AN ANALYSIS OF THE EVOLUTION OF PUBLIC POLICY FOR

AQUIFER STORAGE AND RECOVERY:

EXPERIENCES IN THREE SOUTHEASTERN STATES

by

DANA JEAN WILLIAMS SEERLEY

(Under the Direction of JAMES E. KUNDELL)

ABSTRACT

One of the most important public policy issues of our time, both in the U.S. and abroad, is the management of water resources. A technique devised in recent years to help manage these resources is aquifer storage and recovery (ASR), which allows storage of water in underground aquifers instead of above-ground reservoirs or storage tanks. ASR is growing in use worldwide, more rapidly in some areas than in others. The storage technique is complex in that it entails thorough and site-specific analysis of hydrologic, geologic, and geochemical conditions. Because of its complexity and unfamiliarity to the general public, decisions regarding ASR use and regulation could easily be limited to a small group of experts rather than opened to public opinion. It thus provides an excellent opportunity for examining the policy-making process for such scientific and technological issues in general.

The fundamental question posed in this study is this: in addition to science, what elements—social, political, economic, or other—have influenced the decision-making process regarding the acceptance and implementation of aquifer storage and recovery? The hypothesis is that ASR generally remains the domain of scientists and engineering professionals unless a specific event, or sequence of events, propels it into the public policy arena. At that time, many other factors begin to shape the way decisions are made regarding ASR implementation and/or regulation. Science generally remains an important aspect of the decision-making process, but becomes only one element among many other considerations.

A series of case studies in Georgia, Florida, and South Carolina was used to examine how decisions have been made regarding aquifer storage and recovery. Florida and South Carolina have both implemented ASR, while Georgia has, at least temporarily, elected not to test the technique. It is expected that many aspects of the case study results can be generalized to other locations and circumstances, relative to ASR as well as other scientific policy issues.

INDEX WORDS: aquifer, ASR, groundwater, policy-making, risk

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

THEORETICAL BACKGROUND

INTRODUCTION & THEORETICAL OVERVIEW

We generally assume that public policy decisions about scientific and technical issues take into account all of the scientific information that is available, or at least that is readily accessible, at the time. However, for most issues, the sphere of public policy includes social, political, and economic elements that compete for priority. Does this hold true for highly complex scientific issues as well? What part do non-science factors play in this public policy arena? Assuming that such factors are the domain of public participation, do they compete with relevant scientific information, or are such technical issues beyond the knowledge or interest of the public to the extent that the public does not attempt to participate in the process? If the public were better educated about scientific issues, how might this impact the process of decision-making and the resulting decisions?

These questions are especially pertinent to issues regarding the acceptance or rejection of a new technology, which by virtue of its unfamiliarity, tends to be viewed by policy-makers with at least some trepidation. The use of sound scientific information is vital when initial policy decisions are made about the acceptance and regulation of a new technology because precedent established at this time may have long-term positive or deleterious impacts.

One of the most important public policy issues of our time, both in the U.S. and abroad, is the management of water resources. A technique devised in recent years to help manage these resources is aquifer storage and recovery (ASR), which allows storage of water in underground aquifers instead of above-ground reservoirs or storage tanks. ASR is growing in use worldwide, more rapidly in some areas than in others. The technique is complex in that it entails thorough and site-specific analysis of hydrologic, geologic, and geochemical conditions. Because of its complexity and unfamiliarity to the general public, decisions regarding its use and regulation could easily be limited to a small group of experts rather than opened to public opinion. It thus provides an excellent opportunity for examining the policy-making process for such scientific and technological issues in general.

The fundamental question posed in this study is this: in addition to science, what elements—social, political, economic, or other—have influenced the decision-making process regarding the acceptance and implementation of aquifer storage and recovery? The hypothesis is that ASR generally remains the domain of scientists and engineering professionals unless a specific event, or sequence of events, propels it into the public policy arena. At that time, many other factors begin to shape the way decisions are made regarding ASR implementation and/or regulation. Interest groups begin to form and promote their personal and collective agendas, and decisions are finally made based on which group communicates the most convincing argument to decision-makers. In the process, scientific information may be well integrated into the process; conversely, it may be ignored or manipulated to endorse or condemn specific viewpoints. Science generally remains an important aspect of the decision-making process, but becomes only one element among many other considerations.

A series of case studies in Georgia, Florida, and South Carolina was used to examine how decisions have been made regarding aquifer storage and recovery. Florida and South Carolina have both implemented ASR, while Georgia has, at least temporarily, elected not to test the technique. Other states and countries that use or have investigated the water management approach have unique physical, social, political, and economic conditions that likely contribute to quite different experiences with ASR. However, it is expected that many aspects of the case study results can be generalized to other locations and circumstances, relative to ASR as well as other scientific policy issues.

The dissertation is presented in five chapters: Chapter I provides a theoretical overview within which this research may be viewed, including a review of research concerning relationships between science and policy-making. Chapter II describes the Advocacy Coalition Framework, which helps give a structure to the policy-making process; gives a brief analysis and justification for the use of case study research; and outlines the specific methodology used in gathering data. Chapter III provides an overview of ASR and a description of the aquifer system in the study regions. Chapter IV recounts three case studies which elucidate the policy decision-making process regarding ASR. Finally, Chapter V compares and analyzes the three case studies in relation to existing theories of policy-making and the relationship of scientific information to policy-making.

AN OVERVIEW OF PUBLIC POLICY THEORY

The process of developing public policy is complex, value-laden, and often unpredictable. Many theories of public policy formation have contributed to the understanding of the process, some to a greater degree than others. However, no single policy theory, framework, or model can be said to completely and realistically reflect the complex realities of policy-making.

Sabatier (1999) points out several characteristics of public policy that combine to make it so difficult to grasp. Most significantly, it involves a wide variety of actors, institutions, and levels of government. In every dimension, policy-making is confronted and influenced by individual and collective beliefs, perspectives, and motivations. Issues are often multifaceted and interwoven, making it difficult for any one program or governmental entity to lay claim to a solution. Issues sometimes have technical and/or legal components that lack definitive answers, leaving room for discussion and debate regarding causes, effects, and viable alternatives. In the process of policy disputes, actors may resort to unscrupulous behavior in order to promote their causes. The analysis of public policy also involves long spans of time. It can take years from the initial emergence of an issue to reach a point where experience and time has distanced decision-makers and analysts enough to see the entire scenario and make objective judgments about events and their consequences.

Appendix A contains a summary of the most widely recognized public policy theories, frameworks, and models. Each contributes an important element to the study of policy decision-making and should be considered to some degree when academic research explores the complex reasons for a given scenario of policy decisions. First is a summary of descriptive policy theories arising from political science literature, including bounded rationality; incrementalism; punctuated equilibrium; elitism; group/pluralist theory; and political systems analysis. Second is a summary of both descriptive and prescriptive frameworks and models that the field of policy research has produced, including the heuristic stages approach; the garbage can model; the open system framework; institutional rational choice; multiple-streams; the advocacy coalition framework; and innovation and diffusion models.

APPLICATION OF POLICY THEORY

As noted earlier, no single theory, framework, or model adequately encapsulates every aspect of the very complex public policy process. Depending on the policy issue being studied, some are more applicable than others, and there are circumstances when it may make sense to combine theories or frameworks in order to attend to important aspects of the process. Public policy decision-making must take so many elements into consideration that it is difficult to segregate elements without eliminating at least some nuances of the process and without losing sight of the overall picture.

Elinor Ostrom (1982) points out that political economists rarely consider the full range of inputs into the policy decision-making process. "Implicit or explicit in the theories explaining individual behavior within institutional structures are five working parts, including

- the decision maker;
- the community affected by interdependent decision-making;
- events (or goods and services) interacting individuals seek to (influence or) produce or consume;
- institutional arrangements guiding individual decisions, and
- the decision situation in which individuals make choices."

Ignoring any of these parts, she says, “can misrepresent the decision maker’s environment and produce misleading predictions.”

When applying and evaluating any of the theories, frameworks, and models, it is therefore important to consider the holistic environment within which decisions are made and policies take shape. Together, these approaches offer a relatively complete perspective of the policy-making process. Separately, they can each be useful in an appropriate setting. None, however, completely captures the complexity of human behavior.

SCIENCE AND POLICY-MAKING

As scientific and technological advances are made, the public—and policy-makers —are increasingly dependent on scientists to relay information needed to make decisions on many different levels. Science can be viewed as a mixed blessing, however, as the benefits of technological advances have sometimes been accompanied by damage to human health and the environment. For instance, thalidomide, once commonly administered during pregnancy, was later found to cause birth defects. The construction of reservoirs for flood control and power generation, while providing these benefits, has caused significant ecological damage worldwide. On one hand, people tend to revere the scientific viewpoint; on the other, we are suspicious of the motives of those who hire the scientists, and are all the more skeptical when scientists disagree on seemingly factual issues (McElroy, 1993).

In the realm of public policy, the concern that science is not completely objective may lead to confusion and skepticism by policy-makers. Scientific information may be skewed by the values of the scientist or researcher, and scientific "facts" must be considered with this in mind. Because of the contentious nature of many environmental issues, the scientific process may be even more likely to be influenced by beliefs and values in this policy arena. Several other technical fields may also be similarly value-laden, such as nuclear power production and genetic engineering.

Scientists and policy-makers approach issues from different directions and with different expectations, leading to an inherent tension between the groups (Miller, 2000). In the culture of scientists, understanding is reached iteratively, as new research brings additional facts to light. Policy-makers, however, are faced with issues that require definitive answers upon which to base decisions and implement policies and programs. As one author put it, "Scientific input into the policy-making process often suffers from the hammer and nail syndrome. If all you have is a hammer, the whole world looks like a nail…the specificity and specialization of science may not be conducive to the comprehensiveness and generalizability needed in policy formation" (Smith, 2000). Several authors point out the need for increased cooperation between scientists and policy-makers so that scientists are aware of the questions that policy-makers need addressed and so that policy-makers understand that scientists cannot always provide exact and consistent information (Black, 2001; Rykiel, 2001; Trulio, 1999). However, another author asserts that (on a national level) "in most programs of health, safety, and environmental regulation, consultation between agencies and [science] advisory committees has become almost routine" (Jasanoff, 1990). Another disagrees with the entire process of front-end analysis and favors a model of adaptive management that provides a place for social learning in the policy formation process (Herric, 2000).

Jasanoff (1990) recognizes two primary paradigms for the use of science by regulatory agencies: the technocratic approach, which looks to science to validate policies with high technical components, and the democratic approach, which "views broad public participation as the antidote to the abuses of public authority." "The process is not wholly technocratic or democratic. The experts [science advisors] themselves seem painfully aware that what they are doing is not science, but a hybrid activity that combines elements of scientific evidence and reasoning with large doses of social and political judgment."

Indeed, the policy process holds itself accountable to social, economic, and political realities, reflected by three theories of regulation outlined by Smith (2000). The economic theory holds that regulations are driven by the needs of business; the political incentives theory argues that regulations arise out of political incentives that operate on policy-makers; and the public interest theory holds that policy-makers regulate "in response to broad social movements or crisis situations and act to protect the public from undesirable business practices." Smith contends that although each of these theories contains some truth, all fall short of explaining environmental regulations. "The most appropriate regulatory theory for environmental regulations would seem to depend on the politics surrounding a given regulation" (Ibid).

One theory of policy-making that seems to be without contest is that of incrementalism, described in the review of public policy theories. New policies and changes in existing policies tend to be made in predictably small increments that do not vary greatly from past decisions. Because of this tendency, one author contends, "new, unique, or seemingly radical policy alternatives are rarely, if ever, given serious consideration" (Smith, 2000).

Another area where most authors tend to agree is that of a lack of widespread public participation in the policy-making process, especially in terms of scientific and technical issues. "Science policy agenda is set largely by the leadership group, and the views of the attentive public are influential to the extent that they contact decision-makers to express agreement or disagreement with specific policy positions advocated by leaders or policy-makers" (Miller, 2000). Major issues that generate headlines garner public attention, but apart from interest groups that have a stake in the outcome, the public largely ignores the development of much new legislation and refinements in existing legislation (Smith, 2000).

Science in the Legislature: Feedback from the Front Lines

In a recent project, funded by the National Science Foundation and the Carnegie Foundation of New York, a team of researchers reviewed the availability of science and technology policy support to state legislators (Jones, et al. 1996). The first phase of the project included a survey of all 50 state legislatures in terms of their science and technology support needs and practices. After a review of the findings, the research staff conducted 185 interviews with legislators and staff from 11 states: Florida, Georgia, Kentucky, Louisiana, Minnesota, North Carolina, New Mexico, New York, Ohio, Wisconsin, and Wyoming. Surveys and interviews addressed seven specific areas:

- Need for science and technology policy support;
- Internal and external sources of science and technology support;
- Characteristics of useful science and technology policy support;
- Legislative use of technology;
- Technical information in a political environment;
- Legislative satisfaction with science and technology policy support; and
- Recommendations for improvement.

Following is a brief summary of the study's findings:

(1) State legislators need better access to technology information and analysis, and this need has increased over time as a result of increasing complexities, the importance of technology to state economies, efficiencies afforded by new technologies, the demanding nature of environmental problems, and technical sophistication of the public.

(2) State legislators have access to a variety of sources for scientific and technical information. Internally, they make use of joint research offices, legislative libraries, personal staff, and mentor legislators. Externally, they depend on executive branch agencies, lobbyists, state universities, national and regional clearinghouses, federal sources, and personally known individual sources.

(3) The most important characteristics of useful technical information and analysis pertain to the sources of the information rather than the information itself: sources must be trustworthy and accessible. Information must be accurate, objective, timely, up-to-date, relevant, and presented in a non-technical and usable format.

(4) Legislators and staff generally have personal computers linked to an area network,

and they regularly use internal e-mail systems. Internet and other electronic information sources are not important sources of information, however.

(5) Technology and analysis, used primarily at the stage of drafting legislation, is only one part of legislative decision-making process. Respondents consistently indicated that it was only rarely the most significant or definitive part. Opinions of constituents are generally more important than technology information and analysis. Technical information is used not only in making decisions, but in educating constituencies.

The main barriers to the provision and use of science and technology information and analysis are characterized as either supply-side or demand-side. On the supply side, staff members feel they do not have adequate time to produce information needed by the legislators, lack access to electronic databases and other potential data sources, and are frustrated by a volume of potentially relevant but difficult-to-access information. On the demand side, time is also a primary barrier. Legislators do not have the time to formulate questions properly and to assimilate information once it reaches them.

(6) Legislators responded that they are reasonably well satisfied with science and technology policy support (the average response was 3.86 on a 5-point scale, with 5 representing "most satisfied"), although respondents agreed that legislators do not necessarily know enough to be dissatisfied. Sources of dissatisfaction cited by the respondents are important to note, however. They included:

- Lack of adequate staff expertise in technical areas;
- Desire for technical information to be better linked to political information;

- Need for more coherent and effective synthesis of technical information;
- Need for better translations of technical information for the layperson;
- Unreasonable expectations and confusion about the contribution of computers and information technology;
- Information overload;
- Unclear lines of communication with external sources, particularly with state universities; and
- Inherent uncertainty of technical information.

(7) Recommendations for improvement included the following:

- Improve staff expertise in scientific and technical areas;
- Increase computer access, use, and training for both staff and legislators;
- Facilitate access to technical expertise at state universities and intersectoral organizations; and
- Increase the use of interns from professional societies and universities.

This research project underscores the need for increased cooperation between policy-makers and scientists, especially those at state universities who often support the informational needs of state government. On one hand, scientists need to take a more proactive approach in terms of educating legislators and staff and providing information that is not only relevant to current policy issues, but is understandable for those typically not trained in specialized fields of science. On the other hand, legislators must take responsibility for making their needs known to the scientific community.

Selected Examples of Science and Policy

Several other policy researchers, in looking at specific projects in the U.S., have reiterated some of these ideas. One example is the Central and Southern Florida Project Restudy conducted by the U.S. Army Corps of Engineers and the South Florida Water Management District, where a very complex project requires policy-makers to work closely with a variety of scientists. Walker and Mairs (1999) found that there is a disconnect between the two groups, and often scientific information lags behind the need for concrete answers by policy-makers. In addition, they recognized that both scientists and policy-makers tend to look for support for beliefs they already hold, and scientists are likely to make assumptions about issues and make implicit policy recommendations in reporting scientific information.

Other lessons can been learned from the history of the Carl Vinson Institute of Government at the University of Georgia as it has worked with the Georgia General Assembly on water resource issues. The Vinson Institute effectively translates scientific information to legislators in an accessible and understandable manner, and staff members at the Institute maintain an ongoing relationship with the General Assembly that facilitates informal communication about issues as they arise during legislative sessions. As James Kundell (1999) points out, the availability of scientific and technical information may not result in better policy decisions, but lack of such information and insights can certainly result in ineffective public policies.

A series of case studies conducted on the role of water professionals in developing water resource policy in the Black Hills of South Dakota (Fontaine, et al.) pointed out that hydrologists and water resource engineers there have contributed significantly to policy development. These professionals were often sought by government agencies to help officials understand technical information, acquire funding grants, complete analyses, and help to educate the public.

A report to the Carnegie Commission on Science, Technology, and Government by the Connecticut Academy of Science and Engineering (1994) examined the use of science advisors in six American states. The states included in the study were California, Connecticut, Georgia, New Mexico, New York, and North Carolina. These states use a number of ways to communicate scientific information to policy-makers. Most use a variety of external sources, such as university research centers, to provide timely information. The most prevalent problem found in these states was the lack of a formal mechanism for legislators to obtain reliable scientific advice. Science advice is most often obtained informally from a small group of trusted individuals. Formal advisement is variable and often dependent on supportive attitudes by the state government officials, and rarely is the legislature supported directly by adequate staff and funding.

The previous discussion raises a variety of questions related to water resources management. In the realm of water resources and new technology development, is the scientific literature and local knowledge consistent and trusted by policy-makers? Is the body of knowledge about groundwater and hydrogeology presently sufficient to make sound decisions regarding aquifer storage and recovery (ASR)? How much consultation takes place between policy-makers and the scientific community regarding new technologies for water storage and distribution? How much exchange takes place between different arenas of the scientific community (such as hydrology, engineering, chemistry, biology, ecology, etc.) when presenting information to policy-makers? How much is the regulatory process driven by economic and/or political motivations? If aquifer storage and recovery is slow to be adopted, is it because of inadequate knowledge, a tendency to adhere to the status quo, or other reasons? If it is quickly adopted, is it because of some sense of urgency, or are decision makers more certain of the scientific basis for its viability? Is it sometimes adopted in one location based on its success in another location? How much does the public participate in decision making regarding ASR, considering its technical nature? Is a relatively small group responsible for deciding whether and how the technique is implemented?

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CHAPTER II

RESEARCH FRAMEWORK

& METHODOLOGY

INTRODUCTION

The intricacy of the policy-making process regarding scientific issues, especially issues that entail new technology and some level of perceived public or environmental risk, requires both a research framework and a study methodology that allow flexibility so that the contextual elements surrounding the issue are not lost. One cannot point to a moment of time and understand how and why events happen without first understanding the history of relationships and attitudes that bring an issue to its current status. The advocacy coalition framework has been chosen as an especially appropriate framework within which to view this process because it focuses on how belief structures and learning, on an individual and collective level, affect the policy-making process.

In order to examine a contemporary issue and its policies within a geographical, historical, and social context, the case study method has been identified as the most effective approach. The case study allows research to be tailored specifically to the issue and the setting in which policy decisions about that issue are made. Following is a descriptive analysis of the advocacy coalition framework and the case study method, and an outline for how this study compiled the information required to analyze the process that has shaped policy decisions regarding aquifer storage and recovery.

THE ADVOCACY COALITION FRAMEWORK

First developed by Paul A. Sabatier in 1986, the advocacy coalition framework (ACF) has been revised and elaborated several times. During the last 10 years, the ACF has been used by researchers in the U.S. and abroad to study environmental and energy issues and, to a lesser extent, education, national defense, infrastructure, drugs, telecommunications, and gender discrimination in wages (Sabatier et al, 1999). The fundamental basis of the framework is its focus on the policy subsystem, which consists of all public and private actors who are interested in a particular policy issue and who seek to influence policy decisions regarding that issue. Within the policy subsystem, two or more advocacy coalitions, typically a dominant one and one or two subordinate coalitions, compete with each other in promoting their beliefs about the issue. These advocacy coalitions share fundamental beliefs about the policy issue around which they are built, and they coordinate their efforts to influence opinions and decisions. Learning takes place within and, to a lesser degree, between coalitions, influencing policy decisions. The integration of learned information in the policy process is one of the elements that differentiates the ACF from other frameworks and models.

The basic tenets of the ACF (Sabatier et al, 1999) can be summarized as follows:

- Policy subsystems are the primary aggregate unit of analysis.
- Individuals are assumed to have complex goals and a finite ability to process information due to perceptual limits and filters.
- Policy-oriented learning is an important aspect of policy change.
- Advocacy coalitions are comprised of large numbers of individuals from a variety of organizations and institutions and from various levels of government.

• Beliefs and policies are “mapped on the same canvas” to facilitate the role of scientific/technical/other information in the policy-making process.

• Coalitions promote their belief systems in an instrumentally rational fashion to influence the behavior of governmental and other institutions.

ACF Structure

The policy subsystem, as noted, consists of a wide variety of people and organizations interested in a given policy area or issue. The actions of the subsystem are governed by two sets of variables. The first is relatively stable and consists of the basic characteristics of the policy arena (social structure and values, distribution of natural resources, and rules governing actions of subsystem members). The other set is more dynamic, including elements such as economic conditions, political incumbencies, and policy decisions. (Sabatier et al, 1999)

Within the subsystem are two or more advocacy coalitions, which are comprised of groups and individuals from a variety of private and public organizations: government officials, journalists, researchers, and interest group leaders. The ACF identifies two key characteristics of advocacy coalitions (Sabatier, et al 1999): they share a set of normative and causal beliefs, and they engage in a “nontrivial degree of coordinated activity over time.” The belief systems of the coalitions have a hierarchical structure. At the highest level are *deep core beliefs*, which are the most fundamental, deeply held, and resistant to change. Second are *policy core beliefs*, which include fundamental values and priorities about the way a particular issue should be viewed and problems solved. Third are *secondary beliefs*, which are narrower in scope and include more specific beliefs about the policy issue. These are the beliefs most easily influenced by new knowledge. Policy brokers comprise a separate group that serves a mediating function by trying to find areas for compromise and thus reduce conflict between the advocacy groups.

The ACF identifies three primary sources of policy change: policy-oriented learning; real-world changes, such as socioeconomic conditions; and turnover in personnel, which can alter the resources of coalitions to increase or decrease their effectiveness. Of the three, policy-oriented learning is the main focus of the ACF. It is defined by Sabatier et al (1999) as “relatively enduring alterations of thought or behavioral intentions that result from experience and/or new information and that are concerned with the attainment or revision of policy objectives.” Each coalition is thought to make an effort to gain the knowledge necessary to further their policy goals. Information that conforms to existing beliefs will be used to buttress opinions and possibly attack opponents, and information that conflicts with existing beliefs will be resisted.

Individual/Collective Behavior

An important aspect of this framework is the role of individual behavior in the policy-making process. While some theorists model behavior on goals of political or economic interests, the ACF acknowledges that goals are complex and often difficult to identify. Not only are individuals limited by cognitive constraints and perceptual filters, but actors in coalitions tend to have a weighted view of their strengths and weaknesses compared to other coalitions. Each coalition tends to remember its losses more than its victories, and opponents are seen as "more evil and more powerful than they probably are." (Sabatier, 1999)

The ACF assumes that coalitions use a variety of mechanisms to influence policy decisions (Sabatier, 1999). These include trying to:

- influence legislatures through testimony and campaign contributions;
- change the incumbents of various political positions;
- affect public opinion;
- alter target group behavior; and
- change perceptions of other actors through research and information exchange.

Recent Applications of the Advocacy Coalition Framework

In a 2000 study of globalization and Canadian climate change policy, Karen Litfin applied the ACF to explore how coalitions operate on both a national and international level. She argues that increasing globalization in the environmental policy arena and others is blurring the boundaries of many subsystems, and contends that the ACF can be enriched by incorporating recent literature in international relations theory that acknowledges the convergence of domestic and foreign affairs (Litfin, 2000).

An important contribution that Litfin makes is her analysis of the ACF's utility for studying environmental policy. She presents three reasons that the ACF is ideally suited for this domain:

- Environmental problem solving usually involves multiple agencies and levels of government and is driven by coalitions of diverse stakeholders;
- More than other issues, environmental policy is driven by technical and analytical knowledge; and
- Because the core beliefs of clashing coalitions generally are both deeply held and fundamentally incommensurable, scientific information is politicized easily, particularly in more adversarial policy systems.

According to Litfin, “the politicization of science is a hallmark of the environmental policy process,” and, “despite the fact that the environmental policy agenda often is science-driven, policy outcomes are constrained by socioeconomic and political structures.”

In another environmental policy study, Brian Ellison applied the ACF in the implementation of the Endangered Species Act in relation to the construction of the Bureau of Reclamation’s Animas-La Plata water project in California. His study concentrates on how the ACF can be applied to examine the stability of coalitions over time as implementation complexities arise. The most significant finding of the study was that there was no gap between policy formulation and implementation, but a continual process of reorganization and redesigning in response to implementation difficulties. During the entire process, policy core beliefs held together coalitions, although the coalition promoting water development was forced to concede secondary aspects of its belief system to succeed in completing the project (Ellison, 1998).

Advocacy coalition theorists have consistently concluded that paradigm shifts rarely come about except in response to a major external event. Lertzman, Rayner, and Wilson (1996), in a study of the contentious political debate surrounding British Columbia's forest management, found that this is not always true. Such a paradigm shift can take place when, as happened in B.C., ideas that legitimate the dominant coalition constrain that coalition's freedom of action and thus force change. They also found that scientific uncertainty can undermine the power of dominant advocacy coalitions by removing the certainty upon which their entrenched interests are based.

In 1998, Sabatier conducted an extensive study of how and why coalition beliefs and strategies changed over time in the formation of water resources policy in the San Francisco Bay area. In addition to interviewing present coalition leaders, Sabatier conducted a content analysis of 550 testimonies presented at 60 public hearings that had dealt with some aspect of Bay-Delta water policy between 1953 and 1996. For each testimony, every statement that pertained to 683 belief variables (each of which falls under one of five major categories) was coded. The final analysis of the project showed that although the topics discussed varied from one period to another, there was very little change in beliefs over time. Perceptions and values remained "remarkably stable over time," possibly owing to the fact that the alignment of coalitions remained stable over long periods (Sabatier, 1998).

Analyses and Critiques of the ACF

As the ACF has become more well known since the mid 1980s, a number of researchers have suggested ways to improve the framework and/or to combine it with other models to make it more effective. One such suggestion came from Menno Fenger and Pieter-Jan Klok, who examined how actors with certain policy belief systems develop and maintain advocacy coalitions—an element they say is missing from the ACF as it now stands (Fenger, 2001). Fenger and Klok suggest that it would be useful to look at the relationships between coalitions, particularly the levels of interdependencies that exist between them, to see how these might affect their behavior.

The authors arranged two variables, levels of interdependency (symbiotic, independent, and competitive) and relationships between coalitions' beliefs (congruent, indifferent, and divergent), to show a hierarchy of relationships and behavior. Table 1, shown below, demonstrates a range of possible relationships, from strong coordination to strong conflict.

Table 1 Coalition behavior as the result of interdependency and belief congruence

Level of Interdependency	**Beliefs** Congruent	Indifferent	Divergent
Symboitic	strong coordination	coalitions of convenience	unstable conflict, depolitization, learning
Independent	weak coordination	no coalitions	weak conflict
Competitive	coalition with severe collective action problems	weak conflict	strong conflict

Source: Fenger (2001)

To demonstrate the usefulness of this approach, Fenger and Klok looked briefly at the debate over oil and gas leasing on the Outer Continental Shelf of the United States. Although a more rigorous empirical analysis is needed, the analysis illustrated the plausibility of their hypothesis.

Minstrom and Vergari (1996) examined the possibility of combining the ACF with another approach to advocacy coalitions: the policy entrepreneur model (PE). The PE model recognizes the activities of people who take a proactive part in the formation, growth, and maintenance of advocacy coalitions. These actors, they say, promote their ideas in various ways, including identifying problems, shaping the terms of policy debates, networking in policy circles, and building coalitions (Minstrom, 1996).

The authors suggest that the PE model is not only compatible with the ACF, but that the ACF can gain increased explanatory power by incorporating some of the PE model's insights. First the PE model can help explain how coalitions form. "An important aspect of coalition building involves framing issues in ways that appeal to diverse interests. The policy entrepreneur must devise optimal ways of framing an issue to show potential coalition members how their (often diverse) interests will be served by joining it" (Ibid). Second, the ACF can benefit from PE insights on how policy innovations become part of the policy agenda. "Not only do policy entrepreneurs work to build coalitions, they also go to considerable lengths to network within and around government" (Ibid).

Dale Krane reviewed one of Sabatier's books on the ACF, entitled Policy Change and Learning: An Advocacy Coalition Approach (Krane, 1995). Krane wrote that the ACF's main virtues are its emphasis on the importance of beliefs and their relation to coalition behavior and policy change; the utility it provides in the study of policy subsystem origins and their evolution; and its capacity to support quantitative research. He also noted several shortcomings of the framework, including:

- The ACF authors fail to acknowledge other concepts and research that bear directly on their model.
- The ACF ignores the wealth of empirical and formal work on coalition behavior and bargaining.
- The ACF authors introduce elements of the model such as "policy brokers" and then never quite identify them or explain how they function.

Schlager and Blomquist, in a 1996 article, were critical of the ACF for lacking a mechanism for examining the interests or preferences of the individuals within coalitions. This causes two problems: first, differences and conflicts within coalitions may be viewed by the ACF as differences in learning, when they are actually differences in interests. Second, the ACF offers no basis for explaining or predicting strategic behavior. "One is left instead to presume that individuals act naively on the basis of their beliefs, and that they do not misrepresent their policy preferences when attempting to attain more preferred outcomes. These are questionable assumptions in the context of politics." (Schlager, 1996) Further, the framework tends to attribute policy change over time to changes in the coalition members' beliefs or preferences, rather than to changes in the membership itself. The dynamics that take place within coalitions, including coalition rules, norms, and sanctions, may have a significant impact on the policy outcomes. These dynamics, they contend, are not addressed adequately by the advocacy coalition framework (Ibid).

Applicability of ACF

In conclusion, the advocacy coalition framework provides an excellent structure within which to examine complex policy issues, especially those that include technical or scientific components, such as environmental policy issues. Although the framework has some shortcomings in terms of accommodating the interests of coalition members and how coalitions form and relate to one another, it surpasses other frameworks and models in its ability to explain the belief systems of coalitions and how profoundly they influence the policy-making process.

CASE STUDY RESEARCH

The case study has been criticized as a weak method compared with other social science research strategies. Nevertheless, case studies continue to be used extensively in social science and political science research, including anthropology, economics, public administration and public policy, education, sociology, and social work. Given its continued popularity for rigorous research projects, this strategy must possess many advantages for certain types of projects. Indeed, it has characteristics that permit the understanding of contextual complexities in a way that no other strategy can match. Jensen and Rogers (2001) point out that "public administration is well suited to case studies because they satisfy the recognized need for conditional findings and in-depth understanding of cause and effect relationships that other methodologies find difficult to achieve."

The Landscape of Political Science Research

Political science research generally falls into one of five categories: experiments, surveys, archival analyses, histories, and case studies. The experiment measures and evaluates events in a controlled setting, purposefully removed from the environment in which the events naturally take place. The survey is best used when finite and standardized variables can be identified in order to quantify a phenomenon. The archival analysis and historical approaches are best applied when there is no access to or need for contemporary participants or observation. Yin (1994, p. 6) categorizes the research methods in terms of the types of questions they can answer, as shown in Table 2, below.

Table 2 Relevant situations for different research strategies

Strategy	Form of research question	Requires control over behavioral events?	Focus on contemporary events?
Experiment	how, why	yes	yes
Survey	who, what, where how many, how much	no	yes
Archival analysis	who, what, where, how many, how much	no	yes/no
History	how, why	no	no
Case study	how, why	no	yes

Source: COSMOS Corporation/Yin (1994)

Of the methods that are capable of explaining how or why events unfold in a particular way, the case study is best suited to examine events within their natural and contemporary context. In addition, the case study can include a variety of evidence — documents, artifacts, interviews, and observations—making it an extremely powerful tool when the context of the research question is entwined with the subject of research. Yin maintains that “the essence of a case study is that it tries to illuminate a decision or set of decisions: why they were taken, how they were implemented, and with what result.”

The arguments against case study research are easily met with reasoned counter-arguments. The most common criticism is that case studies can be done improperly so that they present a biased viewpoint. This can be true of any study, including those using surveys and experiments. In order for a case study to have academic merit, it must be done with the same systematic care as any other research method. Second, case studies are said to have little basis for generalization. Again, this is no more true of case studies than of other methods. The replication logic of a case study is the same as that which applies to experiments. In addition, case studies are used to generalize to a theory rather than to a population (de Vaus, 1998). Third, case studies have been known to take massive amounts of time and energy to execute and to result in enormous documents. This is not the norm and certainly is not a necessary or desired feature of case studies.

