# Sharing Water in Times of Scarcity

## Guidelines and Procedures in the Development of Effective Agreements to Share Water Across Political Boundaries

Edited by Stephen E. Draper

ASCE

EWRI

# SHARING WATER IN TIMES OF SCARCITY

GUIDELINES AND PROCEDURES IN THE DEVELOPMENT OF EFFECTIVE AGREEMENTS TO SHARE WATER ACROSS POLITICAL BOUNDARIES

SPONSORED BY

Laws & Institutions Committee of the Environmental and Water Resources Institute (EWRI) of ASCE

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# Preface

This report, Part II of the Final Report of the Task Committee for the Shared Use of Transboundary Water Resources (SUTWR), is provided to the Laws & Institutions Committee of the Environmental & Water Resources Institute (EWRI) and the American Society of Civil Engineers (ASCE) for publication as the SUTWR Task Committee Report, Part II.

The Water Laws Committee (now the Laws and Institutions Committee of the EWRI Planning and Management Council) of the Water Resources Planning and Management Division of the American Society of Civil Engineers (ASCE) created the Model Water Code Project in 1990 under the leadership of Professor Ray Jay Davis of the Brigham Young University School of Law. The purpose of the project was to develop model statutory provisions intended for adoption by state governments for allocating water rights among competing interests and for resolving quantitative conflicts over water.

After Professor Davis retired from Brigham Young University in 1995, the project continued under the leadership of Professor Joseph W. Dellapenna of the Villanova University School of Law. In 1997, the Regulated Riparian Model Water Code was published as the ASCE/EWRI Regulated Riparian Model Water Code (Joseph W. Dellapenna ed. 1997). It was recently accepted as the ASCE/EWRI Standard 40-03 (Dellapenna, 2003b). The Appropriative Rights Model Water Code is presently in the final stages of review for publication as a Committee Report of the EWRI Laws and Institutions Committee and has been accepted for the consensus process by the Water Regulatory Standards Committee of the EWRI Standards Development Council,

Early in the project formulation and development process, the ASCE Water Law Committee recognized that effective water allocation and management required planning and regulation on a water basin basis. However, since most basins are shared by two or more political entities (e.g., states or nations) the committee recognized the need for a companion model code for utilization of waters flowing across or along the boundary of sovereign governments.

### The Need for a Model Water Sharing Agreement

When two or more independent governments share a common water resource, the timing and magnitude of the respective individual uses can be continual sources of conflict. Water scarcity is evident throughout much of the western United States, and the use of shared water resources is often a major source of legal and political conflict. The interstate and international conflicts over the allocation of the waters of the Colorado River began early in the Twentieth Century and have still not been totally resolved. But the problem is not limited to the western states. Even when water is relatively plentiful, the increasing demand for water from shared resources is growing as the population expands, dramatically increasing the needs of public water supply. This has been graphically shown by the recent dispute between Florida, Alabama and Georgia over allocation of the waters of the Apalachicola-Chattahoochee-Flint River basin. The problem is pervasive, since few river basins in the continental United States are contained within a single state's boundaries.

The problem is magnified in the international arena. There are 268 major rivers shared between and among two or more nations. These international river basins cover almost one half of the total land surface of the globe. Fifty-three rivers are shared by three or more nations, with the Danube being shared by 13 riparian countries. International river basins sustain over 40% of the world's population. Almost 25% of the world's population lives in the earth's semiarid and arid zones where scarcity of water is often acute. Therefore, the potential for conflict is enormous. Among others, protracted conflict over shared waters exists between Turkey, Iraq and Syria in the Tigris-Euphrates basin; between Jordan and Israel regarding their opposite bank sharing of the Jordan River; and between nations in the Nile River Basin. The Ganges River is a source of dispute between India and Bangladesh. Armed conflict has occurred between Ecuador and Peru over the Cenepa River. The breakup of the Soviet Union has caused conflict between former members, especially in the arid regions east of the Caspian Sea. Seven active transboundary water disputes currently exist in Africa; six in Europe and Asia; and at least five in the Americas.

The need for effective cooperation among riparian countries has greatly expanded because of the growing demand for water in various international basins and the increasingly harmful effects of activities in upstream countries. While some form of interstate compact covers most of the shared river basins in the United States, many were drafted in the first half of the Twentieth Century. These agreements were often uni-dimensional and limited in scope, being oriented to specific problems rather than holistic management of the basin's water. It can be argued that many of these interstate water compacts are inadequate to resolution of the more complex water sharing issues that will develop in the Twenty-First Century. Water resource experts now recognize that the shared use of water resources is most effective when management is on the river basin level and when management of the shared resource is comprehensive and multi-dimensional. Internationally, the problems are more acute. Over a third of the 200 international river basins are not covered by any international agreement, and only some 30 have truly cooperative institutional arrangements. Therefore, a significant need exists for guidance and procedures that can facilitate the development of agreements that can provide a basis for the effective and efficient water sharing between autonomous political entities.

**The ASCE/EWRI SUTWR Project**

In 1995, ASCE initiated the SUTWR Project. The purposes of the project was to review existing transboundary water sharing agreements and develop both guidelines and procedures for the development of water sharing agreements as well as model agreements for utilization of water by sovereign governments or sub-units within sovereign nations. The focus of these guidelines and model agreements was the allocation and use of shared waters and the resolution of conflicts involving such waters. The goal was to provide agreements that would limit potential conflict while providing an appropriate balance between efficient use of the water resource for economic purposes, public health and ecological protection. The scope of the work was to include international agreements, interstate compacts and state-tribal agreements for regulating water resources along or across political boundaries. It was to apply to any sharing of waters between independent political governments.

Advice and assistance concerning the management of shared water resources were solicited from engineers and scientists engaged in water resources development; from government administrators working with water from a variety of perspectives; from lawyers representing development interests as well as representing environmental and ecological interests; from individuals representing a wide spectrum of business, and industries; from academics in a variety of disciplines, to include civil engineering, ecology, economics, hydrology, law, and political science; and from environmental activists. A number of experts from such varied backgrounds gave detailed critiques of the several drafts of the project; many of these experts also attended two or more meetings per year where the drafts were discussed in detail. Those involved in the project agree that overall the end products are carefully balanced to represent a coherent body of law that would markedly improve the management of shared water resources. (Draper, 2002)

Stephen E. Draper chaired the SUTWR Task Committee. Members of the committee included Joseph W. Dellapenna; Christopher Estes; Marshall Goulding; Conrad G. Keyes, Jr.; Kris G. Kauffman; Zachary McCormick; Don Phelps; and Gerald Sehlke. In addition, Robert Chuck, William E. Cox, J. Wayland Eheart, and Olen Paul Matthews provided significant assistance to the project.

Part I of the Task Committee Report, has been published as the ASCE/EWREI *Model Water Sharing Agreements for the 21$^{st}$ Century*, (Draper, ed., 2002). Part I provided three separate model agreements that may be used to provide a framework around which an agreement could be formed. This publication, Part II of the Task Committee Report, provides narrative guidelines and procedures for the initial formulation stage of the water sharing process.

These guidelines and procedures consider a variety of issues that influence the development of interstate and/or international water sharing agreements. This publication provides guidelines to enable integration of the multiple aspects of the water resource through an analysis that synthesizes the disciplines of science, engineering, technology, economics and law. The document seeks to ensure that all pertinent factors are considered in the development of an agreement so that the agreement accommodates the physical realities of the shared resource along with the different political systems, cultures, and/or water use customs of the particular water basin.

This Committee Report forms a bridge between the theory and the practice of effective shared water management. It provides a process that all states and/or nations can use when creating or modifying a transboundary water sharing agreement. This process includes an assessment of the various factors influence by the shared water use, to include correlating the geographical and political issues surrounding utilization of the water resource, inventorying the sources and uses of the water resource, analyzing the ecological impact of the transboundary use, and examining its effect on economic growth and quality of life of the various constituents. This Committee Report presents the various alternatives available for allocation of water among the parties, with special emphasis on extreme events (droughts or floods). The alternatives include allocation methods for surface water, underground water, and atmospheric waters. Finally, different choices for the administration apparatus that is to supervise implementation are provided.

The final draft of this Committee Report was subject to independent review by three prominent experts in interstate compacts and the law of transboundary water sharing who had not been actively involved in the drafting of the Guidelines and Procedures. These prominent experts included Lisa Bourget, Secretary, U.S. Section, International Joint Commission, *Treaty between the United States and Great Britain relating to Boundary Waters*; Douglas L. Grant, Cord Foundation Professor of Law, William S. Boyd School of Law, University of Nevada-Las Vegas; and R. Timothy Weston, Kirkpatrick & Lockhart LLP and Attorney for the Delaware River Basin Compact. In addition to the independent review, the report was subject to extensive review by the members of the original SUTWR Task Committee and the Laws and Institutions Committee of the EWRI Planning and Management Council. These groups have involved individuals of diverse backgrounds, some of whom were members of the original ASCE Model Water Code Task Committee whose work has provided a foundation from which the SUTWR II report has developed. The review process therefore has been comprehensive both in terms of scope and depth.

# SECTION 1

# FOUNDATION OF EFFECTIVE WATER SHARING

## 1.1 Purpose and scope of these guidelines and procedures.

Economic growth and prosperity and improved quality of life require adequate supplies of quality water on a regular and sustained basis. This requirement means that the utilization of shared waters be carefully and systematically coordinated among or between the parties sharing the waters. At present, there are 268 transboundary river basins worldwide. These basins cover almost two-thirds of the global landmass. Forty percent (40%) of the world's population depends on these shared river basins for the water they need. (International Network, 2002; Sea River, 2002) Of the 71 rivers in the continental United States (excluding Alaska and Hawaii) that are more than 350 miles in length, only 6 are not shared by one or more states and/or countries. Of over 56,000 river miles, less than 7% are not shared. (Pearson Education, 2002) Over 90% of the population in the continental U.S. depends on waters shared with other states. (Draper, 2003) Clearly, guidelines and procedures for efficient and effective water sharing are necessary.

An effective agreement can facilitate adequate planning, conservation, utilization, development, management and control of water resources on a water basin basis, in a manner that is reasonable and equitable under the circumstances and that causes no significant harm to most other parties. A key challenge for the parties is to make more efficient and productive use of water and to reshape the water policies of the individual parties to better respond to periods of water shortages. (Postel 1996; Draper, 2002)

This document provides guidelines and procedures to be used in the formulation of water sharing agreements between and among sovereign governments so they may meet the challenge of devising an effective and equitable water sharing agreement. These guidelines and procedures seek to limit potential conflict while providing an appropriate balance between efficient use of the water resource for existing economic purposes, preserving the common water resource for future needs, and promoting the protection of the environment. The guidelines and procedures focus on the process of creating or modifying a transboundary water sharing agreement to ensure that the sovereign parties include all pertinent factors in their negotiations.

Although these guidelines and procedures have been developed predominately using the American experience with transboundary water sharing, a number of international agreements were analyzed in order to gain an appreciation for other experiences. Consequently, these guidelines and procedures have broad application for use in international agreements, interstate compacts or state-tribal agreements for regulatory purposes along or across intergovernmental boundaries. They can apply to any sharing of waters between autonomous political entities. As presented, the guidelines and procedures can be applied to a variety of circumstances involving shared water. Only those sections appropriate to the particular situation and conditions need be applied.

