler, more qualitative set of project evaluation criteria among themselves rather than rely on staff. A meeting was scheduled for this task, but the discussion produced agreement only on general guidelines for grouping criteria. The IPAG also acknowledged a need to decide which criteria should be given more weight, but they could not agree on any weighting system. So, they appointed a subcommittee to resolve the issues.

In preparation for the subcommittee meeting, staff followed the IPAG’s general guidelines to develop a system and carry out a tentative assessment of projects. In addition, staff prepared maps and graphs to indicate the relation of project sites to groundwater level changes and subsidence risk. Figures 9 and 10 are publication quality copies of the hand drawn maps used to assign points for ground water level effects and subsidence risk mitigation. Graphs displayed historical water level data from wells near specific projects. The nearby wells were used as proxies to show the behavior of the ground water level at particular sites, the assumption being that this gave a more detailed picture than the water level maps. These maps and graphs permitted the IPAG to see the relationship between projects individually and regional ground water concerns.

Participants understood, in general, that recharge near the CAP canal would be faster and cheaper than elsewhere in the TAMA, and they understood that recharge would meet other important water management objectives at other locations. The maps and graphs allowed them to refine their understanding and thus made agreement on the ranking of individual projects easier. The graphs were not reproduced for the plan.
Figure 9. LAND SUBSIDENCE POTENTIAL RELATIVE TO RECHARGE SITES from Institutional and Policy Advisory Group, Regional Recharge Plan (1998) p. IX-6.
Figure 10. 1940 TO 1995 WATER LEVEL CHANGES RELATIVE TO RECHARGE SITES from Institutional and Policy Advisory Group, Regional Recharge Plan (1998) IX-7.
The subcommittee reviewed staff prepared materials in depth and suggested revisions to the assessment strategy, but did not attempt to make a decision on the tentative project assessments. At the following IPAG meeting, the strategy was approved. The actual evaluations were discussed, but agreement on specifics was deferred until everyone had had a chance to review the results in detail. The assessment groups and components are reproduced from the Plan (Figure 11).

There were four feasibility, four water management and related benefits levels, and three capacity levels, giving capacity slightly less weight than the other two equally weighted categories. Although the feasibility category, in theory, had several components; in practice, the distinguishing criterion was how close the project was to full-scale operation. This single measure captured satisfactorily the factors that were most problematic for the participants, and conveniently resolved the problems left by the Committee's inability and unwillingness to second-guess sponsors and regulators on these matters. Capacity and Water Management categorization represented actual, if somewhat impressionistic, assessment group scores on their equally weighted components.

Recharge Project Ratings

The resulting ratings were displayed for the IPAG in several ways. The Committee approved Figure 12 as the display that suited their purposes best. The categorization of individual projects and their relative ranks were reviewed and debated, so that the figure published in the Plan reflected the original scoring done by staff, revisions based on information obtained subsequently, and the judgments and interpretations of the full committee. In other words, "errors" and "inconsistencies" were corrected to the satisfaction of participants (IPAG, 1997c).
### FEASIBILITY

**Operational and regulatory risk**
- Status of project
- Conditions imposed by applicable regulations and policies

**Acceptability**
- Equal access
- Sponsorship potential
- Community support

**Contaminant isolation**

**Hydrologic feasibility**
- Storage potential (Depth to water & groundwater flow)
- Soil, subsoil, & aquifer characteristics

**Cost**
- Dollars per acre-foot of water recharged ($/AF)

### CAPACITY

- Total planned capacity
- Phase-in of capacity
- Capacity in excess of amount likely to be committed to identified sponsors

### WATER MANAGEMENT AND RELATED BENEFITS

**Groundwater level (GWL) change & cone of depression**
- Historical GWL decline
- Recent GWL change
- Potential future GWL declines

**Subsidence**
- Calculated subsidence potential
- Potential impact on infrastructure

**Recreational access**

**Special needs of location (e.g., trees on Tanque Verde)**

**Riparian habitat**

**Multiple purposes/multiple beneficiaries**

**Shared facilities**

**Water quality benefits**

**Long-term water balance**

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Figure 11. PROJECT ASSESSMENT GROUPS AND COMPONENTS from Institutional and Policy Advisory Group, Regional Recharge Plan (1998) p. IX-3.
Lower Santa Cruz RP
Cañada del Oro RP
Avra Valley RP
Pima Mine Rd
CAVSARP
South Avra Valley RP
SXD Arroyos
Santa Cruz River at SXD
Rillito In-Channel
Brawley Wash
Cortaro Marana ID
BKW Farms
Avra Valley ID
FICO-Sahuarita
ASARCO
Kai Farms at Picachio
Pascua Yaqui

One result of separating technical committee tasks from policy committee tasks was that the IPAG was reluctant to add to (or subtract from) the list of projects they received from the RRC. When the IPAG began its phase, the RRC ceased meeting as a group. IPAG members could not easily acquire comparable descriptive information on other projects, and they were unwilling to second guess the RRC except when indisputably new information became available. The IPAG only added two projects and deleted one from the short list, so that 17 projects received full evaluations for the Plan. A project was dropped when no potential sponsor would advocate for it and enough technical demerits were enumerated in general discussion to justify dropping it. (RRC members were present at this discussion.) One GSF was added because it began operating. A project proposed by the Pasqua Yacquis was added to the short list without RRC review because (1) documents reporting an engineering plan and favorable site evaluation were provided to the RRP, and (2) the project was proposed by a representative of the Tribe who was also an IPAG member, and it was assumed that the Pasqua Yacquis had or could obtain the resources needed to construct the project.

The one other site seriously proposed to the IPAG exposed their reluctance to change the list without technical guidance from the RRC. The site was proposed by a private citizen who lobbied the IPAG and individual agencies for it. Despite the fact that it lacked a sponsoring organization, the IPAG was reluctant to rule on its suitability. They decided not to add the site to the list of 17 projects only after a member of the RRC reviewed available data and reported his somewhat negative judgment of it. It was added to a longer list of potential projects (IPAG, 1997c).
Demand Scenarios and Recharge Capacity Projections

The Plan required more than a list of projects. It had to match the need for recharge with the amount of recharge the listed projects would provide. Staff prepared a recharge demand scenario analysis to communicate the range of potential need for recharge. The committees’ discussions and reports had canvassed the sources of uncertainty about future demand for recharge. These were converted into scenario assumptions. Information available from ADWR and other participating agencies was plugged into simple formulas based on these assumptions. These formulas were explained in the Plan to make scenarios predictions transparent. The factors that made the most significant difference among the high, medium, and low level demand scenarios were, first, how much of its CAP water the City of Tucson chose to recharge, and second, the decisions of other AWS regulated municipal providers on how to use their groundwater allowances (Table 4).

The total recharge project capacity predictions for listed projects were more “seat of the pants.” They were based on the intentions of project sponsors modified by the judgments of the sub-committee and subsequent full committee review (Table 5). These predictions were not explained in the Plan. The large increase in capacity between the year 2000 and year 2007 projects reflects the expressed intentions of the sponsors.