Case Study Research Defined

Keith Punch (1998) enumerates four key characteristics of case studies:

• The case is a 'bounded system'— it has boundaries. It is the responsibility of the researcher to identify and describe the boundaries between the case and its context.

• The case is a case of something—identifying exactly what constitutes the case is important in determining the unit of analysis.

• There is an explicit attempt to preserve the wholeness, unity, and integrity of the case, and specific focus is required, defined in part by research questions.

• Multiple sources of data and multiple data collection methods are likely to be used.

Case studies can use sociological and anthropological field methods, such as observations in natural settings, interviews, and narrative reports, as well as question-naires and numerical data. Rather than eliminating historical/contextual factors from the analysis, the case study includes them in order to enhance understanding. The quality of the case study rests on how well it identifies these factors and includes them in any explanation (de Vaus, 1998).

Yin (1994) points out that case study research is often confused with qualitative research. Some qualitative research follows similar ethnographic methods, but ethnographic research does not necessarily produce a case study. Case studies do not require direct observation, and they can include *any combination* of qualitative or quantitative evidence.

Yin (Ibid) enumerates five clear applications for case studies:

• To *explain* the causal links in real-life interventions that are too complex for the survey or experimental strategies;

• To *describe* an intervention and the real-life context in which it occurred;

• To illustrate certain topics within an evaluation, again in a descriptive mode – even from a journalistic perspective;

• To *explore* those situations in which the intervention being evaluated has no clear, single set of outcomes; and

• May be a "*meta-evaluation*" – a study of an evaluation study.

The case study should include the following components: research questions, propositions, unit(s) of analysis (what is considered a "case"), logic linking the data to the propositions, and criteria for interpreting the findings. The most essential aspect of a good case study is the theoretical development that should take place during the research design phase (Yin, 1994; de Vaus, 2001). Whether the case study is to test a theory or create a new theory, a theoretical basis is necessary to guide the data collection.

Is the Case Study Method Appropriate for Exploring the Decision-Making Process for Implementing Aquifer Storage and Recovery?

Based on several analyses of case study research, the case study appears to be the most appropriate research tool for delving into the many dimensions of this complex issue. It is essential that the research strategy allows exploration into the decision-making process in the scientific, social, and political context within which it takes place. It is also essential that a variety of data-collection methods be available in order to explore the full range of possible influences upon the process.

Case Study Design

Following are the basic elements of case study design (adapted from de Vaus, 2001), representing the choices that a researcher must make in setting the parameters of a case study research project:

- *Descriptive or explanatory*: a case can provide a simple description of events or delve as well into cause-and-effect relationships.
- *Theory testing or theory building*: a case can test or refine existing theories, requiring clear propositions, or build theory based on the results of the case.
- *Single case or multiple-case*: single cases are useful when there is a critical or unique case, while multiple-case comparisons are most useful for generalizing findings to similar scenarios.
- *Holistic or embedded units of analysis*: case studies can conform to two basic levels of complexity. The holistic unit of analysis entails viewing social or political structures as a whole within their environment, while an embedded design examines multiple elements within the structure itself.
- *Parallel or sequential case studies*: multiple case studies can be done either at once, with comparisons made only upon the completion of all case studies, or sequentially, with the first case providing information that influences the subsequent choice of cases.

• *Retrospective or prospective*: a retrospective design involves collecting information relating to a specific period of time, involving a reconstruction of history; a prospective design tracks changes over time, enabling a researcher to study events as they unfold.

Case Selection for a Multiple-Case Design

Cases should be selected for theoretical and targeted purposes. There is no "correct" number of cases to include; with multiple case studies, the number of cases is rather a matter of judgment (de Vaus, 2001). A strategic selection of cases requires the researcher to have some knowledge of a case before the case study proper begins, and extensive case screening may be needed before actual cases are selected.

David de Vaus (Ibid) warns, "The temptation is to 'get your hands dirty' early on — to get out there and learn from the cases in full confidence that the truth of the case will somehow emerge. Too often people commence case studies without knowing what their research question is or what propositions they are evaluating. This is a recipe for disaster. It is essential to have a clear research question before beginning a case study. Indeed, we cannot even begin to select cases until we have a clear statement of the research question."

RESEARCH METHODOLOGY

Heeding the previous warning, the foundation for this research was well established prior to gathering specific information to be applied to each case.

Focusing on the fundamental decisions to be made in case study design, the elements chosen for this dissertation are as follows.

- Three states were chosen for case study research: Georgia, Florida, and South Carolina;
- The case studies are explanatory;
- The studies test the application of the advocacy coalition framework;
- Embedded units of analysis examine multiple elements of the policy process;
- The cases are treated as parallel and are analyzed as a group; and
- The cases are retrospective: a contextual history of events is included with a study of more current events that led to particular policy decisions.

Georgia, Florida, and South Carolina were chosen for the study for a variety of reasons:

- The three states' geographical proximity facilitates information sharing about both technology and policy issues. Scientific information as well as public attitudes about science and technology issues would be expected to transfer more easily between contiguous states than non-contiguous states.
- As neighboring Eastern states, they share a similar history of water law, which would tend to shape similar attitudes about water use and management.
- Georgia, Florida, and South Carolina all obtain a substantial amount of their drinking water from the same aquifer—the Floridan—and this commonality allows study comparisons that would not otherwise be available.

• These states share some common concerns: they all are experiencing rapid coastal population growth, all have a history of intensive groundwater use, and all must contend with problems related to excessive withdrawals of groundwater.

• The three states have taken significantly different approaches to ASR. Florida has embraced the technique to a greater extent than any state in the U.S., and the number of wells is growing rapidly. In South Carolina, several wells provide seasonal storage predominantly for municipal systems. Georgia, on the other hand, has not implemented ASR . A temporary moratorium enacted by the Georgia General Assembly prevented its use from 1999 until the end of 2002.

• Finally, the proximity of the subject regions to the University of Georgia allowed access to people and materials that might have been more difficult to obtain from a greater distance.

Information sources included scientific and regulatory documents and reports, interviews conducted in person and by telephone, meeting notes, letters, e-mails, newspaper articles, permitting correspondence and applications, and information from legal proceedings. In order to ensure that the materials collected for each case study were appropriate and indicative of the unique sequence of events that took place in each state, local newspaper articles and preliminary interviews provided an overview of the three states' policy environment relative to ASR.

The sources used for each state were, indeed, quite different, and reflected the unique experiences of the three states. Personal interviews provided a significant amount of information for all three states. However, in Florida, regulatory documents and newspaper articles provided the dominant source of printed documentation. In

Georgia, pertinent documentation was found in newspaper articles, meeting notes and other records of correspondence, and state government agency records. In South Carolina, there was virtually no newspaper coverage of ASR, and documentation for the case study came primarily from state regulatory records and local water facility records.

In order to obtain the most candid responses possible, interview questions were prefaced by an assurance that unless expressed consent was given, specific expressions of opinion would not be quoted in this dissertation. Where direct quotes have been used, the speaker has given such permission. Otherwise, to protect the privacy of individuals who were generous with their time in answering questions about ASR policy-making experience in their state, a certain amount of the information is presented without specific reference.

To begin the interview process, a list of interview questions was prepared and approved by the University of Georgia's Office of Human Subjects. The course of each interview invariably led to other questions that related to additional information volunteered by the individual. Some interviews also necessitated additional questions that pertained to specific details about the operation of ASR facilities. In Georgia, some of the questions did not apply because ASR has not been implemented there, and thus question numbers eight and nine (see below), relating to the safe operation of existing ASR wells, were omitted.

Interview questions:

(1) What do you see as the driving force for ASR being used in your state?

(2) Based on your experience, how have policymakers (in specific agency or agencies responsible for making policy decisions about ASR) dealt with the need for scientific information in making decisions about implementing and regulating ASR?

(3) What formal mechanisms have been established for transferring information to agency members from professionals in fields such as hydrology, geology, geochemistry, ecology, engineering, or other fields?

(4) What informal ways has information been transferred regarding the site-specific scientific needs for making decisions about ASR implementation and regulation?

(5) Do you think agency members have a good understanding of ASR and the site-specific needs to ensure that it is done in a way that protects water resources and public health?

(6) To what extent do you believe scientific information has been used in making decisions?

(7) How do you feel the information has been used? (i.e., to support the use of ASR, refine procedures or controls, limit debate, etc.)

(8) Do you think the process has been effective in ensuring that the technique is implemented safely in terms of protecting water resources and the geological integrity of the aquifer?

(9) If not, what could have improved the flow of information to policy makers so that decisions could have been more soundly based on science?

(10) What other factors (political, economic, or other) do you think influenced decision-making in adopting and regulating ASR in your state?

(11) Is there someone else that you would recommend that I speak with about your state's ASR decision-making process?

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CHAPTER III

THE POLICY SETTING:

AQUIFER STORAGE AND RECOVERY

INTRODUCTION

Prior to exploring the policy experiences related to aquifer storage and recovery (ASR) in Georgia, Florida, and South Carolina, it is helpful to review basic groundwater hydrology principles and survey the aquifer systems that exist in the three states. This chapter provides such background as well as an overview of ASR, including how it works, where and how it is used, what possible adverse effects are possible, and how various states regulate its implementation.

GROUNDWATER HYDROLOGY PRINCIPLES

An aquifer can be thought of as an underground sponge, which, depending on its geologic composition and the size of its particles, can store and transmit varying amounts of water. Water passes through either voids between individual particles in a sedimentary media or through cracks or channels in consolidated media. When an aquifer consists of sand, sandstone, or similar material in which voids are present, water passes through relatively quickly, whereas zones of small voids in clay and silt media tend to restrict the movement of water and may serve as confining layers. Groundwater movement is generally very slow, but can range from less than an inch per year to as much as many feet per day (Kundell, 1978).

The subsurface potentiometric surfaces depend on a balance between recharge (flow of water into the aquifer system), discharge (flow of water out of the system), and storage. Most aquifers discharge flows into bodies of water (e.g., lakes, rivers, or oceans); artificial discharge occurs when wells are constructed for purposes of water withdrawal.While natural recharge relies on the percolation of water from overlying geologic units, or from direct recharge from surface water in direct contact with the aquifer, aquifers may also be artificially recharged through wells.

Groundwater normally contains a higher concentration of dissolved solids than surface water because of its increased contact time with soils and rock. The chemical composition of groundwater is generally influenced by the mineral composition of the geologic layers that comprise the aquifer. Geochemical reactions occur between groundwater and the aquifer materials, which over time result in a geochemical equilibrium. The concentration of dissolved solids generally increases with greater depth and residence time of the water (Kundell, 1978).

The following terminology will also prove useful in subsequent discussions:

Water table – the water level in an unconfined aquifer, occurring at the interface between the zone of saturation and the zone of aeration

Confining layer – a layer of low permeability that limits the flow of water from one subsurface zone to another

Confined aquifer – an aquifer that is overlain by a confining layer

Unconfined aquifer – an aquifer without an upper confining layer that is exposed to the atmosphere, and whose upper surface is the water table

Potentiometric surface – in an unconfined aquifer, this is equivalent to the water table; in a confined aquifer, this is the level to which water rises in a well

Artesian well –a well drilled or bored into a confined aquifer causing water to rise above land surface

Cone of depression – a depression in the potentiometric surface around a well or series of wells that is caused when pumping exceeds water inflow to the area

Drawdown – the lowering of water levels in an aquifer related to a pumping well

Transmissivity – rate at which water moves through an aquifer, determined by both the composition of the aquifer and the aquifer thickness

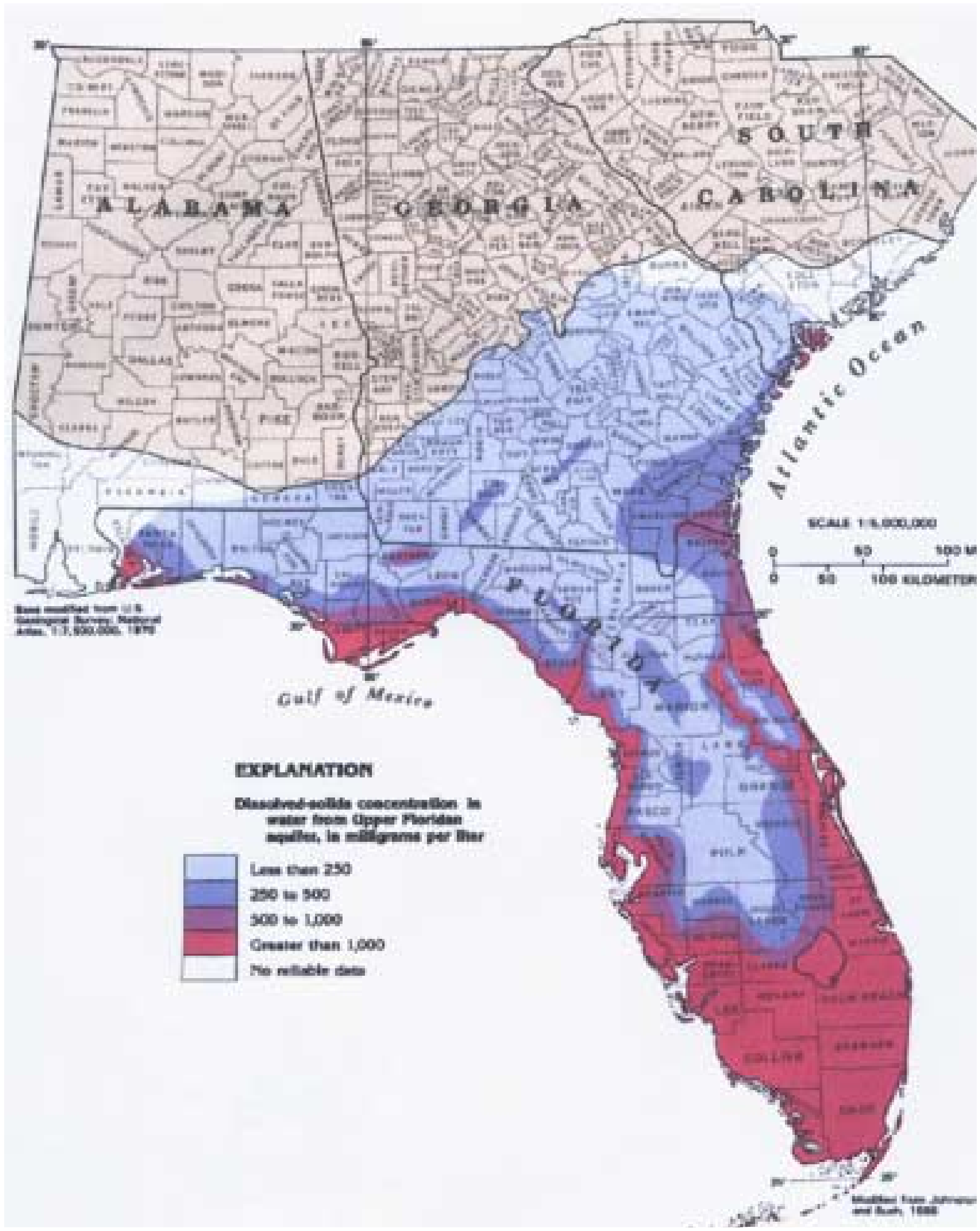
GROUNDWATER RESOURCES OF
GEORGIA, FLORIDA, AND SOUTH CAROLINA

A complex system of aquifers exists in Georgia, Florida, and South Carolina. In most of this region, the Floridan aquifer is the major source of groundwater. Aquifer systems in the region include the surficial aquifer system, the Brunswick (previously known as the Miocene) aquifer, the Biscayne aquifer, the sand and gravel aquifer, the Floridan aquifer system, the Southeastern Coastal Plain aquifer system, the intermediate aquifer, and the Piedmont and Blue Ridge aquifers. The Floridan aquifer is the most prevalent structure in terms of applying aquifer storage and recovery in Florida and part of Georgia and South Carolina. However, it is useful to understand the entire system because where other aquifers lie above or below the Floridan, there has been concern among some groups about migration of injected waters (LEAF, 2002). In addition, ASR may be considered in areas where groundwater is not generally used but where significantly fractured rock might allow subsurface water storage.

Geologic changes take place just north of Beaufort, South Carolina's southernmost coastal city. There, the prolific Floridan aquifer thins, deepens, and gives way to another system of aquifers (Devlin, 2003). In the northern coastal plain of South Carolina, the subsurface layers, from the surface downward, are the Tertiary aquifer, the Santee Limestone aquifer, the Black Mingo aquifer, the Black Creek aquifer, the Middendorf aquifer, and bedrock (DHEC 6/2002). The permeable zones of the Santee Limestone and the Black Mingo correspond to the Floridan aquifer system and are relatively thin (only about 70 feet thick) at Charleston (Campbell et al.).

The Floridan is the aquifer that is generally used for aquifer storage and recovery in Florida and southern South Carolina, and is the aquifer that was considered for its use in Georgia. It underlies an area of about 100,000 square miles, and is the primary water source for most of Florida, southern Georgia, and southeastern South Carolina. (See page 48 for a map showing the concentrations of dissolved solids in water from the Floridan aquifer.) The Floridan is one of the most productive aquifers in the world. In this region, about four times as much water comes from this aquifer than the Biscayne, the second most used aquifer (Ibid). The Floridan aquifer is composed of limestone and dolomite, carbonate rocks which are readily dissolved when they lie at or close to the surface. Rainwater absorbs carbon dioxide as it passes through the atmosphere, which forms a weak acid called carbonic acid that dissolves the limestone and dolomite of the aquifer. This process creates enlarged pores between grains of limestone and forms larger solution channels in the rock, resulting in a topography referred to as “karst.” This topography is characterized by sinkholes, caves, springs, and other features caused by dissolution. In a large area where the aquifer lies close to the land surface in central Florida and southwestern Georgia, sinkholes and springs are common. Activities such as surface water diversion, dredging, reservoir construction, and groundwater withdrawal can accelerate the formation of sinkholes.

Major recharge zones of the Floridan aquifer are along the upper edge of the aquifer in Georgia and the panhandle of Florida, and two areas of central and north central Florida (Alachua and Clay counties to the north and Polk County further south). Water is generally believed to flow southeastward in Georgia and South Carolina, south



(Source: USGS)

Figure 1 Concentrations of dissolved solids in water from the Floridan aquifer in the Florida panhandle, and in all directions from the recharge zones in the central peninsula of Florida (Ibid).

Most of the Floridan aquifer can be divided into the Upper Floridan and the Lower Floridan. Throughout most of Georgia, South Carolina, and about two-thirds of Florida, the Upper Floridan contains freshwater, while along the coast of Florida and beneath all of the peninsula south of Lake Okeechobee, the aquifer contains brackish water.

The Lower Floridan aquifer is separated from the Upper Floridan aquifer by a confining layer that varies in thickness, from a thin or absent confining layer to one of 1000-foot thickness. The confining material varies as well; however, where it exists, it restricts movement of water between the two zones. In southern Florida, two or three confining layers are stacked (Ibid). In some areas, the lower confining unit contains calcium sulfate beds, which, when dissolved, creates concentrations of sulfate in the groundwater and ultimately causes the "rotten egg" taste and smell characteristic of water along the coastal border between Georgia and Florida (Kundell, 1978).

The Lower Floridan aquifer contains water that ranges in salinity (but is generally much more saline than the Upper Floridan), with the most saline zones further south. In southern Florida, it contains brackish water. It has two highly permeable zones: the Fernandina permeable zone in northeastern Florida and southeastern Georgia, and the Boulder Zone in southeastern Florida, which contains brackish water.

The surficial aquifer encompasses most of the shallow aquifers throughout most of the region and includes all otherwise undefined aquifers that lie just below the land surface. The surficial aquifer system consists primarily of sand, shelly sand,

and shell. Because of their proximity to the land surface and the rapid interchange between these aquifers and surface water, they are more susceptible to contamination.

Two of the named surficial aquifers can be found in relatively small areas of Florida. The Biscayne aquifer is the primary water source for the densely populated area of southeastern Florida, including Boca Raton, Miami, Ft. Lauderdale, and the Florida Keys. It is comprised of permeable limestone, sandstone, and sand. Prior to the drainage of wetlands with a series of canals, a shallow sheet of surface water recharged the Biscayne aquifer. Interchange currently takes place between the aquifer and the canal system as well as surface sheets (Miller, 1990).

The sand and gravel aquifer, also a surficial aquifer, can be found beneath the western third of Florida’s panhandle, and serves as the primary water source for Pensacola. As the name implies, it is composed of sand and gravel. It is divided into an upper and a lower zone, with the lower being the main water supply source.

Collectively, aquifers found between the Upper Floridan aquifer and the surficial aquifers are called the intermediate aquifer system. In Florida’s Sarasota, Lee, and Charlotte counties, the intermediate aquifer system is the main source of water supply because the Floridan is deep and brackish in this part of the state. The intermediate system consists of sand beds and limestone that lie between layers of confining clays. In most places, water percolates through the upper confining layer to recharge this aquifer. Georgia’s Brunswick aquifer, which provides groundwater in some coastal communities, is considered an intermediate aquifer.

The Southeastern Coastal Plain aquifer system consists of a system of several regional aquifers that underlay the Floridan aquifer in parts of Georgia and South

Carolina coastal plains. The system consists mainly of fine to coarse sand, with confining layers of silt and clay. In some areas, there is no confining unit between this aquifer and the Floridan aquifer, and water passes freely between them (Miller, 1990). The Southeastern Coastal Plain aquifer is an important water source for the interior parts of the coastal plain, which are not heavily populated.

The Piedmont and Blue Ridge aquifers, in the Piedmont and mountains of Georgia, consist of metamorphic rocks overlain by weathered regolith (clay, rock, sand, and boulders), called saprolite(Ibid). Water storage takes place predominantly in fractures and in thesaprolite, and a dependable well yield generally requires the well to intersect localized water-bearing structures.

WATER RESOURCES MANAGEMENT AND AQUIFER STORAGE AND RECOVERY

Effective water resources management has become an increasingly important worldwide policy area in recent years as urban populations have expanded and agricultural production has begun to rely more heavily on irrigation (Gore, 1993). Increased demands can be met easily enough in times of abundant rainfall, but as droughts across the country have demonstrated, rainfall deficits can cause widespread water shortages that necessitate water usage restrictions. In order to meet Georgia's present and future water needs for population growth, commerce, and natural systems, policymakers will need to consider a wide array of water supply options.

The United States and many other countries have responded to this need for increased storage capacity by stepping up the licensing and construction of surface water reservoirs. The environmental damage caused by damming waterways is well documented (McCully, 1996). In addition to flooding often scenic undeveloped land that provides recreational opportunities for humans and habitat for aquatic and terrestrial plants and animals, dams may cause environmental harm to downstream systems as well. Depending on local hydrologic conditions, Aquifer Storage and Recovery (ASR) can offer a reasonable alternative to surface reservoirs, both environmentally and economically.

In some areas, groundwater is the primary source of public water supplies, and aquifers are in danger of being over-utilized. Along the coast, aquifer overdrafts are causing numerous problems. Well water pressure has declined, wetlands have vanished, land surface levels have dropped (a phenomenon referred to as subsidence), and saltwater intrusion threatens drinking water wells (USEPA, 1999).

ASR was first implemented in the U.S. in 1968 (SFWMD, 2001), and 16 U.S. states now use ASR to some extent to augment water supplies (USEPA, 1999). The method is particularly useful in areas where there is high demand for groundwater or where ground or surface water supplies are limited, especially in heavily populated areas and areas where irrigation agriculture is concentrated.

This water storage approach should be examined more broadly so that where it is technically, economically, and environmentally feasible, ASR can assist water resource management by 1) supplementing existing surface reservoirs and possibly eliminating the need for additional reservoirs; and 2) allowing for the replenishment of underground water supplies to alleviate the effects of over-pumping.

The use of ASR has been limited, in part, because the regulations for well injections developed as a means to protect groundwater resources from injections of waste products from oil production and manufacturing processes. According to David Pyne, an engineer and recognized ASR expert, the principal factor constraining widespread use of ASR "lies in the regulatory framework that has been developed in the past 20 years governing the injection of water into wells. This framework is inappropriate for the regulation of ASR wells and requires modification if the full potential benefits of ASR are to be fully realized" (Pyne, 1995). The evolution of this framework to include aquifer recharge and storage practices will require the access and use of adequate scientific information by policy-makers on national, regional, and local scales.

Aquifer Storage and Recovery

ASR is generally used for storing water underground when supplies are sufficient and of good quality and recovering the water when supplies are low or water quality is poor. Water may be stored during wet seasons and used during dry seasons; or it may be stored during wet years for use in dry years. Stored water may also be used to satisfy emergency demands, such as during floods or droughts (Pyne, 1995; USEPA, 1999).

A similar technique that has been used in recent years is artificial aquifer recharge, which refers to the injection of surface water into underground water-bearing layers. This method is also used for purposes such as aquifer water management, prevention of saltwater intrusion, and control of subsidence (USEPA, 1999). Where ASR differs from artificial aquifer recharge is that the ASR well serves a dual purpose of being used both to replenish the water in the ground and to recover the stored water later.

The source water injected into ASR wells can be treated or untreated surface water, groundwater from another aquifer, or reclaimed water. Some level of pretreatment is usually necessary to ensure that the injected water is of sufficient quality that it does not impair the quality of the groundwater it contacts (USEPA, 1999). The U.S. Environmental Protection Agency (USEPA) recently reevaluated its policy of requiring water stored in ASR facilities to meet treated drinking water standards, and details are still being formulated (SFWMD, 2001). Most ASR facilities treat water to primary drinking water standards, meaning the water meets the Maximum Contaminants Level (MCL), which regulates organic and inorganic chemicals, microbial pathogens, and radioactive elements that may affect the safety of drinking water. Secondary standards include additional requirements for such characteristics as taste, color, and clarity.

ASR systems may store water in fresh water or brackish aquifers, or in zones of poor quality water. A wide variety of geologic settings can provide suitable storage zones, including sand, sandstone, limestone, dolomite, basalt, and glacial drift aquifers (Pyne, 1995). Most sites use confined or semi-confined aquifers, but a few use unconfined aquifers. Brackish water confines the injected water because the fresh water is less dense and floats on the more dense brackish water, forming a zone of fresh water in the upper zone of the aquifer (Pyne, 1995). The diagram on page 55 illustrates an ASR well in relation to the subsurface water storage and confining layers.

The main driving force behind the development of ASR has been its economic benefits. ASR systems can possibly meet water management needs at less than half the capital cost of other water supply alternatives, and there are claims that savings can reach as high as 90 percent when compared with the cost of constructing water

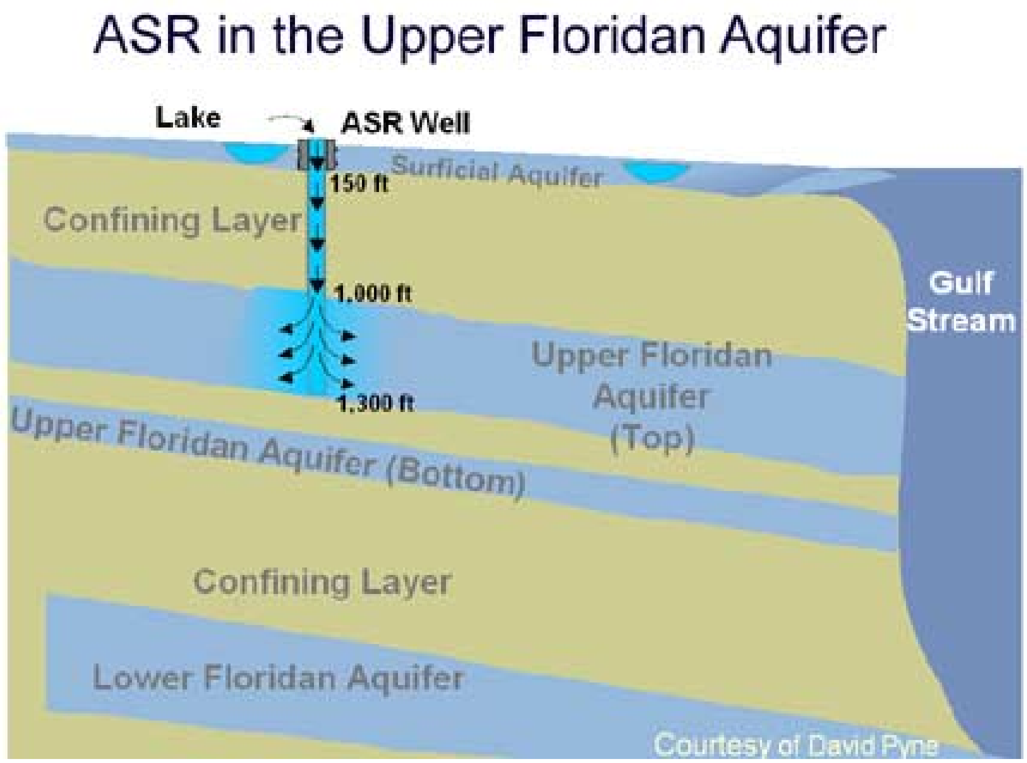


Figure 2 Schematic of an ASR well in the Upper Floridan aquifer

treatment plants and surface water reservoirs (ASR Forum, 2001). Although the relative development costs and long-term benefits will vary by region, an extensive study conducted in Florida showed that the unit cost of the most expensive ASR system was slightly less expensive than the least expensive reservoir option (Everglades, 2001).

As of 1999, there were approximately 1,185 aquifer recharge and ASR wells documented in the U.S., including 807 aquifer recharge wells, 130 ASR wells, and 248 recharge wells not distinguished between the two. In Florida alone, there are 404 aquifer recharge wells and 84 ASR wells, and 200 additional ASR wells are proposed to be built as part of the "Everglades Restoration Project" (USEPA, 1999). The map on page 57 shows the location of ASR wells in operation and development in the U.S.

Comparison of ASR Facilities to Surface Reservoir Operations

The use of aquifers rather than surface water impoundments for water storage offers several advantages (Kazman, 1967):

1) permanence;

2) no loss of storage capacity due to sedimentation;

3) no loss of water due to evaporation;

4) less vulnerability to destruction and contamination; and

5) the absence of threat to downstream communities (by eliminating the possibility of dams breaking and floods occurring.

To this list of advantages can be added the absence of the environmentally damaging effects of dams, noted by more recent literature (McCully, 1996), and the fact that ASR wells are not likely to receive spills or illicit discharges (USEPA, 1999).

Figure 3 Location of ASR wells in the U.S.

Reservoirs serve a useful function that ASR wells cannot in their ability to capture large volumes of rainfall, thus providing an important flood-control function. Some reservoirs are also used for producing hydroelectric power and for recreation. In addition, the pumping capacity of large flood-control reservoirs (up to several thousand acre-feet per day) greatly surpasses the pumping rate of ASR wells (about 14 acre-feet per day, or 5 million gallons per day) (Everglades, 2001).

Overall, because there is no evaporation loss from ASR wells, their capabilities for drought management are superior to surface reservoirs. In the Comprehensive Everglades Restoration Plan (CERP), most of the ASR wells are associated with reservoirs so that both flood control and water supply is maximized (Everglades, 2001).

Technical, Public Health, and Environmental Concerns Regarding ASR

Many uncertainties exist regarding the application of ASR. Some are primarily engineering concerns that affect well operation and sustainability, while others have public health and/or environmental implications. The most common problem encountered when developing ASR wells is clogging. Clogging of ASR wells is not always predictable, and can be caused by numerous factors, including gas bubbles, bacteria, chemical reactions, and suspended solids (Buik, 2002). Injection water containing suspended solids tends to be the most prevalent of these factors, and clogging of this type can usually, but not always, be controlled by filtering, backflushing, or flow reversals (Rinck-Pfeiffer, 2002).

Another common problem is the reaction of disinfection by-products (when a disinfectant such as chlorine is used) with naturally occurring organic matter derived from the decay of plant and animal matter (Dillon, 2002). This reaction can produce carcinogenic trihalomethanes (THMs) or haloacetic acids (HAAs); however, the incidence of this phenomenon has typically been controlled by the addition of ammonia to injection water (Castro, 2002).

Some potential public health risks are specific to the use of reclaimed water in ASR systems. Reclaimed wastewater may contain microbial pathogens or pharmaceutically active compounds, and there is a recognized lack of knowledge about their fate after being introduced into groundwater. Recent Australian studies have suggested that certain viral and bacterial organisms, as well as other organic pollutants, are purged within a number of weeks when introduced into aquifer conditions (Toze, 2002). Additional study regarding the fate of microorganisms is underway in Florida, through the Comprehensive Everglades Restoration Plan (SWFWMD, 2002).

It is possible that even the use of treated water in ASR systems can degrade groundwater quality or cause geochemical reactions, depending on the quality and composition of the water that is injected, the geological characteristics of the aquifer, and the procedure used in injecting and recovering the stored water. When mixed, characteristics (high levels of iron, manganese, or phosphorus, for instance) of relatively pure waters may react in an aquifer in undesirable ways, and care must be taken to make sure that the injected and receiving water characteristics are compatible (Pyne 1995).

Unlikely but equally important to consider is the possibility that chemically polluted water could be injected and mixed with native groundwater. This occurrence would likely be recognized promptly, and the water would be immediately pumped back out of the storage zone. However, if an accident were to go unnoticed, the repercussions could be quite long-lasting, as groundwater pollution is at best expensive and difficult, and sometimes impossible, to remedy.