### 1.2 Distinctive characteristics of water.

In setting the framework for sharing water resources, it is appropriate to briefly discuss several special characteristics of the natural resource, water. Water is central to survival of life itself, and without it plant and animal life would be impossible. Water is a central component of the Earth system, providing important controls on the world's weather and climate. Water is also central to our economic well being, by supporting rain fed and irrigated agriculture, forestry, navigation, waste processing, and hydroelectricity. (Vörösmarty, 2002) Recreation and tourism are other primary uses supported by water, especially in developed countries. (Bourget, 2005)

The water in rivers and some aquifers is different from commodities like oil and gold. Flowing water, like any ambient resource, does not stay within the four corners of any boundaries in the manner of land. (Dellapenna, 2000) Because water is a non-excludable natural resource, it is subject to the same collective dilemmas that plague other common-pool resources: overexploitation of ecosystem services and under-investment in natural capital. (Ostrom 1990)

Water, unlike oil or gold, is a shared, mobile and public resource that it is used and reused for different purposes as moves through the hydrologic cycle. Prior to capture by withdrawal or diversion, a claim of exclusive ownership is difficult to sustain. Water is different because different users use the same water repeatedly as the water travels downstream, as in the case of surface water rivers, or down gradient, as in the case of underground water aquifers. A user upstream, like Atlanta, Georgia withdraws most of its reliable water supply from the Chattahoochee, consumes a portion of the water and returns the rest of the water to the river for use by downstream users such as Lagrange or Columbus, Georgia and even cities in Alabama and Florida. (Draper, 2000a) This use and reuse is the essence of riparian law, the fundamental law theory upon which shared water use historically has been based.

It is often said that water is renewable, but the term can be misleading. Surface water and some underground water moving through aquifers like the Floridan in the Southeastern United States are renewable in the sense that most water moves through the hydrologic cycle as one form or another of $H_20$. Other water, especially underground water in so-called fossil aquifers like the Ogallala in the Midwest United States, is not quickly renewable. (Opie, 2000)

What is important from a sustainability perspective is how much of the water used by the various demands is actually renewable and available for reuse. Some analysts have concluded that globally water availability has declined two-fold during the last 25 years because of population growth and drier trends in the climate. (Shiklomanov, 1998a; Zalewski, 2002) River runoff in Africa has reportedly declined by about one-third in the last ten years while runoff in South America has shown a significant increase. A significant decrease in precipitation has been observed since the mid-20th century in North Africa, Southeast Asia, Indonesia, and Australia. (Georgeyewsky, 1998). When looked at from a global perspective of the hydrologic cycle, the liquid form of $H_20$ is renewable. When considering water available to meet demands at a certain time and place, it is not.

## 1.3 Guiding principles for effective water sharing

The uniqueness of each basin and its riparian states indicates that a universal set of principles should be fairly general. (Wolf, 1999a) However, efficient and effective transboundary water sharing should be based on four guiding principles: coordination and cooperation, interdisciplinary analysis, watershed and river basin planning, and adaptive management.

### Coordination and cooperation

A nation normally enters into any international agreement from a position of self-interest. In the negotiations, each party seeks the rights and authority critical to certain political, economic or social objectives while ceding less critical rights and authority to the other nations. While accepting this fact, all parties have a duty to cooperate and negotiate in good faith. This principle is the foundation of international law, and it applies in all relations between sovereign states. (Draper, 1997) The parties should agree to cooperate and consult with the other parties to the agreement in their development and utilization of the water and related resources of the waters shared by the parties. Coordination and cooperation is essential to ensure effective and efficient use of those waters while minimizing harm to other parties. Additionally, the parties should agree to cooperate on the basis of sovereign equality and territorial integrity in the utilization and protection of the shared water resources. They should conduct themselves with an absence of malice and deceit, and with no intention to seek unconscionable advantage. Coordination and cooperation include the need for good faith implementation. (Draper, 2002a)

### Interdisciplinary Analysis

The development of effective and efficient transboundary water sharing is a multi-faceted challenge. (Kenney and Lord, 1994; Draper, 2001) Although necessarily based on water science, i.e., knowledge of the quantity, quality and timing of the available water supplies, the development of effective water sharing agreements is predicated on an adequate interdisciplinary analysis of water science, engineering, technology, law, and economics. (Draper, 2001; Jackson et al., 2001;

Dellapenna and Draper, 2002a) A social component exists that should not be ignored. (Fitch, 2003; Levy et al, 2003) In addition, this development should include an analysis of the water available for allocation to the various existing and known future water demands, to include economic growth, public health, navigation, water-based recreation and environmental and ecological protection. Finally, the effective and efficient utilization of water requires integration of surface and underground water sharing, as well as consideration of water quantity and water quality, is necessary. The potential effect of climate change should be included.

Watershed and River Basin Planning

Planning and management on a watershed or river basin basis, rather than artificial political boundaries, should be the foundation principle for water planning. (Barlow and Clarke, 2002) Watersheds are the natural spatial unit for predicting future water supply and water demands, at least as they relate to the use and reuse of water as it flows downstream. (Jackson et al., 2001) The reality of political boundaries and the desire for sovereign control should be respected, but water planning and management by watershed or river basin is essential. Watershed planning and management should include three essential components. The first component is maintaining hydrologic integrity within a regional framework. The second component is developing a multi-jurisdictional management structure that coordinates water planning and land use planning. The third component is the use of regional-national-state-local partnerships as well as private-public partnerships in the planning and management of water resources. (Draper, 2001)

Adaptive Management

Water resource management should be based on the best information available, but should be flexible enough to accommodate change and complexity since natural systems are inherently variable, "patchy," and complex. (Sophocleous, 1998) In broad terms, adaptive management is 'a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. (Bennet and Lawrence, 2002) Adaptive management requires deliberate evaluation of resource management activities and active response to what is learned. (Sando, 2002) In essence, adaptive management can be described as "learning by doing." (Lee et al.. 1986) An adaptive agreement is designed from the outset to recognize that clearly formulated hypotheses about the behavior of hydrologic systems may be changed by human use. (Lee, 1993)

For an agreement on water sharing to be effective, it should be able to adapt to potential changes in site-specific circumstances that may develop within the time-period the agreement is in effect. (Bernauer, 2001) The provisions in the agreement should be sufficiently adaptable to allow them to evolve over time and to respond to changes in the climatic, hydrologic, economic, social and even political conditions. (Eaux partagee, 2002; Fitch, 3003) The agreement should be able to accommodate unexpected changes in water source availability that may result from extreme events such as prolonged droughts and climate change. Likewise the agreement should be able to accommodate changes in the demand for water that may arise from changes in the economic foundation of one or more of the parties or from sociological or political changes in the value assigned to particular water demands. As with any water management policy, the provisions and rules within a water sharing agreement can best be developed and implemented by retaining and encouraging innovation and diversity. (U.S Advisory Commission, 1991)

## 1.4 Goals and objectives of water sharing agreements

The goal of water sharing agreements is to create a legal framework between the parties to establish the guiding principles of effecting water sharing, essential to sustaining economic growth and prosperity while enhancing the quality of life for the citizens of the parties. Quality of life requires a strong economy, good public health and safety, good recreational opportunities, and well-managed natural resources. All of these depend on adequate supplies of clean water. (Draper, 2001; McCain, 2005)

Each water sharing agreement should clearly state its objectives, and should consider meeting the needs of both existing and future demands and uses. The procedures to reach the agreement should include emphasis on integrated management and recognition of the economic value of water. A means of stakeholder participation in decision-making is essential as are means of providing access to water services for the poorest users. Institutionalizing an ecosystem approach and integrating private sector contribution should be developed. (The World Bank, 1998; Eaux partagées, 2002)

### Existing demands and usage

The primary short-term objective of a water sharing agreement should highlight meeting existing demands and uses while maintaining reasonable environmental and ecological protection. Essentially the agreement should provide for water use during "normal" years but also provide risk management for extreme conditions, droughts or floods, and allocate water among existing uses in times of water shortages. (McCormick, 1994a; Draper, 1997, 2001) An essential objective for the agreement, for both the short term and the long term, is equity among users. (Eheart, 2002)

### Future demands and usage

The primary long-term objective should highlight meeting the needs of future demands and uses while meeting the long-term needs of the ecosystem. The agreement should be structured to ensure the availability of sufficient quantities of quality water for future growth as planned or predicted by all the parties involved in the agreement. The parties should avoid provisions that may favor existing uses at the expense of new, higher value uses. (Draper, 1997, 2001) Importantly, the objectives should be sufficiently adaptable to respond to changes in water availability due to climate change. (IPCC, 2001)

Quality of Water Allocated

The quality of the water that is allocated is as important as the quantity of water that is allocated. Poor quality water imposes risks that the parties should consider. First, there is the health risk to the population that uses the water for domestic purposes. Second, if the available water will not meet the standards for certain beneficial uses, there is the risk that economic growth will be impaired. Finally, there is the risk that quality degradation will have a severe impact on the ecology of the basin, resulting in the loss of long-term sustainability. Integration of water quality and quantity is essential. (Draper, 2002a) Aquatic ecosystems provide critical benefits for human, plant, and animal life, including improving water quality, reducing erosion and sediment losses, providing habitat (more than 75% of the animal species in arid regions require riparian habitat), creating recreation benefits and other amenities for growing populations, and providing flood control benefits. (Hirji and Ibrekk, 2001) AGENDA 21 from the *United Nations Conference on Environment and Development* held in Rio de Janeiro, Brazil, 1992 obligated all signatories to develop a water and sustainable development program. (Ahlander, 1994) The UN *Convention on the Law of the Non-Navigational Uses of International Watercourses*, United Nations Document A/51/869 (1998), establishes the criterion that "(w)atercourse States shall, individually and, where appropriate, jointly, protect and preserve the ecosystems of international watercourses."