Regional Recharge Plan Conclusions

A comparison of predicted demand and capacity shows that the planned capacity would more than meet the projected demand except in the near-term (2000), high demand scenario. However, the explanatory material in the Plan’s Conclusions contained caveats. The first was that several of the projects were still in the conceptual stage. It was possible that any or all of them would not be completed. These included projects on

<table>
<thead>
<tr>
<th>Scenario 1: Low Demand</th>
<th>2000</th>
<th>2007</th>
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</thead>
<tbody>
<tr>
<td>Tucson Water</td>
<td>35,300</td>
<td>25,000</td>
</tr>
<tr>
<td>Other Municipal</td>
<td>1,400</td>
<td>7,800</td>
</tr>
<tr>
<td>Long-Term Storage Credits</td>
<td>10,400</td>
<td>11,500</td>
</tr>
<tr>
<td>AWBA</td>
<td>30,000</td>
<td>30,000</td>
</tr>
<tr>
<td>Total</td>
<td>77,100</td>
<td>74,300</td>
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<th>Scenario 2: Medium Demand</th>
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<tr>
<td>Tucson Water</td>
<td>62,900</td>
<td>69,000</td>
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<tr>
<td>Other Municipal</td>
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</tr>
<tr>
<td>Long-Term Storage Credits</td>
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<td>18,900</td>
</tr>
<tr>
<td>AWBA</td>
<td>35,000</td>
<td>35,000</td>
</tr>
<tr>
<td>Total</td>
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<th>Scenario 3: High Demand</th>
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<td>Tucson Water</td>
<td>82,500</td>
<td>90,600</td>
</tr>
<tr>
<td>Other Municipal</td>
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<td>15,400</td>
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<tr>
<td>Long-Term Storage Credits</td>
<td>22,900</td>
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<tr>
<td>AWBA</td>
<td>42,000</td>
<td>42,000</td>
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<td>Total</td>
<td>158,000</td>
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<tbody>
<tr>
<td>BKW Farms (RRC #13)</td>
<td>16,000</td>
<td>16,000</td>
</tr>
<tr>
<td>Cortaro-Marana Irrigation District (RRC #12)</td>
<td>20,000</td>
<td>20,000</td>
</tr>
<tr>
<td>Kai @ Picacho (RRC #17)</td>
<td>11,000</td>
<td>11,000</td>
</tr>
<tr>
<td>BKW @ Mile Wide Road ****</td>
<td>600</td>
<td>600</td>
</tr>
<tr>
<td>Avra Valley Irrigation District (RRC #14)</td>
<td>12,500</td>
<td>12,500</td>
</tr>
<tr>
<td>Farmers Investment Company (FICO) (RRC #15)</td>
<td>20,000</td>
<td>20,000</td>
</tr>
<tr>
<td>ASARCO (RRC #16)</td>
<td>0</td>
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<td>TOTAL GSF</td>
<td>80,100</td>
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<tr>
<th>Underground Storage Facilities</th>
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<th>2007</th>
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<tbody>
<tr>
<td>Avra Valley (basins) (RRC #3)</td>
<td>11,000</td>
<td>11,000</td>
</tr>
<tr>
<td>Lower Santa Cruz (basins) ** (RRC #1)</td>
<td>13,000</td>
<td>30,000</td>
</tr>
<tr>
<td>Pima Mine Road (basins) (RRC #4)</td>
<td>10,000</td>
<td>30,000</td>
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<tr>
<td>CAVSARP (basins) (RRC #5)</td>
<td>15,000</td>
<td>30,000</td>
</tr>
<tr>
<td>CDO - Big Wash (basins) *** (RRC #2)</td>
<td>0</td>
<td>30,000</td>
</tr>
<tr>
<td>Pantano, Rillito and Tanque Verde (in-channel) (RRC #10)</td>
<td>0</td>
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</tr>
<tr>
<td>TOTAL USF</td>
<td>49,000</td>
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</tr>
<tr>
<td>TOTAL NON-INDIAN</td>
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<tr>
<th>Indian Water Recharge*</th>
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<th>2007</th>
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<tbody>
<tr>
<td>San Xavier District (basins) *****</td>
<td>0</td>
<td>15,000</td>
</tr>
<tr>
<td>San Xavier District Arroyos (in-channel) (RRC #8)</td>
<td>9,000</td>
<td>9,000</td>
</tr>
<tr>
<td>San Xavier District Santa Cruz (in-channel) (RRC #9)</td>
<td>7,000</td>
<td>7,000</td>
</tr>
<tr>
<td>Pascua Yaqui (basins) (RRC #18)</td>
<td>10,000</td>
<td>10,000</td>
</tr>
<tr>
<td>TOTAL INDIAN</td>
<td>26,000</td>
<td>41,000</td>
</tr>
<tr>
<td>TOTAL RECHARGE</td>
<td>155,100</td>
<td>272,100</td>
</tr>
</tbody>
</table>

* ADWR permits not required on Indian lands. IGA needed to allow storage credit accrual and recovery by non-Indians.
** May be expanded to include managed in-channel component.
*** Design includes spreading basins as well as possible managed in-channel.
**** Not evaluated in recharge site assessment, but included here to match recharge capacity to CAP supply.

CAVSARP - Central Avra Valley Storage and Recovery Project, CDO - Cañada del Oro, RRC - Regional Recharge Committee
GSF - Groundwater Savings Facility, USF - Underground Storage Facility, IGA - Intergovernmental Agreement, CAP - Central
Arizona Project, ADWR - Arizona Department of Water Resources
Indian reservations. In addition, the demand projections contained only non-Indian demand and the capacity of projects on Indian reservations might not be available to meet it. Finally, much of the projected capacity would be provided by GSFs, which some Committee members considered inferior, stop-gap facilities.

The IPAG’s consensus on GSFs was weak. As a result, the Plan contained a gently worded airing of the differing viewpoints and recommended a compromise position.

the benefits from in-lieu recharge in groundwater savings facilities depends on the siting of projects and must be evaluated on a case-by-case basis....GSFs are perceived by some local water interests as postponing rather than preventing groundwater level declines, because after the GSF contracts are completed, water users are likely to resume pumping groundwater. However, the benefits of some GSFs may outweigh those of some USFs due to lower cost or local contributions to water management goals. (IPAG, 1998: X-5)

The Conclusions also revisited the issues of well-injection and Central Wellfield recharge. The judgments reported by the RRC were reiterated. On well-injection, especially, the Plan contains a strong endorsement. Beyond repeating that well-injection may be a superior method for mitigating subsidence,

It also has major advantages in that it can utilize existing infrastructure if wells are appropriately constructed. The City’s two pilot well-injection projects in the Central Wellfield were quite successful for the short period of time they operated. The concerns about disinfection by-products do not appear to be justified based on the experiences of multiple other states. (IPAG, 1998: V-5)

Recommendations to the AWBA

In a process parallel with drafting and revising the Plan, the IPAG developed a set of recommendations for the AWBA. These were provided to the AWBA and included in the published Plan. Recommendation distributed positive attention to the three key groups of participants and their plans: (1) Tucson, (2) participants interested in extending
CAP availability to the south, and (3) participants interested in projects in the northwest area and the Cañada del Oro. Tucson’s project in the central Avra Valley, CAVSARP, received qualified support because short-term political and jurisdictional impediments precluded well-injection recharge in the Central Wellfield.

Population growth, the strong commitment of local jurisdictions, and high cost of proposed recharge in the Cañada del Oro were mentioned as arguments for AWBA involvement there. In the south, on-going pumping, expanding population, and damage from dewatering on the San Xavier District were cited in support of ABWA participation. A GSF on the FICO pecan orchards was recommended particularly, along with projects on the San Xavier District.

The Plan also recommended that ABWA direct attention to TAMA GSFs. Several strategies were suggested for overcoming the disincentives to TAMA farmers of the AWBA’s price for in-lieu water. Approximately 40 to 45 percent of the planned recharge capacity was projected to exist in GSFs. Unless the AWBA’s pricing policy was revised, this capacity would be unavailable to it.

What appears at first sight to be ample recharge capacity for the AWBA may not develop without active AWBA involvement. If GSFs were excluded and some of the listed projects failed to materialize, capacity could be insufficient to meet demand. Because the ABWA is supposed to stand last in line for recharge capacity, it could find itself shut out of the TAMA. If past behavior was a guide, however, it was more likely that local interests would step aside to provide capacity to the Bank. The Plan recommended AWBA involvement in the development of recharge facilities to avoid such a problematic situation.