Another potential problem is that fluctuations in groundwater levels due to the injection and recovery of large amounts of water could cause subsidence or other adverse changes in geologic integrity. Increased water pressure could create additional pathways for fluid migration (Fies, 2002). Such possibilities are of particular concern when considering the unprecedented number of ASR wells planned as part of the Comprehensive Everglades Restoration Plan (see the Florida case study in Chapter four). Even for relatively small ASR projects, site-specific research prior to site selection is important to ensure that the geologic structure of the chosen site is appropriate for the implementation of ASR. This potential impact has been addressed in the permitting process of some states (Pyne, 1995).

The long-term uncertainty related to these issues is a concern among some scientists and environmental groups. Knowledge of groundwater movement is still relatively limited and is highly dependent on modeling. Models provide an educated guess of what will happen when water is injected into an aquifer, but actual water movement is sometimes inconsistent with modeled expectations. Numerous engineers and hydrologists have noted that the use of ASR is site-specific to the degree that even after groundwater modeling has been conducted, the potential success of an ASR project can be assessed with certainty only with extensive on-site testing. The inability to be certain of outcomes in advance of testing leads some people to question the wisdom of using ASR on a wide scale. It also points to the need for adequate regulations and permitting procedures for this storage technique. Regulation of ASR on a federal level is quite limited, and state requirements are variable, as illustrated in the following section.

The Legal Framework for ASR

Federal Regulations

Under the 1974 Safe Drinking Water Act (SDWA) wells are divided into five categories: Classes I through V. Injection wells are considered Class V wells, which include a wide variety of injection practices other than ASR, such as chemical waste injection, which can pose significant environmental threats (Pyne, 1995). Part C of the SDWA specifically requires regulation of underground fluid injection through wells and sets forth a series of Underground Injection Control (UIC) regulations. The UIC regulations allow individual states to implement the UIC program if the state standards are at least as stringent as federal standards. The UIC regulations are directly implemented by the USEPA in19 states and territories. In all other states, called Primacy States, state agencies implement and enforce the Class V UIC program (USEPA, 1999).

Aquifer recharge and ASR wells are subject to the UIC regulations that exist for all Class V wells. If the UIC conditions are met, the wells are authorized by rule and are not required to obtain a permit. Under the UIC program, aquifer recharge and ASR wells are required to submit inventory information and to operate the wells so that drinking water standards are not violated. Owners or operators of all injection wells, including aquifer recharge and ASR wells, are prohibited from injecting any fluids that contain contaminants into drinking water source wells if it would cause a violation of a drinking water regulation or cause adverse health effects (Ibid):

> Underground injection control endangers drinking water sources if such injection may result in the presence in groundwater which supplies or can reasonably be expected to supply any public water system of any contaminant, and if the presence of such contaminant may result in such system's not complying with any national primary drinking water regulation or may otherwise adversely affect the health of persons. (SDWA Part C, paragraph 300H(day)(2))

In developing the UIC regulations, the USEPA interpreted this language to mean that water must meet primary drinking water standards prior to being injected into a well. Depending on the quality of the receiving water, exemptions to this requirement may be made, but to date, the USEPA has approved very few exemptions, and these have been generally issued for regional areas rather than for individual wells (Pyne, 1995).

State Regulations

States have taken varied approaches to aquifer storage and recovery and aquifer recharge technologies. Some have developed stringent regulatory requirements, while others depend largely on federal regulations. Some treat the two processes identically, since a common concern is the protection of existing water quality, while others have specific rules for ASR. Following is a summary of requirements for UIC programs for Class V wells in the states where ASR and AR wells are the most prevalent. Together, these 10 states have more than 1000 ASR and AR wells, amounting to 89 percent of those known to exist in the United States (USEPA 1999). The following information about these 10 states is summarized from the 1999 USEPA study, "The Class V Underground Injection Control Study, Volume 21: Aquifer Recharge and Aquifer Storage and Recovery Wells." Except for California and Colorado, where the USEPA implements the UIC program, all of the states are UIC Primacy States for Class V wells (Ibid).

California

California has 281 injection wells, including both ASR and AR wells. The two types of wells are not differentiated in USEPA's Region 9, which implements the state's UIC program for Class V wells through the California Water Quality Control Board (WQCB). The Board divides the state into nine regions, each with a Regional Water Quality Control Board (RWQCB) that can prescribe requirements for discharges applicable to injection wells. The Department of Water Resources specifies well construction standards.

If treated wastewater is used for aquifer recharge, the injected water must meet treated drinking water standards at the point of injection. The Department of Health Services must approve applications for recharge projects, and county water districts and/or health departments may also impose requirements. Health departments regulate projects involving potable water injections.

Colorado

USEPA's Region 8 implements Colorado's UIC program for Class V wells. With seven ASR wells and two AR wells, the state has enacted regulations for artificial recharge, but not specifically for aquifer storage and recovery. Existing rules require that water artificially recharged into the Denver Basin aquifer is fully consumable and reusable at the time of extraction, in effect requiring that the water be potable at the time of injection.

Permitting requirements apply to the extraction of artificially recharged water rather than the injection of water, however, the application for an extraction well must contain information about the injection procedures. Water injected and extracted must be measured with flow meters, and the State Engineer accounts for these waters to protect the interests of other water users and water rights holders.

Siting and construction requirements for artificial recharge wells are the same as for other water wells, and a permit is issued by the State Engineer for constructing or replacing a well. All projects must meet detailed location and construction standards, established by Colorado's well construction rules (2. CCR 402-2). Operators are also required to install flow meters to measure the amount of water injected and extracted.

Florida

Florida has more injection wells than any other state: more than 400 AR wells, 84 ASR wells, and an additional 200 ASR wells in planning stages. The Florida Administrative Code divides Class V wells into eight categories, with aquifer recharge wells in Group 2 and aquifer storage and recovery systems in Group 7. Permits for underground injection wells are reviewed by the Department of Environmental Protection as well as by one of Florida's five Water Management Districts. Applications must include detailed information about the location and depth of the well, the injection system, the water to be injected, and any pretreatment procedures. The letter of authorization may include site-specific requirements for treatment, monitoring, sampling, and reporting. Monitoring requirements are generally addressed in the permitting criteria, depending on the location and the quality of the water used for injection.

Siting and construction requirements have not been standardized in Florida because of the wide range of well types and uses, however, the state approves design and construction of projects through a permitting process that requires sound engineering practices in accordance with the well's intended use. In addition, wells are required to be constructed and operated so that state water quality standards are met.

Idaho

Idaho has 48 ASR and AR wells (not differentiated). The Idaho Administrative Code classifies these wells as either deep injection wells (more than 18 vertical feet below the land surface) or shallow injection wells. Construction of shallow injection wells is authorized by rule, provided that the state's water quality standards are not violated, while deep injection wells are authorized only by permit. Treated drinking water standards are required at the point of injection, and state officials may impose specific requirements for well construction and operation. Monitoring, record keeping, and reporting requirements are site-specific, depending on whether the injected water poses a possible threat to the quality of the ground water. Idaho has separate, specific guidelines for the abandonment of injection wells, prepared by the Idaho Department of Water Resources (IDWR).

Nevada

Nevada has 110 AR wells. The Nevada Revised Statutes (NRS) and the Nevada Administrative Code (NAC) provide regulatory requirements for the program, which is administered by the Division of Environmental Protection (DEP). The State Engineer also has regulatory authority over the use of groundwater, including recharge, storage, and recovery.

Any injection of fluids into a Nevada well requires a permit issued by DEP. Unless the aquifer is exempted by DEP (and the USEPA does not disapprove the exemption within 45 days of notice), the injected water is prohibited from degrading the physical, chemical, or biological quality of the aquifer into which it is injected.

Nevada UIC regulations require detailed information to be provided in permit applications, including well location, site geology, construction plans, injection procedures, analysis of water to be injected, and a corrective action plan. The statute requires that the State Engineer supervise all wells tapping artesian water or water in definable underground aquifers for which permits are required. A permit from the State Engineer is required for any aquifer storage and recovery project. The State Engineer must determine that the project is hydrologically feasible and that it will not cause harm to others who use land and water in the area of potential impact.

Injection wells in Nevada must be sited on well-drained soil that is not subject to 100-year flooding events and so that the well injects into a confined zone of the aquifer. Construction requirements are established to prevent movement of injected water into other wells that provide drinking water.

Monitoring requirements are specified in the permits for Class V wells. Typically, well operators must monitor injection pressure, rate of flow, and volume of injected fluid, and periodically analyze the injected fluid. In addition, mechanical integrity testing is required every five years.

Oklahoma

Oklahoma has 44 AR wells. The state incorporates parts of federal law (40 CFR) that apply to the UIC program. Included in present requirements are groundwater monitoring, analysis of injected fluids, and a geologic description of the area where injection is planned.

Oregon

Oregon's UIC program, presently regulating 12 ASR wells and four AR wells, is administered by the Department of Environmental Quality (DEQ). Aquifer storage and recovery as well as aquifer recharge are included in regulations of any activities involving underground injection of fluids. ASR is defined as the storage of water from a separate source that meets treated drinking water standards in a suitable aquifer for later recovery and not having as one of its primary purposes restoration of the aquifer (690-350-0010(1)(a) OAR). Artificial ground water recharge is defined as the intentional addition of water diverted from another source to a ground water reservoir (690-350-0110(1) OAR).

A period of testing is required under a limited license before a permanent ASR permit is issued. This temporary license can be for one or a series of wells within the same wellfield. The water to be injected must meet treated drinking water standards and performance standards set by either the state Health Department or the Environmental Quality Commission, whichever is most restrictive.

The application for the limited license must include detailed information such as the maximum diversion and injection rates, aquifer storage volume and duration, maximum withdrawal rate, quality of source and receiving waters, and preliminary hydrogeologic information. The applicant must also obtain a water availability statement from the local watermaster, results from the DEQ's water availability model, or citation of an existing water right. The testing program must include water level and quality monitoring and control measures. The application for a permanent ASR permit requires information included in the limited license application as well as information resulting from the testing period.

South Carolina

South Carolina's program is implemented by the Department of Health and Environmental Control (DHEC). Class V wells are divided into two classes, with the state's 55 aquifer recharge wells assigned to group A. Individual permitting is required for these wells, and permit applications require basic operational data, including rate and volume of injections, injection pressure, a thorough analysis of the injection water, and drawings of the surface and subsurface well construction (R61-87.13.G(2)). Injection of water containing waste or contaminants is prohibited if it would cause a violation of a drinking water standard.

Operating requirements specify maximum injection volume and pressure and any other conditions deemed necessary to prevent initiating fractures in the confining zone adjacent to other underground sources of drinking water. Before operation approval is given, DHEC requires a demonstration of the well's mechanical integrity. Monitoring wells are required, depending on specifications in the conditions of the permit, and operators are required to submit quarterly reports of monitoring results.

Texas

Texas has 66 AR wells and one ASR well. Here, the Injection Well Act and Title 3 of the Natural Resources code provide the regulatory authority for both types of injection wells. Class V injection wells are authorized by rule, however, the Texas Natural Resources Control Commission (TNRCC) may require an injection well permit. No permit is granted if injection will result in the pollution of an underground drinking water supply.

All Class V wells must comply with specifications set forth in the rules, unless the TNRCC authorizes an exception. These include specific construction requirements, as well as provisions for preventing pollutants from entering the well and preventing waters of significantly different chemical quality from commingling as a result of well construction and operation. Like South Carolina, Texas requires that each well demonstrates mechanical integrity.

Washington

Washington, with six AR and six ASR wells, requires individual permits for both types of wells under the Washington Administrative Code. Under the UIC program, the state's Department of Ecology requires that potentially harmful fluids may not be injected into ground waters that contain fewer than 10,000 mg/l total dissolved solid or that otherwise are available for beneficial use. Injections that cause a violation in primary drinking water standards under 40 CFR are prohibited. In addition, new wells that inject industrial, municipal, or commercial waste fluids into an underground source of drinking water are prohibited, and existing wells must obtain permits.

Washington has also set standards for direct groundwater recharge projects using reclaimed water. Where potable groundwater exists, rules include monitoring, sampling, and analysis of the reclaimed water, as well as operational requirements, disinfection, monitoring of groundwater, and mandatory retention times before withdrawal is allowed.

Conclusions Drawn from Regulatory Survey

The primary focus of the state and federal aquifer injection regulations seems to be to protect the quality of water in aquifers that provide drinking water. Most states require that water injected into aquifers be of treated drinking water quality, and virtually all states prevent the injection of pollutants that would potentially degrade existing underground sources of drinking water.

Lacking in both the academic literature and the statutory materials is a recognition of the need for more site-specific analysis. Conclusive data are needed to show how injection/withdrawal schemes, including the consequences of mixing waters of different chemical makeup, may impact hydrogeologic structures as well as the natural systems that depend on groundwater to maintain their long-term biological integrity. Some states, such as Nevada and Oregon, require extensive analysis and testing prior to approving a project. However, many states have no regulations in place to require site-specific hydrogeologic studies prior to project implementation, and even fewer address concerns of long-term geologic integrity. Although some of these issues may be addressed in the permitting processes, the statutory language leaves a great deal of room for trial by error rather than creating the structure for a systematic approach that ensures long-term success.

ASR and the Advocacy Coalition Framework

According to Sabatier's (1999) and other policy analysts' descriptions and assessments of the ACF, the framework is well-suited for application to policy-making processes regarding aquifer storage and recovery issues. Referring to the reasons Lifkin (2001) gave that the advocacy coalition framework is ideal for examining environmental policy issues, this issue certainly contains all of those elements. It involves *multiple levels of government*: federal, state, and sub-state (i.e., Florida's Water Management Districts and California's Regional Water Quality Control Boards). ASR is *highly dependent on technical and analytical knowledge* and, given the site-specific nature of the technique, only general principles and guidelines are easily transferable from one state or region to another. *Core beliefs* about water resources management are *deeply held by stakeholders,* with attitudes about conservation conflicting with desires to develop new water supply sources and ecological values coming head-to-head with business interests. *Scientific information is likely to be politicized*, and coalitions are very likely to take shape along political lines.

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CHAPTER IV

AQUIFER STORAGE AND RECOVERY IN THREE SOUTHEASTERN STATES

GEORGIA

The introduction of the notion of ASR in Georgia was part of a complex sequence of events from which ASR cannot be segregated. The technique itself was swept up and almost lost within a much larger context of regulatory, economic, and political controversies that were played out both on the coast and at the Capitol, and the outcome was a prohibition on the use of ASR that expired on December 31, 2002. This case study investigates a collage of events that have taken place on a local, regional, and statewide level since the summer of 1996, when a private company presented a plan for municipal water supplies. Beginning with a historical overview of coastal Georgia water use and control, the study proceeds with a chronology of recent events. Finally, a discussion includes a more thorough exploration of the various positions taken in the controversies and how Georgia's experiences relate to the Advocacy Coalition Framework and literature on the use of science in policy-making.

A Contextual History

Georgia's coastal region has abundant water resources. The major water source, the Floridan aquifer, is extremely productive, and six major rivers originate in or flow into the coastal area from Georgia's uplands: The Altamaha, Canoochee, Ogeechee, Satilla, Savannah, and St. Mary's. Of particular relevance to this case study are the Altamaha, a large river with a relatively pristine watershed, the Savannah, also a large river that borders South Carolina, and the Ogeechee, a smaller black-water river with significant seasonal flow variations. These rivers flow into thousands of acres of freshwater wetlands, coastal marshes, and estuaries that are ecologically important for many species that depend on a mix of freshwater and saltwater.

Coastal counties in Georgia and neighboring states have seen tremendous population growth during the last several decades. Some municipalities on Savannah's outskirts have tripled in size in the last decade alone. Historically, the availability of plentiful and pure groundwater led to an almost total municipal reliance on groundwater rather than on surface water (USGS, c). With such rapid growth, continued reliance on groundwater has put an enormous burden on the resource. In addition to municipal use, the groundwater used by large, water-intensive paper industries—ITT Rayonier in Jesup, Georgia Pacific in Brunswick, Union Camp (now International Paper) in Savannah, and others— amounts to tens of millions of gallons per day.

As withdrawals from the aquifer have increased, water pressure in the aquifer has decreased and allowed the interface between the ocean water and aquifer water to move inland in some areas. Saltwater intrusion has already begun to cause well contamination on Hilton Head Island, South Carolina, and this saltwater interface is moving southwestward, directly toward Savannah (Ransom, 2002). Farther south, Brunswick has been experiencing problems with saltwater intrusion since the 1950s. There, instead of ocean water creeping inland through the aquifer, salt water is finding its way upward through fissures from the Fernandina Permeable Zone (USGS, c). This zone, like the Upper Floridan, is under pressure, and as water withdrawals reduce the pressure in upper layers, salt water moves upward. In addition, some wells in northern Florida have been closed due to salt water contamination.

Even though scientists have indicated for years that heavy groundwater withdrawals were impacting the pressure in the aquifer and contributing to saltwater intrusion, withdrawals have not been redirected to surface water. Although plentiful in many areas, surface water requires treatment to remove contaminants, and this process equates to added expense. In his 1971 book, *The Water Lords*, James M. Fallows notes, "Groundwater depletion is not a new problem that rushed upon the region before anyone had time to plan for it." As early as 1943, Chatham County Commissioners recognized that "the water supply in and around the county is being seriously affected by the boring of additional artesian wells in said county." He points out that almost 25 years ago, ten coastal counties had major cones of depression, and in those counties, industry use accounted for 197 of the 279 millions of gallons of water withdrawn every day—more than 70 percent of the total groundwater used in the region.

The U.S. Geological Survey (USGS, c) conducted studies of Brunswick's saltwater intrusion problems as early as the 1950s and 1960s, yet nothing came of these studies that required a change in water use practices. Likewise, in 1972, the Ground Water Use Act acknowledged the problem. In addition to establishing new permitting requirements for the use of groundwater in excess of 100,000 gallons per day, the Act also addressed timing of withdrawals, abatement of saltwater encroachment, well depth and spacing, and other means of reducing the impacts of groundwater withdrawals (Kundell, 1978). This measure was not effective, however, in significantly reducing groundwater use along the coast.

In recent years, the Environmental Protection Division (EPD) of the Georgia's Department of Natural Resources (DNR) has made more significant efforts to preserve the integrity of the Floridan aquifer and protect the resource from further threats of saltwater intrusion. One such effort was the development of an Interim Strategy for Managing Salt Water Intrusion in the Upper Floridan Aquifer of Southeast Georgia. The Interim Strategy, which applies to a 24-county area encompassing Savannah and Brunswick took effect in 1997 and will be in place until a final strategy is completed in 2005. In order to provide scientific support for the final strategy, a separate program for scientific investigation was developed and named the Georgia Coastal Sound Science Initiative. It is a cooperative research effort between EPD, the U.S. Geological Survey (USGS, b), private industries, and other organizations in Georgia, South Carolina and Florida. The two programs related to aquifer protection in coastal Georgia are summarized below.

Interim Strategy for Managing Salt Water Intrusion in the
Upper Floridan Aquifer of Southeast Georgia

EPD developed the Interim Strategy in order to preserve the groundwater resources of Georgia’s coastal areas, already threatened by saltwater intrusion. In February of 1996, EPD proposed a draft Interim Strategy and during the spring, held nine public meetings to solicit comments. After receiving comments, EPD also sought input from analysts at Georgia State University’s School of Policy Studies, who suggested a strategy of Rational (or expanded) Use (Georgia EPD, e). The proposed approach was to continue to deplete the aquifer but to levy user fees which would later be used to construct surface water treatment plants as wells became too saline for continued use. Public reaction to the Rational Use strategy was profoundly negative. The EPD received more than 400 comments from stakeholders expressing concerns that such a policy would deplete the aquifer (Kundell, 2003). In reaction to the public outcry, EPD adopted a strategy of sustainable use, which called for withdrawal reductions sufficient to allow continued use, but at levels low enough that further movement of the saltwater wedge would be curtailed (Georgia EPD, e). Nevertheless, EPD's initial acceptance of the Rational Use strategy damaged the agency's reputation in terms of its reliability for protecting the resource.

The Interim Strategy that EPD adopted in April of 1997 divides the coastal area into three zones, with the central zone encompassing the Savannah area. (See Figure 4, on the following page, which shows the 24-county area encompassed by the Interim Strategy.) In the northern and southern sub-areas, withdrawals are not capped at a specific level, and reasonable additional pumping may be continued. Within the central sub-area, the Interim Strategy allows limited increases in withdrawals for least-impacted counties that have developed comprehensive water supply plans. For Chatham, Glynn, and defined areas of Bryan and Effingham counties, there is a principle of "No Impact of Salt Water Intrusion on Existing Users," which has resulted in a cap of groundwater withdrawals in these areas at 1997 rates. In all three sub-areas, inactive permits are cancelled, and EPD restricts new or expanded withdrawal permits to the following conditions (effective as of January 1, 2001):

- Municipal water users must develop water-conservation ordinances, including elements such as low-flow plumbing requirements and transmission loss audits;

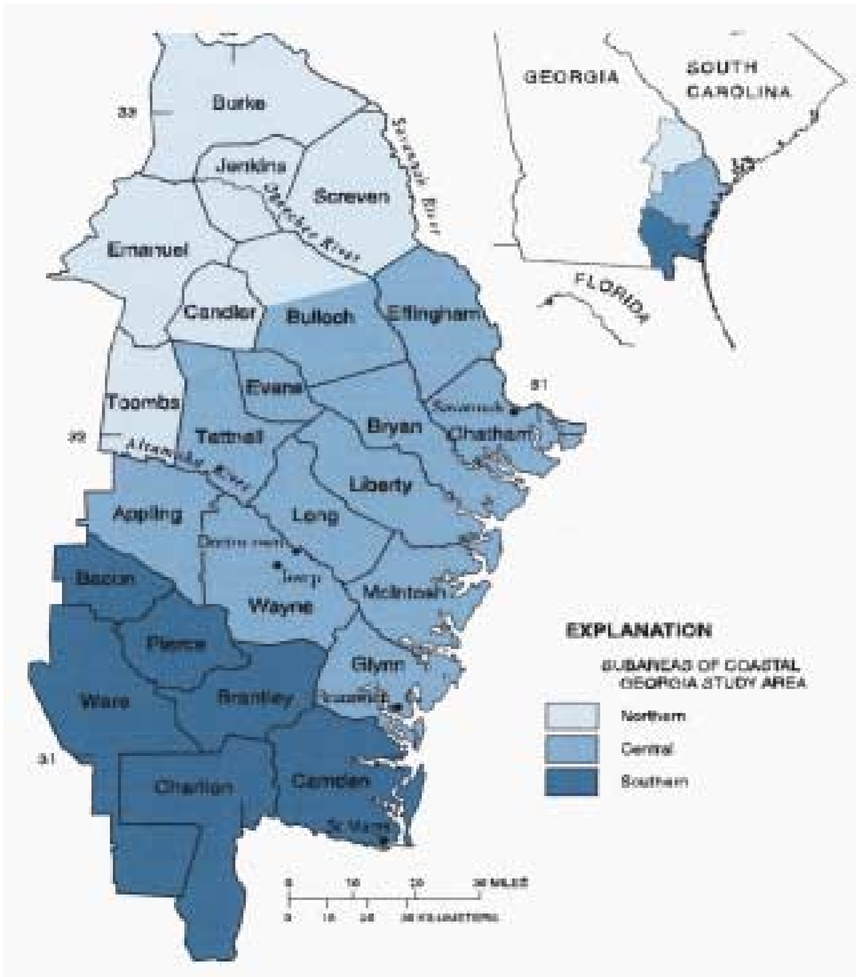

Figure 4 24-county Interim Strategy area (Source: USGS)

• Agricultural water users must take a course on irrigation best management practices and irrigation water conservation; and

• Industrial water users must develop a water conservation plan.

The Interim Strategy will be effective until December 31, 2005, at which time a Final Strategy will be complete. During this interim period, EPD is to conduct regular progress meetings to update stakeholders and to coordinate with the St. John's River Water Management District in Florida and with the South Carolina Department of Environmental Control (DHEC) to establish consistent preventive measures across state boundaries.

The Georgia Coastal Sound Science Initiative

In order to provide scientific support for the development of The Final Strategy for Managing Salt Water Intrusion, the EPD initiated the Georgia Coastal Sound Science Initiative (SSI). A legislative study committee was charged with developing recommendations for funding the project. A technical advisory committee, consisting of representatives from industry, local governments, environmental organizations, and academia, helped guide the parameters of the project and continues to meet periodically to review work plans and products (Kundell, 2003). The Sound Science Initiative, expected to cost $1.5 million, began in 1997 as a series of studies to support development of EPD's final strategy for preventing further saltwater intrusion in the Upper Floridan aquifer. Research participants include USGS, Georgia State University, Georgia Southern University, the Georgia Tech Water Resources Research Institute, SCDHEC, and private consulting firms (USGS, a). The Initiative is administered by EPD, with USGS providing substantial input in terms of data collection, modeling, and simulation. Using a network of monitoring wells and other sources of data and information, the study was designed to increase understanding of groundwater flow and movement of salt water in the Upper and Lower Floridan aquifers; establish an early-warning system for saltwater intrusion; identify the areas most susceptible to saltwater intrusion; and evaluate alternative sources of water.

Although the Sound Science Initiative report is still in progress (the final report is due to be released in 2005), modeling results have thus far indicated that as long as there are significant withdrawals from the Upper Floridan aquifer, saltwater intrusion is inevitable (USGS, b). Under 1985 pumping conditions, models have shown that it will take the salt water wedge 120 to 270 years to reach the cone of depression at Savannah. The salt water plume at Brunswick now occupies about 2.8 square miles and may be growing wider (Ibid).

The Environmental Protection Division and Public Confidence

Recent history of the coastal area had thus established a sensitivity to the protection of groundwater resources and a tentative trust in EPD to protect those resources. The level of confidence in EPD played an important role in public perceptions and reactions as events began to unfold relative to coastal water withdrawals and the use of aquifer storage and recovery. A report published by the Carl Vinson Institute of Government in 2000 provides a good indication of EPD's reputation among various groups (CVIOG, 2000). Representatives from local governments, business and industry, and environmental groups were asked to rank EPD on a variety of indicators, using an electronic polling system. In terms of decisions that are protective of the environment, local government and business/industry respondents rated EPD very highly (70 to 80 percent of ratings were good or very good), while more than 90 percent of environmental group representatives rated EPD fair to poor in this dimension.

The Savannah Group (TSG)

In June of 1996, The Savannah Group (TSG) submitted three separate applications to EPD to withdraw water from rivers in coastal Georgia: the Altamaha, the Ogeechee, and the Savannah. The company submitted applications for very large amounts of water: 36 million gallons per day (mgd) from the Ogeechee, 50 mgd from the Altamaha, and 45 mgd from the Savannah— amounting to131 mgd, more than the total amount used by Savannah and all of Chatham County. The company's ambitious water-withdrawal scheme was designed to provide water to coastal residents and businesses. The application for the Ogeechee project noted that ASR may be included, however, this element went unnoticed until much later, when TSG suggested that its withdrawal plans would include the storage technique. The other two applications were for standard surface water withdrawal, treatment, and distribution.

Along with the applications, TSG submitted to EPD a conceptual plan that outlined the details of its prospective project. The introductory section of TSG's plan noted the need for alternative sources to the Upper Floridan aquifer and the recent cap on groundwater withdrawals in some coastal counties. It also referred to a tax incentive program (HB 1589) recently enacted by the Georgia General Assembly to encourage large industrial groundwater users and other private companies to implement treated surface water and other water conservation solutions to reduce demands on the aquifer.

TGS's permit application was finalized in October, 1996, and EPD issued a public notice of the proposal. EPD received numerous letters in opposition to TSG's proposal (Georgia EPD, d) during the first public comment period, ending December 1st. As the public became aware of the proposal, response was quite negative. The most prevalent reaction to TSG's proposal was the opinion that the company was attempting a regional water grab. EPD received a number of letters in response to the large amount of water initially requested to be drawn from the Altamaha, even though the quantities requested had been reduced dramatically just prior to the comment period. Stakeholders expressed concerns that TSG was apparently trying to lock up a major portion of surface water resources (City of Brunswick) and that such a large amount would have adverse ecological impacts on the river (U.S. Fish and Wildlife Service, EPD Coastal Resources Division (CRD), The Nature Conservancy, and a professor of Marine Science at the University of Georgia). The Coastal Group Sierra Club wrote that it would be unwise to permit such large quantities without knowing how they fit into a comprehensive water supply management plan for the region (Georgia EPD, d). Although later opposed to the project, Harry Jue, the director of the Savannah Water and Sewer Bureau, wrote a letter to EPD in November expressing no objections to the permit, provided TSG could present complete validation of the need for the large volumes requested and that necessary treatment and distribution works be in place prior to the activation of permits (Jue, a).

Meanwhile, at the request of EPD, Ron Cummings and Peter Terrebonne, of Georgia State University's Environmental Policy Program, met with TSG's James (Jim)

Walker, President, and Arnold Ellison, Vice President, to discuss TSG's proposals and the options open to EPD for groundwater management in coastal Georgia (Cummings). Mr. Walker and Mr. Ellison suggested an option that defines a baseline of withdrawal in all counties, with pumping in excess of that baseline to be offset by the injection of an equivalent amount of treated water into Chatham County or a county near Chatham.

At an October 15 meeting with EPD, TSG officials asked EPD for a letter of concurrence and requested that the letter include a commitment that EPD would adopt a reduced-use policy for managing the Upper Floridan aquifer. (A letter of concurrence is the first step toward permit approval. Formally, it acknowledges that the applicant has shown that there is adequate water available to provide for the withdrawal amount sought in the application. Informally, it is an indication of progress toward receiving a permit.) Ten days later, Napoleon (Nap) Caldwell, Senior Planning and Policy Advisor for EPD, sent a memorandum to Director Harold Reheis expressing concerns about setting precedent with the TSG proposals (Caldwell, a). His memo reviewed the October 15 meeting and included the following advisement:

> As I see it, what we have here is a situation where a private concern having a speculative interest in water development is seeking permission from a regulatory entity to have a public resource earmarked for that private entity's development to the exclusion of the development of public entities who might apply for the use of this resource at some later date. That private entity is further seeking a commitment from this regulatory agency to adopt a management strategy that best suits the interests of that private entity.

The same month, EPD officials asked TSG to amend the withdrawal amounts to more closely reflect immediate needs for water, rather than planning 20 years out. TSG revised the withdrawal requests to the following amounts (average annual daily withdrawal): 3.45 mgd from the Ogeechee, 8.5 mgd from the Altamaha, and 3.1 mgd from the Savannah. In anticipation of EPD requirements, TSG submitted reports that the engineering consulting firm CH2M Hill prepared in support of the project, "Analysis of Historical Water Quality and Flow for the Altamaha, Ogeechee, and Savannah Rivers," and "Aquifer Storage and Recovery Preliminary Feasibility Assessment for Coastal Georgia."

Additional opposition to the TSG proposal came at a Glynn County Commission meeting on December 21, 1996, when Jim Walker gave a presentation about the Altamaha River part of his company's plan. A local newspaper reported that Mr. Walker seemed frustrated at the Board's unfriendly attitude and fumbled with his transparencies, dropping most of them. Before the meeting had concluded, the Commission members decided to "vehemently object" to the TSG proposal, and several members agreed to write letters to the DNR (Permar).

In February, 1997 (and reiterated and amplified in a May letter), Harold Reheis, Director of EPD, sent a letter to Jim Walker, detailing the conditions under which TSG would receive a letter of concurrence and a permit for the Altamaha portion of the project. Mr. Reheis said that to receive a letter of concurrence, TSG's proposal must be included in Glynn County's evaluation of water supply options in its (state-mandated) long-term water supply plan. He would also require satisfactory response to a summary list of stakeholder issues and concerns EPD had forwarded to TSG. Once these conditions had been met and a letter of concurrence issued, Mr. Reheis would require the following conditions for permitting the Altamaha project:

1. Glynn County must select the TSG water supply option as its preferred option;

2. TSG must present contractual agreements for supplying water to Glynn County and/or the City of Brunswick, and/or industrial entities within the county;
3. If any conflicts involving competing applications arise, those must be resolved before a permit is issued; and
4. EPD would conduct a comprehensive public meeting, as well as a public hearing, on the proposed withdrawal prior to making a permitting decision.