Surface and underground water may be degraded by a variety of factors. Major problems affecting the quality of these water resources arise, for instance, from inadequate domestic sewage treatment, inadequate controls on the discharge of industrial waste and effluent, the diversion of waters resulting in insufficient water to assimilate waste, the loss and destruction of catchment areas, the improper siting of industrial plants, deforestation, and poor agricultural practices which cause leaching or runoff of nutrients and pesticides. Excessive interbasin transfer may affect the quantity of water available for waste assimilation downstream of the transfer. Transboundary water sharing should include effective plans and programs that reduce or eliminate, or at least minimize, the possible sources of water quality degradation. (Draper, 2002a)

Sustainable Management

Water resources should be managed in a sustainable manner so that current and future generations have access to adequate supplies of quality water that supports both human needs and natural systems. (Fort, 1998; Eheart, 2002; GJC, 2002) This sustainability criterion expands the scope of water sharing beyond efficiency to encompass fairness to future generations as well. (Tietenberg, 1998) However, sustainability is a difficult concept to define and no consensus on a definition has developed. (Fort, 1998) Strict interpretation of the philosophy of sustainability may deny the needs and abilities of humans to make rational choices for their immediate and long-term future. In this light, this document defines water resource sustainability as the reasonable and beneficial use of water that avoids wasting of the water resources, ensures reasonable protection of the environment, while meeting the needs of future generations. Sustainable outcomes for water use include the requirement that a minimum water supply is guaranteed to all humans in order to maintain human health. While the human minimum water needs varies according to the aridity of the region under analysis, an absolute minimum has been determined to be 50 liters per day. (Gleick, 1996) "In November 2002, the United Nations Committee on Economic, Social and Cultural Rights affirmed that access to adequate amounts of clean water for personal and domestic uses is a fundamental human right of all people." (United Nations, 2003) The agreement should provide sufficient water to restore and maintain the health, services, and functions of ecosystems. Specific amounts will vary depending on climatic and other conditions and require flexible and adaptive management. The agreement's provisions should be structured to facilitate human actions in the shared water resources that do not impair the long-term renewability of freshwater stocks and flows. (Hirji, et al., 2001)

**1.5 Summary.**

This document provides guidelines and procedures to be used in the formulation of efficient and effective water sharing agreements between and among sovereign governments. These guidelines and procedures are intended for use in international agreements, interstate compacts or state-tribal agreements for regulatory purposes along or across intergovernmental boundaries. They apply to any sharing of waters between autonomous political entities.

Four guiding principles underlie the formulation and development of the final agreement. (1) Negotiations should be conducted with a commitment to coordination and cooperation. (2) An interdisciplinary approach to water allocation among the parties should be used, to overcome the inherent obstacles facing effective water sharing. (3) The agreement should provide for management on the basis of watershed and river basins. (4) Adaptive management and flexible provisions should be included in the agreement.

The goal of water sharing between the parties should be to sustain economic growth and prosperity while enhancing the quality of life for the citizens of the parties. The water sharing agreement should create a legal framework that clearly states its objectives, and should consider meeting the needs of both existing and future demands and uses. The procedures to reach the Agreement should include, emphasis on integrated management, recognition of water's economic value, enabling stakeholder participation in decision-making, providing access to water services for the poorest users, institutionalizing an ecosystem approach, and integrating private sector contribution. Consideration of the needs of future generation is essential.

# SECTION 2

# WATER SHARING ACROSS POLITICAL BOUNDARIES

Two factors are essential to develop a viable water sharing agreement across political boundaries. First, at the beginning of the formulation process, the parties should understand and analyze major obstacles facing such an agreement. Second, the parties should approach the negotiations leading to the agreement with an understanding and commitment to certain norms of conduct critical to fair and honest negotiation between sovereign parties.

## 2.1 Obstacles to effective water sharing.

The nature of water resource sharing by different political entities results in a number of significant obstacles to effective water sharing. The reluctance to give up dominion and control over the natural resources within the political boundaries of the parties to another party is a significant obstacle. Other obstacles include conflicts in the internal water laws and policies of the parties that make the shared goals of the agreement difficult to reach. An incomplete knowledge of the water resource availability and demand within the shared basin, as well as conflicts between the internal economic policies of the parties may hamper an agreement between or among the parties. (Clarke, 1993; Draper, 2001)

### Agreement across Political Boundaries

Whether a party to the negotiations to share water is a nation-state or a state or tribal entity within a federal system, that party will normally claim the exclusive rights to all natural resources within its boundaries, including ownership of the water resources. When a government enters into an interstate or international agreement, it does so from a posture of self-interest. (Draper, 1997; Albert, 2000) In negotiations, each Party seeks the rights and authorities critical to certain political, economic or social objectives while ceding less critical rights and authorities to the other nations. This inherent friction underlies all negotiations. Water sharing requires each Party to relinquish a part of its control and dominion. How much sovereignty is relinquished determines the scope and possibly the effectiveness of the agreement. (Eaux partagées, 2002)

The political boundaries that exist between the governments present significant obstacles since water basins boundaries seldom coincide with political boundaries. (Dellapenna, 1994b; Libiszewski, 1995; The World Bank, 1998; Wolf, 2001b; Draper, 2002a; Puri, 2002; Vörösmarty, 2002) Rights to use water within a particular shared watershed or aquifer, with few exceptions, differ according to the water laws of the particular party in which the withdrawal occurs. It is a question of jurisdiction; who has the responsibility and authority to regulate water withdrawal and use? (Kenney and Lord, 1994; McCormick, 1994a) With surface water, the conflict may arise because the upstream Party's water policies and consumptive use may adversely affect the water available for use by the downstream party. (Kenney and Lord, 1994) For example, Nile River water use by Sudan has significant adverse affects on water use by Egypt. (Dellapenna, 1997b) Since surface water often marks the boundary between political entities, the conflict may arise from the different water uses on opposite banks by adjacent states. Differing water uses by Israel and Jordan are illustrative. (See *Treaty of Peace between the State of Israel and the Hashemite Kingdom of Jordan*, 34 I.L.M. 43 (1994)) Differing cultures and their concepts of water and its use can be an obstacle to a spirit of cooperation and trust so necessary to an effective agreement. Although the Israeli-Palestinian conflict has many causes, the inherent difference between the two culture's view of water and its allocation provides another obstacle to peace. (Dellapenna, 1994a; Dellapenna, 1997a; Hassoun, 1998) Water is now acknowledged as a major limiting factor in the socio-economic development of a world with a rapidly expanding population. (Sibanda, 2002)

Within the United States this same conflict exists, although arguably to a lesser degree. Three elements of control and dominion clash under the constitutional powers of the federal, state and tribal governments. Under federalism, the states maintain control over inland waters, with some important exceptions. (Kennedy and Lord, 1994; Gelt, 1997; *See Kansas v. Colorado*, 185 U.S. 143 (1902) and 206 U.S. 46 (1907)) These important exceptions include limitations imposed directly or by implication in specific legislation, such as the Endangered Species Act, 16 USC §§ 1531 et seq.(ESA), and the Clean Water Act, 33 U.S.C. §§ 1251 et seq. (CWA), limitations or obligations imposed by interstate compacts, interstate allocations established pursuant to U.S. Supreme Court decisions, and certain other doctrines established by the Supreme Court. Such doctrines include federal reserved water rights that adhere to federal lands in the west, federal control over navigability, and federal supremacy regarding federal waterpower projects.

Indian reservations also may assert dominion and control over certain waters as the result. (See *Arizona v. California*, 373 U.S. 546 (1963)) Thus the elements of dominion and control that obstruct effective and efficient water sharing on the international scene will often obstruct effective and efficient water sharing between the states, between a state and tribe, or even between two or more states and the federal government.

### Conflicting internal water rights

An essential requirement for economic progress is the availability of sufficient quantities of quality water. (Draper, 2001, 2002a, 2002b) Adequate supplies of water for stakeholders within the political jurisdiction are carefully controlled through a legal system of water rights that allocates water. The laws usually are structured to provide a balance between providing water rights to uses that are efficient and beneficial, or at least not wasteful, while still providing legal certainty or predictability and security of tenure to those holding the water rights. Often, however, the water laws of the parties have developed differently and, consequently, will conflict. (Sanchez, 1997; Hearing, 1998; Grant, 2001) The problem is exacerbated for laws that allocate underground water. Different laws for the allocation of surface and underground water present an issue that exists for both intra- and inter-jurisdictional water management. (Kenney and Lord, 1994)

Vested water rights within the territorial borders of the various political parties may be a source of conflict. Within the United States, the property right associated with water varies considerably from state to state. (Beck, 1994; Dellapenna and Draper, 2002b; Draper, 2002e) Consequently, different rights granted to the same source of water may result in inefficient and ineffective allocation of the water, to the detriment of all parties. The right granted by the different parties to withdraw from the same aquifer may differ, as may the rights granted to withdraw from the same surface water source. The parties may have different requirements for return flows and different standards for minimum instream flow requirements. (Evans and England, 1995) To prevent inefficiency of water allocation, all parties having an interest in a water source should either agree on certain water-related issues or at least understand the existence of these issues in order to accommodate them within the framework of the agreement. These issues include determining how the sovereign parties grant the right to use water from a specific source, the amount of water each party allocates under normal conditions from that source, and the amount of water allocated from that source during droughts.

Conflicting internal water policies

An obstacle to effective water sharing agreements may develop from differences in the water policies of the individual governments. A government's water policy should be distinguished from its water rights or water laws. Water policy is founded on the interrelationship of water law, science, engineering, technology, and economics. (Draper, 2001; 2002a; 2002b; 2002d; 2002e) Water-related policies and programs of individual governments usually have very specific objectives, often oriented to water use efficiency for economic plans and needs. Often the result is single-purpose laws and programs that fail to account for the interrelationship between surface, underground, and atmospheric water; quality and quantity of water allocated; or other water rights needs such as instream flow rights. (Vlachos, 1997) The political influence of specific stakeholder groups may be a source of severe distortion in laws and regulations. (Zusman, 1997) A significant obstacle to effective water sharing arises when one party institutes a policy of private water markets while the other does not. Also, drought management and reservoir release policies of the upstream party may conflict with downstream water availability. Finally, one party's policy on interbasin diversions can have serious impacts on the water available to the other party. (Sherk, 2000)

Separate and distinct political units within a government often make water policy independently of other policy-making entities within that same government, hindering effective water-sharing agreements. (Kennedy and Lord, 1994) In the United States, in addition to the states and tribes, over 20 subcommittees of Congress and over 20 federal agencies have overlapping mandates and conflicting policies, each supported by separate constituencies. The laws promulgated to implement these policies are themselves fragmented and distinct. Any agreement should acknowledge and provide resolution mechanisms for these conflicts. (Postel, 1996)

Scientists, economists, and legal scholars have long advocated the integrated and conjunctive management of all water resources within a watershed and river basin. After all, the hydrologic cycle is an integrated whole, and courts or administrative agencies should not segregate the parts of an ambient resource that nature integrates. Water-based activities physically impact each other and should be managed comprehensively if they are to be managed properly. On the other hand, activities related to various parts of the hydrologic cycle do have varying characteristics, including varying degrees of effects upon other uses related to other parts of the hydrologic cycle. (Dellapenna, 2003b)

Minimum flow policies and policies concerning interbasin transfer can have substantial impacts on the effectiveness of an agreement. (Draper, 2002d; Eheart, 2002) There may be conflict because one party wishes to reserve from allocation and consumptive use the waters necessary for the preservation of the protected biological, chemical, or physical integrities of water sources and insist on a mechanism to further protect instream flows. (Dellapenna, 2003b) The other party may have a policy that the instream flow be maintained at a lower level only for purposes of wastewater assimilation. (Draper, 2002d) In other cases, a party may insist that the instream flow mimic the natural cycle of spring floods and summer low flows in order to sustain the biological integrity of the stream. (Christensen, 1996; Glennon, 2002) Transferring water for use outside of its basin of origin with little or no return flow to the basin of origin might pose similar problems to the basin of origin as are likely to arise in interstate transfers even when both the basin of origin and the basin of use are within a single state. (Draper, 2002b; Dellapenna, 2003b) Similarly, significant consumptive uses (such as incorporation of water in a product or evaporation of water through cooling system) may impose substantial downstream impacts similar to an out of basin transfer.