Specifically, the Plan recommended the list of 17 projects. It noted, however, that “[t]he status of projects changes very quickly, and the relative merits of various facilities
may change over time” (IPAG, 1998: X-8). Therefore, the Plan encouraged the AWBA to continue its communication and cooperation with the RRP.
CHAPTER 5. CONCLUSIONS

This paper has sketched a picture of how many public water policy decisions are made. Its perspective is holistic and as such, it differs significantly from the rational model. Instead of participating in a linear process progressing from problem identification to choice among alternative actions to achieve desired consequences, water policy decision makers engage interactively in monitoring, valuing, interpreting and acting upon each other and their environment.

(1) The decision makers are located within a nested and networked set of groups, organizations, and institutional arrangements that constrains their roles. Their activities are guided to some extent by the application of a rational calculus to achieve specific goals, but also by standards of behavior associated with specific roles, by rule-ordered responses to recognizable situations, and by an intuitive or socially constructed understanding of the relationships among actions and outcomes.

(2) The decision process in which they participate responds dynamically to the products of decision maker interactions with each other and their environment. This dynamic system progresses by restructuring the policy issue.

The picture of public water policy decision making described here provides a framework on which to hang hypotheses about specific aspects of the process, such as information use. This perspective provides an entirely different focus from the rational model on the relationship between information and policy. From the perspective of the rational model, information reveals truths upon which decisions should be based; thus, increasing the amount and influence of information will improve decisions. Typical hypotheses propose that better decisions must result from providing a more expansive range of information, reducing uncertainty with more detailed and accurate information,
or communicating information in formats more understandable by its users (Hammond, 1996).

In contrast, public policy making relies, for the most part, on a slow and interactive process of knowledge building to inform decisions. Information is gathered, analyzed and reported, that does not have a measurable impact on the decision (Innes, 1990; Feldman, 1989). Decision making in organizations shows a similar pattern of collecting, analyzing, reporting, and discussing information with little apparent impact on decisions (March, 1994). At the next lower levels of group and individual decision making, researchers have observed that people generally believe they use more information than they actually use, are limited in their information processing capabilities, tend to simplify problems in order to solve them, and then collect and process more information in order to justify their decisions to themselves and others (Kleindorfer, Kunreuther, and Schoemaker, 1993; Hammond, 1996). An image of decision making that takes account of these observations would predict that simply providing more information or improving its presentation would have little direct impact on policy.

It is interesting that investigators in various fields at various levels of organization should have arrived at similar images of information use in decisions. The similarity is suggestive. This paper has assembled the research results and theories of such disparate investigations to create a narrative for public water policy decision making; that is, an alternative or contrasting way of viewing the process. Some alternative or contrasting conclusions it suggests with respect to information use are described below. The list is not exhaustive, but includes major issues that continue to trouble students of public policy, policy professionals, and producers of information for policy makers.

These conclusions are organized as a set of four hypotheses about the roles of information in public water policy decisions. They are contrasted with assumptions...
derived from the traditional, rational decision model. Conclusions are organized in this way to highlight the different implications of the alternative conceptions.

NARRATIVE VALUE

In the traditional, rational model a problem first is identified and its parameters are defined. Once this occurs, the relevance of information to the decision process is objectively verifiable. Either the information becomes part of the decision calculus or it does not. If it does not, it is either irrelevant or ignoring it is an error.

A conclusion consistent with the holistic view of water policy decision making presented here is that decision relevant information contributes to a narrative. There is no single policy question; the scope and definition of the issue is an interpretation shared among decision makers. The decision participants, their histories, and the structure of their interactions all contribute to defining the problem and creating its shared interpretation. The issue interpretation or narrative determines what information is relevant and what is not. To be useful, information must find a hook in the interpretation or narrative framework upon which decision makers hang facts. Interventions that address a different interpretation of the policy issue are less likely to have an impact than information that addresses the decision makers’ interpretation.

Because of their implications for values, facts seldom speak for themselves. Facts need advocates. The implications of information for an issue interpretation may be immediately apparent and seized upon by participants. If a new viewpoint is expressed or a new angle examined, its implication may need to be explained. The policy analysts observed by Feldman (see page 79) needed negotiation skills to advocate for their interpretation of the issue and the value of their information.
The RRC Report contained several issue studies whose content was not reflected in the Plan as conclusions, recommendations, or project sites. The RRC members raised issues that applied to their conception of the recharge issue. For example, a detailed analysis reported by the RRC determined the savings to any project that took advantage of the CAP system operating head for conveyance. It stated that the costs of failure to use CAP system pumping head capacity could be substantial, but the information failed to attract any further attention.

Because issue interpretation is a work in progress, facts may be developed to fit the narrative, but they also may be used to shape the interpretation. The impact of the Endangered Species Act on CAP recharge projects received considerable attention because of the advocacy of one participant for whom it represented a major concern. Its influence on the Plan was negligible, but it won a prominent place in the longer, slower process of policy issue interpretation where its influence may be felt in the future.

Facets of the recharge issue also were intentionally excluded from consideration. Most of this information related to source water compatibility, receiving water quality, water treatment, and contaminant plume containment. Although the water compatibility problems were listed in an overview of possible problems affecting recharge projects (i.e., carbonate equilibrium, sorption reactions, and cation exchange reactions), they were not included as criteria or factors affecting technical merit. Physical descriptions of recharge projects did compare a few water quality parameters in source and receiving waters to estimate the effect of recharge on concentrations of specific constituents, but uniform data were not available on all projects. Lack of data and the differences in type and amount of data provided for the various project sites may have made water quality information difficult to use. However, the IPAG specifically minimized the role of water quality issues in their decision process. Participants agreed in IPAG meetings that the
RRP was not the appropriate forum for addressing water quality issues and, given the state of knowledge about water quality consequences of CAP recharge, water consumer preferences, and ADEQ regulations, they were not in a position to predetermine future treatment decisions. They were in a position to avoid judgments on most water quality factors as irrelevant to their decisions. It was generally assumed for decision purposes that CAP water quality was worse than ground water, although participants were aware that this would not be true in all locations. In this, public perception was probably reflected by RRP participants. There was no attempt by the committees to direct recharge to areas of known low quality groundwater. Although mitigating groundwater quality concerns is an important objective of recharge in other arenas, it was not a significant part of the policy issue interpretation for the RRP.

Some of the information generated by the RRC was emphasized in conclusions and recommendations, but had no observable impact on project site selection. Its primary use may have been to reinforce the established conception of recharge that had been challenged implicitly by the WCPA. Thus, the information that no more than 15,000 acre-feet of CAP water could be recharged by in-channel methods in the Central Wellfield and the information on the subsidence risks of surface recharge methods produced recommendations for a return to well-injection recharge at the same time that no well-injection projects appeared on the short list of recommended sites. On the basis of the water policy making framework proposed here, it could be inferred that the report and recommendations were contributions to discourse meant to influence issue interpretation. Action on well-injection would have to wait on the evolution of public understanding.

A great deal of information was collected specifically for the project site selection process that found no direct expression in project site rankings. Descriptions of the
physical characteristics of potential recharge projects, such as infiltration rate and long-term average recharge rate, volume of potentially recoverable water below the recharge facility, and depth to water were scrutinized, up-dated, and discussed. No one questioned the value of such information to the rational process of project site selection. Yet none of it was cited during ranking deliberations.

There were practical and political reasons the information was not used. Practically, the link between the physical characteristics data and the relative value of particular projects was too tenuous. Without agreement on physical criteria, there was no way to interpret the data. The practical arenas for consideration of physical characteristics were (1) preliminary studies by sponsoring organizations and (2) permit application proceedings. Given the generally favorable conditions for recharge throughout the TAMA, the IPAG was fairly safe in assuming that any project with active institutional support, especially if permitted by ADWR, had received the appropriate level of scrutiny on its physical characteristics. It reduced potential conflict to rely on this assumption.