EPD held public meetings concerning the Altamaha proposal in March and October of 1997, and accepted comments in conjunction with both of these meetings. Between the two comment periods, EPD received a great number of letters, the vast majority in opposition to TSG. Although the focus during this period was on the Altamaha portion of TSG's proposal, some of the issues, and thus the responses, applied to all three applications. The arguments were extremely varied, and some were multi-faceted, as shown in a summary of concerns from individuals and organizations (Georgia EPD, g):

- Apprehension about a private entity being granted a permit to withdraw a public resource
    - Takes an important growth-management tool away from local governments
    - Lack of duty to the public welfare
    - Lack of broad-based regulatory oversight
    - Exploitation of a public resource for personal or corporate profit
- Applicant has no water conservation plan or drought management plan
- Applicant has identified no specific customers: proposal is speculative
- Withdrawals may have a negative impact on the riverine ecosystem, including estuaries

- Once treatment facilities are in place, future withdrawal increases will be inevitable
- Lack of data available to ascertain cumulative impacts of withdrawals
- Shrimp, crab, and American shad, and shortnose sturgeon would be adversely impacted

• Regional water management plans were not yet in place and any significant permitting should wait and be an integral part of these plans—opposition to "water planning by permit"

• Additional withdrawal permits would increase the likelihood of unplanned growth in the region

• Uncertainties about ASR and the possibility of groundwater contamination (Although as late as September, 1997, EPD said "There is nothing in the applicant's application that requests that EPD grant permission for such a use of any portion of the proposed withdrawal. Therefore EPD is not considering aquifer storage and recovery.") (Georgia EPD, g)

• TSG would inject water at one location and withdraw from another (essentially using the aquifer as a transport mechanism)
    - TSG would transfer water from one river basin to another

• Issuing the permit could bring new growth and development

• Uncertainty about how rates would be established (TSG to sell water wholesale to municipalities, who would sell to individual customers.)
    - Potential for inequities

• Uncertainty about the financial viability of TSG

Although most respondents had more than one concern, and virtually all opposition groups were opposed to a private company using a public resource for profit, certain groups could be identified with certain types of objections. “Watermen” (shrimpers, crabbers, and fishermen), especially in Glynn county, focused on recent declines in species that rely on a certain mix of fresh and salt water in the estuary. These species might be further jeopardized by increased withdrawals from the Altamaha. Environmental groups focused primarily on withdrawal issues, as well: that the cumulative effects of even the smaller proposed amounts would have unknown impacts to the Altamaha river system and its estuary. These groups tended to ask EPD to wait until management plans were in place and more research had been done on a regional scale before issuing permits. A third group consisted of local municipalities, which in the southernmost coastal counties, were galvanized against TSG. Glynn County and the City of Brunswick opposed the plan because, among other reasons, they were in the process of developing a plan for managing their ground and surface waters, and it seemed like a circumvention of their planning efforts to issue permits prior to plan completion. There was also a fear that granting TSG’s withdrawal request would prevent municipalities from later being able to withdraw more water if needed.

The following groups are on record with EPD as having expressed a written statement either opposing or supporting the TSG proposal:

TSG Proposal Opponents

The Nature Conservancy	The Georgia Conservancy
Jack Amason, Sea Garden Sea Food, Inc.	Bryan County Board of Commissioners
Glynn County Board of Commissioners	Liberty County Board of Commissioners
McIntosh Board of Commissioners	City of Savannah
Sierra Club	Georgia Wildlife Federation
U.S. Fish and Wildlife Service	Ogeechee Audubon Society
Georgia Marine Business Association	Georgia Shrimper's Association
Glynn Environmental Coalition	Marshwrack
City of Sylvania	City of Brunswick
City of Darien	Screvin County Chamber of Commerce

League of Women Voters

Coastal Environmental Organization of Georgia

Coastal Georgia Center for Sustainable Development

South Atlantic Fishery Management Council

TSG Proposal Supporters

Savannah Electric	City of Pooler
Chatham County Commission	City of Springfield
City of Rincon	City of Richmond Hill

Several top EPD officials met with selected stakeholders in the DNR Board Room on June 16, 1997. The invited participants were from the Georgia Wildlife Federation, The Georgia Conservancy, The Nature Conservancy, the Coastal Georgia Center for Sustainable Development, the U.S. Fish and Wildlife Service, the Sierra Club, the Georgia Environmental Policy Institute, and the Chatham-Savannah Metropolitan Planning Commission. Mr. Reheis began the meeting by summarizing his perceptions of major concerns: that a withdrawal permit decision should not be made without knowing all of the potential impacts; that TSG is a private entity and thus should not be permitted for water withdrawals; and that issuing a surface water permit will lead to more growth—if the permit to withdraw from the Altamaha is stopped, so will the growth. Responding to a comment about the privatization of water supply, Mr. Reheis pointed out that we have a number of private water companies in Georgia, including a large number in Chatham and Glynn counties.

TSG submitted to EPD a report prepared by CH2M Hill, “Altamaha River Hydrology and Fisheries Assessment, in August 1997. Harold Reheis sent a copy of the report to the Coastal Resources Division (CRD) for the division’s comments, asking the division to send comments by September 3, at which time he intended to write a letter of concurrence to TSG (Reheis, b). Records indicate that the Coastal Resources Division replied that since they did not employ a hydrologist, they could not provide adequate feedback on TSG’s modeling of the effects of the withdrawals, but that the report did not adequately address the impacts the withdrawals may have on shortnose sturgeon (Brewton, h). TSG subsequently revised its report and in October, submitted a technical memorandum to EPD that addressed that issue.

The October 1997 public meeting in Brunswick was significant because, as host, Harold Reheis began the meeting by saying that the effects of the Altamaha withdrawals would be in the acceptable range in terms of environmental impacts—essentially unmeasurable. (Drought flows on the Altamaha are about 1300 mgd (Georgia EPD, h).) "If, in our judgment, the impacts would not be acceptable, then the law requires that we deny the permit," a local newspaper quoted him to say. According to the same newspaper account, four hours of discussion ensued after Mr. Reheis' announcement, and by the meeting's end, all of the approximately 40 speakers, except one, had disagreed with his conclusion (Horton, c). A later newspaper report (Krueger, b) said that Mr. Reheis had been "roundly criticized by residents of Glynn and McIntosh counties for what critics called his agency's apparent lack of concern about fisheries questions raised by the TSG permit request."

After the October public meeting, EPD sent the CRD specific questions that arose related to the effects that TSG's proposal might have on Altamaha fisheries, and the CRD responded on December 1, 1997. Although the CRD acknowledged that an 8.5 mgd withdrawal alone was not likely to have a measurable impact on salinity, its report also noted that salinity varies, and that the cumulative impact of many withdrawals is much more of a concern. Shrimp populations were said to be relatively stable since 1978, but the CRD reported significant decreases in crab and oyster populations and could not ascertain a definitive cause. In several aspects, there was not enough scientific information to give adequate answers to the questions posed by EPD.

On December 3, 1997, Harold Reheis wrote a letter of concurrence to Jim Walker for the Altamaha project. In his letter, he summarized the conclusions EPD had drawn from the CRD's analysis, and added an explanation of a water balance analysis done by EPD that strengthened his opinion that the impact of an additional 8.5 mgd withdrawal would be negligible. Opposition letters promptly arrived at EPD offices, this time questioning the issuance of the letter of concurrence and an obvious relaxation of the previous requirement for TSG to have a commitment from a local government or industry that would justify its withdrawal. TSG had no such commitments; in fact, Glynn County had informed Mr. Walker in a June 1997, letter that the Glynn County Long Term Water Resources Management Advisory Committee had decided not to directly name TSG as a provider in its water management plan. (Gilmour). It is noteworthy that Glynn County had only recently (September 1997) negotiated a contract with Atlanta-based consultants Jordan, Jones and Goulding for the development of its long-range conservation plan—an $85,000 investment (Horton, b).

TSG's proposal for withdrawals from the Savannah River were less controversial from an environmental standpoint, since the withdrawal request was relatively small (3.1 mgd). Public comments, received by EPD for a period ending September 30, 1997, and a public meeting on January 20, 1998, revealed no significantly different arguments than had been expressed earlier, relative to the three proposals in entirety (Rincon).

EPD collected comments on the Ogeechee River proposal through September 1997, and held a public meeting on February 24, 1998, in Savannah. Meanwhile, in November, TSG wrote a letter to EPD to amend its application for the Ogeechee River to include aquifer storage and recovery, solidifying this potential aspect of the application.

At the February meeting, there was considerable criticism of EPD. One citizen commented that it was arrogant for EPD to assert that it knows what no one else does, in the absence of scientific data. Concerns about the use of ASR came out, as well. Pete Macaques, of the Savannah City Council, questioned the suitability of ASR for this area and the Upper Floridan aquifer. Among the many concerns of Ben Brewton, Chairman of The Coastal Environmental Organization of Georgia, were the idea of putting treated water into virgin aquifer water, that EPD was going forward with an incomplete application from TSG, and that public comment was falling on deaf ears (Ogeechee).

Since the Ogeechee and Savannah withdrawal locations were to be close to the City of Savannah, many comments pertained to both of these applications as one issue. A letter from Savannah Electric encouraged EPD to permit TSG's proposal because it would "break the current monopoly on public water supply controlled primarily by municipalities," and because it would encourage economic growth that could otherwise be limited by reliance on groundwater use. Some municipalities (including Pooler, Rincon, and Springfield) supported the TSG proposal because it would give them an alternative to buying water from the City of Savannah. Bryan County Commission Chairman Brooks Warnell wrote to Harold Reheis to express his concern about withdrawals from the Ogeechee, and on a separate occasion to inform EPD of the intention of Bryan County and the towns of Richmond Hill and Pembroke to work together to provide water for county residents (Warnell). Savannah expressed three major arguments against the TSG plan (Brown). First, the permitting would be "presumptuous and premature," given the scope of research that was underway to guide region-wide prevention of saltwater intrusion. Second, the proposed intakes would be just downstream from Savannah's newly-expanded Georgetown Wastewater Treatment Facility. (The concern was that the proposed withdrawal did not impact the assimilative capacity of the river at the Georgetown outfall.) The third concern was that the withdrawal permits would be granted without firm contractual agreements for water purchase.

Despite protests, Harold Reheis issued a letter of concurrence for the Savannah application on May 13, 1998. However, that application was hindered when the Chatham County commissioners refused to sell TSG a small water and sewer facility for which TSG offered $3.3 million and had counted on as part of its water supply plan. Commissioners expressed concern about possible rate increases and lack of county control to protect quality of service. A news account (Krueger, d) said that after the vote, Jim Walker was visibly angry, saying "This is a circus. [The TSG proposal has been] all screwed up…and misrepresented to the public," and later he accused the City of Savannah of bullying the county into refusing the sale.

A letter of concurrence for the Ogeechee application was never written, and no permits were ever issued for any of the three withdrawal applications. To the knowledge of EPD officials (Caldwell, 2002), TSG never obtained the necessary commitments from local governments or industry that would allow them to continue the pursuit of withdrawal permits.

Focus Turns to ASR

Throughout the application and public response process thus far, ASR appeared to be a minor issue compared with other concerns expressed by stakeholders in public meetings and through letters to EPD. However, two events had set the stage for the public to lose trust in the EPD in terms of its ability to effectively manage the state's water resources. First was the EPD's initial acceptance of the Rational Use strategy proposed by Georgia State water policy analysts. The second was that EPD handled the TSG applications in a way that led to a perception that EPD condoned what many coastal residents perceived as a water grab and an effort by a private company to profit from the exploitation of a public resource. There was thus a significant lack of public confidence in EPD's ability to properly manage a highly technical process like ASR.

Interestingly, even though the ASR portion of the proposal was only a possibility, one of the first documents on file in EPD's records regarding TSG's permitting process included this aspect of the project. EPD had the consulting firm CH2M Hill prepare a preliminary analysis of the feasibility of ASR for coastal Georgia. The findings were sent to Bill Frechette, Principle Geologist for the Georgia EPD, on October 17, 1996, as follows:

> ASR is feasible and beneficial in the coastal areas of Georgia, primarily because of the Floridan aquifer. Access to one of the most productive aquifers in the country is relatively easy, resulting in high yields and low construction costs. Site specific feasibility can be confirmed with investigations and appropriate testing at the locations selected for use.
>
> Since this application uses ASR as part of the initial water treatment plant design, supply from surface water sources during periods of low flow is minimized. Surface water can be diverted during high flow periods and stored via ASR. During low flow periods, ASR storage is used to supply water use demands. This reduces or eliminates streamflow diversion during periods of low flow, maintaining downstream water quality and possible other beneficial use of this water.
>
> By incorporating ASR into regional water management plans, continuing trends of Floridan aquifer water level decline can be slowed or reversed. A small percentage of the stored water can be left in the aquifer each year, or increase storage during wet years can be accumulated, to eventually bring water levels to within a target range of elevation. TSG may be in a position to improve groundwater conditions within the coastal areas of

Georgia through the use of ASR and promote their contribution to the improvement of declining water levels and salt water encroachment.

Public attention to this element of TSG's plan was nonexistent, however. The stakeholder response records at EPD revealed only three references to ASR during all of 1997, as follows:

- At the March 27, 1997 meeting in Brunswick regarding the Altamaha proposal, a participant commented about protection from nuclear contaminants in the use of aquifer injection (Shipman).
- In a September 12, 1997, letter to Harold Reheis, Michael Brown, City Manager of Savannah, states, "It is one of the objectives of [The Sound Science Initiative] to provide the scientific knowledge that this ASR will work in Coastal Georgia. Without a good understanding as to how the aquifer works, the location of saltwater, and the sustainable use of the aquifer, the application of any new technology may create more problems than they solve….let us not shortcut the system before we obtain the answers."
- A letter from Wesley Woolf, of the Georgia Conservancy, to Nap Caldwell on March 27, 1997, includes a lengthy section on ASR, including the suggestions that EPD should wait until a management strategy for the Floridan aquifer is in place; that there are unknown regional and local implications of ASR; that ASR may not be an appropriate component of a surface water withdrawal permit; that neighboring groundwater rights might be affected by injections and withdrawals; and that evidence is needed regarding successful ASR applications.

Attention given to ASR during early 1998 (in addition to the February meeting comments referenced earlier) included a presentation to EPD on April 16 by David Pyne, an expert on ASR then employed by CH2M Hill. His presentation included a summary of the history, applications, permitting, and design of ASR systems (Cardin). Also, on May 26, 1998, Bill Frechette sent the following e-mail message to Nap Caldwell and David Vaughn (His message noted to please read attached document from [Dr. Bill McLemore, State Geologist,] first. However, the referenced attachment was not included in EPD file.):

> I encourage public participation on this material to the fullest. If people have a concern it should be addressed by TSG through EPD. Either solve the concern, address the concern or declare the concern unimportant. But all people need to be involved, if only to avoid the appearance of EPD and TSG having done this in secret.
>
> My personal recommendation is that any TECHNICAL ASR detail can be worked out by CH2M Hill (Injection rates, hydrologic capacity, movement off site, gradients, pressure changes, pumping rates…). They surely have the experience on these matters and hydrologists enough to assure the geologic and engineering success of the proposal.
>
> The treatment plant would be injecting dw [drinking water] quality downhole, which MAY OR MAY NOT be cleaner in some/most aspects than the water already in the aquifer. This will really attract public notice. My informal recommendation is that TSG use the middle or lower Floridan aquifer for injection zone, thereby by-passing the upper aquifer that MOST people are using for a takepoint. This may diminish some of the opposition to injection.
>
> From my perspective, which I have already verbally discussed with TSG and some folks at CGS, is that any engineering/geologic matter can be solved. The MAIN concerns and possibly project killer, are the POLITICAL (ie...non-engineering) aspects of the project. Such as:
>
> • Does Georgia actually wish to foster ASR projects, since this one would be the first. What sort of statewide precedent will be set?
> • If we wish to encourage S.C. on Hilton Head to take an engineering solution to the SW intrusion problem, can we afford to turndown the exact same project in OUR backyard?
> • Will people in Chatham want “TRITIUM” (or any other exotics from “that filthy river” injected into their groundwater, no matter what the actual standards are? etc……….
> • How accepting are they of the Beaufort-Jasper project, which will ALREADY be doing that?
>
> These problems (and more), I project are going to be the determining factors on this proposal, not any of the technical or engineering issues.

In June of 1998, the Savannah Business Journal published a lengthy article entitled, “Aquifer Storage Recovery Promises Future Supply of Water” (Sav. Bus. J.). The article explains in lay terms how ASR works, quotes water managers in Florida and South Carolina who are using ASR successfully, and expounds on the benefits of ASR. The article also relates Jim Walker’s perspective of TSG’s proposals: “City and county governments do not need to be in the water and sewer business to serve their constituents’ needs. They don’t need the obligation of debt or the requirements of operating, maintenance, and quality control. Right now the county is totally dependent on the City of Savannah for its future water. TSG would simply give Chatham an alternative water supply.” The author concludes by saying, “Water is essential to business, so regardless of what method is used, planning must begin immediately to insure that water needed tomorrow is available. ASR technology can give Savannah the opportunity to say clearly to new and relocating businesses, ‘We have water.’”

On August 4, 1998, Representatives Anne Mueller, Terry Barnard, and Burke Day hosted a public meeting at Armstrong Atlantic State University to gauge public sentiment about TSG and the ASR technique the company proposed. According to a report in the following issue of the Savannah Morning News (Krueger, d), more than 100 people attended, and the walkway leading to the auditorium was lined with anti-TSG, anti- Harold Reheis, and anti-ASR signs. Ms. Mueller and Mr. Barnard said that they planned to introduce legislation in January to ban the use of ASR in Georgia until it could be better understood. Among the speakers at the meeting was Ben Brewton, who reiterated many concerns about the potential withdrawals and added that “ASR poses additional threats to our coastal resources.” (Brewton, c)

A few weeks later, at a Chatham County Commission ASR Work Session, Ben Brewton presented the following detailed statement (Brewton, e):

> Of the tens of thousands of U.S. water systems, there are only 28 systems using ASR according to CH2M Hill (TSG's engineering consultant). Twenty-one of those systems were engineered by CH2M Hill. A number of those systems are considered to be "trial" or "experimental" systems. Therefore, there are a very, very small number of systems where this technology is "in use." Further, many of the locations where this experimental technology is in place are fundamentally different from the Floridan Aquifer in coastal Georgia. These differences include size, geology, amount of available water in the aquifer, and the quality of the water in that aquifer. In fact, most places where ASR is being used, the situation is EXACTLY THE OPPOSITE of what is being proposed here – the water in the underground aquifer is of lower quality and the injected water is of higher quality.
>
> Just a few of the many facts that must be considered are:
>
> - Injected water WILL mix with the aquifer water in a "mixing zone" at the periphery of the "bubble" of injected water. The more water injected, the greater the zone of mixing.
> -Injected water (and the "mixed" water) WILL move. This movement can result from either the very slow natural flow of the aquifer, or there can be a much higher velocity movement resulting from a pressure gradient caused by withdrawals. All of western Chatham County is in a gradient caused by the very large withdrawals at Union Camp, the City of Savannah, Kemira, and others. Therefore, there will be movement of underground water in a radial manner toward those withdrawal points.
> - Due to mixing of different water chemistries, there is a recognized potential for precipitation of a calcite "cement" which could seal the pores in the aquifer and cause permanent damage. (Surface water is high in dissolved oxygen, and low in carbon dioxide; underground water is low in dissolved oxygen and high in carbon dioxide.)
> - The potential for chemical reactions in the Floridan aquifer involving residual organic compounds in the injected water is presently unknown.
> -Corrective treatment for contamination of underground water is costly, lengthy, and only partially effective. Damage to the aquifer could result in a permanent need to provide additional treatment for all water withdrawn from the contaminated area. (And what would be the effect of contamination for people and businesses not on a system that could provide additional treatment?)
>
> We should also correct the misconception that there might be some sort of "restorative" benefit to the aquifer or prevention of saltwater encroachment as a result of the proposal – the TSG proposal seeks only to use ASR for the purpose of creating "a storage tank" in the Floridan

aquifer, so that the applicant will not have to build or seek other storage facilities for their water.

TSG has repeatedly responded to questions about the threat of contamination by saying that accidents would be "impossible." However, reading the daily newspaper, viewing television, and just plain old "common sense" make it obvious that this kind of unconditional statement is erroneous and irresponsible.

We agree that in a perfectly designed and managed system the probability for an accident might be small. However, in the real world, technology is not perfect, so in addition to the probability of an accident, we must look at the potential effects of such an accident, and this is where the evidence compels us to avoid the urge to use this experimental technology as a "quick fix."

Finally, the use of ASR should not be looked upon as simply a technical question. If we can put a man on the moon or land a machine on Mars, surely we can pump water out of a river and into the ground.

- It is a quality of life question…What is the value of clean, fresh water?
- And it is a public policy question, one that deserves rigorous scientific research and extensive discussion and debate…A discussion that must involve all users and be handled on a regional basis.

Furthermore, why should we take this risk now? Some quick math shows that a small amount of conservation could yield a tremendous amount of water for economic development. Additionally, if coastal industries would shift all of their non-consumptive water uses from the aquifer to surface water, there would be plentiful water available in every part of every coastal county for both new and existing residential and small business use.

ASR is simply a risk that is not worth taking at the present time.

As a college professor of hydrogeology stated to us just this morning:

"Contamination of groundwater is irreversible on a human time scale."

The following January, two bills were introduced in the Georgia General Assembly to prohibit the use of ASR in Georgia: one by Representative Anne Mueller of Savannah (House Bill 129) and one by Senator Eric Johnson (Senate Bill 48). According to a news account (Jones) Jim Walker responded to the legislation by saying, "This is really a science issue, not a legislative issue. It would be really sad that, because of Anne Mueller's inability to understand the science of it, that we would pass a law." But Anne

Mueller dismissed the lack of consensus in the issue: “Most people who think it’s OK don’t live down there.”

Considerable correspondence to legislators and between interested parties followed the introduction of these bills. Lines of support and opposition regarding the legislation were very close to those established in response the TSG proposal, with the addition of the Georgia Chamber of Commerce, which did not favor legislation against ASR because of its possible impact on companies considering locating in Georgia. There was less opposition to ASR specifically than to TSG’s proposal, but the issues had become substantially entwined. In one message advocating the legislation, Jerry McCollum (Georgia Wildlife Federation) illuminates a widely-held viewpoint: “SB 48 will, in fact, prevent a commercial monopoly of our coastal water supply for five years, giving us time to assess the real value of the injection technology on one of the purest groundwater aquifers in the world. No judgment is made about the injection technology! SB 48 speaks to the issue of making a long-term commitment to one solution with reckless speed and total disregard for the water resources study now underway; a study which will, coincidentally, be completed in five years.” (McCollum, c) A few proponents of the legislation, including Anne Mueller, were simply opposed to ASR and supported a permanent ban in Georgia (Mueller). An engineering consultant, Gus Bell, sent a letter to several legislators to encourage passage of the prohibition, listing a number of technical concerns about ASR but saying that he is in favor of the technique. His concerns were essentially the points that Ben Brewton had enumerated at the Chatham County ASR work session (Bell). A letter from David Pyne soon followed to refute each of the potential problems Mr. Bell had noted. Mr. Pyne’s letter included several key points

(Pyne, a): First, that [if the goal is to study the viability of ASR in Georgia,] the net effect of the proposed legislation would be to delay ASR testing and implementation in Georgia for many years. Second, that a regional study of ASR in the Floridan aquifer in coastal Georgia is not necessary, nor would it be particularly useful because site-specific study is required. Third, that the risk of contaminating the Floridan aquifer is the same negligible risk we take every day when water is treated and pumped into our distribution system… "Water treatment plants are not hazardous waste sites…and the operation of water plants is handled by licensed, trained professionals." Fourth, in answer to worries about chemical reactions, calcite precipitation, and other geochemical questions, he contends that these issues have been successfully resolved in the process of developing existing ASR sites.

House Bill 129, as presented to the House Natural Resources and Environment Committee, was written as follows:

> <u>House Bill 129</u>
> Brought before the Georgia House of Representatives January 15, 1999 and January 25, 1999.
> Introduced by Anne O'Quin Mueller (152nd), Terry Barnard (154th), Buddy DeLoach (172nd), George H. Mosley (171st), Ann R. Purcell (147th), and Ron Stephens (150th)
>
> Section 1.
>
> Code Section 12-5-31 of the Official Code of Georgia Annotated, relating to permits for the withdrawal, diversion, or impoundment of surface water, is amended by inserting at the end thereof the following:
> "(p) (1) The director shall not grant any permit for surface-water withdrawal, diversion, or impoundment for any applicant who uses or proposes to use aquifer storage or recovery of surface water. No water withdrawn pursuant to a permit obtained under this Code section shall be diverted, recharged, or otherwise placed into any aquifer. For the purpose of this subsection, the term 'aquifer' shall have the meaning set out in Code Section 12-5-92. This section shall be automatically repealed December 31, 2004.
>
> Section 2.
>
> All laws and parts of laws in conflict with this Act are repealed.

The Senate version, SB 48, was introduced by Eric B. Johnson (1st), Diane H. Johnson (2nd), Rene D. Kemp (3rd), and Jack Hill (4th). This version of the bill was brought before the Senate on January 26, 1999, and passed on third reading, March 8, 1999. It added a provision that included only the eleven counties of Georgia's coastal region:

> (2) The provisions of this subsection shall apply only for permits requested in a coastal area, as such term is defined in paragraph (4) of Code Section 12-5-322.

The senate passed the legislation as written, prohibiting the use of ASR until the end of 2004. However, members of the House Natural Resources and Environment Committee were not wholly convinced of the wisdom of the bill or its expiration date. During the course of the 1999 legislative session, Ms. Mueller and other legislators made several attempts for the bill to be heard by the full House as an amendment to existing legislation, and several times the Speaker of the House, then Representative Tom Murphy, said that the bill was not germane to the legislation being addressed. This was reportedly at the request of Representative Bob Hanner, Chairman of the House Natural Resources and Environment Committee, who is reported to have said, "We're not holding the bill up. We're trying to get a hold of the issue of ASR. I don't see the need to hurry the bill because [EPD staff] have told us there's no way anybody can get a permit before next session." (Sadowsky) Finally, the bill was attached as an amendment to a House bill (HB 502) affecting water well contractors, prohibiting the state from accepting a bond or letter of credit from any contractor planning on drilling a well to inject surface water into the Floridan aquifer, effectively placing a moratorium on the use of ASR:

> "(i) No bond or irrevocable letter of credit provided for in this Code section shall be accepted by the director from any water well contractor or driller who shall drill any well or borehole for the purpose of injecting any surface water into the floridan aquifer in any county governed by the Georgia coastal zone management program provided by Code Section 12-5-327 after July 1, 1999, and before December 31, 2002."

Speaker Murphy allowed the bill to be heard on the last day of the session, and Bob Hanner signed off on the bill after its sponsors agreed to shorten its length and apply it only to the coastal counties. According to a news report (Williams, f) Bob Hanner said the moratorium is essentially meaningless because EPD would be unlikely to issue a permit that soon: “We’ve been told there is no possible way for anyone to receive a permit for at least three years.” But one of the bill’s sponsors, Representative Terry Barnard said, “Something might have happened where they were able to get EPD to grant them a permit earlier. What we’ve done here is a guarantee …we know now that we’ll have plenty of time to make sure that what we’re doing is going to be good for all of coastal Georgia.”(Ibid)

Meanwhile, in January, The Savannah Morning News printed an editorial criticizing the entire process (Sav. Morn. News, b):

> Mrs. Mueller says the extra time is needed to study ASR. However, the technology has been around for almost 30 years. It’s also used in at least 100 other places in the country, and the risks appear to be safely managed. If it takes five years for the State of Georgia to determine if ASR would work here, then the head of the Environmental Protection Division must be the Nutty Professor. He’s not, of course. He’s Harold Reheis. His agency is trying to strike a balance by weaning coastal Georgia off groundwater, encouraging surface water use and not upsetting local governments that have their own agendas. ….If the EPD can’t be trusted to do its job, then lawmakers should be pushing Governor Roy Barnes to shake up that division. …I believe that Mrs. Mueller is sincere about her concerns with the science of ASR. But the real underlying issue isn’t water treatment. It’s water politics.

Later that spring, it came to the attention of EPD and Georgia legislators that just across the river from Savannah, the Beaufort-Jasper Water and Sewer Authority (BJWSA) was planning to install an ASR well in order to provide storage to meet seasonal demands. This raised significant concerns, among which was the fear of water containing tritium from The Savannah River Plant being injected into the Upper Floridan aquifer and migrating to Savannah. Anne Mueller went on record opposing the BJWSA plan (Connor): "I just feel like there are a lot of questions that need to be answered. The technology may be just fine, but I don't know that it is." In response, Dean Moss, general manager of BJWSA, insisted that the water would be treated to drinking water standards and tested for tritium before being injected into the aquifer. Also, he said that the purpose of having water in storage is to retrieve it. "We store it during times of plenty and use it in times of scarcity. We don't put it in there to wander off to Savannah." Mr. Moss said the issue in Savannah is a matter of competition between the City of Savannah and a private company that wants to introduce the storage plan in Georgia. Ms. Mueller refuted his conclusion, saying that the environment was taking precedence over politics on this issue (Ibid).

In the summer of 1999, a Georgia delegation including Harold Reheis, State Geologist Dr. Bill McLemore, Representatives Tom McCall and Frank Bailey, and Dr. Jim Kundell, University of Georgia professor and Science Advisor to the Georgia General Assembly, went to Tampa to meet with officials from the Southwest Florida Water Management District (SWFWMD) The district had been operating two ASR wells since the 1980s and was planning the construction of a third well.

In October, 1999, the House Natural Resources and Environment Committee held a two-day hearing on ASR. The first day, members of the committee heard arguments from a variety of supporters and opponents of ASR. The second day, representatives from the Southwest Florida Water Management District gave a presentation on the district's development and use of ASR since 1984. Some discussion involved whether the Sound Science Initiative should include an investigation of the feasibility of the use of ASR in Georgia. EPD members held that site-specific research is needed to properly study ASR, and that the Initiative should not be extended unnecessarily in terms of time and expense. A newspaper report said that Mr. Reheis assured the committee that TSG or any other applicant for an ASR project would have to undertake an extensive environmental-impact study before EPD would issue permits. "It's going to have to be a very site-specific study to see what the characteristics of the aquifer are at the site they intend to use," he said. "We don't want to make a problem where there isn't one." (Williams, d)

In February and May of 2000, EPD conducted meetings in Midway, Georgia, to identify groundwater management questions that stakeholders thought should be addressed by EPD and USGS in the Sound Science Initiative. The Georgia Conservancy planned and hosted the meetings. Stakeholders included representatives from industry, agriculture, local government, non-profit groups (including environmental groups), and recreational organizations. Among the issues stakeholders wanted addressed were several specific questions related to ASR. During the first meeting, the group identified a list of issues, and during the second, those issues were prioritized and synthesized for presentation to USGS. In July of that year, USGS responded with specific ways that modeling efforts would address the questions posed. This modeling work has been completed along with other work associated with the Sound Science Initiative, but not compiled or published (Johnson, 2002).

The following year, EPD released a report entitled "Assessment of Environmental Effects Associated with Potential Aquifer Storage Recovery Projects in Coastal Georgia." The report includes assessments done by two consulting firms, CH2M Hill and Golder Associates. Each firm was charged with answering questions posed by stakeholders in the previous groundwater meetings, in addition to other questions posed by EPD. The report details the findings of both firms, peer reviewed by the consulting firms LAW Environmental and Engineering, Inc. and Camp Dresser and McKee. The reports were summarized as follows:

> CH2M Hill: Experience during the past 17 years with ASR development in other states has shown that initial uncertainties, such as questions posed in this memorandum (the CH2M Hill Assessment) are relatively normal…Full confidence in the applicability of ASR in Georgia can only come from having at least one full size ASR well constructed, tested, permitted, and placed in operation. Until that time arrives, partial confidence can be achieved through literature reviews, investigations, modeling, and site visits to other nearby operating ASR sites utilizing the upper or lower zones of the Floridan aquifer as a storage zone.
>
> Golder: In summary, ASR has the potential to be a useful water resource management tool in coastal Georgia. Some concerns have been identified, but no environmental impacts have been identified that could not

> potentially be mitigated. An active permit program administered by GAEPD could insure that pre-construction investigations, pilot testing, and ASR design, operation, and monitoring are adequate to achieve the water resource management benefits while mitigating environmental impacts."

These reports have satisfied EPD staff members that there is now adequate information to say that ASR is "environmentally benign" (McLemore, 2002). In the meantime, environmental lobbyists and certain legislators have pushed for legislation to extend the moratorium on ASR at least until all reports from the Sound Science Initiative have been completed and released. During the 2000 and 2001 legislative sessions, the proposed bills were held back at the committee level.

Discussion and Analysis

The previous account was predominantly what went on record through newspaper reports, meeting notes, and letters in the months and years following TSG's proposals. What was not effectively recorded was the high level of emotion with which coastal Georgians responded to TSG's applications and the ensuing actions of others. Meetings were often loud and filled with angry accusations. A member of one environmental group said that meetings sometimes got quite nasty and personal. "It lost all semblance of civility. People were willing to do almost anything to win the fight. No one was talking science any more. It was very emotional." (Jennings, 2002) Even several years after the controversy, interviews with some of the participants elicited anger and insults toward other participants.

Had TSG initiated the application process with the smaller withdrawal amounts that were later proposed, the negative public perception might have been diminished. As it happened, however, the company became such a villain in the eyes of the public that virtually every move the company made became suspect. Groups worked against TSG for very different reasons, but the different ideologies became inconsequential in the face of a common enemy.

Likewise, the use of ASR may not have been questioned to the extent that it was if the proposal to use the technique had come from another entity, such as one of the local governments. Being tied in with the TSG proposal made ASR guilty by association, and stakeholders who might have normally supported the use of ASR used legislation against it to help defeat the proposed water withdrawals. Following is an analysis of the various positions taken, based on official and unofficial records as well as a great number of personal interviews.