Until recently, water sharing agreements have primarily been concerned with surface water sources. Now, however, with newer water withdrawal technologies and with the exponential growth in the demand for water of the last several decades, underground water has emerged as a critical regional, national, and transnational resource. The sharing of aquifers will increasingly become the focus of conflict. (Dellapenna, 2001a)

A significant challenge to reaching an effective agreement may arise from the different standards the parties apply to consumptive use, reuse and conservation.

Increased consumptive use can have a dramatic effect on the water available to downstream users, as can reallocation by a party from older, "lower value" uses that may be less consumptive to newer, "higher value" uses that have greater consumption of the water withdrawn. (Draper, 2002c) Water reuse policies can assist or hinder downstream users. If the reuse is structured to assure that water available to downstream users remains unchanged or even increased, reuse policies can greatly assist the parties in reaching agreement. On the other hand, if the reuse policies can result in less water being available downstream. they can greatly impede the parties reaching an agreement. Finally, as discussed earlier, the introduction of water markets by one Party can result in increased water scarcity for the other Party, especially when interbasin transfers occur or the new water user engages in significantly greater consumptive use and other Party is downstream. (Postel, 1993)

Incomplete knowledge of water resource availability

Incomplete knowledge of the waters subject to the agreement is a significant obstacle to effective water sharing. Effective agreements are predicated on a detailed knowledge of the quantity of water available for use and the quality of that water available for specific uses. (Fort, 1998) Incomplete knowledge, however, may arise from uncertainties regarding geologic matters (such as the relationship between underground water aquifer areas versus surface water basins), data limited by the timeframes for which information was collected, and uncertainty regarding prediction of future hydrologic conditions and technological developments. While incomplete knowledge will hinder the agreement's effective allocation of water to the respective parties, a more significant effect will be that an agreement will not adequately cover all water needs, especially during extreme events.

A water sharing agreement usually focuses on allocation of water under average hydrologic conditions as well as that allocated under drought conditions. Developing an effective agreement requires accurate and precise knowledge of all these conditions. Otherwise, the result may be significant disputes over the terms of an agreement, significantly impairing the agreement's usefulness for the parties. (Berman and Wihbey, 1999; The Ohio Valley Sanitation Commission; 2000)

Lack of knowledge about underground water availability is especially prevalent. (Hillel, 1994; Tsur, 1995; Dellapenna, 2003b) The hydrological characteristics of some aquifers may be unknown, as is the case in many areas of the developing world. Substantial data gaps exist on the condition of different underground water basins, extraction amounts, current pumping practices, and recharge rates. (Gleick, 1998)

The question of the reliability of past hydrologic records may be a significant problem. Even what appear to be long-duration records (say the last 50 or 100 years) may not be representative of the cycles of hydrologic variation. Man-made changes in flow conditions (from storage, diversions and changes to impervious surfaces) may skew the reliability of historic data. The uncertainty of climate change presents an equal uncertainty when the historical record may become unreliable as global warming changes precipitation patterns, volumes of snow pack, and the timing of spring thaws. (IPCC, 2001) The agreement needs to contain a mechanism that allows for adjustments for lack of information, misinformation, or changes due to long-term trends.

Incomplete knowledge of the water resource demands

An effective agreement requires a comprehensive understanding of the existing requirement for water as well as projected requirements. Sound water policy planning requires a comprehensive, coordinated and reliable source for water-related data and current reliable information. (Georgia JSC, 2002) The information needed includes data on water requirements that may be gathered by local, state, and national government as well as academic institutions, the private sector and organizations. (Draper, 2001)

The agreement's purpose should be to allocate the available water between and among the political parties themselves. The parties can effectively accomplish this objective only when the water requirements within the individual sovereign entities are known. These water requirements are often described as needs or demands. Within each jurisdiction, the available water use should be divided between various, and often conflicting, uses as agricultural and municipal demand, waste assimilation and recreational uses, environmental and ecological protection and industrial demand, navigation demand and hydropower. Each jurisdiction should balance its requirements with the needs of the other jurisdictions and with the available quantity of sufficient quality water for each use. Finally, an imperfect knowledge of the withdrawal amounts impacting the sustainability of the water resource may cause a non-replenished loss of water that reduces water availability, thus effectively nullifying the agreement at some future date. (Nebraska, 1983; Gleick, 2000b; Sherk, 2000) A significant problem of inadequate knowledge of the requirements for water is especially prevalent in the agriculture sector for a variety of reasons. Even in the United States, precise knowledge of agricultural use is lacking because metering and annual reporting is not required of many irrigation users. (Cummings, et al., 2001b) Such knowledge is critical as agricultural use accounts for approximately two-thirds of global water use. (Postel, 1993) Domestic use is normally consolidated in the category municipal use. Information on industrial and commercial water use is incomplete at best. (Gleick, 2002b)

Conflicting internal economic policies

Autonomous economic policies among governments may hamper effective water sharing agreements. Different governments have different plans and priorities when balancing economic growth and the sustainability of water resources. Economic policy may be fragmented as to the means of promoting water use efficiency, with one government allocating according to the common law, (Georgia Chamber, 2002) another allocating on the basis of codified water law and regulation, (Dellapenna, 2000) and a third using a free-market approach (Cummings, et al., 2002) to economic planning and water use prioritization. (Draper, 2004) Policies regarding environmental and ecological protection and their relationship with economic growth are also a source of conflict that a water-sharing agreement should accommodate. (Espland, 1998; Draper, 2001; Draper, 2004)

### 2.2 Negotiating obstacles.

Certain principles of negotiations and management are essential for the development and implementation of a viable water sharing agreement. These principles are equally necessary for the agreement's ongoing effectiveness. A number of significant principles should form the framework of the agreement. They include an obligation to cooperate and negotiate in good faith, an obligation to prevent unreasonable harm to other parties, a commitment to the equitable utilization of the shared water, an obligation to exchange all available data with the other parties, and a commitment to the values of water resource sustainability. (Hey, 1995; Caponera, 1995; Draper, 1997; Albert, 2000; Dellapenna, 2001a)

Obligation to cooperate and negotiate in good faith

Normally, a government will negotiate an interstate or international agreement from a posture of self-interest. (Draper, 1997; Albert, 2000) In the negotiations, each Party seeks the rights and authorities critical to certain political, economic or social objectives while ceding less critical rights and authorities to the other governments or an international or interstate institution. This inherent friction underlies all negotiations. While accepting this fact, however, all governments have a duty to cooperate and negotiate in good faith. (See U.N. *Convention on the Law of the Non-Navigational Uses of International Watercourses,* United Nations Document A/51/869 (1998)) This principle is the foundation of international law, and it applies in all relations between Sovereign parties. All parties are expected to conduct themselves with an absence of malice and with no intention to seek unconscionable advantage, or otherwise be deceitful. This obligation is a critical foundation for water sharing agreements. (Kliot, et al., 1998) A commitment by all parties is essential. (German Foundation, 1998)

Reaching an effective and efficient agreement to share a water resource means that the parties should proceed in the negotiations with some forethought. Water sharing requires each Party to relinquish a part of its control and dominion. How much sovereignty is relinquished determines the scope and possibly the effectiveness of the agreement. (Eaux partagées, 2002) While self-interest may be a guiding factor in many negotiations, such a position is not conducive to reaching an effective and efficient agreement.

In most water-sharing cases, the purpose should be to find a way of accommodating the interests of all parties who share in the common resource – to find operating rules, water development investments, and other sharing arrangements that allow the legitimate needs and desires of the respective parties to be achieved.

Good agreements focus on the parties' interests rather than a particular position. Defining a problem in terms of positions means one party will "lose" the dispute. When a problem is defined in term of the parties' underlying interests, it may be possible to negotiate a solution that satisfies both parties' interests. (Fisher and Ury, 1983)

As an example, consider the case of the dispute between Alabama, Florida and Georgia over the management of the Apalachicola-Chattahoochee-Flint (ACF) River Basins. Initiated in 1990 with a suit against the U.S. Army Corps of Engineers' proposal for expanding the Metropolitan Atlanta Region's available water supply, the water sharing dispute eventually led to a 1997 compact between the states. (Dellapenna, 2002c; Lipford, 2003; DuMars, 2004) In this compact, the states agreed "to enter into future agreements establishing allocation formulas equitably apportioning the waters of the affected rivers among the party states." (Stephenson, 2000; Muys, 2001) Essentially, the compact directed the parties to "develop an allocation formula for equitably apportioning the surface waters of the ACF." (DuMars, 2004). After a number of extensions, the parties were unable to agree on an allocation formula and the Compact dissolved. (Clemons, 2003; Ritchie, 2003) Although a number of explanations of the failure have been postulated, the rigid positions of the Florida and Georgia positions stands out.

Georgia's main concern was being able to withdraw sufficient water from the Chattahoochee River, a tributary of the Apalachicola River, to fuel Metropolitan Atlanta's future economic and population growth. (Dellapenna, 2002c; DuMars, 2004). Florida's main concern was having sufficient water in the Apalachicola to maintain the ecological diversity of the Apalachicola corridor and assure sufficient water flow into Apalachicola Bay to nourish oysters and other marine life. (Wade et al, 1994; Dellapenna, 2002c) Georgia proposed that the allocation be based on ensuring a minimum flow during drought conditions at the state line with Florida. (Kerr and Reheis, 2003; Ritchie, 2003) The Florida position held that a "mimic" of the natural flows of the river were necessary to maintain the integrity of the Apalachicola ecosystem and that the Georgia proposal would ultimately result in their proposed minimum flows being delivered under all conditions, both normal conditions as well as drought. The Florida proposal was that Georgia limit irrigated farm acreage and control reservoir levels. (Clemons, 2004; Shelton, 2004) Georgia would not accept "micromanagement" of Georgia's water use. (Sanders, 2003) Neither state was prepared to alter their positions. The Compact's original time limitations and several extensions expired.

By maintaining these apparently irreconcilable positions, the states have effectively left resolution of the dispute to the courts, a solution that has been acknowledged to be fraught with peril, as discussed below. Had the dispute been defined in term of the parties' underlying interests, as noted above, it might have been possible to negotiate a solution that satisfied both parties' interests, a solution that would have reduced the expense of protracted negotiations and eliminated the potential enormous expense of U.S. Supreme Court involvement.

Prevention of unreasonable harm

The duty to prevent unreasonable harm requires that water allocation and use by one riparian Party cannot unreasonably harm the allocation and use by other riparian parties. (Kroes, 1997) The duty may be best explained by drawing an analogy to the riparian doctrine of reasonable use. Under U.S. common law, this doctrine restricted water withdrawal by a riparian owner to those circumstances where the withdrawal was for reasonable use. The withdrawal could not unreasonably harm another riparian. The balancing of certain factors determined reasonable use. Such factors may include the purpose of the use; the suitability of the use to the water resource; the economic value of the use; the social value of the use; the extent and amount of harm the water use causes; the practicability of avoiding the harm; the protection of existing uses; the availability of alternative sources; and the equity, or justice, of requiring the user causing the harm to bear the cost of remediation measures. (Dellapenna, 2001b)

Degradation of the quality of water resulting from inadequate treatment of domestic and industrial wastewater, from urban stormwater runoff or from combined sewer outflows may cause unreasonable harm. Other examples of causation of unreasonable harm include the overuse of pesticides and fertilizer on suburban lawns and/or agricultural lands. Harm may also be caused by water use by one Party that reduces the amount of water available for use by other parties, or by water use by one Party that causes the flooding of other parties. The water sharing agreement should describe the general standards for reasonable, beneficial use and specifically exclude certain uses, or certain laws and regulations that may result in unreasonable harm to others.