Some information was used directly in the ranking of project sites. This was information that filled specific slots created for it in an overt, rational decision calculus. Agreement was reached on a policy of siting recharge projects for groundwater management goals. Among these were to stabilize groundwater levels in areas depleted by pumping and to mitigate subsidence risk. Specific criteria were devised for these management goals. It was agreed that projects should receive ranking points if they were near areas of historic and projected groundwater level declines and high subsidence potential. Therefore, it was possible to use information on groundwater level declines and subsidence potential directly in the decision.
FACT AND REALITY

The picture of water policy decision making painted above relies on the concept of the social construction of meaning. Well-constructed meaning depends on the practical correspondence between accepted facts and objective reality. Reality is what exists. Fact is the perception/conception of some issue-relevant aspect of reality. Reality is objective or neutral with respect to a decision. Fact cannot be. Its existence implies a value choice.

Agreement about what is provides a base upon which to build agreement on what is desirable and what may be. As decision makers reach agreement through the creation of a shared interpretation, they will ignore alternative interpretations, which deploy a somewhat different set of relevant facts. These ignored interpretations many be shared by excluded interest groups or form the basis of public understanding of the policy issue. In direct contrast to rational decision models, this conception of the process would predict that conflict between groups with different interpretations of the policy issue usually will not be resolvable with reference to some objective set of facts.

Instead, conflict resolution requires enough agreement on the issue interpretation to arrive at a shared set of relevant facts. Innes (1990) refers to negotiations or discourse that result in agreement between information producers and information users on what constitutes fact. According to Innes, this discourse is necessary to produce information that policy decision makers can use. The use of information for the subsidence risk criterion is a simple example.

Subsidence risk estimates (RRC, 1996a) and maps (IPAG, 1998) were based on the most recent published work by USGS researchers. In general, the USGS was considered a source of objective, high quality research. The USGS investigators created a model of subsidence risk based on aquifer characteristics (principally percentage of clays) and pumping history. The Avra Valley model was based on an assumption that pumping
would continue at the relatively high 1977 levels. The Santa Cruz Valley model used different pumping assumptions based on data from the 1980s (Hanson, Anderson, and Pool, 1990; Hanson and Benedict, 1994). The two USGS reports, thus, were not comparable and even at the time of publication, probably exaggerated the risk in the northern Avra Valley in comparison to the Central Wellfield in the Santa Cruz Basin.

By the time the IPAG deliberated, it was known and demonstrated by groundwater level recovery, that pumping in the north Avra Valley, where the model showed significant subsidence risk, had been reduced substantially. It was clear that the change in pumping regime would affect model predictions, yet no attempt was made to adjust project evaluations to reflect this knowledge. The USGS report provided rational justification of project evaluations that would be jeopardized by *ad hoc* (less than objective expert) adjustments to its results. The risk estimate remained the best prediction of what would happen if or when pumping resumed. Furthermore, high subsidence risk increased the urgency of recharge and thus reinforced support for the RRP.

Downward adjustment of risk in the Avra Valley because of reduced pumping also would disadvantage projects in the northwest area already contending with conceptual disadvantages because they were close to the northern boundary of the AMA. A conceptually simple view of recharge assumes there will be more benefit to adding water up gradient--at the southern end of the basins, thus giving it a longer residence time in the AMA and more opportunity to solve basin problems. Also, a presumption had to be overcome that water recharged in the north Avra Valley would flow into the Pinal AMA.12 (Lower Santa Cruz Project designers used computer models to show that recharged water would stay in the AMA well beyond the life of the project.) Northwest

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12 Lower Santa Cruz Project designers used computer models to show that recharged water would stay in the AMA well beyond the life of the project.
area interests argued for a different conception of groundwater recharge in which movement and residence time are dependent on local geologic conditions (Franzi, 1997).

**RATIONALITY AND RATIONALIZATION**

Within the holistic image of water policy decision making, the traditional, rational model retains important functions. An important *myth* of water policy is decision rationality, a narrative complete with rules, values, and roles that provides policy participants with procedures and standards of behavior. Feldman (1989) remarked on the dominance of a rationalistic perspective in society in general and the policy analysts she studied in particular. In addition, the practice of scientific or rational method provides a practical connection between fact and reality and therefore improves the ultimate functionality of socially constructed meaning.

The myth of decision rationality also affects the legitimacy and acceptability of decisions. In the context of water resources planning and policy making, there can be no single rational solution to complex, evolving problems. Just as in formal research, “there are some technically incorrect ways of ordering and relating the data, but a good many alternatives which are not incorrect” (Innes, 1990:5), there are multiple way of achieving sufficiently rational decisions. Decision makers, therefore, have scope to negotiate their interests in selecting among solutions. Solutions that appear rational or achieve an acceptable level of rationality, by demonstrating a coherent means-ends linkage, more successfully achieve the support of participants and their publics than solutions that appear arbitrary. More information is often sought than is used in decision making in order to reinforce the appearance of rationality. This reinforced rationality may be needed to garner public support, but it is as likely to be used by the participants themselves for
reassurance or to evoke the unity of purpose required for implementation (March, 1997; Brunsson, 1989).

On the other hand, rationalization is unlikely to overcome conflicts of perceived self-interest. Group water policy processes emphasize agreement on information collection and rational analysis procedures to minimize interest conflicts; however, decisions about methodology becomes particularly difficult at points where participants realize or suspect that different methodologies will have differential effects on competing interests. The RRP’s process for developing project selection criteria involved creation of a rationale for choosing among methodologies one that yielded acceptable criteria. The entire IPAG phase was concerned with rational process. The final Plan largely reiterated the choices and recommendations of the RRC Report, but only after participant preferences were determined, objectives were set, project sites were evaluated, the future need for recharge estimated, and the capacity of selected projects to meet the need established. Information played a major role at each stage of this process.

FACTS AND VALUES

The traditional rational model of decision making assumes that facts can be separated from values, at least to the extent that technical experts can resolve issues of fact without biasing the choice of policy makers among competing values. However, in the model proposed here, there are no neutral facts, because facts have no meaning without interpretation. The goal of separating fact from value is largely illusory. It has been called a “soothing fantasy” policy makers adopt when they delegate to technical experts and research studies (Rein and White, 1977).

As Innes observed, however, “we need the ‘soothing fantasy’ of the division between politics and knowledge.” (1990:39). It may be possible and frequently useful to separate
questions participants agree to resolve through fact finding from other questions. It allows policy makers to identify segments of the decision for which investment in professional knowledge production may reveal acceptable solutions.

In the RRP, the technical committee had a major impact on the Plan because they made value decisions. Meeting first, without detailed guidance from the policy making group, they were left to define the issues to be studied, the objectives of recharge, and the criteria for screening recharge sites. Any agreement on interpretation they shared with the policy group was tacit and established outside the process. A common interpretation of the policy issue was well enough elaborated among the participants on both committees that major divergences in perspective were minimal. That the TAMA staffed both committees and provided record keeping and coordination probably contributed to the concordance of viewpoints. Where the RRC faltered was precisely where more detailed, explicit prior guidance on values would have been required--development of acceptable site selection criteria.

Several studies have demonstrated the effectiveness of fact and value separating strategies for specific policy issues (Brown, 1986; Hammond and Adelman, 1986; Edwards, 1992). In these studies, a stakeholder participation process determined the policy objectives and the criteria for selecting among options. Experts determined the degree to which alternatives met established criteria. A third party, sometimes the decision analyst with his/her algorithm, identified which alternative optimized achievement of the policy objectives.

The view of water policy decision making presented here reinterprets these successes. It recasts the strategies as arriving at a generally accepted agreement about the domain of technical decisions and policy decisions. This kind of specific agreement between producers of information and users builds a slot into the decision narrative for the
information. Acceptance and direct use of the facts in the decision is not guaranteed, however. Surprising or counter-intuitive information that does not fulfill the expectations of decision makers may be suspect. Such information may require a time consuming adjustment to the issue interpretation or bolster an alternative interpretation. In addition, success in producing consensus depends on particular circumstances. Decision makers must settle on a single set of weights among objectives unless by chance an alternative is found that dominates all others. Failing this, the facts may polarize interests around specific alternatives.