The Environmental Protection Division

Harold Reheis and EPD are in the unenviable position of balancing environmental protection with the economic needs of communities affected by the agency's decisions: no matter what the decision, someone will likely be unhappy. EPD was ambivalent about TSG's proposal to some degree. When faced with the TSG applications, EPD recognized the potential benefits that could be gained by having an alternative water source in the region, and EPD had itself been promoting an increased use of surface water. The bottom line, however, for EPD's decision was the need for TSG to produce contracts from coastal municipalities or industries, which was a basic requirement for permitting. When accused of promoting TSG, Mr. Reheis was reported to say that the decision had been laid on the shoulders of local municipalities because without a contract, TSG would simply not be permitted (Ball). The last communication with TSG was a request by EPD to produce contracts with either municipalities or with large industries that would justify the amounts requested (Caldwell, 2002).

In retrospect, the opinion of people interviewed at EPD is that the legislation prohibiting ASR was unnecessary because during the period the prohibition was in effect, an ASR project was not likely to have been permitted, anyway. Even if TSG had lined up customers for the Ogeechee project, the company would have had to do extensive site-specific work to show that ASR was feasible and safe at that location. EPD will be heavily dependent on engineering consultants in the event that another ASR permit application is submitted because there was, and continues to be, no protocol developed for the assessment of ASR facilities in Georgia. (Three permits would be required to operate an ASR system in Georgia: an Underground Injection Control (UIC) permit, a non-consumptive groundwater use permit, and a permit to operate a drinking water supply system (CH2M Hill, d). However, procedures specific to ASR have not been established (Ogeechee).)

Savannah

Savannah had been required, along with the other counties in the 24-county Interim Strategy area, to develop a comprehensive water management plan and to comply with EPD's requests to reduce its groundwater use. City officials saw these new requirements as a significant burden, but something that EPD clearly would enforce, at threat of lawsuits from neighboring states over groundwater use. In part to meet the groundwater reduction goals, the city was in the process of constructing a $17-million expansion of its Industrial and Domestic (I & D) surface water treatment plant. In addition, Savannah had also recently lost one of its major water customers, Stone Container Corporation, which had used about 25 mgd for its production facility. Savannah had counted on Stone to help pay for the I & D plant. In the context of these events, it did not seem at all equitable to Savannah's officials that a private firm could be permitted without its own long-term plan—and then to compete speculatively with Savannah for a share of limited water resources. Supporters of TSG, as well as a significant number of relatively neutral observers, thought Savannah's opposition was an effort to maintain a monopoly on water provision in that part of the state. City officials will readily admit that annexation is part of the city's strategy to avoid becoming like Atlanta, with a poor inner city surrounded with wealthy suburbs that don't contribute to the city's tax base. Like most large cities, Savannah has seen much of its wealth and new growth move to suburban areas. Savannah also expressed concerns similar to other groups, such as protection of the riverine systems and the need for a thoughtful planning process; however, these arguments were possibly viewed as secondary to Savannah's other motivations.

Savannah's Bedroom Communities

Communities and unincorporated areas surrounding Savannah generally welcomed an alternative for their water supplies. With a cap on groundwater use, many of these areas were beginning to exhaust their permitted withdrawal amounts, especially given the rapid growth that they were experiencing. Savannah was more than willing to supply water, but it would be on Savannah's terms: a 20-year contract at a price of Savannah's choosing. Municipalities wanted to have independence from Savannah and be in control of their own destinies, which they knew would be dictated to a large degree by their capacity for service provision. Not only did towns like Pooler, Richmond Hill, and Rincon welcome TSG, but they were open to the idea of a new approach that would allow them to comply with the limits on groundwater withdrawal and that was designed to make the most of surface water flows.

Once the controversy surrounding TSG subsided, a new controversy has taken center stage, for one of these communities in particular. (It helps to illustrate the resistance of these communities to the control that Savannah exerts over the region's water resources, which continues to exist.) Unwilling to purchase water from Savannah, Richmond Hill applied for a permit to withdraw water from the Lower Floridan aquifer and treat the slightly saline water with reverse osmosis. City administrators were led to believe that this would be easily permitted, and they contracted the construction of a well and the execution of a pump test that they thought showed satisfactory results. However, a permit was not issued, and EPD began to encourage the city to buy water from Savannah. Richmond Hill brought suit against EPD in 2002. In January, 2003, EPD released a new protocol for withdrawing water from the Lower Floridan, which requires that any affect to the Upper Floridan as a result of Lower Floridan withdrawals must be monitored and mitigated by reductions in withdrawals from the Upper Floridan. This process will add significantly, perhaps prohibitively, to the cost of Richmond Hill's endeavor, and the town may continue its legal action against EPD on the grounds that the Lower Floridan Protocol did not exist when the permit application was first submitted.

"Watermen"

Shrimpers, crabbers, and fishermen on the lower coast were among the earliest and most vocal opponents to TSG's plans. The issue for them was the decline of their fisheries, which they attributed to a reduction in freshwater flows to the estuary. When EPD's Coastal Resources Division produced statistics that showed shrimp harvests to remain relatively stable since 1978, the shrimpers believed from experience that despite what the numbers said, this was not the case (Holland). This group was therefore staunchly opposed to anything that would further reduce river flows, primarily in the Altamaha, which flowed into a productive near-shore fishing zone.

The Lower Coast (Brunswick, Darien, and surrounding areas)

Lower coast communities were likewise sensitive to river flows on the Altamaha, as the health of the fisheries is of significant economic importance to the area. Additionally, as noted earlier, Glynn County was in the process of developing a long-term water management plan, as required by the Interim Strategy. Under those circumstances, it seemed particularly unfair to allow a private company not only to circumvent planning efforts, but to commence activities that might affect the county's own future water consumption.

The Savannah Group

TSG contends that the large amounts of water first requested in their original permit applications were simply an effort to comply with what they thought EPD expected, and certainly not intended as the “water grab” it was perceived to be. Company officials were frustrated for the entire duration of the debate by a public perception that they felt did not match their intentions. According to company staff, there was no speculative motive behind any of the permit applications. A need for an alternative water source was recognized, and it simply made business sense to try to fill that niche (Sprague). Admittedly, the goal was to make a profit, however, their view was not that they would be selling a public resource per se, but that their profit would come from the treatment and distribution of the water. They were surprised and baffled by the hostile response they received from coastal residents, since what they proposed seemed very similar to projects they had completed elsewhere.

Part of the negative reaction to TSG was due to the initially large amounts of water proposed in their applications, and part was due to a poor choice of representatives. Jim Walker was apparently not the appropriate person to sell this venture to coastal residents. He was said by many sources to display an attitude that implied that he was the ‘worldly and knowledgeable one’ trying to help out South Georgia’s ‘ignorant hicks.’ He is said to have personally offended many, many people, including Representative Anne Mueller (Mueller). Mr. Walker is no longer employed by TSG.

Hydrologists and Geohydrologists

A number of scientists employed by state universities, private firms, EPD, and USGS were interviewed to assess an objective scientific viewpoint of ASR in the fields of hydrology and geo-hydrology. Each of these scientists indicated that ASR is likely to be technically feasible in coastal Georgia, but each indicated that until site-specific studies have been done on the coast, its utility there will be unknown. Aspects of possible chemical and geochemical interactions between the injected and native groundwaters were acknowledged as issues that would require careful analysis at each location considered for ASR.

Environmental Groups

Environmental groups have a long-standing distrust of private companies because of many companies' historical reputation for disregarding environmental quality in favor of economic gain. This distrust came out very clearly in this controversy, when a private company stood to gain financially from the free use of a public resource.

Another element of trust came into play in terms of the engineering aspect of ASR. As Ben Brewton notes, the technical aspects are certainly possible: it is the long-term outcome that has not been proven yet (Brewton, 2002). Engineers generally hold limited credence with environmental groups because engineers are perceived to seek a technical "fix" to problems, which can sometimes create additional and compounded problems over the long term. When TSG hired its own consultants to do the "Altamaha River Hydrology and Fisheries Assessment," it was viewed to some extent as "the fox watching the hen house." Later, when EPD hired CH2M Hill and Golder Associates to do an environmental assessment of ASR, the results were criticized (Brewton, 2002).

In addition, Georgia's environmental groups are wary of EPD in terms of its willingness to truly provide environmental protection. EPD has gained a reputation for talking about the need for science, but in the end expediting permits that may lead to long-term, if indirect, environmental degradation. Even though TSG's first letter of concurrence was not written until about 18 months into the process, EPD (and Harold Reheis in particular) was accused of rushing the process and endorsing TSG. The fact that letters of concurrence were written without the originally stated requisites was seen as an indication that EPD would likely relax other requirements in favor of TSG. When EPD officials essentially said, "Don't worry, we'll take all this into consideration in the permitting process," many people feared that the process could be haphazard and somehow harmful down the road. With such a lack of trust that the organizations in charge of ensuring that this plan would be carried out with thoughtful, careful regard to protecting the riverine and estuarine ecosystems as well as the Upper Floridan aquifer, it was no surprise that these groups supported protective legislation.

Another aspect of the environmental groups' perspective, relative to the use of ASR, was whether the technique was truly needed at that time. Georgia had made few efforts to conserve its water resources, and it made more sense to explore the demand side of coastal water supply prior to taking possible risks with the groundwater supply. Because there were other means of dealing with the groundwater problems, there was no sense of urgency to embrace such a new storage technique—and upon completion of the Sound Science Initiative, ASR's risks could be more easily assessed.

Pulp and Paper Industry

Intensive water users such as ITT, Union Camp, and Georgia Pacific were not on the front lines of the debate because, for the most part, they were comfortably entrenched with their existing water provisions. They were also in the process of applying conservation measures so that overall use was reduced. Georgia Pacific, for instance, had voluntarily reduced its permit quantities from 55 mgd to 45 mgd (Roper). One of many arguments surrounding this issue was that the paper plants should be forced to use an alternative source of water, since their use is extremely high compared to all other uses in the region. Switching to surface water or any other source water that must be treated is an expensive proposition for these companies, one that will likely be undertaken only under absolute necessity.

Legislators

Legislators are called upon to become informed on many issues in any given legislative session, and it is virtually impossible to gain in-depth knowledge of each one. As a result, coastal legislators depended on their constituents' opinions to make judgment calls on TSG and ASR. Members of the Georgia General Assembly did not know the complex science of ASR, and even those who sponsored the bill had little knowledge of its advantages and disadvantages.

After the moratorium was in effect, a small legislative contingent (that did not include any of the legislators who sponsored the bill) went with EPD officials to Florida to assess how ASR was being used there. A few months later, the House Natural Resources and Environment Committee held a hearing with stakeholders and ASR experts designed to get further input and provide education on the subject. Opinions have changed little, however, and in the four years that have passed since prohibiting the technique, ASR has become an issue of little importance compared with the state's other pressing water issues.

The legislature seems to have been involved in this debate as a last resort to make sure that TSG did not succeed in implementing its proposals. To the hearts and minds of people truly concerned about contamination of the aquifer, there needed to be a higher authority than EPD to do the job—thus the legislative approach.

ASR's Future in Georgia

Possibly the most important issue to consider regarding the use of ASR in Georgia is whether there is a need for the storage technique. A meeting held in November, 2001, as part of the Sound Science Initiative, focused on water supply alternatives for Georgia's 24-county coastal area. The most popular solution the group identified was a conjunctive use strategy: use of surface water when it is available and use of groundwater in times of surface drought (Georgia EPD, j). The report noted that in the event of increased year-round use of surface water, ASR could provide significant savings for storing the treated water and could help protect instream flows from over-use in times of low flow.

Georgia's Experience and the Advocacy Coalition Framework

Relative to the advocacy coalition framework (ACF), the policy subsystem in this case consisted of all members of stakeholder groups and members of the public who had an interest in the outcome of the TSG permitting process and/or the legislative efforts related to ASR. Within this subsystem, two advocacy coalitions formed: one very large coalition composed of many organizations and individuals opposed to TSG (and some to ASR), and one smaller coalition that consisted of organizations that supported TSG. According to the framework, coalitions "share normative and causal beliefs and engage in a nontrivial degree of coordinated activity over time." This was true only to a very limited extent because the interests and motivations of the opposition groups were quite disparate. The only coordinated activity between all of these groups was an active participation in the public comment process conducted by EPD.

The hierarchical structure of coalition belief systems suggested by the ACF would be difficult to identify in this scenario because the different groups were operating from a variety of values and beliefs. Two common threads among many of the groups were varying degrees of distrust of a private company delving into the provision of public resources and varying degrees of concern for environmental protection.

An important tenet of the ACF is that within each coalition, policy-oriented learning occurs, and that each coalition makes an effort to gain the knowledge necessary to further their policy goals. Policy-oriented learning took place within certain interest groups and, at public meetings and hearings, between groups. The coalitions sought knowledge only on a limited scale because for the most part, only a superficial amount of information was needed to influence public and legislative opinion. Both coalitions used a variety of mechanisms to influence policy decisions: people sent letters to EPD and to legislators, traveled to Atlanta to attend meetings, made public pronouncements at meetings, and attempted to change behavior by exchanging information.

The ACF also says that information that conforms to existing beliefs will be used to buttress opinions and possibly attack opponents, and information that conflicts with existing beliefs will be resisted. This aspect was apparently true, as information that supported wariness about ASR was embraced, while a comprehensive document produced by EPD's consultants, which might have quelled fears about ASR, was criticized because peer review of the document was considered inadequate. Interest groups attempted to garner support from the scientific community. During the interview process of this research project, several interest group members encouraged communication with specific scientists thought to be sympathetic to their viewpoint. However, when interviewed, the scientists invariably expressed an objective viewpoint that took many variables into consideration.

Finally, the framework acknowledges that individuals' goals are complex and often difficult to identify. Each interest group in this scenario has a set of underlying belief systems, and each faces complex political, economic, and social realities. There were many possible motivations here, some of which may be included in this case study, and some of which may never be revealed.

Use of Science in Policy-Making

One problem mentioned repeatedly in this controversy was a perceived lack of knowledge—about the rivers, the estuaries, the aquifer, and this alien technique called ASR—with which to make scientifically-based decisions. This problem entails two elements. First, a general knowledge is required about the needs of the river and coastal ecosystems and about the dynamics of water in aquifers. These can and are being addressed to some extent by River Basin Plans and the Sound Science Initiative. Second is a site-specific knowledge of whether ASR is suitable for Georgia's coastal areas. Specialists agree that this assessment cannot be done in the absence of site-specific studies. As David Pyne pointed out to legislators prior to their passage of the moratorium on ASR, such an analysis will not be done while a moratorium is in place.

Use of available scientific information during the TSG controversy and during the ensuing legislative debate over ASR could be characterized as sporadic and superficial. Various interest groups shared among themselves and similar groups a limited amount of information regarding TSG's plans, but the information was not adequate to allow truly informed decisions. Information exchange between groups took place, for the most part, at meetings, and as noted earlier, scientific information was obscured by the emotional interests at those attending.

An attempt to engage broad public participation—a democratic approach—was the primary decision-making method employed by EPD during the permit evaluation process. However, public participation, as predicted in the literature, was heavily weighted to stakeholders who had a vested interest in the outcome. Then, in the absence of adequate information, legislators depended on input from those stakeholder groups. Thus, the groups with a vested interest controlled not only the short-term decision about Georgia's use of ASR, but had a tremendous influence on a lasting public perception. Even though the moratorium has expired, ASR will continue to be viewed with suspicion. As summed up by Harold Reheis recently, "ASR can be a viable option. But it got off to a bad start here: it got a black eye from its association with TSG, and anyone who tries ASR in the future will face an uphill battle." (Reheis, 2003)

FLORIDA

Aquifer storage and recovery has been practiced in Florida for almost 20 years, with the first well constructed in 1983 in Manatee County. To date, all ASR facilities operating in Florida have been designed to provide storage for public supply, and all are required to treat water to primary drinking water standards (defined in Chapter III) prior to injection. More recently, ASR has been included as an integral and possibly essential part of the Comprehensive Everglades Restoration Plan (CERP), with 333 wells planned to eventually provide the storage needed to re-supply water to the Everglades system in an attempt to restore its ecological integrity. This is the most extensive use of ASR ever proposed worldwide, as part of a $7.8 billion effort. State legislation was proposed in 2001 to reduce the treatment requirements for recharged water used for this project and other ASR facilities, and this sparked a heated state-wide public debate that called into question the quality of water that should be required of ASR operations and, to some extent, the use of ASR in general.

This case study will summarize the physical aspects of Florida's water resources and the state's water use, and then briefly describe the structure of Florida's water resource management, as it is significantly more complex than most states. Not only is it important to view Florida's use of ASR within this context, but terms related to this structure will be used in the case study. The state's ASR development and use will then be examined on two levels: at the district level (St. John's River Water Management District) and at the state level in terms of the projects that have received state-wide, national, and even international attention. Finally, the study will explore and evaluate the controversy regarding ASR that has developed during the last several years.

The Physical Setting

Florida is a water-rich state with rainfall averaging 53 inches per year. However, like in Georgia, areas of plentiful water sources and areas of high water demands are not always parallel. Public water supply comes predominantly from groundwater because the state's flat topography and high solar radiation make surface reservoirs less feasible for water storage than in most states. The Floridan aquifer system underlies the entire state, beginning in the north with a structure similar to that in Georgia, and transitioning southward to a zone in central Florida where the aquifer lies close to the surface, and then to the area south of Lake Okeechobee, where the aquifer system becomesbrackish. In the southern zones, productive fresh-water aquifers lie above the brackish Floridan aquifer, frequently close to the land surface. Major water supply sources in southern Florida are these freshwater, surficial aquifers.

Florida's Water Resource Management

Florida has a complex history of water resource management and water conservation efforts, with great changes beginning with the passage of the Water Resources Act of 1972 (Title XXVIII, Chapter 373, F.S.) and its establishment of the current regulatory structure. Management takes place on several levels, governed by regulations set forth in Chapter 373 under the supervision of The Florida Department of Environmental Protection (DEP).

Florida Department of Environmental Protection

Among other responsibilities, the Department of Environmental Protection coordinates water quantity and quality efforts throughout the state and serves as a repository and dissemination vehicle for scientific and factual information generated at other levels of government. Its Water Resources Management division has the ultimate responsibility for protecting water quality by establishing standards for drinking water and surface and groundwater quality, and conducting monitoring programs. In addition, the DEP has been required by statute to develop the Florida Water Plan, in cooperation with the water management districts, regional water supply authorities, and other organizations. The Florida Water Plan includes a description of the DEP's water quality and quantity programs, flood protection and floodplain management, standards of water quality, and plans developed by each of the water management districts, described below.

Water Management Districts

Florida's five water management districts (WMDs or districts) operate autonomously for the most part, following guidelines established by Chapter 373. This legislation gives the DEP "general supervisory authority" over the districts and directs the Department to delegate water resources programs to them where possible. Each district is governed by a board of nine members who are appointed by the Governor to serve staggered four-year terms. The districts are delineated as follows:

- Northwest Florida Water Management District;
- Suwannee River Water Management District;
- St. John's River Water Management District;

• Southwest Florida Water Management District; and

• South Florida Water Management District.

Each district governing board is required to develop a district management plan that addresses water supply, water quality, flood protection, floodplain management, and natural systems. The plans are based on a 20-year planning period and are updated at least every five years. Regulatory programs delegated to the districts include programs to manage the consumptive use of water, aquifer recharge, well construction, and surface water management. The districts are responsible for implementing protection and recovery programs for Water Use Caution (WUC) areas. These are areas where current or projected withdrawals are likely to impact natural systems in surface waters and wetlands, reduce groundwater levels, increase saltwater intrusion, or create competition between existing water users. Constitutionally, each district may levy up to one mill in ad valorem taxes, except that the Northwest Florida WMD may levy only one-twentieth of a mill.

Legislation Governing ASR in Florida

The following statutes of Chapter 373, F.S., establish regulatory guidelines for ASR well construction and operation and related activities:

> *373.087 District works using aquifer for storage and supply:* The governing board may establish works of the district for the purpose of introducing water into, or drawing water from, the underlying aquifer for storage or supply. However, only water of a compatible quality shall be introduced directly into such aquifer.
>
> *373.106 Permit required for construction involving underground formation:*

(1) No construction may be begun on a project involving artificial recharge or the intentional introduction of water to any underground formation except as permitted in chapter 377, without the written permission of the governing board of any water management district within which the construction will take place.

(2) Each water management district has the exclusive authority to process and issue permits under this section.

(3) A water management district may do any act necessary to replenish the groundwater of the district. [Additional rules apply to inter-basin or inter-district transfers.] The district may, among other things, for the purposes of replenishing the groundwater supplies within the district:

- (a) Buy water;
- (b) Exchange water;
- (c) Distribute water to persons in exchange for ceasing or reducing groundwater extractions;
- (d) Spread, sink, and inject water into the underground;
- (e) Store, transport, recapture, reclaim, purify, treat, or otherwise manage and control water for beneficial use within the district; and
- (f) Build the necessary works to achieve groundwater replenishment.

373.308 Implementation of programs for regulating water wells:

(1) The Department shall authorize the governing board of a water management district to implement a program for the issuance of permits for the location, construction, repair, and abandonment of water wells.

373.250 Reuse of reclaimed water:

> (1) The encouragement and promotion of water conservation and reuse of reclaimed water are state objectives and considered to be in the public interest. The Legislature finds that the use of reclaimed water provided by domestic wastewater treatment plants permitted and operated under a reuse program approved by the Department is environmentally acceptable and not a threat to public health and safety.

In general, ASR facilities are permitted for a period of five years, at which time a renewal application must be submitted to the DEP. In the mid-1990s, a rule change was made that allowed utilities, under specific circumstances, to operate ASR facilities under a letter of authorization from DEP rather than a permit. A letter of authorization is issued if a facility has constructed an ASR well (for which a construction permit is required) and has conducted enough cycle testing to show that the system is operating as designed and that there are no problems with water quality or recoverability. (A cycle is the complete recharge and recovery of a certain amount of water.) A letter of authorization does not expire as long as the facility makes no changes in its operation. Generally, the DEP requires some level of reporting to show that the facility is meeting basic standards (Haberfeld, 2003).

ASR Facilities in Florida

ASR is a quickly burgeoning storage method in Florida. There are currently eight drinking water facilities in Florida authorized by permit or authorization letter to use ASR, operating a total of 25 wells. Five of the facilities are in the process of expanding their ASR capacity, with 35 additional wells either constructed or in operational testing phases (DEP, 2002). All of these facilities use ASR storage to meet the needs of municipal water use, and in general, the facilities use ASR to provide for seasonal storage and/or long-term storage for drought management. Some of the facilities also use ASR to help control saltwater intrusion problems.

In addition, 39 more facilities are in a preparatory stage (i.e., have applied for a permit, have constructed one or more wells, or are conducting operational cycle testing) of ASR development. If all the wells currently constructed or under consideration eventually come online, Florida will have a total of 145 operational ASR wells operated by 47 separate water facilities (Ibid).

In the southern half of the state, where much of the ASR development is taking place, water is stored in the Upper Floridan aquifer, which there dips hundreds of feet below the surface and is quite brackish. Source water used for Florida's ASR systems is either surface water or potable ground water in aquifers closer to the surface, and some facilities use a combination of the two. Most of the facilities with operational ASR wells use treated drinking water for injection, although a few that use surficial groundwater sources pure enough to require no treatment are considered "raw ground water ASR" facilities. Several facilities are now testing the use of reclaimed water.

Problems with the development of ASR wells in Florida have been relatively few, and most have been overcome. There have been several instances when during testing, only a small amount of the total water injected could be recovered, and wells were abandoned. The most intractable problem thus far has been the appearance of arsenic in the recovered water in certain regions, such as the Tampa Bay area. Scientists at USGS suspect that the oxygen level in the injected water, compared to the lack of dissolved oxygen in the Floridan aquifer, is releasing arsenic bound in the aquifer matrix into solution. When this happens, the only remedy is to treat the water completely for a second time, when withdrawn, which adds to the cost of recovery (Haberfeld, 2003). It should be noted that arsenic concentrations have been shown to decrease over time as successive cycles of testing are conducted (McNeal, 2003).

Thus, for almost 20 years, there was no opposition to the use of ASR: it was a water management tool that was the domain of hydrologists, geologists, and engineers within or hired by the water management districts and local governments. Only a statewide controversy regarding the level of treatment that water injected into ASR wells receives (to be discussed in detail later) seemed to bring ASR under the scrutiny of environmental groups and, in turn, the general public.

ASR in St. John's River Water Management District

Because hydrogeologic conditions in the St. John's River Water Management District are most comparable to conditions in southeastern Georgia, research on municipal use of ASR in Florida focused on this area. This district is experiencing rapid growth similar to coastal Georgia, especially in its coastal areas and along the Interstate-4 corridor between Disney World and Daytona. In its 2000 District Water Supply Plan, the district declared the need for alternative water supplies other than groundwater to meet expected future demands. The plan identified surface water as the most cost-effective alternative, but because of high seasonal variability in both quality and quantity, the use of surface water will require significant storage and treatment. The St. John's River WMD managers consider ASR to be a reasonable option for storage for several reasons.

The potential storage volume is unlimited; wells can be developed close to the area of demand (highly useful for remote distribution); the cost of meeting peak demands with ASR is less than half the cost of other supply alternatives; and ASR has a variety of environmental benefits. This district alone will devote $11.82 million for ASR construction and testing for the fiscal year 2002-2006 period, split between ad valorem taxes levied by the district and cooperator funds (SJRWMD, b).

ASR projects can be initiated in two ways: the district may solicit participation by water supply facilities (referred to as “cooperators”) in order to further long-term planning goals, or cooperators may apply for consideration by submitting a letter of interest to the district. The district would screen the proposed projects for their applicability to the district’s goals and assess the feasibility of each. The St. John’s River WMD standard tasks for all ASR projects are as follows (Ibid):

- ASR Construction and Testing Program Plan (description of evaluation criteria and a list of candidate projects , to be distributed to policymakers, interest groups, potential Cooperators, and the technical community);
- Project Evaluation and Site Selection (point at which a project is deemed feasible or not, based on a set of criteria outlined in “A Tool for Assessing the Feasibility of Aquifer Storage and Recovery,” developed by CH2M Hill in 1997);
- Cooperator Agreement (establishes objectives and responsibilities);
- Site-Specific Data Collection and Preliminary System Design (district and cooperator prepare and execute plan for data collection and evaluation, and exploratory testing; a preliminary design is developed);

- ASR Pilot Project Design (includes design of well and wellhead facilities by firm contracted by cooperator);
- Regulatory Permitting (primarily through DEP);
- ASR Facilities Construction, Monitoring, and Testing (responsibilities of cooperator include hydraulic and water quality testing, geophysical logging, geochemical modeling, evaluation of pretreatment requirements, and cycle tests);
- Startup and Training (district provides consultant to assist Cooperator);
- Large Cycle Operational Monitoring and Evaluations (to be conducted during the first two to three years of operations, as needed to make adjustments to system); and
- Peer Review of ASR Consultant Team Work (review of products by other team members, as considered necessary by the district).

The two ASR facilities operating in the St. John's River WMD are good examples of the state's ASR facilities in function as well as size. One, in the City of Cocoa, is one of the largest of Florida's ASR sites, and another, in Palm Bay, is one of the smallest. Both, like most ASR systems in Florida, meet a variety of needs, with the primary purpose being the provision of seasonal storage and thus drought protection.

City of Cocoa

The City of Cocoa (Claude H. Dyal Water Treatment Plant) has one of the largest ASR facilities in the state. Construction began in 1985, and six wells became operational in 1990. In 1991, four additional wells expanded the system to a total of 10 wells. The system provides seasonal storage, reduces saltwater intrusion by reducing peak withdrawals, and increases the plant's peak supply capacity.

The water stored in Cocoa's ASR wells comes from a combination of sources: the Wewahootee well system, about eight miles west of the water plant, and the Taylor Creek Reservoir, with the amounts from each dependent on recent precipitation quantities. Prior to aquifer storage, the waters are blended and treated to drinking water standards with softening and chlorination. After recovery, water is chlorinated again and, if turbidity is high, the water is also filtered.

Water is stored in the Upper Floridan aquifer at a depth of about 370 feet, where the native water is relatively fresh (300-500 mg/L). The facility generally stores 500 to 600 million gallons of water, and the total pumpage capacity is 12 million gallons per day (mgd) from the 10 wells combined (each well can recover 694 gallons per minute). By permit, the facility must stop drawing water when the chloride concentration reaches 200 mg/L, but this tends not to be a factor because the facility does not attempt to recover back to the recharge amount. During initial testing, 60 to 80 percent of the injected amount could be withdrawn before reaching 200 mg/L (Larrabee, 2002).

Palm Bay

The (City of) Palm Bay water facility, formerly named Port Malabar, began operating its first ASR well in 1989. The facility has one ASR well and, unlike many of Florida's small plants, has thus far not applied for a permit to add additional wells. ASR is used here for meeting peak usage demands, preventing saltwater intrusion, recovering groundwater levels and improving its quality, and increasing flow and pressure in the distribution system.

Palm Bay's source water comes from 30 shallow wells (about 100 feet deep) in the surficial aquifer and three deep wells (about 800 feet deep) in lower reaches of the Upper Floridan aquifer. Prior to aquifer storage, most of the water receives standard drinking water treatment: lime softening, coagulation, sedimentation, filtration, and chlorination. A limestone softening plant has a 6-million-gallon capacity, and a recently-added reverse osmosis (R.O.) facility has a 1.5 million-gallon capacity. Another R.O. treatment plant will soon be constructed and will add 10 million gallons of treatment capacity. After recovery, the only treatment required is chlorination.

Storage, usually of about 80 to 90 million gallons, takes place in a shallower area of the Upper Floridan aquifer, at about 370 feet deep. Native groundwater in the storage zone has a salinity level of about 600 mg/L. The rate of withdrawal is a great deal lower than at Cocoa, at about 1/2 million gallons per day, averaging about 400 gallons per minute, and about 80 to 90 percent of the water injected can be recovered (Van Deventer, 2002).

The Comprehensive Everglades Restoration Plan

ASR took on state-wide and national importance when it was introduced as an important component of the Comprehensive Everglades Restoration Plan (CERP). The federal Water Resources Development Act of 2000 (signed into law by President Clinton on December 11, 2000) approved the CERP as a framework for modifying the Central and Southern Florida Project in order to restore damaged ecosystems and to provide for other water-related needs in southern Florida. Design and construction efforts for the CERP were estimated to cost $1.8 billion, to be shared equally between the federal and non-federal sources (USGS, b). The non-federal portion is to be split between the South Florida Water Management District and the State of Florida. To date, about $33 million has been authorizedby Congress for ASR pilot projects. Implementation will take place over a 40-year time span, and will involve a very significant coordination of efforts. The South Florida Water Management District and the U.S. Army Corps of Engineers (USCOE) will play important partnership roles, along with a variety of other state and federal agencies, in implementing the plan.

A great deal of water storage will be needed to implement the plan, and surface reservoirs cannot serve as the exclusive storage option because not only are reservoirs subject to high evaporation in Florida, but there is a very limited amount of land available or suitable for reservoir construction. The chosen storage option designed to complement surface reservoirs is a system of 333 ASR wells that are planned for storing water in the Upper Floridan aquifer, at depths of 600 to 1000 feet. Excess surface water will be collected during wet periods and stored, and then during dry periods it will be used to supplement waters in the Everglades ecosystem and help augment the region’s municipal and agricultural needs. The scale of this project is unprecedented anywhere in the world: approximately 1.7 billion gallons of water per day is projected to be stored underground in a relatively small geographical area around Lake Okeechobee and the northern Everglades. The amount of the CERP budget allocated for the ASR program is $1.7 billion (USGS, b).

A broad spectrum of people—scientists, environmental groups, and others—have expressed concerns about the magnitude of the plan, including geological issues and water quality issues. Geological issues focus on possible rock fractures caused by such significant hydraulic changes over periods of months and years. Water quality issues include the extent of treatment required for the proposed source waters, whether the water quality will change during storage, and whether the recovered water will pose any public health risks. Because much information is lacking about the subsurface characteristics of the area, the CERP included a series of pilot ASR projects.

In February, 2001, The National Research Council's Committee on Restoration of the Greater Everglades Ecosystem (CROGEE) published a critique of the pilot ASR projects and CERP's related plans. The report agreed with the incremental implementation called for in the CERP, but suggested that the utility of the pilot projects was too limited and that prior to implementing the pilot projects, more intensive research was needed. This research was necessary to increase understanding of 1) regional hydro-geologic properties and the possible combined effects of the wells; 2) water quality changes that would occur during storage and the effects on the recipients of the water; and 3) how local hydrogeologic properties and well construction features interact to influence well capacity and recovery efficiency.

Response to the report foreshadowed the later conflict between water managers and environmental groups. Water management district officials agreed with the majority of the report, but disagreed about the need to postpone the pilot studies, since these would take at least two years to complete and could be used in conjunction with the more comprehensive research projects. Additionally, the regional scientific studies are dependent on the ASR pilot projects to provide field data needed for regional modeling purposes. Peter Kwiatkowski, P.G., project manager for the Lake Okeechobee ASR pilot project, was quoted in the Vero Beach Press Journal to say, “If we hold off, there’s a delay, and I don’t think we need to wait for that.” (Sergent)

Quoted in the same report, Jonathan Ullman, the Everglades field representative for the Sierra Club, said, “We were suspicious that the testing wouldn’t be done right and this confirmed our suspicions. The report today shows that the pilot programs are woefully inadequate to protect our drinking water in Florida.”