Equitable utilization of water

A fundamental aspect of transboundary water use is the mutual recognition of each Party's rights to equitably share in beneficial use of the transboundary water. At the international level, beneficial use of transboundary waters is determined according to the doctrine of Equitable Utilization. (UN Convention, 1997) In addition, a large number of decisions from the United States Supreme Court in the exercise of its original jurisdiction over suits between States have decreed equitable apportionment of their shared waters. (Grant, 1996) This doctrine requires governments to use transboundary water resources in a manner that is reasonable and assures equity for all riparian parties. Certain factors are relevant to reasonable and equitable use. The weight to be given to each factor is to be determined by its importance in comparison with that of other factors. Such factors may include the geographic, hydrographic, hydrological, climatic, environmental, ecological and other factors of a natural character and the social and economic needs of the governments concerned. The effects of the use or uses of the water resources by one riparian party on other riparian parties and existing and potential uses of the water resources may be considered. Other factors in the analysis could include conservation, protection, development and economy of use of the water resources and the cost of measures taken to that effect. The availability of alternatives to a particular planned or existing use could also be relevant. (Dellapenna, 2001b)

Water resource sustainability

Sustainability is a complex concept with as many definitions as there are settings and advocates. (Hirji et al., 2001) It has been suggested that development is sustainable if "it meets the needs of the present without compromising the ability of future generations to meet their own needs." (Brundtland, 1987) In its strictest sense, water resource sustainability requires that withdrawal and consumption of specific waters be limited in quantity to their long-term natural replenishment and that return flows be of a quality that does not adversely affect other uses of the same resource. Such a philosophy would assure that sufficient quantities of quality water are available for human consumption and economic purposes far into the future. (Fort, 1998) However, this definition may be considered impracticable for a number of reasons. It has been suggested that an accurate measurement and quantification of sustainability is generally not possible because of limited knowledge about long-term response of natural systems. Additionally, such a philosophy does not take into account technological advances, such as economically viable desalination, that may reclaim water for additional use. The philosophy suffers from vagueness in that the geographical scope of water resource sustainability is normally not defined. It has been suggested that the philosophy of sustainability in its strictest sense denies the needs and abilities of people to make the rational choices for their immediate and long-term future. (Beck, 2001)

ASCE has developed the following Policy Statement 418, adopted April 27, 2001:

> *Sustainable development is the challenge of meeting human needs for natural resources, industrial products, energy, food, transportation, shelter and effective waste management while conserving and protecting environmental quality and the natural resource base essential for future development.* (ASCE, 2001)

Other definitions of sustainable use have been proposed. (Hirji and Ibrekk, 2001; Gleick, 2000a)

> *... the use of water that supports the ability of human society to endure and flourish into the indefinite future without undermining the integrity of the hydrologic cycle or the ecological systems that depend on it.*

All of these definitions seem to point to an agreement that water resource sustainability may be defined as follows.

> Sustainable development is the reasonable and beneficial use of water that avoids wasting the resources, ensures reasonable protection of the environment, and considers the needs of future generations.

This means using water in quantities sufficient for economic and environmental progress, according to a consensus established in the political process. However, it also means efficient use of water that proscribes unbridled consumption. The philosophy requires that the water use for a particular purpose be as efficient as possible in relation to the current technology. It requires restricting water consumption for activities that do not serve a purpose of economic or social progress.

Obligation to exchange adequate data

Sound management of transboundary waters requires compilation of a comprehensive database. (Eheart, 2002) A successful transboundary water sharing program requires the combined expertise and analytical ability of experts in hydrology, hydrogeology, water resources engineering, ecology, economics, and other scientific and technological disciplines as well as water law and policy. (Draper, 2002d) Effective scientific and technological analysis requires, in turn, accurate and precise information about the climate and hydrology. Water project operations should be documented. An understanding of wastewater discharge and water quality monitoring is important. Knowledge of water development plans is critical as are water demands for consumptive uses. Water policies and programs that affect water quantity and/or quality should be well documented.

In order to develop a useful agreement and to make it work, each Party should provide the necessary data and information in an accurate and understandable form. Normally management on a watershed basis is preferable. (Draper, 2002a) To be adequate, data provided by each Party should provide a comprehensive view of the water resource under consideration. Data concerning water use and activities affecting both the quality and quantity of water are also essential to understanding existing resource conditions. However, data collected independently by several parties generally possesses varying degrees of incompatibility that may limit full integration of the data. The willingness of all parties to adopt a common approach to minimize such problems is a basic need to facilitate transboundary management. The parties should also consider providing mechanisms within the agreement for modification, in the event the underlying data proves inaccurate, or conditions change significantly.

## 2.3 Integrated water resources management and water sharing.

The obstacles presented by conflicting economic objectives and priorities as well as satisfying other goals of society are especially difficult to overcome because of the conflicting philosophical concepts of economic efficiency and its relationship to effective water management. (Draper and Sehlke, 2005; Draper, 2005)

The issue of water sharing cannot be separated from the larger issue of developing effective water policy, law and regulations to meet present and future water challenges. No issue in this larger context is more pertinent to effective water sharing than is evident in the debate between the balance between economic efficiency and the other goals of society. (Draper, 2005)

The issue became significant for water management in the United States in 1980 when the United States Supreme Court ruled that underground water, under certain circumstances, could be considered a commodity of interstate commerce. The ruling distinguished between water as a human need and water as an economic good. (*Sporhase v. Nebraska ex rel. Douglas* (458 U.S. 941 [1982]).

> *Although water is indeed essential for human survival, studies indicate that over 80% of our water supplies is used for agricultural purposes. The agricultural markets supplied by irrigated farms are worldwide. They provide the archetypical example of commerce among the several States for which the Framers of our Constitution intended to authorize federal regulation.*

The statement presented the duality of water. Water is essential for human preservation, both for ingestion and other domestic needs, and for assimilating waste. However, water is also essential to economic prosperity and, in that sense, is an economic commodity.

This duality mushroomed into a global debate in 1992 when the International Conference on Water and the Environment, held in Dublin, Ireland announced as one of four Guiding Principles for the management of water (Dublin, 1992)

> *Fresh water is a finite and vulnerable resource; essential to sustain life, development and the environment ... Water has an economic value in all its competing uses and should be recognized as an economic good.*

## The Debate

Water scarcity is becoming rampant throughout the Globe. To solve, or at least mitigate, water scarcity problems, some have recommended the introduction of tradable property rights to water. The proposal is essentially to introduce property rights to water and allow a private market to shift water use in the state to "higher and better" uses. Capitalizing on the Dublin statement that water is an economic good, the World Bank, among others, has proposed that nations and states introduce tradable property rights to water in order to "increase the productivity of water use, improve operations and maintenance, stimulate private investment and economic growth, reduce water conflicts, rationalize ongoing and future irrigation development, and free up government resources for activities that have a public good content or positive externalities." (Thobani, 1997)

While these proposals may have merit in an economic analysis of strictly private transactions, the question is whether these proposals are appropriate as a solution to water scarcity, considering the broader goals of society. These broader goals would include economic justice for water users not party to the transaction, effective water management, social equity, environmental and ecological sustainability, good governance and intergenerational justice. This debate has profound significance since its consequences to effective water management are considerable. (Draper, 2005)

An economic view: private water allocation

In evaluating existing systems of public allocation, economists have noted certain significant inefficiencies that result in waste and misallocation of water. (Dinar et al., 1997) In their view, no mechanism exists under public water allocation to shift water from old uses to new. (Gillilan and Brown, 1997) The claim is that government subsidies, such as those provided to agriculture, have artificially depressed the cost of water or its value to the user. (Karkkainen, 2001) It has also been suggested that regulators "tend to be captured by the industries they control" because they are reliant on information provided by those same industries (Morgan, 1995) and fragmented investment and management of existing water resources often result. (Le Moigne, 1997) It has also been noted that public allocation does not always support user participation. (Dinar, 1997) A number of authors have suggested that water can be managed in a more productive and efficient manner when treated as a "tradable standardized commodity" rather than as a product of engineering or an integral part of nature. (Tarlock, 1997a; Thoboni, 1997; Easter and Feder, 2000; Doughman, 2001; Garcia-Acevedo, 2001)

*Market mechanisms, competition and the value of water.* It has been argued that the best, most efficient use of the water can be made only through private, for-profit markets. (Just et al., 1997a) The key argument advanced for privatization is the theoretical benefits of competition. Water markets have been defined as "a market-based allocation of water … referred to as an exchange of water-use rights, compared to a temporary exchange of a given quantity of water between neighboring users." (Dinar et al., 1998) Tradable property rights to water are supported by a number of individuals and institutions. (U.S. Advisory Commission on Intergovernmental Relations, 1991; de Haan, 1997; Fort, 1998; World Bank, 1998; Hirji et al., 2001) It has been suggested that "trade in water will not be different from international trade in other necessities of life such as food, medicines and sanitary articles" (de Waart, 2000) and that "[w]ater transfers are essential to the satisfaction of future demands." (Tarlock, 1997b) Australia's Water Policy Agreement in 1994 endorsed the adoption of tradable water entitlements and clarification of property rights in water. (Pigram, 1997) It has been postulated that "*it is incontrovertible that water markets are the most efficient way to allocate water.*" (Griswald, 2001)

Many natural resources economists consider water as an economic good, like oil or gold, and argue that water should be allocated to those uses that bring the highest economic return. (Mann, 1993; Frederick, 1993; Mohanty and Gupta, 2002; Draper,

2005) Maximizing the economic efficiency of water allocation is often defined as maximizing the financial return gained from the allocation. (Rosegrant and Gazmuri, 1994) Consequently, many economists contend that the best way to allocate water efficiently is to use market mechanisms. (Hillel, 1994) Moreover, it is stipulated, market incentives lead people "in a direction that are desirable from a social perspective." (sic) (Heal, 2000) Simplified, the hypothesis is that private markets, where individuals buy and sell water according to economic rules, rather than governmental regulators, can determine the true economic value of water, thereby ensuring that water is allocated to its highest and best use. (Tarlock, 1997a)

The accepted procedures for measuring the value of water are by society's willingness to pay for the increment of production resulting from the additional allocation of water. (Mitchell et al., 1995; Johannson et al., 1995, Dasgupta et al., 1995) Often, this "willingness to pay" may be reflected in the market price of the product. In other cases, especially when large projects are involved, this "willingness to pay" may be greater than the market price. The difference between the market price and the "willingness to pay" is termed "consumer surplus." This consumer surplus arises from the fact that market competition is rarely perfect and large projects, such as hydropower generation or municipal water supply, for which the market price may be lower because of government subsidies. Estimating a value for consumer surplus is difficult and requires a significant number of assumptions and estimations of subordinate data. (ADB, 1997)