A large effort went into developing comparable cost estimates for the 16 projects evaluated by the RRC. These costs, simplified into dollars per acre foot of recharge, were maintained, referred to, and up-dated based on new information throughout the process. Economic information was fairly uniform because descriptions were based on uniform cost calculations rather than actual costs. In this way conceptual projects could be compared with actual projects. In the end, however, cost was not used to evaluate projects.

This was because participants could not agree on a definition of a costs indicator compatible with their concept of the recharge issue. The various components of cost differ for different kinds of projects with different objectives. The RRP participants found that objectives, site characteristics, project design, and cost were related dynamically. Projects were designed to meet the particular demands of a site and the particular objectives of the sponsors. The higher costs of one project could be justified by its greater expected benefits. Recovery assumptions, for example, affect total project costs, because construction of recovery wells adds substantially to total costs of recharge. Regulations permitted recovery from existing wells even if those wells are distant from the site of recharge, so some projects did not include recovery in cost estimates.
Opinions varied on the advisability of permitting distant recovery wells because it allowed groundwater to be depleted in the distant sub-basins. On the other hand, jurisdictions receiving recharge water wanted local groundwater extraction by outside storers limited. If recovery costs are disregarded, GSFs cost much less than USFs. Considering cost as a major factor would advantage GSFs when most of the interest in the RRP was development of USFs. Use of cost information would have required prior or simultaneous agreement on recovery policy and the relative value of GSFs to USFs with development of a cost indicator. Unresolved issues like recovery preferences made comparison of projects on the basis of cost impossible. The interaction of fact and value had to be addressed before they could be separated.

SUMMARY

Research from many disciplines has contributed to an view of how people actually make decisions that is substantially different from the rational model. This view shows decision making holistically, as a complex, dynamic process. Looking at public water policy decision making from this view reveals features of the process, like information use, in a new light. It suggests that the impact of information is usually indirect, that it is assimilated into evolving narratives or interpretations of the policy issue. Information is most likely to influence issue interpretations when someone advocates for it in the decision forum. A decision forum creates a shared interpretation of the issue through discourse. Discourse alone can create tautological interpretations, divorced from reality. Facts link the process to reality, but the choice of facts determines what aspects of reality will receive attention. The producers of information make policy relevant choices when they design their studies and report their results. Their choices are guided by motives and assumptions of which they may be unaware, but which are not value neutral. Fact and
values cannot be completely separated, but wide-spread belief in the rational, scientific paradigm requires that decision makers demonstrate reliance on objective facts in their decisions. Deciding in advance how to use such facts provides a place where information may have a direct impact on decisions. Agreement on the use of information requires consensus on the components of policy that will be affected by it. Failure to agree in advance reduces the direct impact of the information.
APPENDIX A: WATER CONSUMER PROTECTION ACT
SECTION 2. Chapter 27 of the Tucson Code is amended by adding a new Article VII to read as follows:

ARTICLE VII. WATER QUALITY STANDARDS

.C. 27-100. PURPOSE. THE PURPOSE OF THIS ARTICLE IS TO ASSURE SAFE, AFFORDABLE AND HIGH QUALITY DRINKING WATER TO ALL CITY WATER CUSTOMERS BY ESTABLISHING MANDATORY WATER QUALITY STANDARDS.

SEC. 27-101. WATER QUALITY STANDARDS.

(a) THE CITY SHALL AT ALL TIMES PROVIDE DRINKING WATER TO ALL ITS DRINKING WATER CUSTOMERS THAT MEETS ALL APPLICABLE STATE AND FEDERAL PRIMARY DRINKING WATER QUALITY STANDARDS.

(b) THE MAYOR AND COUNCIL IS AUTHORIZED TO ADOPT ADDITIONAL WATER QUALITY STANDARDS APPLICABLE TO THE DRINKING WATER PROVIDED BY THE CITY TO ALL ITS DRINKING WATER CUSTOMERS, PROVIDED SUCH DRINKING WATER QUALITY STANDARDS ARE MORE STRINGENT THAN STATE OR FEDERAL PRIMARY DRINKING WATER QUALITY STANDARDS AND ARE EQUALLY APPLICABLE TO ALL DRINKING WATER CUSTOMERS.

SEC. 27-102. ADDITIONAL MANDATORY STANDARDS.

(a) TCE. THE CITY SHALL NOT PROVIDE ANY WATER TO DRINKING WATER CUSTOMERS CONTAINING TRICHLOROETHYLENE (TCE) IN AN AMOUNT THAT EXCEEDS ANY STATE OR FEDERAL DRINKING WATER STANDARD.

(b) CORROSIVENESS. THE CITY SHALL NOT PROVIDE ANY WATER TO DRINKING WATER CUSTOMERS THAT IS MORE CORROSIVE THAN THE GROUNDWATER PROVIDED BY THE CITY TO ITS DRINKING WATER CUSTOMERS DURING THE MONTH OF JANUARY, 1997.

(c) HARDNESS. THE CITY SHALL NOT PROVIDE ANY WATER TO DRINKING WATER CUSTOMERS THAT HAS A HIGHER TOTAL DISSOLVED SOLIDS LEVEL THAN THE STATE OR FEDERAL SECONDARY DRINKING WATER QUALITY STANDARD OF 500 PARTS PER MILLION TOTAL DISSOLVED SOLIDS.

(d) A VIOLATION OF THIS SECTION SHALL BE A MISDEMEANOR PUNISHABLE BY A FINE OF NOT MORE THAN $2,500 OR ONE YEAR IN PRISON.

SEC. 27-103. CITIZENS WATER QUALITY OVERSIGHT COMMITTEE. WITHIN NINETY DAYS OF THE ADOPTION OF THIS ARTICLE, THE MAYOR AND COUNCIL SHALL ESTABLISH A CITIZENS WATER OVERSIGHT COMMITTEE. THE COMMITTEE SHALL MONITOR CITY COMPLIANCE WITH THE DRINKING WATER QUALITY STANDARDS OF THIS ARTICLE. THE CITY'S WATER UTILITY SHALL PROVIDE THE COMMITTEE WITH SUCH INFORMATION ABOUT THE QUALITY OF DRINKING WATER SERVED TO THE CITY'S DRINKING WATER CUSTOMERS AS THE COMMITTEE MAY REQUIRE TO DISCHARGE ITS DUTIES UNDER THIS SECTION.

SECTION 3. Severability. If a provision of this Ordinance, or its application to any person or circumstance is held invalid, the invalidity does not affect other provisions or applications of the Ordinance that can be given effect without the invalid provision or application, and to this end the provisions of this Ordinance are severable.
APPENDIX B: RECHARGE FACILITY DESCRIPTION & BASIC ASSUMPTIONS
### FACILITY DESCRIPTION
Vacant land north of Tangerine Rd., east of the I-10 freeway and west of the CAP canal has potential to be used to construct recharge basins. Land appears to be retired farmland. A portion of the site in Section 36, was planned for development by MST properties and requested changes to the 208 plan was approved further, siting a sewage treatment facility. Location is T 11S, R 12E, Sec 31, and T 11S, R 11E, Sec 25, and 36. There is a levee on the north side of the CAP canal which serves to protect the canal from flooding by sheetflow from the Tortolita fan to the north. The site is in the path of the discharge from two drainage overchutes, each consisting of 3-72" pipes, which transports the drainage collected by the dike over the top of the canal. The CAP turnout which is proposed for the Northwest Tucson Active Management Area Replenishment Program can also be utilized to serve this project, thereby reducing costs for both projects.