Agency officials responded to the report by establishing teams to address the research needs identified. The “ASR Regional Study” was established to address the regional issues that went beyond the scope of the ASR pilot projects. The lead agencies for the study are the South Florida Water Management District and the U.S. Army Corps of Engineers. Because of the geographical scope of the project, the Southwest Florida Water Management District and the St. Johns River Water Management District will make contributions of data and other information specific to their districts (Kwiatkowski). USGS, the Florida Geological Survey (FGS), the U.S. Fish and Wildlife Service (USFWS), and the Florida Freshwater Conservation Commission (FFWCC) are also involved as members of the study’s project delivery team. Activities under the purview of the ASR Regional Study, including water quality studies, groundwater modeling, environmental studies, and many other aspects of potential regional impact, will continue until early 2010 (CERP, 2002).

To meet some of the research needs related to water quality, the “Fate of Microorganisms in Aquifers” study was initiated by the South Florida WMD and the

Southwest Florida WMD. The Southwest Florida WMD had recently developed water supply plans, in which ASR was chosen as a promising storage method. The level of treatment required (water must meet federal primary drinking water standards) by the U.S. Environmental Protection Agency and Florida law for water injected into ASR wells is quite significant because of the costs associated with treatment compared with using untreated or partially treated water. (It is also important to note that water destined for environmental restoration use could possibly be rendered *less* desirable through drinking water treatment.) This issue is significant not only for the South Florida WMD for Everglades restoration, but for the Southwest Florida WMD and many other regions of Florida where lower treatment costs would make the use of ASR more economically feasible.

The DEP's current standards for eliminating coliform bacteria in recharge water are based on its interpretation of the federal Underground Injection Control (UIC) regulations. If it could be demonstrated through testing and monitoring methods that sufficient treatment occurs naturally in the aquifer within a "discharge zone" around the well, unnecessary treatment could be avoided. The savings for the Everglades project would be on the magnitude of $250 to $400 million dollars (SFWMD, 2002).

The Fate of Microorganisms in Aquifers Study (generally referred to as the "Fate of Microbials" study) was established and funded by the South Florida WMD and the Southwest Florida WMD and contracted to the University of South Florida (under the leadership of water pollution microbiology expert Dr. Joan Rose, now with Michigan State University) and the consulting firm CH2M Hill. At a Project Advisory Committee (PAC) meeting, the scope of work was developed with the help of state and federal agencies that provide peer and technical review of data collection and testing, "to ensure that the results shall be of maximum value statewide." (SWFWMD, 2002) These organizations include the DEP, the Florida Department of Health (FDOH), the USGS, the Environmental Protection Agency (USEPA), the U. S. Army Corps of Engineers (USACE), and the water management districts. In addition, the Southwest Florida WMD was charged to "seek an integrated approach to achieving broader legislative and regulatory goals for ASR storage of high quality surface waters," meaning that the district would explore the value of possible changes to the current regulatory structure for ASR (Ibid).

<u>ASR Water Treatment Legislation:</u>
<u>The Aquifer Storage and Recovery Act</u>

During the 2001 session of the Florida Legislature, companion bills sought to reduce the treatment requirement for surface water injected into ASR wells: Senate Bill 854 and House Bill 705, referred to as the Aquifer Storage and Recovery Act. Although the impetus for the legislation was to reduce costs related to the CERP, the bills applied to ASR wells across the state. The bills, introduced during the last week of February, 2001, can be summarized as follows (Please refer to Appendix A for SB 854 in its entirety):

> The Legislature finds that it is in the public interest to conserve and protect water resources, provide adequate water supplies, provide for natural systems, and promote quality aquifer storage and recovery projects by removing inappropriate institutional barriers." …ASR wells must be constructed to prevent violation of state groundwater quality standards at the point of discharge, except as specifically provided in this section.
> The permit applicant must demonstrate that:
> • total coliform bacteria is the only primary drinking water standard other than the standard for sodium that would not be met before injection;

• the native groundwater within the proposed zone of discharge contains no less than 1500 milligrams per liter total dissolved solids (TDS) [drinking water is less than 500 mg/L];
• the proposed zone of discharge is not currently being used as a public or private drinking water supply, nor can any person other then the permit applicant reasonably be expected to withdraw water from the zone of discharge in the future for such use;
• directly or indirectly through the use of indicator organisms approved by the department, that biological contaminants will experience die-off such that primary drinking water standards will be met at the edge of the zone of discharge and that those contaminants will not pose an adverse risk to human health; and
• the department has approved a monitoring plan that specifies the number and location of monitoring wells, monitoring parameters, and frequency of monitoring.

> In addition, the applicant must demonstrate, based on hydro-geological conditions, the vertical and lateral limits of the zone of discharge, and must provide written notice to all landowners whose property overlies the zone of discharge. If drinking water wells are present within 2.5 miles of the zone of discharge, additional monitoring wells may be required to detect possible movement of injected fluids. All monitoring wells must be sampled at least monthly. After the ASR well is in operation, the applicant must demonstrate that biological die-off is occurring, that injection activities pose no adverse risk to public health, and that primary drinking water standards are met outside the zone of discharge. If these standards can not be demonstrated, the department will require operational modifications, reduction or cessation of injection, partial or full recovery of water, remediation, or other actions necessary to ensure compliance at the edge of the zone of discharge and to protect public health.

In response to the bill's introduction, an editorial ran on March 11, 2001, in the St. Petersburg Times with the headline, "DEP is pushing a bill that would allow water unfit for drinking to be injected into the aquifer for storage. The plan is too risky and should be rejected." The editorial goes on to say, "The aquifer is Florida's lifeblood, a plentiful and relatively clean source for most of the state's drinking water. So it is puzzling that the Florida Department of Environmental Protection is pushing a bill through the legislature that would allow water suppliers to pump tainted surface water into the subterranean aquifer for later use. …Storing water underground is less expensive than holding it above ground. But that wouldn't explain why the agency would open up aquifer storage of coliform-tainted water throughout the state."

While Georgia's TSG/ASR debate had taken place primarily at public meetings and through personal correspondence, Florida's ASR battlefield became the media. Through late March and April 2001, newspapers across the state printed frequent articles that almost invariably expressed disagreement with the legislation by environmental groups or associated "critics." Attacks on the proposed bills and their supporters were unabated, and rebuttals by the DEP and district officials were overwhelmed by the volume and emotion of the critics' arguments. Many news articles were written by staff reporters, while similar opinions also came out in editorials and letters to the editor. A few newspapers included illustrations that depicted smelly, dark water being pumped underground. A sampling of headlines gives a good indication of the tone of the news coverage:

March 15, *The Palm Beach Post*:	"Plan to Pump Dirty Water into Aquifer Moves Ahead"
March 25, *The Tampa Tribune*:	"Waste Water May go to Aquifers"
April 4, *The Ledger, Lakeland*:	"Don't Foul Florida's Nest"
April 9, *The Palm Beach Post*:	"Restrict Underground Wells; Science Uncertain"
April 12, *St. Petersburg Times*:	"Aquifer May get Tainted Water"
April 17, *St. Petersburg Times*:	"Aquifer Vote: Evidence that Reality is Not in Session"
April 18, *St. Petersburg Times*:	"Tainting our aquifer defies common sense"

Beyond the headlines was an even more heightened sense of alarm and dismay:

“This is a disaster waiting to happen.”

— Susie Caplowe, lobbyist for the Florida Chapter of the Sierra Club (Ash, b)

“The danger here is that you are jumping way ahead of the science.”

— Charles Lee, lobbyist for the Florida Audubon Society (Cox)

“The thoughtless lawmakers should be ashamed. The rest of us should be outraged.”

— Staff writer for the St. Petersburg Times (Webb)

“This bill gives me a queasy feeling in my gut. If we go forward and we are wrong we will not be able to fix this problem and fix its consequences.”

—Representative Dan Gelber, Miami Beach (Royse)

“Is this a deal with the devil?”

—Rep. Lois Frankel, West Palm Beach (Troxler)

Even out-of-state legislators entered the fray:

“Well, that’s dumber than dirt.”

—Georgia Representative Anne Mueller, told of Florida’s bills (Don’t Foul Florida’s Nest)

Aside from blatant affronts, many news articles and editorials were filled with negative jargon, often untrue, that mixed fact with judgment. A typical example was the opening line of a Lakeland Ledger editorial: “The Florida Legislature wants to pump dirty water into the virgin water of the Floridan Aquifer that supplies drinking water for much of the state and for portions of Georgia.” (An Iron-Clad Guarantee?) (Yet, according to the bill, if the facility had demonstrated that bacterial die-off would occur, the injected water would still have to meet all other standards, and the virgin aquifer to be used would have total dissolved solid (TDS) levels of at least 1500 mg/L. In addition, presently none of this water is used for drinking supplies because it would require treatment by reverse osmosis.)

The bill's supporters, for the most part, were quoted in the media to reiterate their views of the validity of the proposal and to point out the safety measures that were built into the legislation. However, the arguments that appeared in the newspapers were not well articulated, thorough, or often even accurate in their explanation of the ideas on which bill-proponents' views were based. A typical depiction was that the bacteria should die off, and that even if they did not die, the water would not move—yet if monitoring showed that the water did move, remedial measures would be taken. The arguments presented in newspapers throughout the debate did not engender confidence in the proposal. Oddly, the one thing that was not pointed out in the collection of articles studied was the fact that the legislation clearly made it incumbent on the ASR permit applicant to demonstrate that die-off occurs before the well is permitted for operation.

Occasionally, bill supporters answered critics' attacks with counter-attacks, such as when David Struhs, Secretary of the DEP, was quoted in the St. Petersburg Times to accuse environmental groups of using the issue to boost their fundraising efforts (Houserman, b). Jack Latvala, known as the Senate's environmental champion, was quoted in the same publication to call the concerns "much ado about nothing" and to blame "extreme environmentalists" for whipping up opposition (Hauserman, a). Another Senator damaged his own cause and took ridicule for saying, "I don't believe we're going to do anything to contaminate the aquifer. If we do, I'll be the first one to apologize." (Houserman, a)

In the midst of controversy, on April 13, 2001, the Senate voted 29-7 in favor of its version of the bill. A few days later, the House approved its version, 74-40, but added an exclusion of the Florida panhandle, which meant the bill would go back to the Senate. At this point, legislators were receiving hundreds of calls, letters, and e-mails in opposition to the bills, and some of the media assaults became quite brutal. One St. Petersburg resident wrote to the Times (Goffard), "…While realizing that the true motivation for support is a matter of speculation and will vary from senator to senator, it is better to think they were driven to "yes" for purely political reasons. Why? Because the alternative is to assume that they are brick stupid."

An interesting revelation of viewpoint appeared in the following article from *Calusa Digest*, a publication of the Sierra Club in southwest Florida, dated May, 2001 (italics added):

> Aquifer Storage and Recovery
>
> What is the Issue?
>
> SB 854/HB 705 would eliminate the standards for fecal coliform and other contaminants in Florida's underground drinking water supply through an experimental process called Aquifer Storage and Recovery (ASR). The Georgia Assembly recently passed a moratorium on ASR creation in coastal counties until 2003 because of safety concerns. *ASR is thought to be an inexpensive way for developers and local politicians to augment water supplies beyond their reasonable, safe consumption limits. The Florida Legislature is now being forced by developers and some local utilities to address this sprawl-encouraging storage procedure.* Bill texts are available at: http://www.leg.state.fl.us/Welcome/index.cfm. "We have taken strong stands against offshore drilling because of the risks associated with harming our marine environment from oil spills. What about drilling on a massive scale that will release *untold toxins* and fecal coliform into our drinking water supply?" said Sierra Club ASR spokesperson Alan Fargo. ASR wells pump excess surface fresh water under considerable pressure into a brackish (partially salty) underground source of drinking

> water (USDW) and later this water can be pumped up for municipal, environmental, or agricultural uses. In Florida, the immediately-targeted water source and the state's main fresh water source is the "Floridan Aquifer." It extends from Alabama, South Carolina and Georgia through the length of Florida. *The vast majority of fresh water is supposed to stay in an underground layer of porous limestone, not mixing with or migrating into the brackish water. This is rarely the case.*
>
> Monday, April 26, THE HOUSE PASSED HB 705 WITH 74/40 VOTES! That's the bad news. The better news is, that they picked up the amendment that excludes some counties in North Florida. That means the bill will be sent back to the Senate and the fight goes on. The following people voted a correct NO: [a list of legislators follows]. If these are your representatives, please call them and thank them for their good vote.
>
> These representatives voted YES, and deserve a call. Tell them how disappointed you are: [a list of legislators follows].

Three Florida scientists spoke out in opposition to the bill, and their views appeared in newspaper articles across the state. (Members of the scientific community who may have supported the legislation were not featured in the press coverage. Scientific viewpoints from bill supporters generally came from either DEP or the water management districts, who were not perceived as neutral analysts.)

Arguments by Harold (Hal) Wanless, Chairman of the Department of Geological Sciences at the University of Miami, were noted in newspaper articles on several occasions. His concerns were two-fold: that there is no concrete proof that the bacteria die off in storage because most of the state study has been done in a lab; and that there is no evidence that the injected water will stay confined once it is sent into the aquifer. (Pfankuch) "It's ridiculous to think that, until you know everything, you'd even think of putting pollution below our drinking water. The homework hasn't been done. This is a high, high risk." (Hull, e)

John Veccioli, recently retired as Florida's USGS district director, was also often quoted, saying, "This is something that really has not been studied yet with respect to the injection of untreated surface water. I think the state could be opening the door to a lot of problems." (Jehl) His concerns focused on the unpredictability of water travel in Florida's aquifers.

Finally, John Burns, Director of CyanoLab, specializes in harmful algae. He was noted for his concern that blue-green algae from Florida's rivers would be pumped into the aquifer. (Hull, c) Even if the algae itself died, the algae's toxins may persist and create a public health risk.

Also fuelling the unease of the legislation's opponents, news surfaced that Governor Jeb Bush had sent a letter, dated January 22, 2001, to newly-elected President George W. Bush, outlining federal programs that hampered state objectives. He specifically mentioned ASR in his letter, and urged his brother to "encourage your new managers at EPA" to meet with state officials to determine how to "assist the states in executing their agendas." (Pitman, c)

Meanwhile, DEP officials requested that the USEPA allow levels of total coliform to exceed primary drinking standards in the case of ASR injections. The USEPA was willing to allow such a variance, under the condition that such injections would not cause a public drinking water system to violate the Clean Drinking Water Act or otherwise adversely affect public health. Variance criteria must also include a demonstration of total coliform die-off, as well as safeguards such as monitoring and testing (Banister, 2001). According to news accounts, the USEPA's position in the controversy was that such variances should be issued instead of making a legislative change. (Pittman, c)

A related issue that environmental groups pointed out was that in at least two locations in South Florida, treated wastewater has been injected into the Lower Floridan aquifer for many years. The USEPA approved these injections, under the condition that the water did not migrate. The water has, indeed, migrated upward, but has not entered any aquifers used or likely to be used for drinking water. The USEPA has now changed the regulation to allow movement, but still prohibits movement into drinking water sources (Howe). Some news accounts during this period said that this practice had polluted drinking water wells, further eroding the public's trust in scientists to know what would happen to storage waters.

Toward the end of April 2001, the public campaign against SB 854/HB 705 finally had its intended effect: several legislators originally in support of the bill began to declare a change of heart. Still, at the close of the week on Friday, April 27, both supporters and opponents fully expected the ASR legislation to pass, awaiting only final approval in the House and a seemingly certain signature by Governor Bush. On Sunday, a last round of editorials and letters to the editor blanketed the state, including one written by the founder of the Legal Environmental Assistance Foundation, Suzi Ruhl, arguably the most active and outspoken member of the environmental community on this issue, and one written by David Struhs and Robert Brooks. On Monday, Governor Bush announced that he would likely ask the sponsors of the bill to withdraw it. He was quoted to say, "We can get the bill passed right now, but I'm not sure I want to put my friends on record on any issue that could be grossly distorted." (Ash, d)

After the death of the legislation, a different type of news coverage began to emerge. Along with continued affronts to bill supporters ("Saving the Governor from

Himself," St. Petersburg Times editorial, May 5, and "Deep-six treatment; Flood of Democracy Stalled Risky Wells, Sarasota Herald Tribune, May 7) came commentaries that explored to a greater level of detail the possibility that the legislation might have made sense. For instance, the following excerpt came from a Stuart News letter to the editor (Friday):

> The debate over aquifer storage and recovery (ASR) has obscured an important fact: The aquifer in which the excess surface water would be stored is undrinkable in its natural state. Occurring 1,000 feet beneath the surface in South Florida, the Floridan Aquifer is so salty that it would kill vegetation if pumped to the surface and used for irrigation. Hundreds of feet of dense clay protect the shallow drinking water aquifer above from the brackish aquifers below. …We now lose billions of gallons of surface water to tide, especially during the rainy season. ASR technology simply would allow this water to be stored in an undrinkable saltwater aquifer for future use, rather than be wasted.
>
> Critics of ASR also misrepresent the success of similar technology, deep-well injection, that has achieved a 30-year record of safety for discharge of highly-treated wastewater effluent into the saltwater aquifer approximately 3,000 feet beneath the surface. No actual drinking water source has been affected nor has any future drinking water source been negated because of deep-well impacts. …All other discharge alternatives place the water in closer proximity to human contact than deep-well discharge.

It is significant that in a collection of 77 news articles that appeared between March 1, 2001, and May 30, 2001 on the subject of the proposed legislation, this letter expressed ideas and facts that appeared in no other article. (Still, the crux of the matter, that the legislation did not simply authorize, carte blanche, the use of this water of questionable quality, did not appear here or in other passages sympathetic to the bill.) The collection of articles studied is certainly not exhaustive, but is the sample of articles made available through a "Lexis Nexis" and Internet search of "aquifer storage" related to Florida for that period of time.

The failure of this measure to become law did not leave a large impact: it simply would have allowed a cost saving for implementing the CERP (treatment costs were part of its original cost estimate) and new opportunities for water management districts to use ASR. Following the controversy, however, environmental groups expressed the intention to lobby for a constitutional amendment that would disallow injecting untreated water into the state's aquifers (Hull, g). To date, this measure has not been formally proposed.

Controversy Participants

The lists that follow—organizations and individuals in support of the legislation; organizations and individuals opposed to the legislation; arguments supporting legislation; and arguments opposing legislation—summarize the groups and positions taken in this controversy. Since the debate was largely guided by what appeared in Florida's newspapers, the individuals and groups are limited to the names and organizations that often appeared in news articles or editorials, and omitted the majority of representatives, who expressed their views by ballot.

A great many members of the public are assumed to have taken clear positions, some of which appeared in published letters. The newspapers listed were those among the collection reviewed that contained editorials and headlines that indicated a clear opinion on the matter. (As noted earlier, this study was not meant to provide an exhaustive content analysis of Florida's newspaper coverage.)

Similarly, the list of issues revealed in the newspaper coverage was not exhaustive of arguments that may have been made elsewhere, but representative of the points made in the press that influenced public and legislator opinion. This was, in many ways, a classic environmental dispute. Unlike in Georgia's ASR controversy, the participants here shared basically the same arguments, rather than expressing significantly different reasons for opposing or supporting the same measure. Members of the public lined up either behind the environmental groups or behind the DEP, water management districts, and others which, for the sake of simplicity of not perfect accuracy, will be referred to as "water management groups.'

<u>Supportive of Legislation (Water Management Groups)</u>

Governor Jeb Bush

Ken Pruitt, R-Port St. Lucie (introduced SB 854)

Joseph Spratt, R-LaBelle (introduced HB 705)

DEP, notably Secretary David Struhs

South Florida WMD

Southwest Florida WMD

St. John's River WMD

Tampa Bay Water

The Tampa Tribune

Many cities and water authorities who would use ASR if treatment standard were relaxed

<u>Opposed to Legislation (Environmental Groups)</u>

LEAF, namely founder Suzi Ruhl

Florida Sierra Club, namely Jonathan Ullman, Everglades Representative

Florida League of Conservation Voters

Florida Consumer

Audubon Society of Florida

USEPA (preferred variance approach)

John Vecchioli, retired USGS Florida district chief

Harold Wanless, Chairman, Department of Geological Sciences, University of Miami

John Burns, Director of CyanoLab

St. Petersburg Times

The Ledger (Lakeland)

Sarasota Herald-Tribune

The Palm Beach Post

The Florida Times-Union

The following lists present arguments by legislation supporters and opponents that actually appeared in newspaper articles. Additional information was revealed during interviews with officials at DEP and water management districts, as well as members of environmental groups. Using these lists as a foundation, such additional information will be presented separately, in the following discussion of the controversy in Florida.

Water Management Groups' Arguments Supporting Legislation:

- Water will be naturally cleansed during storage, making treatment unnecessary.
- There is enough data to support the die-off theory. (The purpose of the fate of microbials study is only to determine how, and how fast, the bacteria die.)
- Fresh water tends not to mingle with saline water.
- The bill would allow treatment rules to relax only for quite brackish aquifers (more

than 1500 mg/L TDS, compared to the maximum of 500 mg/L for drinking water).

- Permit applicants would have to prove that bacteria would die off and that the injected water would not migrate to drinking water supplies.
- Wells would not be placed near drinking water supplies.
- All private wells would be monitored to guard against contamination.
- Such wells are needed to keep pace with Florida's growth.
- The measure contains enough safeguards to meet federal and state water standards.
- A savings of $250-400 million would be realized in implementing CERP.
- Cost savings from reduced treatment could be used for other environmental projects.
- The need for potentially environmentally harmful treatment plants in the Everglades would be eliminated.
- The legislation would mandate a rigorous approach to evaluating every ASR project.

<u>Environmental Groups' Arguments Opposing Legislation:</u>

- Coliform bacteria and other contaminants could be pumped underground.
- Not all of the injected water is recoverable.
- Cost savings will come at the expense of public health.
- The Upper Floridan aquifer, though brackish in this region, could be a future source of drinking water.
- There is no guarantee the injected water will stay put: water movement in Florida's aquifer is unpredictable.
- Wastewater injections in South Florida have migrated into drinking water wells.
- Untreated water could migrate to private wells, where water is typically not treated.

- Monitoring wells are not sophisticated enough to track all the leakage.
- There is no guarantee that the viruses, parasites, and other organisms found in surface water will die underground: the bacterial die-off theory has yet to be proven.
- Raw water ASR is unproven.
- ASR is an inexpensive way for developers and local politicians to augment water supplies.
- The law would open the way for hundreds of new ASR wells in Florida.
- The bill would apply statewide, and regulators would be hard-pressed to monitor a large number of wells.
- Layers of rock could collapse, causing water to bubble up on the bottom of Lake Okeechobee.
- High-pressure injections could disrupt the subterranean geology and cause unwanted mixing between fresh water supplies and brackish water.
- If supporters are wrong, the damage could be irreversible.

Discussion and Analysis

Two distinct eras of ASR policy have become evident in Florida since the legislative debate in 2001: prior to the debate and since the debate. What was once an unheard-of storage method was transformed into a subject of state-wide debate, and although its limelight will likely fade, it will never return to obscurity again. As Florida expands its ASR storage capacity for municipal use and for the CERP, political agendas will likely take on an increasingly important role in its use and regulation. The three following sections provide an analytical summary of ASR policy formation before, during, and since the "great ASR debate" of 2001.

ASR Policy Prior to 2001

Until the issue of water treatment brought ASR to the forefront of public attention in 2001, ASR policy was quietly guided by the state's water resource managers: the DEP, water management districts, and local governments. A thorough system of analysis and testing was established, based on scientific principles from the combined fields of geology, chemistry, hydrology, and engineering. Professionals in these fields are included in the staffs of the DEP and districts; however, specialists in the development of ASR were also contracted to assist with engineering and technical aspects specific to the technique. Additional research is typically conducted by the USGS, especially where groundwater modeling is required, and by other institutions, such as universities.

If viewed in terms of its environmental impact, the members of the water resource management community considered it an environmentally positive storage method because it helped to preserve instream flows and existing high-quality groundwater resources. A system was established, based on the federal UIC permitting standards, for the DEP to implement the permitting procedure for new wells and to oversee the water management districts in the testing, analysis, and operational aspects of ASR. Although technical and engineering problems have sometimes arisen during project development, this system has been successful thus far in its ability to provide safe storage of drinking water, and has not given rise to pubic concern for the safety of drinking water resources. It seems that as long as ASR was relegated to relatively small systems (rather than such a huge undertaking as the Everglades project) and was restricted to the use of treated drinking water, there was no cause for alarm among the environmental community or other members of the public.

ASR Policy Debated

Each of the distinct sides of this debate naturally felt justified in its position. The environmental groups felt that the legislation was irresponsible, while the "water management" groups felt that environmentalists were spreading unwarranted fear and hysteria. Following is a more detailed view of each of these positions, with each followed by a list of hypothetical responses to the arguments (presented earlier) that were illuminated in newspaper coverage.

Environmental Groups

Many people in the environmental community would insist that this was not simply an environmental issue, but a practical public resource issue. Here, the consensus of opinion was that the bill proponents should slow down the process and wait until more is known about sub-surface processes. Knowing that research is in progress, and knowing that many aspects of biological and viral die-off are still unknown, the passage of such legislation seemed to completely by-pass the careful, deliberate progression that had been presented as imperative to the implementation of CERP. This was very similar to the attitude expressed by some groups in Georgia's debate about the use of ASR. (Georgia's environmental groups wanted the EPD to wait until the Sound Science Initiative was complete before such decisions were made.)

The environmental community in Florida has thus far not expressed opposition to the use of ASR if potable water is used for injection. This may be less true in South Florida, where the stress of burgeoning populations has contributed to an anti-growth sentiment that questions the provision of services that will contribute to sprawl. Also, there has been a push from environmental groups to convert land from sugar cane farming back to wetlands, and ASR is perceived as a possible impediment: if the storage takes place underground, it frees up more land for unwanted development. The massive scale of ASR that is planned for the CERP is a tremendous concern, not only for its water quality implications, but for its potential geological consequences. This concern is not unique to the environmental community: those working closely with the Everglades plan readily concede that the potential cumulative impacts of such a large number of wells need to be studied quite carefully.

Finally, like in Georgia, trust is an underlying issue. In general, environmental groups in Florida do not trust the DEP or the water management districts to provide adequate environmental protection. There is also a lack of trust in the consulting firms who specialize in developing and constructing ASR facilities, since this has been a field dominated by engineering professionals.

Environmental Groups' Hypothetical Rebuttals to Arguments Supporting Legislation:

- *Water will be naturally cleansed during storage, making treatment unnecessary.*

Not enough research has been done to prove this. Research has been limited to laboratory experiments, therefore you cannot know what will happen in the real world.

- *There is enough data to support the die-off theory. (The purpose of the fate of microbials study is only to determine how, and how fast, the bacteria die.)*

Even if the existing data were conclusive, which we do not believe is true, only a handful of bacteria have been studied. *Cryptosporidium* and *Giardia*, two of the most common disease-causing bacteria, have not been studied specifically, and "indicator bacteria" die-off does not necessarily prove that all bacteria die. In addition, viruses and endocrine-disrupting chemicals have not been examined in Florida's research efforts.

- *Fresh water tends not to mingle with saline water.*

However, fresh water injected as a "bubble" within or below saline water would tend to rise through any fissures that exist or that could result of hydraulic changes.

- *The bill would allow treatment rules to relax only for quite saline aquifers (more than 1500 mg/L TDS, compared to the maximum of 500 mg/L for drinking water).*

If we cannot count on the water to stay in place or its microbial contaminants to die off, it matters little where the water is injected: it could still end up causing a problem for drinking water wells.

- *Permit applicants would have to prove that bacteria would die off and that the injected water would not migrate to drinking water supplies.*

Too much information is lacking to adequately prove these things in the near future.

- *Wells would not be placed near drinking water supplies.*

Again, it matters little where the injected water is placed if we cannot trust it to stay there.

- *All private wells would be monitored to guard against contamination.*

To have an adequate number of monitoring wells would be prohibitively expensive. Furthermore, once you have contamination, it is virtually impossible to correct. If the injected water has migrated, it cannot simply be drawn back out.

- *Such wells are needed to keep pace with Florida's growth.*

We see no reason to subsidize needless sprawl and development.

- *The measure contains enough safeguards to meet federal and state water standards.*

There is not enough information to be able to say this with 100 percent certainty.

- *A savings of $250-400 million would be realized in implementing CERP*.

The cost to the natural environment and to public health could be immeasurable.

- *Cost savings from reduced treatment could be used for other environmental projects.*

We are not that easily placated: there is no guarantee of how the money saved would be spent.

- *The need for environmentally harmful treatment plants in the Everglades would be eliminated.*

The environmental degradation likely to be caused by the treatment plants is small compared to the damage that could come from the hydraulic pressure changes caused by pumping billions of gallons of water underground. You tried the engineering approach once before, and made a mess of the Everglades.

- *The legislation would mandate a rigorous approach to evaluating every ASR project.*

A lack of adequate knowledge would preclude adequate analysis.

Water Managers

These groups did not understand why the legislative proposal became such an emotional issue. If an ASR facility could not prove that bacterial die-off actually occurred, it would simply not be allowed to operate. It seemed very straightforward: put fairly good quality water into an aquifer of very poor quality where, during its storage, purification will take place in the water to be recovered—a “no-brainer.” In the engineering and water supply community, information about ASR projects flows easily between different countries, and there is a large international network of people involved in ASR development. (For instance, several of the professionals interviewed for this research project traveled to Australia in August of 2002 for an international conference on ASR.) Some countries (e.g., The Netherlands) already have years of experience using aquifers specifically for water treatment with the use of dual-injection wells: water is pumped into one well and drawn out of another, perhaps 300 feet away. Even in this country, other states’ laws (e.g., Arizona) allow a zone immediately adjacent to the wellhead where water is not required to meet drinking standards (Pyne, 2002). With this perspective, the reaction seemed unreasonable for what seemed to be a reasonable plan that included a number of safety measures.

Water Managers’ Hypothetical Rebuttals to Arguments Opposing Legislation:

- *Coliform bacteria and other contaminants could be pumped underground.*

Bacteria and salinity are the only two “contaminants” dealt with in the legislation. The temperature, native bacteria, pressure, and other aquifer characteristics work together to cause bacteria in the injected water to die off. We do not know all of the exact processes and interactions between processes that take place to cause this phenomenon, but we do know that this occurs. Fecal coliform does not last even 10 days under aquifer storage conditions.

- *Not all of the injected water is recoverable.*

Environmentally, it does not matter if the water is recoverable if the quality of the water injected is better than the native aquifer water.

- *Cost savings will come at the expense of public health.*

We believe this will not be the case. Based on international research and practice, we believe the process is safe.

- *The Upper Floridan aquifer, though brackish in this region, could be a future source of drinking water.*

If such highly saline water is ever used for drinking water, it would have to receive RO treatment. The water proposed for injection is of better quality than the existing water in the aquifer.

- *There is no guarantee the injected water will stay put: water travel in Florida's aquifer is unpredictable.*

Movement is not a problem because the water will have been purified by the natural conditions present in the aquifer.

- *Wastewater injections in South Florida have migrated into drinking water wells.*

Wastewater has been shown by monitoring wells to have migrated into neighboring saline zones. It is not true that the water has entered wells that are actually used for drinking. The Upper Floridan aquifer is technically categorized as a potential drinking water source in South Florida; however, its high salinity in this region makes this use realistically unlikely except if reverse osmosis facilities are provided.

- *Untreated water could migrate to private wells, where water is typically not treated.*

If the water has been in the aquifer long enough to migrate, the natural processes in the aquifer will have purified it enough so that this would not pose a problem.

- *Monitoring wells are not sophisticated enough to track all the leakage.*

See the response given above.

- *There is no guarantee that the viruses, parasites, and other organisms found in surface water will die underground: the bacterial die-off theory has yet to be proven.*

We are relying on the results of studies done on indicator bacteria. Projects will not be permitted unless it can be proven that the bacteria will die at that injection location.

- *Raw water ASR is unproven.*

ASR has been proven over a 20-year period in the U.S. and in other countries to be a safe and effective way to store water. The only difference is that instead of using chemical treatment methods, we could be saving money by using the aquifer's natural cleansing properties to purify the water.

- *ASR is an inexpensive way for developers and local politicians to augment water supplies.*

This is a good thing. Facing such population growth projections, we need to be planning for future water provision.

- *The law would open the way for hundreds of new ASR wells in Florida.*

Such wells would be allowed only in areas where the salinity of the receiving zone is above 1,500 mg/L (drinking water is less than 500 mg/L), in addition to other siting requirements. Thus, these wells would be limited to very specific areas.

- *The bill would apply statewide, and regulators would be hard-pressed to monitor a large number of wells.*

Permitting would proceed only to the extent that monitoring protection could be adequately and consistently applied.

- *Layers of rock could collapse, causing water to bubble up on the bottom of Lake Okeechobee.*

The CERP is a project that will take many years to complete, using adaptive management to determine the ultimate product. Modeling efforts are currently underway to determine the possible impacts of injection on this scale.