*Advantages of market mechanisms.* A number of potential benefits have been attributed to private markets for water rights. It is claimed that a market-based system is more responsive than centralized allocation of water. Ownership of water rights itself, rather than just the right to use water, provides security of water rights tenure to the water users. If well-defined rights are established, the water users can invest in water-saving technology knowing that they will benefit from the investment. For the irrigated agricultural users who use more water than any other water users, allocation of water through tradable rights will provide maximum flexibility in responding to changes in crop prices and water values as demand patterns and comparative advantage change and diversification of cropping proceeds. (Rosegrant and Binswanger, 1994)

The World Bank has outlined similar benefits when tradable property rights to water are introduced. First, tradable rights to water improve the productivity of water by providing an inherent value or opportunity cost that creates a built-in incentive to conserve water and to put it to the most productive use. Second, tradable water rights can change water to higher-value uses in a way that is cheaper and fairer than other alternatives. Finally, in addition to stimulating growth directly by improving the productivity of water, tradable property rights to water encourage investment and growth in activities that require assured supplies of large quantities of water. (Thobani, 1995; Draper, 2005)

Advocates claim that markets supposedly avoid the Tragedy of the Commons by assigning higher prices to relatively scarce commodities. This form of rationing encourages people to find ways of economizing on scarce resources. (Perelman, 2003) Other advocates a tradable property right in water would give both farm and non-farm permit holders an incentive to give up all or part of their right to use water, so the water may be used for higher valued uses. Several natural resources economists have stated that, in many, perhaps most, cases the price that water users pay does not reflect the water's opportunity cost nor its scarcity value. If water prices did reflect these costs, users would have increased incentives for efficient use and conservation. Essentially, the core of the advantages is that water reallocation from lower to higher best use can be accomplished most efficiently and effectively by private, free-market mechanisms. (Cummings, et al. 2002) Proponents claim that allowing farmers to transfer their water rights creates an opportunity to encourage balanced growth. Tradable property rights to water would encourage farmers to be more conscientious and efficient about their water use. Such a system also would provide an element of social equity because industry might then have more incentive to locate to other areas. Redistributing industry would encourage economic diversification in rural areas, potentially offsetting or diverting the population migration to urban centers. (Anderson and Snyder, 1996)

*Examples of effective water markets.* Advocates for private tradable water rights provide examples to show how successful market institutions have been in reallocating water, leading to the conclusion that market institutions can provide flexibility, encourage conservation, and help to prevent negative economic consequences that stem from water scarcity. The advocates describe the success of water markets in western states to bolster their claims. The nation of Chile is also presented as an example of how reallocation of tradable water rights can help meet growing demands for water. (Mentor, 2001; Cummings, et al., 2002; Mohanty and Gupta, 2002) The water rights reform is considered an innovative, legal and institutional water allocation development since it provides secure transferable water rights expressed in volume. (Shen, 2003)

It is claimed that a review of water markets in the western U.S. provides evidence of how successful market institutions have been in re-allocating significant quantities of water. (Cummings, et al, 2002) Chile is introduced as a model of tradable water property rights to water that has produced two significant benefits to water management: legal security and increased capacity for water reallocation. The legal security of private property rights to water has encouraged private investment in water use, for both agricultural and nonagricultural uses. The increased capacity for reallocation of water resources to higher-value uses in certain areas and under certain circumstances has developed from the ability to buy and sell water rights. (Bauer, 2004)

For a well-functioning competitive water market to exist, there are a number of requirements. First, exclusive, secure, well-defined, non-attenuated, transferable and enforceable private property rights should exist. (Winpenny, 1997) There should be an absence of collusion or market power among buyers or sellers. There should also be the absence of unpaid-for benefits, known as positive externalities, and uncompensated costs, known as negative externalities. An example of a positive externality is the benefits that derive to all persons using a public waterway that is cleaned and maintained by a volunteer adopt-a-stream organization. The costs and harms deriving from water pollution are an example of negative externalities. Finally, each transaction should operate in a competitive market under the motivation to maximize profits. Under such conditions, demand and supply forces will determine the quantities to be traded and the unit price for the commodity in this market. In this manner, water will act as a commodity and will move from low value uses to highest value uses. Therefore, market-based allocation is considered economically efficient from an individual and social point of view. (Le Moigne et al., 1997)

The view from the commons: public water allocation

There is, however, an equally compelling case that water allocation should not be entrusted to the market place. Water markets offer theoretical advantages in being able to transfer water to higher and better uses, at least when these uses are valued according to their financial return. However, even the "perfect" market has disadvantages, not the least of which is the fact that the theory is based on each transaction being based on a rational individual, with perfect knowledge, deliberately maximizing utility. (Thurow, 1983; Kuttner. 1996; Draper, 2005)

Given the 1634 tulip mania in Holland and the more recent high tech "dot.com" frenzy in the U.S., (Perlman, 2003) the rationality in some economic decisions is questionable. Given the complexity of the global economy, some doubt may be raised concerning the perfect knowledge of individual decision-makers. Other disadvantages demonstrate that, while markets are appropriate for many, if not most, situations, they are not appropriate in every instance. An efficient and effective institution is more than an institution that provides economic efficiency; it should also provide for efficient decision-making, efficient communications in terms of the rules and regulations of water transfers, as well as efficient enforcement. (Coase, 1960) In any event, efficiency principles might not coincide with equity and political considerations. (Becker et al., 1997)

Historically public water allocation has been the norm, in part because water has been considered a public asset, not a marketable commodity. (Ford et al., 2001) Water allocation is controlled, regulated and administered by the public sector. (Kärkkäinen, 2001) Public allocation can promote equity objectives and enable decision-makers to deal with some of the unusual aspects of water resources. (Ford et al., 2001) The public sector can fund large-scale water development that is generally too expensive for the private sector. Public allocation can protect the poor and sustain environmental and ecological needs. (Le Moigne et al., 1997) The case for public allocation is particularly strong in inter-sectoral allocation and reallocation since the state is often the only institution that includes all users of water resources, and has jurisdiction over all sectors of water use. (Dinar et al., 1997)

*Allocation equity.* Stakeholders for a specific water source often place different values for the same resource (Wolf, 1999; Draper, 2005) and "allocation efficiency" for one stakeholder may not be the same for another stakeholder. In addition there is the question of "allocation equity. " "Allocation equity" can be described as an equitable, or fair, distribution of gains from an allocation of a shared resource to various stakeholders and third parties. (Howe 1996; Draper, 2005). The 2001 International Freshwater Conference in Bonn presents the case for Public Water Allocation:

> *Issues of water allocation, of course, lead to all sorts of conflicts between major stakeholder groups: the poor need drinking water for survival and their livelihood; farmers want water for irrigation, industry for production; and the urban elites claim water for basic as well as luxury consumption. Water uses and water rights, therefore, also touch on power issues in the society which can only effectively be negotiated by the state. ... The primary responsibility for ensuring equitable and sustainable water resources management rests with governments ... Public responsibility includes the task to set and enforce stable and transparent rules that enable all water users to gain equitable access to, and make use of, water.* (Catley-Carlson, 2002)

*The value of water.* Determining the value of water means different things to different people. Stakeholders for a specific water source often place different values for the same resource (Wolf, 1999) and "allocation efficiency" for one stakeholder may not be the same for another stakeholder. In addition there is the question of "allocation equity." "Allocation equity" can be described as an equitable, or fair, distribution of gains from an allocation of a shared resource to various stakeholders and third parties. (Howe 1996).

The value of water often extends beyond its financial benefits. To many individuals and societies, water symbolizes security, opportunity, and self-determination. (Shiva, 2002; Draper, 2005) In areas where water scarcity is the norm, water is associated with life, power, and status. (Whiteley and Masayesva, 1998; de Haan, 1997; FAO, 1993; Ingram, 1990) Certain water uses exist which are associated with quality-of-life issues or which have social and/or civic purposes that cannot be appropriately quantified in a valid benefit evaluation. In a manner similar to minimum flows established for environmental and ecological protection purposes, these equitable and reasonable uses should be established by the parties within their internal political process and vested in agreement with the other parties. (Draper, 2002) Additionally, there exists the question of distributive equity, another issue in addition to economic efficiency that needs to be considered. (Tietenberg, 1998; Dellapenna, 2000)

Adam Smith realized the problem with valuation of natural resources, stating:

*Nothing is more useful than water: but it will purchase scarce any thing; scarce any thing can be had in exchange for it. A diamond, on the contrary, has scarce any value in use; but a very great quantity of other goods may frequently be had in exchange for it.* (Kuttner, 1997; quoting Smith 1776, Lv.13, p. 52.)

*Economic equity.* Treating water as a common pool asset provides better economic equity for the broader effects of changing the time, location or manner of water use. Maximizing the economic efficiency of water allocation is often defined as maximizing the financial return gained from the allocation. (Rosegrant and Gazmuri, 1994) Some economists believe important to distinguish between the true "economic" value of goods and the "financial" value of goods. (Perry et al., 1997) This distinction is based on a definition of economics as "the science, which studies human behavior as a relationship between ends and scarce means which have alternative uses." (Robbins, 1935) This definition relates economics to the scarcity of goods and how they are allocated to competing uses. Under this definition, the question is not whether water is an economic good, but whether it is a "financial" (or private) good or a "social" (or public) good. Proponents of this view recognize that there are certain important ecological, environmental, aesthetic and spiritual benefits, in addition to the benefit of human survival that should be met at prices well below the market price for water as these benefits serve the greater good for society as a whole. (Perry et al., 1997) The obvious difficulty is quantifying the needs related to "social" benefits.

The most serious direct disadvantage is the inability of bilateral water transactions between sellers and buyers to consider the effects of the transaction on third party, public, or environmental interests. Equally serious is the difficulty for a system of tradable property rights to adequately develop effective river basin planning and environmental and ecological protection. Additionally. these proposals cannot appropriately examine the needs of public values, such social equity. Equally problematic is the potential loss of the authority and control of the internal water resources of a nation or state. (Draper, 2005)

Market failures occur, for instance, when there are important externalities that are unaccounted for (e.g., social or environmental impacts) that go uncompensated or unpaid (e.g., positive or negative third-party side-effects). (Hermans and Hellegers, 2005) The impacts can be direct, as in the case of reduced in-stream flows below the diversion point for a transfer, or secondary, as represented by the loss of farm-related jobs in an agricultural region in which farmers chose to transfer their water supplies. (Lund and Israel, 1995) Transaction costs can severely distort the economic efficiency of private water allocation markets and even considering a market model in the absence of transaction costs does not suggest that markets are necessary for economic efficiency. (Roumasset, 1997) For example, rarely can a transaction be made to change the time, location or manner of use of a water right without affecting other water users, designated as third parties. If the benefit-cost of the transaction is the basis on whether the water rights transfer should take place, the transaction costs to third parties should be included. (Dellapenna and Draper, 2002).