### BASIC ASSUMPTIONS
Approximately 332.9 acres are available. There is no information on infiltration rates. Assuming an infiltration rate of 1 ft/day results in the annual recharge volume = 50,000 AF. Soils along the CAP alignment north and east of the site have exhibited subsidence (assumed due to "collapsible soils"). However, since this land was farmed in the past, it may not subside. The soil is sandy with less than 15% fines and may be suitable for recharge. Land ownership is unknown. This could be operated as a "put-and-take" facility due to proximity to the canal.

### TECHNICAL CRITERIA

<table>
<thead>
<tr>
<th>TECHNICAL CRITERIA</th>
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<tbody>
<tr>
<td>1. INFILTRATION RATE (FT/DAY)</td>
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<tr>
<td>2. VOLUME OF POTENTIALLY RECOVERABLE WATER IN VADOSE ZONE (AF)</td>
</tr>
<tr>
<td>3. DEPTH TO GW (FT)</td>
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<tr>
<td>4. TOTAL HISTORICAL GWL DECLINE (FT)</td>
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<tr>
<td>5. POTENTIAL TO ALLEVIATE SUBSIDENCE</td>
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### RRC SITE NO. 7 DESCRIPTION/DATA/ASSUMPTION

<table>
<thead>
<tr>
<th>RRC SITE NO. 7 DESCRIPTION/DATA/ASSUMPTION</th>
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<tbody>
<tr>
<td>CONFIGUERATION</td>
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<tr>
<td>VOLUME OF INFILTRATION</td>
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<td>POTENTIAL WATERS TO CONTINUE</td>
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<td>REQUIREMENTS</td>
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<td>INFILTRATION RATE</td>
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<tr>
<td>TOTAL HISTORICAL GWL DECLINE</td>
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<td>POTENTIAL TO ALLEVIATE SUBSIDENCE</td>
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### TECHNICAL CRITERIA

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<th>RRC SITE NO. 7</th>
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<tr>
<td>DESCRIPTION/DATA/ASSUMPTION</td>
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<tr>
<td>6. GW QUALITY IMPACTS</td>
</tr>
<tr>
<td>A. AMBIENT WATER QUALITY</td>
</tr>
<tr>
<td>B. POTENTIAL TO DEGRADE NATIVE GW</td>
</tr>
<tr>
<td>C. POTENTIAL SOURCES OF CONTAMINATION (LANDFILLS, EXISTING PLUMES, TDS IMPACTS, ETC.)</td>
</tr>
<tr>
<td>D. MIGRATION OR CONTAINMENT OF CONTAMINANT PLUMES</td>
</tr>
<tr>
<td>A. Ambient water quality is unknown, but there is a possibility of high nitrates and/or pesticides from historical farming use.</td>
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<tr>
<td>B. Not known, but there may be an initial flush of nitrates and/or pesticides.</td>
</tr>
<tr>
<td>C. None known or expected.</td>
</tr>
<tr>
<td>D. None known or expected.</td>
</tr>
<tr>
<td>7. OTHER TECHNICAL ISSUES (TRANSMISSIVITY OF AQUIFER, IMPERMEABLE LAYERS IN VADOSE ZONE, SURFACE ELEVATION OF FACILITY (MSL), ETC.)</td>
</tr>
<tr>
<td>Transmissivity unknown. Geologic logs along the CAP Santa Cruz River siphon show lean to fatty clay in the upper 10 ft. Poorly graded sand with cobbles is predominant below 15 ft., which should provide high infiltration rates. Assuming a very conservative infiltration rate of 1 ft/day, the capacity of this site could be 49,750 AF/yr. Elevation at site is 2045 feet. CAP max. water elevation adjacent to site is 2038.5 feet.</td>
</tr>
<tr>
<td>8. ESTIMATED ANNUAL RECHARGE VOLUME</td>
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<td>50,000 AF/yr.</td>
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### ECONOMIC FACTORS

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<tr>
<th>RRC SITE NO. 7</th>
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<tbody>
<tr>
<td>DESCRIPTION/DATA/ASSUMPTION</td>
</tr>
<tr>
<td>1. CAPITAL COSTS</td>
</tr>
<tr>
<td>A. DESCRIBE CONVEYANCE SYSTEM COMPONENTS</td>
</tr>
<tr>
<td>B. DESCRIBE RECHARGE FACILITY COMPONENTS (EARTHWORK, LENGTH OF REACH/AREA OF BASINS, ON-SITE CONSTRUCTION, PIPING &amp; CONTROL SYSTEM, OTHER)</td>
</tr>
<tr>
<td>1. Recharge capital costs = $6,874,592 (including land acquisition). Annual costs for 20 years @ 8% = $700,203 or $14.07/AF.</td>
</tr>
<tr>
<td>A. The site is adjacent to the CAP canal. A new CAP turnout and pumping station (91.62 cfs @ 113.6 BHP) and approx. 500 ft of 42-inch diameter conveyance pipeline.</td>
</tr>
<tr>
<td>B. Excavation of top 5 ft of fine-grained soils for basin &amp; berm construction = 473,897 cubic yards; distribution piping consisting of 3160 linear feet of 42&quot;, 1979 linear feet of 36&quot;,1451 linear feet of 24&quot; and 14,900 linear feet of 12&quot; pipe; 8 each 4&quot; diameter monitoring wells 400 feet deep; and acquisition of 333 acres @ $10,000/acre.</td>
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<tr>
<td>ECONOMIC FACTORS</td>
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<tr>
<td>2. AVERAGE ANNUAL O&amp;M COSTS (ENERGY, CONVEYANCE SYSTEM MAINTENANCE, RECHARGE SYSTEM MAINTENANCE)</td>
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<tr>
<td>3. LAND &amp; RIGHT OF WAY ACQUISITION (AVAILABILITY, OWNERSHIP, COST, ACRES REQUIRED, LAND USE COMPATIBILITY, PRIOR LAND USE)</td>
</tr>
<tr>
<td>4. ENVIRONMENTAL CONSTRAINTS (ARCHEOLOGICAL, AESTHETIC, HABITAT-RELATED, FLOODING POTENTIAL, OTHER)</td>
</tr>
<tr>
<td>5. REGULATORY CONSIDERATIONS (ADWR, ADEQ, PCFCD, FEMA, COE, F&amp;WL, SAWRSA, ETC.)</td>
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<tr>
<td>6. RECOVERY ASSUMPTIONS (LOCATION OF RECOVERY SYSTEM, DEPTH TO GWL, TRANSMISSIVITY OF AQUIFER, POTENTIAL USE OF EXISTING WELLS &amp; PIPELINES, REQUIREMENT FOR TREATMENT, ETC.)</td>
</tr>
<tr>
<td>7. TIME REQUIRED TO IMPLEMENT (PERMITS, DESIGN, CONSTRUCTION, ETC.)</td>
</tr>
<tr>
<td>EXTENT OF REGIONAL BENEFITS</td>
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<tr>
<td>1. MULTIPLE USERS OF CONVEYANCE, RECHARGE, AND/OR RECOVERY FACILITIES</td>
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<tr>
<td>2. RECHARGE OBJECTIVES THAT CAN BE MET BY THIS FACILITY</td>
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<tr>
<td>3. RECREATIONAL USES</td>
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<tr>
<td>4. ENVIRONMENTAL BENEFITS</td>
</tr>
<tr>
<td>CURRENT STATUS</td>
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<tr>
<td>--------------------------------------------</td>
</tr>
<tr>
<td>1. SITE EVALUATION</td>
</tr>
<tr>
<td>2. BOREHOLES/TEST-PITS</td>
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<tr>
<td>3. EXISTING OR PROPOSED FUNDING ($, SOURCES)</td>
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<td>4. PILOT PERMIT APPLIED FOR/ISSUED</td>
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<tr>
<td>5. FINAL STORAGE FACILITY PERMIT ISSUED</td>
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<tr>
<td>6. OTHER PERMITS APPLIED FOR/ISSUED</td>
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APPENDIX C: TAMA REGIONAL RECHARGE PLAN WATER NEEDS SURVEY QUESTIONS
TAMA Regional Recharge Plan Water Needs Survey Questions

I. IDENTIFICATION OF SURVEY RESPONDENTS

Name of entity/interest represented by survey respondent(s)

Name
Address
Phone
FAX
Point of contact [for additional questions/clarification]

Name(s) of actual respondent(s)

II. PROBLEM GOAL IDENTIFICATION

A. What are your entity's most urgent water supply problems? Describe and rate specific problems from very important to unimportant.