- *High-pressure injections could disrupt the subterranean geology and cause unwanted mixing between fresh water supplies and brackish water.*

See the response given above. Also, mixing does not tend to take place. If brackish water is displaced by the injected water, no harm is done because the injected water has been naturally purified.

- *If supporters are wrong, the damage could be irreversible.*

We have no reason to suspect that a slight difference in the quality of injected water will cause any significant damage, especially given the quality of water that now exists in the proposed storage zone.

ASR Policy Since 2001

Since the debate about the Aquifer Storage and Recovery Act, ASR policy is not the quiet domain of engineers, hydrologists, geochemists, and geologists. With ASR now a salient public policy issue, environmental groups and other citizens will pay attention to decisions made on a state, district, and local level. The kind of controversy that took place in 2001 is not likely to happen again in Florida unless a serious problem occurs to make the public question the way ASR is currently practiced. The issue of water treatment regulations for ASR is one that DEP officials are happy to leave shelved for a long while.

Florida's Experience and the Advocacy Coalition Framework

Most of Florida's history with ASR involves no controversy, and thus has little relationship with the advocacy coalition framework: there was no need for coalitions. Prior to the legislative proposal to relax standards for water treatment for storage in ASR wells, many people in Florida had little knowledge or interest in ASR. When the legislation was proposed, there was a small policy subsystem consisting of individuals and groups who attended to legislative matters. The issue gained state-wide salience quickly, and the policy subsystem became quite large. Compared to Georgia's ASR debate, with many groups operating with clearly differing agendas, Florida's debate was relatively straightforward. There were two distinct advocacy coalitions here: those supporting, and those opposing, the ASR legislation. The arguments were fairly uniform within the two coalitions, but the two operated very differently from one another.

The environmental groups, recognizing a common enemy, worked together to gain public awareness of their side of the argument. They not only spent time and resources to promote their ideas in the media, but also used their membership affiliations to disseminate information and encourage members to take action. Information shared between groups was also used to influence public opinion. This coalition was extremely effective and ultimately accomplished the goal of defeating the ASR bills.

Those supportive of the legislation, on the other hand, were bound together only by an assumption that what they had in mind was reasonable. It seems that they were caught off-guard by the strength of their opposition and, had there been more time for forethought, may have taken actions that might have diffused the controversy. In this coalition, there was virtually no coordination of efforts to defend against what was seen as a misinformation campaign, and their ideas were not effectively communicated.

The Use of Science in Policy-Making

A discussion of the use of science in Florida's ASR policy, like the discussion of ASR in general, must be separated into two eras: prior to the 2001 legislative debate and after the debate. Prior to the debate, ASR policy was decided by the scientific and regulatory community, and was relatively devoid of public input. The debate changed this completely by involving the public in an issue that virtually everyone could relate to: clean drinking water. Referring to the works of Jasanoff (1990), there was a dramatic shift from a technocratic approach, in which scientific information is used to make decisions, to a democratic approach, in which the public is an active participant.

Scientific policy is generally thought of to be determined by a small leadership group. This, too, was true prior to 2001, but has since ceased to be the case for ASR policy.

In an article that appeared in the St. Petersburg Times, a legislator commented, “The debate turned, not reassuringly, to a contest of newspaper editorials.” (Troxler) Above all else, this case study demonstrates the power of the media to shape public policy, even for a highly technical issue such as ASR. The problem that exists in such a scenario is that the issues are simplified for public consumption to a degree that important realities may get lost, and in the end, almost forgotten. The debate becomes one in which the groups with the most effective public relations abilities win, and the final outcome may have little to do with what science says is “the right thing to do.” This analysis makes no judgment on the decision made to continue to require primary water treatment for all aquifer storage projects in Florida. Indeed, the “right thing to do” may have been exactly what happened. However, because the voice of thoughtful, deliberate reasoning for the ASR legislation was not adequately represented in the newspaper coverage during the controversy, the decision could be said to have been made for the wrong reasons. The public response may have been the same even if the legislation had been presented differently, but we cannot know that since the apparent main sources for public knowledge—newspaper articles and information presented by environmental groups—rarely presented any justification for supporting the bill. Florida’s environmental groups pointed to the success of our democracy in this scenario, but true democracy is dependent on a fully informed citizenry.

SOUTH CAROLINA

South Carolina began using aquifer storage and recovery in the late 1980s. Four facilities, in the vicinities of Beaufort, Charleston, Myrtle Beach, and Kiawah Island, now have operating aquifer storage and recovery wells. A pilot project was initiated within the last year in Orangeburg, about 30 miles south of Columbia. Additional pilot projects conducted several years ago in Charleston and in Myrtle Beach produced disappointing rates of withdrawal, and these facilities have not applied for operational permits. This case study will explore South Carolina's experiences with testing, permitting, and operating ASR systems and describe each active facility and pilot project. South Carolina's experience with ASR has been straightforward and based on a foundation of hydrogeologic principles and a quickly growing knowledge base of this storage method.

South Carolina, like Georgia and Florida, is blessed with abundant water resources, but the timing and location of availability do not necessarily correspond with the timing and location of demand. Therefore, the main impetus behind ASR use in South Carolina was, and continues to be, the need to meet demands that tend to peak daily and seasonally. ASR allows treatment facilities to meet these peak demands without incurring the cost of significantly expanding treatment plants. ASR is thus used both for short-term peaking storage and for longer-term seasonal storage, and is used as well for emergency supply in the event of alternative system failures or hurricanes.

Also like the other two states, South Carolina has experienced significant population increases and subsequent development pressures in its coastal zone. An important difference between this state and the others, however, is that groundwater withdrawal in South Carolina does not dominate total water usage. In fact, according to a recent report by the South Carolina Department of Health and Environmental Control (DHEC), surface water use in 2000 made up 99.6 percent, and ground water made up .40 percent of total water use in the state. Considering only public water supply, groundwater was used significantly more but still accounted for only about 22 percent of total usage (DHEC, June 2000). Most of the state's groundwater use takes place in small communities of the coastal plain. In the large population centers, both above and below the Fall Line, municipal water supplies depend on surface water (Devlin, 2003), including the state's three largest rivers, the Santee River, the Great Pee Dee River, and the Savannah River. ASR complements the existing system of surface water withdrawals by allowing storage in coastal counties that would otherwise require much more expensive manmade structures.

South Carolina's Water Resource Management

Water use in South Carolina is regulated by two state agencies: the Department of Health and Environmental Control and the Department of Natural Resources. In 1973, the State Board of Health and the Pollution Control Authority were combined to form the Department of Health and Environmental Control (DHEC). Under the current structure, DHEC is responsible for regulatory functions that can broadly be divided into two spheres: protecting the environment and protecting public health. The Bureau of Water within DHEC is charged with implementing the federal Safe Drinking Water Act and the South Carolina statutes, the 1976 Groundwater Use and Reporting Act and the1976 Surface Water Withdrawal and Reporting Act. DHEC develops permitting procedures and processes all permit applications. The Department of Natural Resources (SCDNR) is responsible for conducting research and water resources planning, and managing wildlife resources. The DNR developed the South Carolina Water Plan in 1998.

The Ground Water Use and Reporting Act provided legal authority for the designation of Capacity Use Areas. The Board of Natural Resources is authorized to designate these areas "where excessive groundwater withdrawal presents potential adverse effects to the natural resources or poses a threat to public health, safety, or economic welfare, or where conditions pose a threat to the long-term integrity of a groundwater resource, including saltwater intrusion." (Ground Water Use and Reporting Act) When an area is designated as a Capacity Use Area (CUA), groundwater use equal to or in excess of three million gallons per month must be permitted by the Department. In addition, new groundwater users are required to issue public notice and allow a public comment period. Aquifer storage and recovery wells are exempt from this regulation if they are permitted in accordance with Underground Injection Control (UIC) regulations and the amount withdrawn is less than or equal to the amount injected.

For groundwater withdrawals outside CUAs, well operators must notify DHEC of the intent to construct a well or increase the capacity of existing wells at least 30 days prior to initiating action. Beyond this requirement, reporting of water use outside of CUAs has historically been voluntary. However, as of January 1, 2001, anyone withdrawing three million gallons per month of groundwater or surface water must register with DHEC and report that use annually.

South Carolina's Underground Injection Control Regulation (R.61-87) provides authority for DHEC to issue construction and operation permits for ASR wells and other underground injection wells. The goal of the permitting program under DHEC is to ensure that all underground injection systems are designed and operated so that water quality is maintained in the receiving aquifer as well as other aquifers.

ASR Permitting Procedure

South Carolina requires all ASR facilities in the state to treat any water injected into an aquifer to meet both primary and secondary drinking water standards prior to injection. In order to operate an ASR well, a facility must obtain sets of permits from two divisions of DHEC. The Underground Injection Control division issues a permit for construction and, after specified conditions have been met, a permit for operation. The UIC permitting process concentrates primarily on the storage and retrieval process. The Water Supply division also issues permits for both construction and operation, focusing on water withdrawals, whether from a ground or surface source (Devlin, 2003). Each permitting step may vary in complexity, depending on site-specific needs. The application for a UIC permit, issued for a 10-year period, must include the following attachments for DHEC review:

- Summary of activities that require a UIC permit
- Well construction details (surface and subsurface)
- Operational data, including average and maximum rate and volume of injection at each well, average and maximum injection pressures, pumping schedules, and duration of project
- Description of monitoring program, including monitoring devices, frequency, sampling protocol, and hydraulic control of the injected water
- Existing state or federal permits
- Description of business
- Area of review (radius of 1/4 mile)
- Map of wells and area of review
- Geologic cross-sections and diagrams
- Name and depth of underground sources of drinking water (USDWs)

• Sufficient supporting data to demonstrate hydraulic control over injectate/groundwater computer models

Overview of ASR Development in South Carolina

The earliest tests of ASR in South Carolina began in the mid-1980s and were conducted by the USGS and the South Carolina Water Resources Commission (since incorporated into DHEC). A steering committee and advisory committee, consisting of representatives from universities, state agencies, local facilities, and other stakeholders, helped guide the progression of South Carolina's testing program and helped procure project funding from the state and local municipalities. Florida had already constructed its first ASR well (Manatee County, in 1983), and as Florida expanded its use of ASR, South Carolina was able to benefit from its learning experiences. As general testing progressed to project development, CH2M Hill, an engineering consulting firm with expertise in ASR, worked through the ASR development process with DHEC and the local water facilities.

The first new ASR well in South Carolina was constructed in Mount Pleasant, a suburb of Charleston. In Myrtle Beach, several wells were abandoned during the 1980s as the city transferred its water supply from the Black Creek aquifer to surface water. Therefore, one of Myrtle Beach's water facilities, Grand Strand, was able to re-work an existing well to be used for ASR.

ASR Facilities in South Carolina

In order to avoid unnecessary redundancies, one ASR facility in South Carolina was chosen for an in-depth analysis of ASR operations, and discussion regarding other facilities is limited to specifics significant to each facility. The Beaufort-Jasper Water and Sewer Authority was chosen for a more thorough investigation for two reasons. First, because of its proximity to Savannah, where ASR is most likely to eventually be used in Georgia, there are similarities in geology, geohydrology, water chemistry, and possible utility for ASR in the two areas. Second, its proximity to Savannah was the subject of concern expressed by Savannah officials and the Georgia Environmental Protection Division.

Beaufort-Jasper Water and Sewer Authority

Beaufort-Jasper Water and Sewer Authority (BJWSA) operates two ASR wells for recharge and recovery and one well for recovery only. The facility was permitted to operate its first ASR facility in June 1999 at the Chelsea Water Treatment Plant, and this well (AR-1) became operational in 2000. CH2M Hill has been the primary consultant for each of the three wells. Water for storage comes from the Savannah River via a seven-mile earthen canal, treated to secondary drinking water standards (including chlorine and fluoride), and stored in the Upper Floridan aquifer at a depth of about 150 to 300 feet (Parham, Smith). Typically, water is injected during October, stored during the winter months, and recovered beginning in April. When withdrawn, more chlorine is added because the chlorine dissipates during storage.

The plant currently supplies an average of 24 million gallons per day to its service area. Tests show that the water has not moved beyond the Authority’s property (of approximately one acre) and that it would take 116 years for any injected water to migrate to Savannah. ASR-1 is permitted to store up to 500 million gallons of water at any given time, and DHEC allows up to 90 percent if the injected water to be recovered.

The test well drilled prior to the construction of ASR-1 lies approximately 1500 feet away from ASR-1, and this well was used for more than two years for sampling and monitoring purposes. Because the storage system was highly productive, the Authority applied to DHEC to drill an alternative monitoring well (about a mile from the treatment plant) so that the original test well (TW-1) could be used for withdrawal. In August 2001, the Authority was permitted to use the test well to recover water stored in the aquifer via ASR-1. Treated drinking water is recharged to the aquifer through ASR-1 and can be recovered through either ASR-1 or TW-1.

ASR-2 was constructed about seven miles away from the main treatment facility, in another part of the BJWSA service area. Cycle testing is underway, and the well is scheduled to begin operation during the summer of 2003. The Authority is considering installing additional ASR wells in more remote locations within the service area to realize the cost savings of having wells located close to areas of demand. Where wells are removed from the treatment plant, water is treated and piped to the ASR well, injected, and when the water is recovered, it receives only disinfection at the wellhead before it is distributed.

DHEC makes permitting demands that are specific to each proposed ASR site; therefore, certain requirements are not standardized but are generally practiced. Prior to being permitted, along with the standard attachments required for a UIC permit, DHEC required BJWSA to submit the following information (which are, in practice, generally required for ASR permitting):

- A water-quality analysis using data from treated water at the existing water treatment plant and native groundwater from the Upper Floridan aquifer to determine if any adverse geochemical changes could occur;

- A geochemical computer model to analyze the above information, along with geochemical logs, drilling logs, and cutting descriptions;
- A cycle testing program must be completed and submitted; and
- Information from an observation well, including aquifer transmissivity, storativity, and all raw pumping test data observations and calculations.

Permitting was also subject to the following conditions:

- The chemical, physical, and bacterial quality of the well water must meet USEPA primary and secondary standards or treatment may be required. The water must be evaluated for corrosivity to comply with the Lead and Copper Rule;
- Before an approval to “Place Into Operation” could be issued for the proposed construction, a comprehensive operation and maintenance (O & M) manual was to be developed for all facility processes.
- All required chemical parameters were to be tested, with results shown to be below current MCL’s (maximum contaminant levels established in the federal Clean Water Act). Results must be submitted and approved by DHEC’s Water Supply Permitting Division prior to final inspection.
- Due to the well withdrawing a mixture of injected water and native groundwater, it requires a Capacity Use Permit.

Grand Strand Water and Sewer Authority

Four ASR wells operate at the Grand Strand Water and Sewer Authority in Myrtle Beach, primarily to provide storage to meet high summer demands and emergency needs without costly additional treatment facilities. The first well was permitted in 1996. Grand Strand has 25 wells, four of which are now ASR wells and 21 of which are native groundwater wells. CH2M Hill was the primary consultant for construction and testing of the facility's ASR wells (construction here entailed converting existing standard wells to ASR wells). Water for the ASR wells is drawn from Bull Creek, a tributary of the Great Pee Dee River. The water is treated to secondary drinking water standards, injected and stored, then disinfected with chlorine after recovery. Storage takes place in the Black Creek aquifer, at a depth of about 700 feet, where the native groundwater is slightly saline and has high fluoride content. About 80 to 90 percent of the water injected is generally recovered.

Mount Pleasant Waterworks and Sewer Commission

The Mount Pleasant Waterworks and Sewer Commission serves Mount Pleasant, a northern suburb of Charleston. The primary purpose for using ASR there is to help meet peak daytime demands. It was also developed to serve as an alternative water source and for emergency supplies in the event of a hurricane. Two ASR wells are currently operational. The first was permitted to operate in June 1997, and the second one was permitted in May 1998. CH2M Hill was the primary consultant for the testing and construction of both wells. Unlike most ASR operations, Mt. Pleasant withdraws water from an aquifer—the Middendorf aquifer. Water is treated with reverse osmosis, then injected into the Santee Limestone aquifer. After recovery, ammonia and chlorine are added. (Chlorine alone breaks down quickly, but the addition of ammonia creates chloramine, which has a longer life. After recovery, water may stay in above-ground storage tanks or in transmission lines for up to several days.)

Kiawah Island Utilities

Kiawah Island is a predominantly private resort community southeast of Charleston. Seasonal water use varies tremendously, with very little demand during winter months and quite heavy demand during summer months. The primary purpose for ASR use is thus to store water to meet high summer demands. In addition, the stored water is used for emergency supply.

Kiawah Island Utilities has operated one ASR well since 2000 and is in the final cycle testing phase for a second well that will go online in mid-2003. CH2M Hill drilled the first and second wells, and The Savannah Group (TSG) designed the wellhead facility for the first well (McDonald, 2002). Treated water is purchased from Charleston's Commission of Public Works (CPW), stored in the Santee Limestone aquifer at a depth of about 600 feet, then treated again with chlorine and ammonia after recovery (Dennis, 2003).

City of Charleston, Moultrie Park (pilot project)

The interest in ASR at this facility was initially for fire protection and for emergency supply. USGS installed the well into the Santee Limestone and Black Mingo aquifer, at a depth of about 440 feet (Petkwich, 2002). USGS is working with the City of Charleston's Commission of Public Works on this project.

The testing results have been disappointing thus far for use of the well for fire protection. In the first testing phase, which began in 1994, the injection rate was only 30 gallons per minute and the withdrawal rate was 100 gallons per minute. In the second phase, permitted around 1998, injection was limited to 11 gallons per minute because it is a screened well. The withdrawal rate is 120 gallons per minute. (According to a USGS hydrologist involved with the project, the city's fire hydrants would require 500 gallons per minute.)

Phase one was completed in 1995, and USGS has delivered the corresponding report to Charleston's Commission of Public Works. The Commission is now waiting for USGS to complete a report from the second phase on the water quality, pumping and recovery rates, due to be delivered in mid-2003. The interest in continuing to pursue ASR as even an emergency source of water has waned because the length of time between possible emergencies does not justify continued injections of treated water (Hoagland, 2002). Even if the well were to be used only for fire protection, DHEC would require the injected water to meet primary and secondary drinking water standards.

City of Orangeburg (pilot project)

The City of Orangeburg is unique because it is the first inland test of ASR in South Carolina. The city is interested in water storage afforded by ASR for several reasons. First, the water withdrawn from the raw surface water supply is of undependable quality and sometimes has high levels of manganese and organic concentrations. The cost to remove excessive manganese is relatively high, and when chlorine is added to the water, the high organic levels contribute to the production of haloacetic acids (HAAs) and trihalomethanes (THMs), known carcinogens. These problems only occur during a small portion of the year, and the use of ASR would allow withdrawals to occur during those times when surface water quality is the best.

The second reason for exploring ASR is the need to meet increasing summer peak water demands. Projected demand increases are expected to exceed the capacity of the current system, but the addition of ASR wells dispersed in the service area would enable the facility to operate at a steadier rate and with greater reliability. Third, ASR would provide a reliable supply of water in times of extreme drought, as experienced in 1999 through 2002 (ASR Systems, 2002).

The City of Orangeburg contracted with a regional engineering firm, B.P. Barber, to conduct initial feasibility studies and testing, and B.P. Barber has contracted with ASR Systems to assist with the project. According to a B.P. Barber hydrologist, his company provides the water and wastewater expertise, while David Pyne of ASR Systems provides the knowledge of ASR systems. USGS also drilled several test wells near the proposed project area, and these data will be used in the analysis (Rivers).

Two wells, 100 feet apart, are to be drilled into two different aquifers: one into the Pee Dee aquifer, at about 400 to 500 feet deep, and the other into the Black Creek aquifer, at about 700 to 900 feet deep. The water injected will thus be vertically stacked, and water will be injected and recovered from both wells. In addition, a monitoring well will be installed within 300 to 400 feet of both test wells. Applications for construction have been submitted, and the project is expected to begin in early 2003.

City of Myrtle Beach (pilot project)

The Public Works Department of the City of Myrtle Beach contracted with the USGS to drill ASR test wells during the 1980s because the Black Creek aquifer, from which the city was drawing water for its public supply, was becoming depleted. The intention was to withdraw water from the Atlantic Intercoastal Waterway (which is fed nearby from the Great Pee Dee and the Wakamaw), treat it, and store it in the Black Creek aquifer. Thirty-one deep wells were drilled into the aquifer, and the results were disappointing. The wells could withdraw water only at a rate of about 250 to 300 gallons per minute, and early tests showed that the water tended to increase in fluoride concentration during storage. Twenty-one of the wells were abandoned and plugged, and ten wells remain open. The remaining wells are not likely to be used in the near future because, according to a Public Works official, even if 10 wells were operated, their combined production would not produce enough to meet 10 percent of the demand (Oliver, 2002). Water supply is now adequately met with withdrawals from the Intercoastal Waterway.

It may be noteworthy that the two systems developed by USGS were the only ASR systems constructed in South Carolina that thus far produced wholly unsatisfactory results. (At other sites, certain wells have proven unsuccessful, but the overall project achieved success.) An engineer at CH2M Hill speculated that this is possibly because USGS approaches ASR on a smaller scale. USGS uses smaller pipes which deliver smaller volumes. As a result, they have produced a smaller-scale result: lower recharge rates and lower recovery rates (McDonald, 2002).

Georgia Concerned

Apparently, the only significant apprehension regarding South Carolina's ASR operations has come from Georgia. On May 1, 1998, Harry Jue, Director of the Savanna Water and Sewer Bureau, wrote a letter to Dr. Bill McLemore, Georgia's State Geologist, indicating that Savannah had expressed concerns to Beaufort County officials regarding the proposed ASR project at the Beaufort-Jasper Water and Sewer Authority. Mr. Jue conveyed Savannah's concerns, primarily that the gradient of flow is significant between the BJWSA and Savannah, which might cause possible aquifer contamination caused by ASR operations to migrate. He suggested that BJWSA install monitoring wells to track any such migration.

On May 6,1998, Harold Reheis, Director of the Georgia Environmental Protection Division (EPD), wrote a letter to R. Lewis Shaw, Deputy Commissioner of DHEC, to inform him that EPD and other Georgia stakeholders had reservations about the proposed plan at BJWSA. Mr. Reheis noted the potentiometric gradient in the Upper Floridan aquifer between Hilton Head Island and Savannah and the likelihood of tritium-contaminated water migrating to Georgia wells. Shortly thereafter, he requested the opportunity for Dr. McLemore, to meet with an appropriate representative at DHEC and review the plans for BJWSA's proposed aquifer storage and recovery project (Reheis a,b).

Mr. Reheis wrote to Mr. Shaw again on September 2, 1998, requesting that two conditions be included in permitting an ASR well at the Beaufort-Jasper facility. First, the total volume of injected water should not exceed 100 million gallons at any one time. Second, a monitoring well should be constructed slightly beyond the edge of the injected "bubble," somewhere along a straight line between the injection well and the center of the cone of depression at Savannah and that this well be periodically analyzed for tritium.

Georgia's concern regarding tritium concentration arises from the fact that water withdrawn from the Savannah River tests high for tritium in some locations due to releases upriver from the Savannah River Plant. As pointed out in the case study of Georgia's experiences, coastal Georgians' perception of using Savannah River water for public consumption is decidedly negative. Conversely, South Carolina has a long history of surface water consumption, including water withdrawn from the Savannah River. Georgia's requests, apparently amplified after Mr. Reheis's initial suggestions, were willingly addressed. Presently, tests are conducted to measure tritium at monitoring stations along the Savannah River, when water is withdrawn from the river, before the water enters the Beaufort-Jasper treatment plant, and after it is injected into the aquifer for storage (Devlin, 2003). The extent of monitoring done for tritium on Georgia's behalf is typically viewed by DHEC staff as overkill. (Records show that during cycle testing of the first ASR well at BJWSA, the tritium level in the recovered water ranged from 900 to 1700 pC/L, while the EPA and DHEC maximum allowable level is 20,000 pC/L (McDonald, 2/16/99).)

Environmental Groups Unconcerned

According to several staff members at DHEC as well as facility operators, environmental groups in South Carolina have voiced no objection to the use of ASR in their state. The only response from environmental groups has apparently come from Georgia, in relation to the Beaufort-Jasper facility. Georgia environmental groups were said to encourage Georgia legislators to voice objections to its use in South Carolina. This assessment was verified by the director of the S.C. Chapter, Sierra Club. When asked if his group has a position on ASR, he did not immediately remember what the acronym “ASR” stands for. “My counterparts in other states have talked about it, but it really hasn’t been an issue in South Carolina.”

Discussion and Analysis

South Carolina’s experience with aquifer storage and recovery has been quite straightforward compared to experiences in Georgia and Florida. There has been little public awareness of ASR in this state, and therefore no public debate of ASR policy issues. The Advocacy Coalition Framework is thus not applicable to the sequence of events in South Carolina, as its major utility is in the exploration of advocacy groups that form when public controversy arises. Similarly, the use of scientific information used in the development of ASR in South Carolina has been somewhat insulated from external social and political influences. In-house agency scientists and contracted consulting firms have coordinated ASR development efforts with the facilities that have constructed wells for storage.

Since the storage technique was first implemented in South Carolina, the permitting process for ASR has been relatively smooth. The most challenging issue seems to have been a problem of turnover within DHEC during the last several years. Apparently, key personnel left the agency and were replaced by staff members who lacked knowledge about the ongoing projects, and this caused some delays in permitting procedures. Other than this problem, the consensus among USGS staff and each of the water facility staff members interviewed, is that DHEC is a thorough and exacting agency with a staff of highly qualified hydrologists, geohydrologists, geologists, engineers, and other scientists. Water facility staff members often commented during interviews about the "hoops" DHEC required them to jump through during the permitting process. According to a USGS hydrologist, DHEC was quite exacting in its permitting requirements for the Charleston pilot project, and "wanted things just so, for wellhead protection." He continued, "DHEC wouldn't allow a below-grade well because of the potential for flooding. DHEC was very conscientious…did a very good job."

DHEC's reputation for being exacting may explain why there have been no apparent objections from South Carolina environmental groups, despite controversies in neighboring states that might have brought possible concerns to light. DHEC is apparently trusted to conduct the permitting process in a manner that is thoroughly protective of groundwater resources. The Program Coordinator for the University of South Carolina's Institute for Public Service and Policy Research agreed with this assessment. She added that DHEC maintains open lines of communication between its staff members and environmental groups, as well as other interest groups, and that DHEC gives genuine consideration to opinions expressed by these groups (Steagal, 2003).

Another factor contributing to South Carolina's relative lack of public concern about ASR compared to that in Georgia may be that South Carolina depends much more on surface water than groundwater. This would tend to make the public and environmental groups less sensitive to groundwater issues than is the case in Georgia. South Carolina's greater use of surface water has also made water treatment more common there than in coastal Georgia, where groundwater requires little treatment.

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CHAPTER V

ANALYSIS & CONCLUSIONS

ANALYSIS AND CONCLUSIONS

This study began with the following research question: In addition to science, what elements—social, political, economic, or other—have influenced the decision-making process regarding the acceptance and implementation of aquifer storage and recovery? The hypothesis was that unless a specific event or series of events propels ASR into the public arena, it generally remains the domain of water resource managers and a relatively small group of scientists. This is the status of ASR in South Carolina, where scientists and water resource managers at the Department of Health and Environmental Control and the Department of Natural Resources work together and with local water facility managers to make appropriate decisions regarding ASR. South Carolina's general public is, for the most part, unaware of the specific tools used to manage water resources. Also, due at least to some degree to open lines of communication and a basic trust of the state regulatory agencies, environmental groups there have apparently not identified a reason to become involved in decisions about ASR.

The second aspect of the hypothesis was that if or when ASR becomes a public issue, social, political, and economic factors begin to shape the decision-making process, and interest groups begin to form and promote their personal and collective agendas. Decisions are finally made based on which group communicates most effectively to the public and to policy-makers, and scientific information becomes only one of many elements considered. In this scenario, science may be well integrated into the decision-making process—or ignored or manipulated to achieve certain objectives.

For almost 20 years, Florida's decision-making process for ASR was similar to that in South Carolina: the Florida Department of Environmental Protection worked together with water management districts and local water utilities. Decisions regarding ASR were based on information provided mainly by scientists within these state and regional agencies and consulting firms hired by those interested in using ASR. In response to the Comprehensive Everglades Restoration Plan, legislation was proposed to relax the treatment standards of water injected into wells if a water supply facility could prove that the practice would not jeopardize groundwater resources or the public health. The relaxation of this standard would apply not only to Everglades restoration, but to ASR use statewide. ASR suddenly became a salient public policy issue, and social, economic, and political elements began to enter into ASR policy decisions. Among the issues that became included in evaluating the legitimacy of the legislation proposed for ASR water treatment were the following:

- Environmental groups did not trust the DEP and the water management districts to enforce adequate controls to ensure that ASR would be implemented safely if this constraint were removed.
- Press coverage gave the public the impression that the DEP and the water management districts were being irresponsible regarding the protection of groundwater resources, and this eroded public trust in the DEP and the districts that supported the legislation.
- At least some environmental groups had an anti-growth agenda that worked against this water management tool in general: if ASR became too easy for local governments to implement, water supply issues would not be as effective

as a development constraint throughout the state.

• Some environmental groups opposed the Comprehensive Everglades Restoration Plan's use of ASR because they prefer alternatives such as purchasing and flooding properties owned by sugar companies.

Regulation of ASR became entwined in a fundamental rift between Florida's environmental groups and state and regional water management agencies. It also brought to light the expectation of environmental groups that developers and engineers, in their quest for financial gain, are likely to run roughshod over the need to protect natural resources. In this scenario, science was used to promote specific viewpoints, and widespread media attention to these viewpoints effectively obscured important facts that might have influenced public opinion and action. The proposed legislation failed, and agency members have indicated that they do not expect similar legislation to be initiated again in the near future. The more important outcome, however, was that the public was left with an unwarranted negative impression of the Florida DEP and the water management districts that supported the legislation, as well as a negative impression of ASR. These impressions are likely to influence public reaction to both the agencies and this and other water management tools for years to come.

Possible implementation of aquifer storage and recovery in Georgia was side-tracked by the fact that the company proposing to use this technique became a public enemy among coastal residents and, more importantly, environmental groups and certain coastal legislators. ASR was not the fundamental issue here. Controversy ensued because most coastal residents did not want The Savannah Group to garner control over a significant portion of the region's water resources. Aquifer storage and recovery was a tool that would have helped TSG achieve one element of its plan, and this was the major reason that groups opposing TSG favored legislation to place a moratorium on the use of ASR. Science was used selectively in Georgia's controversy, and many issues were more important than scientific information that would be valuable in assessing the viability of ASR, including the following:

- TSG gained a bad reputation immediately when its proposed withdrawal amounts were extremely high. This raised red flags about private control over a large portion of coastal water resources.
- TSG exacerbated its poor public image by conducting ineffective public relations when it tried to sell its plan to an already wary coastal population.
- Watermen and environmental groups were concerned about the economic and environmental ramifications of increased surface water withdrawals, especially from the Altamaha River.
- Local governments resented the idea that TSG would not be required to develop a long-term water plan, which EPD required of all local coastal governments.
- The anti-growth agenda of some environmental groups opposed policies, such as the use of ASR, that may facilitate further development in coastal counties.
- Savannah had a significant economic motivation to discourage competition in its local water market.
- Georgia's environmental groups generally did not trust EPD to take the steps necessary to ensure that the proper controls would be enforced for ASR to be conducted in a way that would protect groundwater resources and public health.

- Georgia’s environmental groups also tended to believe that EPD takes a pro-business position and issues permits too haphazardly.

The Georgia General Assembly was strongly influenced by certain coastal legislators who did not even claim to have adequate scientific foundation to support their positions. A principal champion of the legislation opposing the use of ASR freely admits to knowing little about the scientific aspects of ASR as a water management tool, but is bothered by the lack of knowledge about groundwater and aquifers in general. A pivotal event in the controversy was the public meeting (August 4, 1998) hosted by Representatives Anne Mueller, Terry Barnard, and Burke Day, where public sentiment was gauged to vehemently oppose TSG, the Georgia EPD, and aquifer storage and recovery. The legislators who proposed SB 48/HB 129 were striving to serve a constituency that they possibly presumed were more informed than they actually were, especially regarding ASR. Ironically, ASR requires site-specific analysis such that even with a great deal of knowledge about the coastal aquifer system and the water stored and transmitted in it, extensive studies will need to be done to evaluate whether ASR is a viable alternative at any given location. The Georgia Environmental Protection Division recognized this fact, but failed to communicate to the public that adequate safeguards must be established before permits would be issued for any ASR well to operate. (Since EPD would develop rules and safeguards specific to ASR during the first permitting process, such confidence would have been difficult to project, especially given the lack of trust certain groups held for the agency.)

The moratorium on the use of ASR in Georgia expired in December 2002. In terms of preventing the use of ASR in Georgia for the period it was in effect, the legislation served little purpose because, as noted earlier, the EPD was not likely to have issued a permit during this time. The more lasting result of the controversy was a profoundly negative impression of TSG as well as a negative impression of the Georgia EPD and any possible future use of ASR in Georgia. Staff members at EPD have agreed that the strength of public opinion resulting from the controversy surrounding TSG clearly inhibits research efforts that would seriously consider whether ASR is a feasible storage method to use in coastal Georgia or other areas of the state.