Determining the transaction costs to third parties is, however, problematic. While it is easy enough for someone to own and manage water unilaterally in relatively small amounts (for example, bottled water), withdrawing water on a large scale necessarily affects many others, making it difficult to procure the consent of all significantly affected persons. But, unless the agreement of all affected parties is obtained, third parties may be effectively deprived of their right to use the water without consent. Wealth is transferred from those who formerly used water to those who thereafter would use water. Typically those who lose out are small users without capital resources or alternative sources of supply of water. Allowing such uncompensated transactions to occur result in the transfer of wealth from the general public to the privileged few. Yet, if the rights of third parties are protected, transaction costs with respect to all but the smallest water bodies quickly become prohibitive. (Draper, 2005)

In any large and complex hydrologic system, the difficulty and expense of structuring the necessary transactions (transaction costs) prevents markets from developing unless the law chooses to disregard the externalities. However, usually the law protects against such externalities by the rule, found in nearly all legal systems, that one cannot alter the time, place, or manner in which one uses water without the consent of other affected holders of water rights. The reality of transaction costs should give even the most free-market oriented economist pause to consider whether true markets could function effectively for water resources. (Dellapenna, 2000)

An example of the effect of externalities is shown by a proposed water transaction between the City of Denver and Coors Beer. *City of Denver v. Fulton Irrigating Ditch Co.,* 506 P.2d 144 (Colo. 1972) The Coors Beer Company, known for the high quality of the water used in its brewing, was unable to produce enough beer to satisfy the demand for its product without a greatly enlarged supply of water. Denver, consistently one of the fastest growing cities in the United States, was looking for new sources of water for its continued growth. Denver proposed that it take Coors' clear mountain stream while Coors would have the right to use unlimited quantities of Denver sewage water in its brewery.

The transaction failed not because of the possible outrage on the part of beer drinkers, but because farmers downstream from Denver (organized as the Fulton Irrigating Ditch Co.) obtained an injunction against the trade. The transaction would have deprived them of the water they relied on, even though, 30 years earlier, the farmers had contractually recognized the seniority of Denver's rights over their own. Coors or Denver could, of course, have paid the farmers to surrender their right to block the deal. However, that would have opened the way for others, yet further downstream, to challenge the transaction. The number of potential claimants was many thousands, at least, and some of them could be become "holdouts"—persons who either were wholly unwilling to deal, or who were willing to deal only at prohibitive prices wholly out of line with the market values at stake. Denver and Coors simply abandoned the transaction, with Coors going on to establish satellite breweries in other parts of the country because of its inability to obtain more water for its original brewery. (Dellapenna and Draper, 2002)

The difficulty involving third party effects is compounded if one considers more than the effect on other holders of water rights. (Draper, 2005) Changes in the location or manner of use affect all those businesses that depend on the original location and manner of use. Consider agricultural use. The farmer engaged in irrigated agriculture supports a variety of businesses and industries that provide the farmer his seed, farm equipment and other daily or seasonal needs. Both a permanent and a seasonal labor market develop to support the farmer. When the farmer's water withdrawal permit is transferred to another location or manner of use, say to municipal water supply, an entire business community begins to be adversely affected. Consider the tax base of counties that lose water. For instance, values for agricultural land with a water withdrawal permit in Georgia are almost double those for land without a permit. (Demeo, 2003) As permits are sold across county lines, the losing county can suffer substantial loss in their tax base. Loss of the tax base could have substantial effect on the losing county's ability to provide effective programs of public health and safety as well as quality education. (Draper, 2005)

Although this would not be an issue if only a few farmers in the county choose to trade their water withdrawal, as more farmers see the financial wisdom of trading their permit, the drain on the county mounts up. Is there a limit? What percentage of the irrigated land should be taken out of production before the drain on the county is too great? Who decides when the limit is reached? How does the law determine which farmer can trade and which cannot? These are serious problems that have a significant economic impact one individuals and local governments.

Moreover, small farms wishing to expand their farming operations will have to pay a high price for permits or water, weakening their profit margin. Municipalities will have to compete to purchase expensive water withdrawal permits or purchase expensive water. Small businesses wishing to expand will have to compete to purchase expensive water withdrawal permits or purchase expensive water. These problems demonstrate the need to consider *social equity* in any transaction to trade water rights. These effects can be greatly reduced, however, if the transfer is restricted to the consumptive portion of the water withdrawal. (Draper, 2002c)

It has been argued that public allocation systems do not shift water allocation to reflect higher and better uses. However, mechanisms to shift water from old uses to new do exist in regulated riparian rights jurisdictions. In these jurisdictions, laws and regulations for water withdrawal permits normally are issued for specific "reasonable uses" that normally are given for a specific period of time, often 20 years. Theoretically, once the time period for the permit is over, the permit conditions are reevaluated to determine of the permit should be renewed. The stakeholder groups as well as the permittee him- or herself heavily influence this analysis and potential renewal, so the claim that public allocation does not support user participation is arguable. The exception is agricultural irrigation use, which is often either exempted from the requirement for a permit or the irrigation permit is not limited to a specific time period. Additionally, with respect to this point in favor of private allocation, the Delaware River Basin Compact, among others, provides for mechanisms to shift water from old uses to new uses. (Weston, 2004)

With respect to a National Academy of Science statement that "the value of water in agriculture is generally less than in industrial or municipal uses ... only the higher value water are likely to be justified economically," the Western Water Policy Review Advisory Commission responded:

> *Careful consideration should be given to the fact that water for agriculture while relatively inexpensive, supports our ability to produce the food we eat at reasonably [sic] prices. Water is an input, a cost, into the production of food and fiber. Indeed, consumers in the United States spend less, as a percentage, of their per capita income on food than any other industrialized nation, and less of the less-developed nations.* (Fort, 1998)

While an acre-foot of water used to produce silicon chips may be of "higher" value in pure economic terms, this argument misses the point. The raw material of everything we use or consume comes from one of two sources: they're either grown or mined. If it is grown, it requires water. Only in a society as affluent as ours is the value of food and commodity production as easily discounted as it is in this report.

*Effective water management.* Beginning with the Dublin Principles, which emerged from the International Conference on Water and Environment held in Dublin in 1992, there has been recognition that effective water management should be based on four guiding principles; economic, sociopolitical, gender and economic issues. These four principles evolved into a doctrine of *integrated water resources management* (IWRM). (Draper and Sehlke, 2005) The primary goal of IWRM is to develop a comprehensive understanding of the available water resources and human and ecological water resource needs within a given basin, and then to manage those resources in an equitable and sustained basis. IWRM stands on a foundation of four legs: economic efficiency and growth, social equity, environmental and ecological protection, and effective governance. It is a water management process that integrates the assessment, management, protection and utilization of all water resources within a basin to meet the needs of humans on a sustainable basis, while still protecting the integrity of the resource and its associated ecosystems. (Draper and Sehlke, 2005) Tradable property rights to water have a negative impact on IWRM. The value of water often extends beyond its financial benefits. Such values include social equity and environmental and ecological protection. Certain water uses exist which are associated with quality-of-life issues or which have social or civic purposes that cannot be appropriately quantified in a valid benefit evaluation. (Draper and Sehlke, 2005) Draper, 2005)

Tradable property rights to water make the fourth leg of IWRM, good governance, problematic. An analysis of the history of water institutions demonstrates that among the characteristics for effective water management, stakeholder involvement and equitable participation are essential. (Gleick, 1998; Kakebeeke et al., 2000; Draper, 2002) The governance structure should assure equitable treatment of all interests involved with or impacted by the agreement. Mechanisms should exist for equitable participation, including participation by politically weak stakeholders, and consideration of ecosystems and future generations. All relevant stakeholders should be involved in the decision-making process. (Olem and Duda, 1995; Fort, 1998; Bandaragoda, 2000; Kakebeeke et al., 2000; Lubell, 2000; Planning, 2000; World Commission on Dams, 2000; Gooch et al., 2002) These stakeholders should include governmental and non-governmental organizations as well as private stakeholders. (Fort, 1998; German, 1998; Barlow and Clarke, 2002) Water management restricted to a private transaction between a willing buyer and seller essentially precludes this characteristic from the governance structure.

*The broader goals of society.* The damage to social equity, environmental and ecological protection and intergenerational justice can have a significant negative effect on effective water management. The "market price" of water reflects the economic value of water, the financial value of water. Other considerations are important in effective water management. The development of effective water management is a multi-disciplinary endeavor, requiring input from the disciplines of science, engineering, political and social science, and law as well as economics. From a scientific and engineering view, there are several prerequisites for effective water management that transcend economics. One involves managing water in its natural framework of watersheds and river basins. Water management should respect political boundaries but effective planning and management requires considering the hydrologic realities. There is no incentive for the marketplace to engage in river basin planning. Another prerequisite of effective water management concerns acknowledgement of both the long-term economic and the intergenerational justice need for environmental and ecological protection and sustainability. (Draper, 2005)

Although many individuals and organizations have tried for years to quantify social, environmental costs and values and other non-production values (e.g., valuing social, religious or aesthetic needs and desires or valuing ecological sustainability and ecosystem services), our inability to fully understand and to fully quantify the total impacts of our economic decisions and our inability to assign generally acceptable economic values to those actions has severely limited our ability to evaluate and balance the overall costs and benefits of such actions in economic terms. For example, water provided by a river or an aquifer is typically the basis of local or regional ecosystems and rivers are often the primary focus of local and regional development. Although they do provide direct economic services and values, they also provide many ecological services and values and non-economic social services and values to others who may not be participants in the withdrawal and use of water for a given economic activity that are typically not fully understood and are not or cannot be quantified in economic terms. (Draper, 2005)

Additionally, preserving the opportunities for future generations, often presented as intergenerational justice, is an important value. (NRC, 1997; Page, 1997) Environmental issues affecting ecological sustainability often occur over long time horizons. For instance, climate change issues develop over a half a century timeframe or more. Species extinction and biodiversity loss and storage of nuclear waste occur over similar time frames. Such time horizons are completely outside the normal range in economic decision making (Heal, 2000)

One option is to alter the discount rate used for planning. (Sustainability, 1998) With a higher the discount rate, a larger amount of the resource will be allocated to earlier periods. (NRC, 1997; Perelman; 2003) There is, however, some debate among economists over the appropriateness of lowering discount rates to give more weight to the future. While future net benefits are given increased importance with lower discount rates, more marginal projects, ones that may or may not be good for the environment or result in sustainable policies, also become more economically attractive. Thus it is not obvious that lower discount rates will always result in more sustainable resource management policies. (Sustainability, 1998) Although it is theoretically possible for the marketplace to include a value for these demands, recent history would show that the marketplace tends to focus on short-term economic gain rather than long-term economic planning.