B. What (other) reasons does your entity have for developing recharge or other projects for increasing renewable water supplies in the Tucson area?

C. What are your concerns, if any, about any risks that may be associated with recharge projects?

III. CURRENT AND PROJECTED OPERATING CONDITIONS

A. Needs (If you have already given any of this information to DWR, do not collect it again)
   1. Type of water use(s) [who uses water for what]
   2. Amount of water used annually for each use, current and projected
   3. Quality requirements for each use [beyond current DEQ/EPA requirements, if any]
   4. Institutional requirements or restrictions on use [e.g., statute, regulation, contract, policy, ordinance]
   5. Other use considerations [e.g., seasonality, peaking, preferred quality]
B. Water sources (If you have already given any of this information to DWR, do not collect it again.)

1. Current and future water source(s) [e.g., CAP allocation, groundwater]

2. Amounts from each source [current and projected]

3. Limits on quantity: physical, institutional, or other factors (e.g., financial, infrastructure) that limit the quantity of water from each source

4. Quality: water quality factors that affect usefulness of water source for specific uses

5. Do you match water source to use [currently or intend to in the future]? [e.g., effluent to turf irrigation] yes/no, explain

6. Without recharge, do you anticipate a shortfall in supply [actual or regulatory (e.g., AWS)] to meet projected demand? Describe: when, how, and how much

IV. OPTION IDENTIFICATION

A. Describe the ideal project to meet your needs.

1. What factors/components make it ideal? [e.g. recharge close to existing recovery wells, puts CAP allocation to use almost immediately, revitalizes riparian corridor, lowest cost alternative]

2. Rate these factors/components from very important to unimportant.

3. What factors have you identified that would disqualify a project from consideration by your organization?

B. Facilities/arrangements for recharge or “in lieu” projects

A list of potential projects identified by the Regional Recharge Committee and a map showing their locations are attached. Use them to indicate the type and location of projects you are currently pursuing and/or that are likely to meet your needs. If you are interested in projects not listed, please describe them and indicate locations on the map.

1. Type(s) of project/arrangement [e.g., GRD, water swaps, groundwater savings, treatment, recharge, recovery, other]

2. Project(s) status [e.g., existing, planned, studied, contemplated]
C. Project water source(s) for each project that has not reached permit stage

1. What source(s) of water do you expect to use [e.g., CAP, effluent, surface/storm water, remediated ground water, industrial waste water, imported ground water]

2. Allocation status/ownership [e.g., who holds CAP allocation, does contract exist, relationship with allocation holder, does agreement exist]

3. Amount, annual [initial, final]

4. Restrictions on availability of water [current or future, e.g., timing, seasonality, claims of others, increases or decreases]

5. Proximity of point of use/recharge to canal or other conveyance system [ownership of system, limits to use, rights of way]

6. Volume of water credits expected [in terms of water available for recovery or groundwater savings, if applicable]

D. Financial considerations

1. Source(s) of funds for water projects [e.g., Bonding capacity (current and planned), Outside funding (obtained and/or sought)]

2. Constraints on amount

3. Constraints on use

4. Years or time period

E. Partnership potential

1. Identified partnership entities

2. Types of partnerships [e.g., capacity sharing, cost sharing]

3. Status [e.g., talks in progress (are these public information?), agreements made (are copies available?)]

4. Do you see any other opportunities for partnerships?

5. What benefits to your organization from current and potential recharge partnerships have you identified? Describe
3. Project(s) time line:
   a. How soon would the project begin recharging water?
   b. When would water be recovered?
   c. How long would water be stored at project location?

4. Cooperators: *What other entities are involved in the project(s)?*

5. Project(s) location [*refer to map*]:
   a. Where will water be recharged?
   b. Where will water be recovered?
   c. If recharge, recovery, conveyance, or other facilities associated with a project must be built, indicate where.

6. Project(s) objectives: $x=\text{yes}$

<table>
<thead>
<tr>
<th>PROJECT OBJECTIVE</th>
<th>PROJECT NAME</th>
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<tbody>
<tr>
<td>Recovery for potable use</td>
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<tr>
<td>Recovery for non-potable use</td>
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<tr>
<td>Annual storage/recovery</td>
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<tr>
<td>Long-term storage, recovery at same location</td>
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<tr>
<td>Long-term storage, recovery at distant location</td>
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<tr>
<td>Recharge/no recovery</td>
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<tr>
<td>CAWCD reliability storage</td>
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<tr>
<td>Assured Water Supply recharge</td>
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<td>Riparian enhancement</td>
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<tr>
<td>Subsidence control</td>
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<tr>
<td>Contain/manage poor quality ground water</td>
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<tr>
<td>State water bank</td>
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<td>SAWRSA claims settlement</td>
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</table>

7. If no listed projects are likely to meet your needs, explain why.
F. Barriers to cooperation

1. Identified barriers: *What, if anything, is preventing you from forming recharge partnerships?*

2. Proposed remedies: *What would it take to overcome these barriers?*

3. Actions for cooperation: *Can you identify specific actions you or your organization can take to improve relations among interested parties or overcome obstacles to cooperation?*

V. ADDITIONAL INFORMATION

A. Other entities/interest groups who should be interviewed [suggested contacts]

B. Comments and suggestions
APPENDIX D: NEEDS ASSESSMENT - RECHARGE GOALS AND RISK CONCERNS
Needs Assessment - Recharge Goals, Risk Concerns and Possible Methods of Participation

A. Goals of Survey Participants

The goals listed below were expressed by the interviewees on behalf of specific entities. They are interrelated and overlapping, but each represents a distinguishable set of preferences and intentions by which recharge projects are judged. Capital letters (A) separate subgroupings that have differentiable implications for recharge projects.

1. Water Credits. This objective reflects the need for groundwater pumping credits because of ADWR regulations. The various reasons for wanting credits include: a) to meet AWS requirements (or in anticipation of meeting those requirements); b) to avoid relying on the CAGRD to replenish; c) in anticipation of other regulatory incentives (e.g., to offset GPCD violations or golf course water use); and d) in anticipation of development of a market for credits. This objective implies no bias with respect to the location of the facility where credits are accrued; that is, the entity may prefer that the facility be near or distant to meet other objectives.

2. CAP Use. This objective includes: (A) The desire to take wet CAP water from the canal. This implies having a specific use (e.g., farming) or a direct stake in the use of the water itself and therefore an interest in proximity to the canal. (B) The desire to obtain some benefit from a CAP allocation. This implies willingness to sell, lease, or exchange an allocation or to participate in USFs or GSFs at a distant location. (C) The desire to see CAP water used in the Tucson AMA, which implies the lack of a direct stake in the use of the wet water.

3. Effluent Use. This objective reflects the desire either (A) on the part of entities with current supplies of effluent to put them to use as renewable water or (B) on the part of other entities to gain control of effluent produced within their area of jurisdiction. Where effluent is collected and treated has implications for the location of its use. A third goal (C) is the general desire to see more use of reclaimed wastewater in the basin.

4. Income. This objective implies that the entity sees involvement in recharge projects as a source of revenue (and/or marketable credits).

5. Groundwater Level Stabilization/Restoration. This objective may or may not contain concerns about subsidence. It includes the desire to apply wet water (A) within the entity’s area of jurisdiction or (B) in areas of identified water level decline.