ASR Policy Decisions and Public Policy Theory

Decisions regarding the use and regulation of aquifer storage and recovery in Georgia, Florida, and South Carolina have, in many ways, taken place as could be predicted by general characteristics of public policy. These characteristics are particularly evident in the experiences of Georgia and Florida, where controversies brought out significant differences in individual and collective opinion. The issues that have influenced these ASR policy decisions are multifaceted and interwoven and have been influenced by a variety of individual and collective beliefs, perspectives, and motivations. Definitive answers are difficult to agree upon because, like many scientific issues, the feasibility and the regulatory needs for ASR are dependent on site-specific analyses of a variety of variables, many of which may be subject to scientific disagreement. No single policy theory or framework encompasses all of the realities of public policy-making, but many elements of public policy theory are evident in the decision-making scenarios that took place in Georgia and Florida.

The *bounded rationality* theory (Appendix A), which evolved from Adam Smith's notion of the "invisible hand," claims that human action is never completely logical, but is limited by partial knowledge an individual has about a situation or set of circumstances. It is difficult to separate facts from values, and humans are condemned to be irrational because they are always acting on the basis of one perspective or another. This theory is clearly applicable to experiences in Georgia and Florida, where the values of many different groups were inextricably tied to the decisions that were finally made. In Georgia, much of the controversy regarding ASR seemed to take place in an informational vacuum. Apparently, neither side had enough information to make a strong science-based argument, yet emotions were high enough in reaction to the TSG proposal that the voices opposing TSG/ASR gained legislative support. In Florida, the outcome of the legislative debate was due in large part to the specific information made available in newspaper press coverage. In the absence of more complete information, the public acted upon this limited and biased information when they petitioned legislators to vote against the potential relaxation of water treatment for ASR.

The *punctuated-equilibrium* theory (Appendix A) focuses on the rise and fall of issues on the public and political agenda, and on the sudden bursts of change often brought about when an issue comes to the forefront of the political agenda. This theory, too, can be easily seen in Georgia's and Florida's experiences, where a single event (in Florida, the introduction of SB 854/HB 705, and in Georgia, the water-withdrawal plan by TSG) propelled ASR into the public eye. In Florida, ASR had been used for years before such an event occurred, and although ASR is not likely to become obscured in the near future, years may pass before significant changes are proposed again. In Georgia, TSG was the first organization to apply to EPD for a permit to use ASR, and based on the current public perception, other private and public water providers are likely to be hesitant to suggest its use again for some time.

Additional elements of the two states' experiences were the direct and indirect influence of historical and geographic conditions and the behavior of government institutions and the public as a whole, which are highlighted in Hofferbert's *open system framework* (Appendix A). Events in Georgia and Florida—and the total lack of controversy in South Carolina—cannot be separated from a long history of previous events. Actions taken over many years by the Georgia EPD, the Florida DEP, the water management districts, and the South Carolina DNR and DHEC contributed to public reaction to more recent events. Likewise, the social and geographic issues (land use and development issues in Georgia and Florida, for instance) contributed to the way environmental groups and members of the public perceived ASR.

Awareness of events and public perceptions of these events do not remain localized, but are shared among states in close proximity. The *regional diffusion model* (Appendix A) focuses on the dissemination of information between neighboring states. Learning is facilitated between such states, and events in one state may influence the course of events in another. The extent to which events in one or more states influenced actions taken in other states is not clear because many small increments of information may have affected events in ways that are not evident to an outside observer. Three areas of influence are clear, however. (See Figure IV below for a timeline of major events in the three states.) South Carolina depended on Florida's experiences to a great extent as it developed its ASR programs, and continues to watch for problems and additional opportunities that arise in Florida. Georgia's controversy presumably contributed to some degree to the public response in Florida to SB 854/HB 705 because in some of the articles that appeared in Florida, reporters used the fact that Georgia had placed a moratorium on ASR to strengthen arguments against Florida's proposed legislation. Finally, Georgia's opposition to the proposed ASR well at the Beaufort-Jasper Water and Sewer Authority in South Carolina was likely to have been influenced by the controversy that was nearing its end in Georgia. Other than agreeing to make certain concessions at BJWSA to ease the concerns of Georgia officials, South Carolina was apparently not influenced significantly by the controversies in the two other states. Future use of ASR in South Carolina will likely not become a controversial public policy issue unless a change occurs either in the way the technique is practiced or in public knowledge and perception of ASR.

Table 3 Timeline of ASR events in Georgia, Florida, and South Carolina

1983	First ASR well operational in Florida
1996	First ASR well operational in South Carolina
1996 (June)	Proposal by TSG in coastal Georgia
1996-1998	Consideration of TSG's proposal by Georgia EPD / public controversy
1998	Georgia expresses concerns about ASR activity in Beaufort, S.C.
1999 (March)	Legislation passed in Georgia to prohibit the use of ASR until December 31, 2002
1999 (June)	ASR facility at Beaufort-Jasper Water and Sewer Authority permitted for operation
2001 (late February)	Companion bills introduced in Florida to reduce the treatment requirement of water used for ASR injection
2001 (early April)	Governor Bush asked sponsors to withdraw SB 854/HB 705
2002 (December)	End of Georgia's moratorium on ASR

The controversies in Georgia and Florida support David Truman's *group theory* (Appendix A) as well, which says that a group's influence is affected by a group's strategic position in society, internal characteristics of the group, and characteristics of governmental institutions that may propel or impede a group's effectiveness. This theory is closely related to the *advocacy coalition framework*, discussed relative to Georgia and Florida in the previous chapter. (In South Carolina, advocacy groups did not form because ASR has never become a controversial issue there.)

The Advocacy Coalition Framework

The Advocacy Coalition Framework proved to be an appropriate structure within which to view the controversies that evolved in Georgia and Florida regarding aquifer storage and recovery. The defining aspect of the framework is the existence of a policy subsystem (comprised of individuals and organizations interested in a policy issue), within which coalitions (within that subsystem, those that share a set of beliefs and engage in coordinated activity) operate to influence public opinion. The types of coalitions in the two states were significantly different, and the framework provided adequate flexibility to allow for each scenario.

In Georgia, the diversity of motivations prevented a cohesive alliance-formation except for a common desire to defeat TSG, but each group's strategic position helped affect the final outcome. Savannah itself had significant political influence, and the combined efforts of watermen, environmental groups, and certain local governments, such as Savannah and Brunswick, synchronized to create a formidable opposition force against TSG. This eventually spilled over into a weaker, but still effective opposition to aquifer storage and recovery. The legislation to temporarily prevent the use of ASR was finally passed in large part because members of the Georgia General Assembly did not have enough information (partially because much information would need to be gathered during the permitting process) to contradict the prominent voices of certain coastal legislators.

In Florida, the dominant voice came from an unofficial consortium of environmental groups which worked together to share information and promote their objective of defeating SB 854/HB 705. The dynamics in Florida were interesting because the environmental groups proved to be a more powerful force in terms of shaping public opinion than the combined efforts of the Florida DEP and the water management districts. As noted earlier, this was likely because agency members never mounted any organized informational campaign, but rested rather complacently on what they saw as the reasonableness of the legislation. The ability of the environmental groups to so significantly sway public opinion took them by surprise. In both Georgia and Florida, a stronger voice by the primary regulatory agency might have made a significant difference in the outcome of the controversies.

Use of Science in ASR Policy-Making

The previous case studies provide excellent illustrations of how policy decisions about a scientific issue can be politicized and driven by input from a variety of interest groups. Where the experiences in Georgia and Florida depart from theoretical expectation is the extent to which the general public became involved in the controversies. As noted in Chapter I, Smith (2000) contended that apart from interest groups that have a stake in the outcome, the public largely ignores the development of much new legislation and refinements in existing legislation. Where drinking water is concerned, an interest group easily becomes inclusive of individuals and organizations that might remain uninvolved in issues with a more narrow range of impact. In Florida, the controversy about ASR water treatment garnered statewide public attention, while in Georgia, issues surrounding The Savannah Group and ASR were of widespread regional importance.

Recommendations

Policy decisions related to aquifer storage and recovery in Georgia and Florida were largely the result of inadequate planning and communication on the part of the primary regulatory agencies. In both states, the public was ill-informed about both the scientific elements of ASR and the responsibilities of the regulatory agencies to conduct and fund necessary scientific analyses or to require site-specific analyses as part of the permitting process. As a result, decisions were made based on many elements other than the scientific validity of the respective proposals in the two states. In both scenarios, there were unanswered scientific questions pertaining to the use of ASR, and reasonable plans of action for filling this informational void were not adequately communicated to the public. Recommendations suggested by this study for better integrating into the policy-making process for new techniques such as ASR are thus twofold:

1) The primary regulatory agency should engage in a proactive planning process that foresees the possible incorporation of alternative water management techniques. This planning effort should incorporate the latest scientific developments for water management activities not only in neighboring states, but nationwide and worldwide. It should look forward to the possible adoption of new techniques and develop at least tentative measures so that agency staff members are in a position to respond

appropriately to a variety of alternative proposals. If, in 1996, Georgia had had a long-term plan in place that included whether ASR should be a part of the state's overall water resource management strategy, ASR may not have become embroiled in the controversy, but would have simply been viewed against what the water plan called for.

2) The primary regulatory agency should institute a comprehensive public communication program. This communication should take two forms. First, agencies should communicate with the public about issues handled routinely by water regulatory agency, so the public has at least a general understanding of fundamental issues and the agency's stance on those issues. (In Georgia, a chronic problem is lack of funding for the EPD, which limits the effectiveness of many of its assigned tasks. Such an ongoing public communication campaign would increase the public perception of the importance of EPD activities and could thus boost both its credibility and its funding potential.) Second, agencies should communicate more effectively with the pubic about specific projects proposed. If a comprehensive plan is in place and the agency clearly communicates how a new project fits into that existing plan, controversy can be reduced or avoided entirely. The Florida DEP has comprehensive water management plans, both on a statewide and a water management district level; however, in the 2001 legislative controversy, the DEP failed to communicate the bigger picture of the legislation to the public. In promoting the legislation to reduce water treatment standards for ASR injection, the DEP was not abdicating its role to protect public health and the environment. Instead, it was insisting that any organization that proposed to use untreated drinking water for ASR would be responsible for proving (to the DEP) the safety of the practice *at that location* prior to being permitted for operation. In the scenario proposed

in the legislation, a private company, water management district, or other entity would have to devote its own finances to conduct extensive testing and monitoring. This would not only accomplish an important research function without requiring the allocation of state tax dollars, but would promote innovation without compromising human or environmental welfare. Instead of gaining this perspective, the public was left with a lasting impression that the bills and their supporters were irresponsible—because the real purpose of the legislation was never effectively communicated.

The issue of where the lines of responsibility are drawn became an issue for Georgia as well, when members of the public argued that ASR analysis should be included in the Sound Science Initiative. The Georgia EPD, in recognition of the site-specific analysis that would be required, viewed this as the responsibility of the facility proposing to implement ASR. Again, this was not effectively communicated, and the public was left with the impression that ASR permitting in Georgia is likely to be done haphazardly and without adequate regard for groundwater resources.

Suggestions for Further Research

This study points to several questions for additional research in terms of how ASR and other innovative techniques might be integrated with a sound basis of science into overall water resource management.

• How has public policy developed in other states and countries regarding ASR? Are such issues of communication and planning common impediments to science-based policy-making?

- Are state water management plans generally written to incorporate new water management techniques?
- How much scientific research do most states conduct (or obtain through contracts with other researchers) in the preparation of water resource management plans?
- How much do controversies feed on events in other states or regarding similar issues?
- Are public relations activities generally practiced by environmental regulators? How proactive are they in making sure the public is given accurate information about new procedures or activities?
- Are people in more arid regions more likely to accept new water management techniques because they are more sensitized to limited quantities of water?

APPENDICES

APPENDIX A

Policy Theories

Bounded rationality is a theory of decision-making that evolved from Adam Smith's notion of the "invisible hand." Smith contended in his 1776 *The Wealth of Nations* that in a properly functioning market system, the process by which each individual acts in his own self interest efficiently serves to promote the interests of society (Munger, 2000).

Bounded rationality acknowledges the limits of the human mind to make wholly rational purposeful decisions. Herbert Simon introduced the idea in the 1950's in an attempt to provide a socially sensitive perspective on decision-making. The bounded rationality theory asserts that human action is never completely logical, but instead is limited by partial knowledge an individual has about a situation or set of circumstances. Logical decisions are limited also by individuals' limited capacity for information processing and by the difficulties of completely separating facts from values. According to Simon, there are two renditions of reason: God's and Man's. Humans are condemned to be irrational because they are always acting on the basis of one perspective or another (Amer J Econ Soc). Many more options may be available in any given scenario than are perceived to be available, and actors tend to "satisfice," or accept a solution that is "good enough" rather than pursuing truly optimal solutions (Marshall).

The theory does not abandon the assumption of perfect rationality, but recognizes the fact that rational judgments are constantly threatened by irrational impulses.

Philosophers have long questioned the universality of reason, but Simon's theory is more concerned with modern challenges to rational decision-making (Amer J Econ Soc).

Bounded rationality is typically used in behavioral and decision-making models, where a realistic set of variables is employed in an attempt to predict behavior patterns, typically in economic, social, and political research. It is also used in game theory and organizational theory.

Incrementalism, a theory popularized by Charles Lindblom, describes policy-making as a series of decisions that build on previous choices. In an analysis of policy formation for complex problems, Lindblom compares two approaches: the "root" method and the "branch" method (Lindblom, 1963). The root method is characterized by starting from fundamentals with each decision, building on the past "only as experience is embodied in a theory, and always [being] prepared to start completely from the ground up." The branch method is characterized by decisions building from the current situation, step-by-step in small degrees. The theory of incrementalism is based on the branch method, the more realistic of the two scenarios.

Lindblom attributes the following characteristics to the branch method (Ibid):

- Values and the policies chosen to attain them are entwined and decided upon at the same time. The policy-maker focuses his attention on marginal values as he compares one choice with another.
- A means-ends relationship is absent from the process because means and ends are simultaneously chosen.
- There is no standard of "correctness;" the test of a good policy is whether administrators reach agreement on the policy.

• Consideration is limited to policies that differ in only small degrees from present policies, and possible consequences and the values attached to negative consequences tend to be ignored.

• Policy formation proceeds chronologically. Also, policy is not made once and for all, but made and remade endlessly, as it evolves through a succession of incremental changes. By making only slight changes, past consequences provide knowledge about probable outcomes, and mistakes can be relatively easy to remedy.

The outcome of this incremental process is that policy-makers may overlook excellent policy opportunities simply because they are not part of a successive chain of choices. Public administrators are thus restricted to relatively few alternative policies among the countless alternatives.

The <u>*punctuated-equilibrium*</u> theory emphasizes the tendency of public policy to remain stable, for the most part, and driven by incremental changes —but to be punctuated by large-scale and sometimes sudden changes. Punctuated-equilibrium focuses on the rise and fall of issues on the public and political agenda. Authors True, Jones, and Baumgartner (1999) assert that "American institutions were conservatively designed to resist many efforts at change and thus to make mobilizations necessary if established interests are to be overcome. The result over time has been institutionally reinforced stability interrupted by bursts of change."

Founded on the bounded rationality approach to decision-making, punctuated-equilibrium recognizes two fundamental ideas at work in policy-making: "subsystem politics," in which a policy monopoly of institutional values works to dampen change through processes of incrementalism, and “macropolitics,” the politics of large scale agenda-setting and change. Change occurs not necessarily when policy preferences change, but when attention shifts and an issue comes to the forefront of the macropolitical agenda.

Although the punctuated-equilibrium theory is a useful way to look at stability and change, it doesn’t provide a mechanism for predicting when the punctuations of change will take place. It is difficult to predict when a particular issue will become a focus for the policy-making agenda or what the outcome will be.

The theory of ***elitism***, developed by C. Wright Mills during the 1950s, includes the following principles (Anderson, 1984):

- Society is divided into the few who have power and the many who do not.
- The few who govern are not typical of the masses that are governed. Elites are disproportionately from the upper socioeconomic strata of society.
- The movement of non-elites to elite positions must be slow and continuous to maintain stability and avoid revolution.
- Elites share a consensus on the basic values of the social system and the preservation of the system. (In the United States, the elite consensus of basic values includes private enterprise, private property, limited government, and individual liberty.)
- Public policy does not reflect demands of the masses but rather the prevailing values of the elite.
- Active elites are subject to relatively little direct influence from apathetic masses. Elites influence masses more than masses influence elites.

Group theory concentrates on how groups function as part of the governmental process. According to David Truman (1971), “organized interest groups are as clearly a part of the governmental institution as the political parties or the branches formally established by law or constitution.” As such, group politics comprise a dynamic process of constantly changing relationships and shifts in relative influence. Group influence is affected by a variety of characteristics, including the group’s strategic position in society, internal characteristics of the group, and characteristics of governmental institutions that may propel or impede the group’s effectiveness.

The major focus of political interest groups has traditionally been on legislative bodies because it is here that the law-making process can be persuaded. Access to a legislature is thus of critical importance to a group’s level of influence. One of the ways that group members achieve and maintain access and influence is through the “social lobby,” a devise to create a feeling of obligation on the part of a legislator toward individuals who have established social relationships with him/her (Ibid).

Group theory also emphasizes the alliance-formation process. Alliances with other groups are important for a variety of reasons (Ibid):

- Cooperative agreements are possible, strengthening the overall positions of the groups involved.
- Alliances permit information flow that might not be possible otherwise.
- The focus of each group is likely to be widened through association with

other groups, acting to have an educational and unifying effect through the political system.

Pluralism, closely related to group theory, can be defined as a system in which relatively independent groups, organizations, and associations operate in the political environment. Truman (1971) attributes two primary characteristics to a pluralist system: first, it disperses power, influence, authority and control away from any single center toward a variety of individuals, groups, associations, and organizations, and second, it fosters attitudes and beliefs favorable to democratic ideas.

Within both group theory and pluralism, three forces operate to influence the achievement of the groups' self-interests relative to societal interests.

- "Potential power" refers to the level of an individual's or group's power that is theoretically attainable, given optimal circumstances; this potential power is virtually never attained (Ibid). An aggregate of individuals may form a formidable collective power, however.
- "Rules of the game" are unwritten codes—norms, values, expectations, and appropriate limits—that largely define the way institutions and their members operate.
- Adam Smith's "invisible hand," the process by which people achieve overall efficiency by acting individually in their own self interests.

David Easton introduced the idea that *political systems analysis* can link all natural and social sciences and help generate communication between them. Interactions among individuals, governmental units, and other organizations, form social subsystems, and such interactions from the basic unit of political systems. Such systems operate within the physical and social environment and cannot be separated from that environment (Easton, 1965). Within its environment, each system includes a variety of inputs and outputs, feedback loops, and adjustments.

Political systems theory is thus capable of incorporating elements from many other theories and is very general in nature. This trait has been viewed as a limitation of the theory, for it constrains its usefulness as a predictive or explanatory tool (Anderson, 1984).

Policy Frameworks and Models

The first framework for describing policy processes that received widespread attention was the "*stages*" approach, first developed by Harold D. Lasswell in the 1950s. His original list of policy stages included seven stages, later revised and shortened by one of his students to the following list of six sequential policy activities: initiation, estimation, selection, implementation, evaluation, and termination. This approach allowed researchers to take a fresh look at policy-making as a problem-solving process and was the most popular theoretical framework for about 20 years. Although the stages approach has been criticized because it defines each stage as an unrealistically distinct entity, it continues to be functional for categorizing policy activities. It is now recognized that these activities typically overlap and repeat during the course of a policy cycle.

The *garbage can* model describes the process of decision-making in an "organized anarchy." This is a term coined in 1972 by Cohen to explain organizational decision-making situations characterized by

• poorly-specified and inconsistent goals;

• uncertain processes for achieving goals (unclear technology); and

• fluid participation by individual actors in the decision-making process which can result in uncertain and changing boundaries to the decision-making situation" (Deyle, 1995).

According to the model, decisions result from the intersection of four relatively independent streams: choice opportunities, problems, solutions, and participants. Choice opportunities are the 'garbage cans,' or occasions when a mixture of problems, solutions, and participants come together and form the impetus for an organization to make a decision (Ibid).

John W. Kingdon (1984) expanded on the garbage can theory, suggesting the existence of two types of policy windows that afford opportunities for decisions: problem windows and political windows. Problem windows occur when the public perceives a problem and pressures decision-makers to take action. Decision-makers then look to the solution stream for an action that can be coupled to the problem as a solution. Political windows occur when politicians, in an effort to enhance their stature and visibility, promote to the public their vision of a problem, along with a solution they have already formulated.

The <u>*multiple-streams*</u> framework provides a stark contrast to institutional rational choice, in that rather than examining policy processes under conditions of known circumstances and priorities, it is used exclusively to study ambiguous policy issues (Zahariadis, 1999). These are issues in which the problem definition, and thus desirable solutions, can shift, depending on one's perspective. Kingdon developed the multiple-streams approach as an adaptation of the garbage can model, which characterizes decision-making in organizations in terms of three properties (Ibid): fluid participation (participants come and go), problematic preferences (participants often don't know what their objectives are), and unclear technology (lack of awareness of how individual responsibilities fit into organization's mission). Kingdon, in an attempt to determine what puts certain issues on the agenda while other issues are neglected, conceptualized three streams that define issues: problems, policies, and politics. The problem stream offers indications of why and how an issue is defined and recognized as a problem. The policy stream includes ideas generated and considered by policy specialists. The politics stream has three elements: national mood, pressure group campaigns, and administrative or legislative turnover. Any of these three elements can propel an issue into a prominent place in the political agenda. One of the most important elements of the multiple-streams framework is the idea of "coupling," in which the three streams join together to create fleeting periods of policy-making opportunities. These may be predicable or unpredictable, but always exist for only a short time.

Institutional rational choice is embodied in a framework called *institutional analysis and development* (IAD). In the 1970s and early 1980s, IAD was used for studying public service issues, but since the late1980s, as a result of work done by Elinor Ostrom and her colleagues, its main utility has been in the analysis of common-pool resource management (Ostrom, 1999). The framework's dominant feature is that it makes a distinction between three tiers of decision-making, each with its own set of governing rules: constitutional, collective choice, and operational decisions. With an "action arena," identified, the framework offers a language for examining and explaining how rules, physical and material attributes, and properties of the community affect decisions within the three tiers. Using evaluative criteria, institutional analysts are able to predict outcomes and evaluate outcomes under existing or alternative arrangements. In some circumstances, it is possible to develop straightforward models of resource use, however, the effects of certain characteristics of the community, strategies by actors, or other factors may make it more difficult to predict patterns and outcomes.

The ***advocacy coalition framework*** (ACF) is more complex than most of the other theoretical approaches and will be examined more thoroughly in a separate section; therefore, only a brief overview will be provided here.

The ACF was developed about 15 years ago by Paul Sabatier and has undergone a number of changes as it has been tested and other theorists have offered suggestions for revision and elaboration. The most fundamental aspect of the framework is its focus on the policy subsystem, which consists of all public and private actors who are interested in a particular policy issue and who seek to influence policy decisions regarding that issue. Within each policy subsystem, there are two or more advocacy coalitions who take a distinct stance on the issue and who compete with each other for supremacy. These advocacy coalitions share fundamental beliefs about the policy issue around which they are built, and they act in a coordinated fashion to influence opinions and decisions about that issue. Beliefs, according to the ACF, are a key aspect of policy decision-making, and exist in a hierarchical structure, from beliefs most deeply-held and resistant to change to secondary aspects that are more easily adjusted. This hierarchy is an important part of the framework's focus on "policy-oriented learning," in which new information may cause changes in positions held by coalitions or serve to buttress or change existing positions.

Because the ACF lends itself particularly well to complex and technical issues, it has been most widely used in examining environmental and energy issues. However, it has also been applied to a variety of other policy research domains in the U.S. as well as Canada, Europe, and Australia (Sabatier, 1999).

Hofferbert's *open system framework* represents the policy formation process as a "funneling" of influences toward a formal decision-making event (Blomquist, 1999). According to Hofferbert, politically relevant incidents occur as a result of the direct and indirect effects of a variety of influences, including historic/geographic conditions; socioeconomic composition; mass political behavior; governmental institutions; and elite behavior. Incorporating components from many theoretical approaches, this framework addresses the complexity of the policy-making environment; however, it lacks explanatory power for interactions between and among policy-makers and the public, and does not provide for the feedback loops and adjustments that occur in the real world.

Innovation and Diffusion Models

Innovation and diffusion models seek to explain the fundamental impetus of policy adoption. Stokes and Berry (1999) offer two broad categories for explaining policy adoption: *diffusion models* attribute innovation to external factors, such as policy adoptions in neighboring states; *internal determinants models* explain innovation in terms of factors internal to the state, such as social, political, and economic factors.

Diffusion Models

The ***national interaction model*** assumes communication between state officials that allows them to randomly learn about policies adopted in other states. It asserts that as a policy becomes more widespread among states, those states that have not adopted the policy yet are increasingly likely to do so. The ***regional diffusion model*** is similar in its assumption that interaction between states influences policy adoption. Here, however, the focus is on states that are in close proximity to each other. Rather than random influence, neighboring states are influenced by competition between states, learning opportunities due to proximity, and public pressure. Competition, in particular, is a factor exhibited regionally far more than nationally. ***Leader-laggard models*** base policy adoption on the learning process rather than regional diffusion models' assumption of competition and public pressure. Known and respected policy-makers in certain states are likely to be emulated by other states. This can occur on a national or regional level, but is more likely a regional phenomenon. ***Vertical influence*** models see states' learning processes tied to federal policies rather than policies adopted in other states. Here, the federal government serves as the pioneer, rather than another state, and is similarly emulated. This model has been used in examining state programs that have been federally mandated or for which the federal government provides incentives, as in grant-in-aid programs.

Internal Determinant Models

Internal determinant models assume that all policy decisions are founded on internal characteristics of the state, its inhabitants, and its policy-makers. Several hypotheses have been offered to explain variations in the propensity of a state to adopt new policies. The following characteristics tend to stimulate a state to be innovative (Ibid):

- motivation to adopt a new policy;
- relatively high levels of education and wealth;
- fiscal health of state;
- electoral security of public officials; and
- policy advocates/entrepreneurs promote ideas.

Applied individually, none of the diffusion or internal determinants models is extremely useful because policy adoption is generally a result of factors both internal and external to the state. Recent studies have allowed for more integration of the internal and external components of policy innovation.

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APPENDIX B

Senate Bill 0854

By Senators Pruitt, Bronson, Garcia, Villalobos, Campbell, Klein, King, Horne, Smith, Latvala and Clary

A bill to be entitled
An act relating to aquifer storage and recovery wells; creating s. 403.065, F.S.; providing findings; providing for classifications and permitting of aquifer storage and recovery wells; providing a zone of discharge for aquifer storage and recovery wells meeting specific criteria; providing monitoring requirements for aquifer storage and recovery wells; requiring an aquifer exemption for an aquifer storage and recovery well that does not meet primary drinking water standards other than those relating to total coliform bacteria or sodium; requiring the Department of Environmental Protection [hereafter, the department] to make a reasonable effort to issue or deny permits within a period; providing rulemaking authority; creating s. 373.222, F.S.; providing requirements for certain domestic wells; providing an effective date.

Be It Enacted by the Legislature of the State of Florida:
Section 1. Section 403.065, Florida Statutes, is created to read:

403.065 Aquifer storage and recovery wells.--
(1) The Legislature finds that it is in the public interest to conserve and protect water resources, provide adequate water supplies, provide for natural systems, and promote quality aquifer storage and recovery projects by removing inappropriate institutional barriers.

(2) The storage of water through the use of aquifer storage and recovery wells must not endanger drinking water sources, as established in the federal Safe Drinking Water Act, 42 U.S.C., s. 300h., and the regulations adopted thereunder.

(3) Aquifer storage and recovery wells must be classified and permitted according to department rules, consistent with the federal Safe Drinking Water Act, and must be constructed to prevent violation of state groundwater quality standards at the point of discharge, except as specifically provided in this section.

(4) Aquifer storage and recovery wells must be allowed a zone of discharge for sodium and secondary drinking water standards, if the requirements of paragraphs (5)(b), (c), and (d) and subsection (7) are met.

(5) Aquifer storage and recovery wells used to inject water from a surface water or groundwater source must be allowed a zone of discharge for total coliform bacteria and other biological contaminants demonstrated to die off within the zone of discharge when the applicant for the aquifer storage and recovery well permit demonstrates through a risk-based analysis:

(a) That the native ground water within the proposed zone of discharge contains no less than 1,500 milligrams per liter total dissolved solids;
(b) That the native ground water within the proposed zone of discharge is not currently being used as a public or private drinking water supply, nor can any person other than the permit applicant reasonably be expected to withdraw water from the zone of discharge in the future for such use;
(c) That the presence of the stored water will not cause any person other than the permit applicant to treat water withdrawn from the aquifer in any way that would not been required in the absence of the aquifer storage and recovery well;
(d) That the department has approved a monitoring plan that specifies the number and location of monitor wells, monitoring parameters, and frequency of monitoring;
(e) That total coliform bacteria is the only primary drinking water standard other than the standard for sodium that will not be met before injection;
(f) Directly or through the use of indicator organisms approved by the department, that biological contaminants will experience die-off such that primary drinking water standards
will be met at the edge of the zone of discharge and that those contaminants will not pose an adverse risk to human health; and
(g) That the environmental benefits to be derived from the storage, recovery, and future use of the injected water and the use of the recovered water is consistent with its intended primary purpose.

(6) The department may allow a zone of discharge for sodium, total coliform bacteria and other biological contaminants demonstrated to die off within the zone of discharge, and secondary drinking water standards if the total dissolved solids concentration of the native ground water within the proposed zone of discharge is less than 1,500 milligrams per liter and if the requirements of paragraphs (5)(b)-(5)(g) are satisfied and:
(a) The applicant for the aquifer storage and recovery well permit demonstrates that no person, other than the permit applicant, may in the future withdraw water from the zone of discharge for use as a public or private drinking water supply because of legal restrictions imposed by a water management district, state agency, local government, or other governmental entity having jurisdiction over water supply or well construction; and
(b) The permit applicant provides written notice, including specific information concerning the proposed aquifer storage and recovery project, to each land owner whose property overlies the zone of discharge. The department shall revoke the zone of discharge and require the withdrawal of injected water upon a demonstration by any party that the legal restrictions required under paragraph (a) are no longer in effect.

(7) The zone of discharge for an aquifer storage and recovery well may not intersect or include any part of a 500-foot radius surrounding any well that uses the injection zone to supply drinking water.

(8) The permit applicant must demonstrate, based on hydrogeological conditions, the vertical and lateral limits of the zone of discharge by providing the department with calculations or the results of modeling that include, but are not limited to, reasonable assumptions concerning the expected volume of water to be stored and recovered and

reasonable assumptions regarding aquifer thickness and porosity. Compliance with the primary drinking water standards for total coliform bacteria and sodium and the secondary drinking water standards is required at the edge of the zone of discharge. The department shall specify the vertical and lateral limits of the approved zone of discharge in the permit.

(9) After the aquifer storage and recovery well is in operation, groundwater monitoring must demonstrate that biological die-off is occurring, that no exceedances of the primary drinking water standards have occurred outside the zone of discharge, and that there is no adverse risk to human health from the injection activity. If the applicant fails to make this demonstration, the department shall require operational modifications, reduction or cessation of injection, partial or full recovery of water, remediation, or other actions necessary to assure compliance at the edge of the zone of discharge and to protect public health.

(10) If drinking water supply wells are present in the injection zone within 2.5 miles of the edge of the zone of discharge, additional monitor wells may be required to detect the possible movement of injected fluids in the direction of the drinking water wells.

(11) Monitor wells must be sampled at least monthly for the parameters specified in the permit for the aquifer storage and recovery well. The department may modify the monitoring requirements if necessary to provide reasonable assurance that underground sources of drinking water are adequately protected.

(12) The department shall make a reasonable effort to issue or deny a permit within 90 days after determining that the permit application is complete. In accordance with s. 403.0876(2)(b), the failure of the department to issue or deny an underground injection control permit for an aquifer storage and recovery well within the 90-day time period will not result in the automatic issuance or denial of the permit and will not prevent the inclusion of specific permit conditions that are necessary to ensure compliance with applicable statutes and rules.

(13) The department may adopt rules for the regulation of aquifer storage and recovery wells necessary to administer this section.

<u>Section 2</u>. Section 373.222, Florida Statutes, is created to read:

373.222 Regulation of domestic use from ground water affected by aquifer storage and recovery wells.--

(1) Notwithstanding s. 373.219(1), the [water management district's] governing board or the department shall require a permit for the domestic use of ground water from a well that overlies or may influence or be influenced by a zone of discharge for an aquifer storage and recovery well approved by the department under s. 403.065. The governing board or the department may impose such reasonable conditions as are necessary to

assure that such use is consistent with the overall objectives of the [water management] district or department and is not harmful to the water resources of the area.

(2) The governing board and the department may adopt rules necessary to administer this section.

Section 3. This act shall take effect upon becoming a law.