6. Shortage Insurance. This objective implies consciousness of risks to the reliability of water supplies, either because of potential groundwater contamination, canal outages, or future shortages on the Colorado River. It suggests the desire to store wet water in the basin. The two groupings are (A) the need to bring renewable supplies to the area to be available as an alternative supply and/or for long-term groundwater storage or savings; and (B) the a need for system
redundancy and/or short-term storage.

7. Population Growth and Development. This objective reflects the desire to accommodate anticipated growth and ancillary amenities, including new golf courses, or to promote growth.

8. Cost Control. This objective may be interpreted as (A) attention to the bottom line or (B) desire to reduce cost uncertainties.

9. Land Use Controls. This objective focuses on links between water availability and land use. It implies the desire to direct development of certain types to certain areas to protect the quantity and/or quality of groundwater or advance other policy goals (such as reducing "urban sprawl").

10. Community Involvement. Participation in recharge and groundwater savings activities is motivated by a sense of community membership that may or may not imply a commitment to promoting "the public good" or desire to improve the sector's public image.

11. Water Balance. Entities wish to balance water supply and water demand without mining groundwater. This probably implies the goal of using directly or storing renewable water (CAP and/or effluent) in the area of jurisdiction. It may or may not be couched in terms of "sustainability" or "basin management" and may include expression of values of appreciation and protection of the desert environment and its resources.

12. Environmental Enhancement. This objective may be (A) the general expression of a value or may (B) imply a commitment to create, restore, and/or maintain riparian habitat and/or recreational opportunities apart from other recharge benefits.

13. Indian Water Settlements Implementation. This objective entails enabling SAWRSA CAP allocations and exchange water delivery for use on the reservation (for farming, habitat restoration, generation of transferrable groundwater credits, generation of funds to pay for water supply deliveries, etc.).

14. Farming. This objective implies a desire to obtain a reliable, schedulable source of wet water of suitable quality. It also implies a positive value for farming beyond its economic return.

15. Responsiveness to Consumers/Public. Activities are in response to consumer/public demands.

16. Drinking Water Quality. This objective encompasses the issues of health and aesthetic appeal of drinking water. It may or may not be associated with concerns about raw CAP water quality and/or treatment methods and treated CAP water quality. It also may or may not imply a desire to save the highest quality water (groundwater) for domestic use.

17. Conservation Requirements. This objective seeks help in meeting conservation
requirements (GPCD). Entities may view the provision of renewable water supplies as a higher use of resources than stipulated conservation programs.

The following tables show the objectives, and their relative level of importance, to all of the entities interviewed.

**Survey Participants**

1. ASARCO  
2. Avra Valley Coop  
3. AWBA  
4. BKW Farms  
5. U.S. Bureau of Reclamation  
6. CAWCD  
7. CAGRD  
8. CMID  
9. Community WC of Green Valley  
10. Cyprus Sierrita  
11. FICO  
12. Flowing Wells  
13. Green Valley WC  
14. Interchange WC  
15. Kai Farms  
16. Marana  
17. Metro DWID  
18. Oro Valley  
19. Pascua Yaqui  
20. Pima County FCD  
21. Pima County Parks & Rec  
22. Pima County Wastewater Management  
23. Sahuarita  
24. San Xavier District (TON)  
25. Spanish Trail WC  
26. Arizona State Land Dept  
27. Tucson Water  
28. Tucson - Ward 6
<table>
<thead>
<tr>
<th>RECHARGE GOALS (SURVEY PARTICIPANTS 1 - 15)</th>
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<tbody>
<tr>
<td>GOALS</td>
</tr>
<tr>
<td>1. Storage credits</td>
</tr>
<tr>
<td>2A. Use CAP water</td>
</tr>
<tr>
<td>2B. Benefit from CAP allocation</td>
</tr>
<tr>
<td>2C. See CAP water used in TAMA</td>
</tr>
<tr>
<td>3A. Put effluent supply to use</td>
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<tr>
<td>3B. Capture and use effluent locally</td>
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<tr>
<td>4. Income/revenue stream</td>
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<tr>
<td>5A. Reverse GWL decline</td>
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<tr>
<td>5B. Prevent GWL decline</td>
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<tr>
<td>6A. Alternative water supply and/or long-term storage</td>
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<tr>
<td>6B. Supply system redundancy and/or short-term storage</td>
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<td>7. Population growth (golf)</td>
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## RECHARGE GOALS (SURVEY PARTICIPANTS 16 - 28)

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*Assumes CAP allocation to Metro is approved.
B. Survey Participant Concerns about Risks of Recharge

By far the most often mentioned risk was:

1. **Long-term effects on the aquifer and groundwater quality.** This risk was mentioned in conjunction with both CAP water and effluent and refers to the higher salinity of those waters. For some, these risks were highest for well-injection recharge and lowest for GSFs. In one instance, (A) this risk was associated with the desire to recharge at locations distant from existing wells; (B) there was no such association for others. For some (C) it was an argument in favor of GSFs.

Other risks mentioned by two or more entity representatives were:

2. **Groundwater contamination.** This risk refers to the mobilization of contaminants by recharge.

3. **Third-party harms.** Concerns were expressed that storage and/or recovery by another entity will have a negative impact on groundwater levels, existing wells’ yields or water quality, land values, and/or growth potential in or near the responding entity’s area of jurisdiction.

4. **Flooding.** The risk is that recharge projects will increase the threat of flood damage either directly in flood-prone areas (by raising water levels and reducing infiltration capacity) or indirectly by increasing riparian vegetation.

5. **Rejected recharge.** There is a risk that artificial recharge will displace some naturally occurring recharge, rather than adding to it.

6. **Effects of in-lieu CAP water use on agriculture and mining.** Some stated concerns about increases in the cost of production, decreased yields, and salt buildup on land from in-lieu recharge.

7. **Post-recovery treatment.** This risk is that recovered water may have to be treated.

8. **Cost-effectiveness.** This risk refers to cost uncertainties involved in both (A) choosing recharge as a water management strategy alternative and (B) making a choice among projects.

9. **Credit accrual - security and value.** There is uncertainty about the number of credits accrued, how the performance of partners affects that number, and/or the value of those credits. This concern includes uncertainty about future regulatory decisions.

10. **Cost recovery.** Entities may not be able to recover CAP water and/or recharge project costs under ACC rulings.
## PERCEIVED RISKS OF RECHARGE

| RISKS                                           | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|------------------------------------------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 1a. Long-term water quality impacts (local)     |   | P |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 1b. Long-term water quality impacts (general)  | P | P | P |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 2. Contaminant mobilization                     | S | P | P |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 3. Third-party harms                            | P | P |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 4. Flooding                                    |   | T |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 5. Rejected recharge                            |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 6. Effects on agriculture & mining             | P | P | P |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | S  |
| 7. Post-recovery treatment                      |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | S  |
| 8a. Cost-effectiveness of recharge             | P | P | P |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | P  |
| 8b. Cost-effectiveness of project              | P | P |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | S  |
| 9. Credit accrual                               | S |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | P  |
| 10. CAP cost recovery                           | S |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | P  |
| 11. Legal liability                             | T |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    | T  |
| 12. ESA requirements                            | P | S | S | S | S | S | S | S | P |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

**Legend:**
- **P**: Primary objective
- **S**: Secondary objective
- **T**: Tertiary objective
11. Legal Liability. This risk refers to any of several possible sources of liability including contamination of existing wells, other third-party impacts, and accidents on site.

12. ESA requirements. The ESA and requirements for protection of endangered native fish may affect the feasibility of recharge projects.

The following table shows the risks, and the relative levels of significance, mentioned by each entity interviewed. (Note: All of these risks are taken into consideration by entities when developing recharge facilities. The following table shows the three most important risks for each entity; however, entities are likely to be concerned with all of these risks.)
REFERENCES


Johnson, Bruce. 1996. Personal communication.