The Australian Chamber of Commerce, itself an advocate of the tradability of private property rights to water, recognizes the significant adverse effects, both environmental and socio-economic, that can occur with water trading is if water is taken out of the catchment (either tangibly by physically moving the water elsewhere or non-tangibly by virtue that a water allocation is granted or an entitlement is purchased) by a water purchaser with no intention of consuming the allocation or trading the allocation in the period it relates. (Australian Chamber of Commerce, 2004)

*Monopolies/Oligarchies.* The potential for ownership of water rights to be accumulated by wealthy and powerful interests may have a significant impact on social and economic equity. The concern has been raised that that a lack of competition could result in excess (or monopoly) profits to individuals who choose to market water. (Wodraska and von Haam, 1998) While monopolies or oligarchies would be difficult to achieve with large numbers of transactions, two market conditions may lend themselves to their formation. One is when new non-consumptive rights are assigned. . The second condition under which monopolies might develop is when large volumes of new water rights, consumptive or non-consumptive, are awarded to private entities while privatizing large hydraulic projects. Tradable property rights to water in Chile are a case in point, as discussed below. Regulation or the impositions of appropriate taxes are the logical among the means to protect against monopolistic of oligarchic propensities. (Mohanty and Gupta, 2002)

Using the monopoly alliteration, it has been argued that water distribution, like many other public services, is not appropriate for a competitive market since water is considered a natural monopoly, "an industry in which the economies of scale...are continuous up to the point that one company supplies the entire demand." (Morgan and Chapman, 1995) It has also been argued that there is very little competition in water as the private part of the industry is dominated worldwide by only a few multinationals. (Hall, 2001) Whether water allocation, as opposed to water management, is also a natural monopoly may be debated.

*Sovereign control of internal water resources.* Another significant unintended consequence of tradable property rights is the possible loss of control by of the internal waters of a nation or state. The potential exists that the state will lose its ability to manage the economic growth and quality of life of its citizens. Several U.S. Supreme Court decisions and two international agreements could have a dramatic effect over the state's ability to manage its water. (Draper, 2005)

In 1982, a landmark decision by the U.S. Supreme Court determined that underground water was an article of commerce and, therefore, fell under the Commerce Clause. (*Sporhase v. Nebraska ex rel. Douglas* (458 U.S. 941 [1982]). In the ruling, the Court specifically noted that water used for agricultural purposes involved commerce. By introducing any form of tradable property rights to water, the Commerce Clause takes effect and a state cannot exclude out-of-state buyers from bidding for the water. For instance, if a riparian state allows water withdrawal permits to be bought and sold in private markets, the state cannot exclude citizens from other states from taking part in the private market.

If an industry is allowed to put its underground water withdrawal permit up for bid from other industries, any out-of-state industry should also be allowed to bid for the permit even if, absent similar subtle, non-discriminatory restrictions, the intended use is out of state. Similarly, if a farmer is allowed to put his underground water withdrawal permit up for bid from in-state industries or municipalities, out-of-state industries or municipalities should be allowed to bid even if the intended use is out of state. If the proposal to allow tradable water withdrawal permits is adopted, it will set into motion a situation in which the state and local governments could lose authority and control of the surface and ground waters. Once a law is passed that makes water withdrawal permits marketable in private water transactions, the state loses much of its ability to restrict when, where and for what purpose the water within the state's boundaries water is used. These are significant consequences for states whose water laws are based on riparian rights. Professor DuMars explains the consequences directly. (DuMars. 2001)

*In the Western United States, where there are active water markets,*

> *and where rights to water are actually bought and sold and freely transferred, this is a very different circumstance from the situation wherein water is considered part of the soil, is utilized as part of the soil and is not transferred away from the soil. The distinction is important. In the case of the already created in-state market, the argument can be easily made that the refusal to sell water for use out of state is a discriminatory regulation of an existing market that discriminates against users in other states. In the case of a state with the riparian doctrine (and) there is no market, the question may well be framed in terms of whether an out of state user can come in and create a market.*

Trade agreements like the North American Free Trade Agreement and agreements sanctioned by the World Trade Organization aggravate the reach of the Commerce Clause. These agreements prohibit laws and regulations that discriminate against citizens of other countries, similar to the Commerce Clause prohibitions but more expansive. Although these international agreements are still evolving, the consequences of existing and future international agreements potentially could supersede and nullify any water transfer restrictions imposed by the State of Georgia. Foreign interests ultimately may be able to buy Georgia permits for shipment of water by pipeline or ship to other nations. (Draper, 2005)

For instance, NAFTA Chapter 3 establishes the goods that are subject to the agreement's obligations. (*North American Free Trade Agreements,* ILS RR KDZ 944. A41992 N68, 6 vols.) These include "waters, including natural or artificial waters and aerated waters." The NAFTA adds an explanatory note that "ordinary natural water of all kinds (other than sea water)" is included. In 1993, then U.S. Trade Representative Mickey Kantor said in a letter to an U.S. environmental group, "When water is traded as a good, all provisions of the agreement [NAFTA] governing trade in goods apply. Several other provisions of the NAFTA and the WTO may impact the state's ability to control its internal water resources. Under NAFTA Articles 315 and 309, no country can reduce or restrict the export of a resource *once the trade has been established.* (emphasis added) This suggests the DuMars comment extends to any national or state law; once trading is authorized within the state or nation, NAFTA and other international trade agreements apply to the waters within the state's internal boundaries.

Article XI of the GATT at the WTO specifically prohibits the use of export controls for any purposes and eliminates quantitative restrictions on imports and exports. (*Final Act Embodying the Results of the Uruguay Round of Multilateral Trade Negotiations*, Apr. 15, 1994, The Legal Texts: The Results of the Uruguay Round of Multilateral Trade Agreements 2 (1999), 1867 U.N.T.S. 14, 33 I.L.M. 1143 (1994)) This means that quotas or bans on the export of water imposed for environmental and ecological purposes could be challenged as a form of protectionism. Even though commercial trade in water can be destructive to water sheds, the WTO could prevent countries from restricting that trade.

A Real World Laboratory for Tradable Property Rights to Water

The poster child for tradable property rights for water has been the nation of Chile. Free-market trading of water rights has been the law in Chile for over twenty years and is the world's leading model for water as a fully marketable commodity. The Water Code of Chile provides a laboratory to analyze the strength and weaknesses of tradable property rights to water since almost all decisions about water use and management in that nation are made by individual water rights owners or by private organizations of canal users.

*Water allocation in Chile.* Chile's 1981 Water Code declares that water is public property, to which the state can grant private rights of use. However, water rights are explicitly guaranteed as private property in the Constitution. Water rights are separated from land ownership and can be freely bought, sold, mortgaged, inherited and transferred like any other real estate. Water rights owners can freely change the types or methods of use of their water rights without administrative approval from government; the one exception is changing the location of diversions from a natural channel. Owners have no legal obligation to actually use their water rights and no penalties are assessed for lack of use. Chile distinguishes between surface water rights and underground water rights, and between consumptive and non-consumptive uses. Since water rights are governed by private law rather than public law, conflicts between users are resolved by ordinary civil courts. (Bauer, 2004)

*Advantages of water allocation system in Chile.* In Chile the benefits of tradable property rights in water have been effective in encouraging investment in water use and in reallocation of water to economically defined higher and better uses. This legal security of private property rights to water has encouraged private investment in water use, for both agricultural and nonagricultural uses. The increased capacity for reallocation of water resources to higher-value uses in certain areas and under certain circumstances has developed from the ability to buy and sell water rights. The World Bank was a major advocate for the Chilean model, reporting that the Water Code "successfully improved water delivery and use, stimulated investment, and reduced water conflicts," increasing the value of water, reducing environmental and ecological damage, and benefiting poor farmers at the expense of "politically influential water users," (World Bank, 1994) Other economists supported the World Bank's position. (Rosegrant and Binswanger, 1994)

*Disadvantages of water allocation system in Chile.* However, other researchers have expressed some concerns about how effective the free-market approach to water allocation has been. These concerns included the observation that the system of tradable property rights to water does not confront the externalities, such as third party effects or environmental and ecological issues, caused by water rights transactions. (Vergara, 1997; Dourojeanni and Jourarvlev, 1999; Bauer, 2004)

Bauer, in an in-depth analysis of the efficacy of the Chilean approach to tradable property rights to water has noted that the Chilean system seems "incapable of handling the complex problems of river basin management, water conflicts, and environmental protection." (Bauer, 2004)

> *The Chilean model of water management has one strong economic leg and two weak social and environmental legs, making it unbalanced overall. The social and environmental legs cannot be strengthened without weakening the economic leg in ways that - at least in Chile - are politically and constitutionally difficult. Moreover, even the economic leg is weaker than it appears because the ineffective mechanisms for resolving conflicts and internalizing externalities also reduce economic efficiency and growth, especially over the long term. Because the Chilean approach to managing water as an economic good puts all the emphasis on water as a private good and tradable commodity, it is very difficult to recognize or enforce the other aspects of water as a public good.* (Bauer, 2004)

It would appear then that the real world laboratory confirms discussion about the benefits and detrimental aspects of tradable property rights to water and conforms the suspicions that that while a system of tradable property rights to water has merit in a strictly private transaction, economic sense, such a system is incapable of accomplishing the broader goals of society, goals such as economic justice for water users not party to the transaction, river basin management, social equity, environmental and ecological sustainability, and intergenerational justice. Considering the broader goals of society, water truly is a common good that requires governmental or institution to regulate its allocation.

Public-private partnerships.

The externalities and other difficulties discussed above reveal that there can be no reliance on market forces without public oversight and intervention. There are no markets for goods and services well into the future, so that with respect to the future the market cannot perform effectively its role of bringing together suppliers and consumers and providing incentives for the former to meet the needs of the latter. Too many environmental goods arc public, and too many environmental problems are beyond the of property rights for the market to solve all of our problems. (Heal, 2000) However, there is a place for market-like structures within the context of public allocation. Many water policy experts, to include economists, see a role for economics in water management that encompasses both public and private participants.

Market mechanisms for water allocation have been suggested that range from charging a price for water that reflects its scarcity to introducing a program of voluntary permit transfers. (Thobani, 1995; Eheart, 2002) As an example, economists have noted that inappropriate prices stimulate greater water use, perpetuate inefficient use, and result in increased water scarcity. This leads to conflict between different uses and different users. (International Round Table, 1998; Perry et al., 1997; U.S. Advisory Commission on Intergovernmental Relations, 1991) The hypothesis is that, when properly priced, water use efficiency increases. Other rational economic instruments, including water tariffs with incentives for conservation and appropriate sanctions, have been proposed as necessary elements of effective water management. (International Round Table, 1998) Market-like structures can provide conservation incentives where possible is a necessary step in attaining sustainability but is not on its own sufficient. (Heal, 2000).

The Australian experience with permit trading is instructive. The rules for permit trading in 10 different river basins are different and are structured to accommodate both interbasin transfer and transfer of rights across political boundaries under restricted circumstances. The rules for interbasin transfer limit such transfers to adjacent basins whose outflows are physically interconnected so as to make downstream water flows unchanged. The rules for transfers across political boundaries are more restrictive in nature. These rules are subject to such things as stream carrying capacities, water resource availability, water quality, environmental and ecological constraints and socio-economic considerations. Each transfer is subject to local regional approval, and broad statewide rules such as the requirement to develop property management plans in certain circumstances. Preliminary findings indicate water trading offers substantial potential benefits to individual water users and the New South Wales_economy. (NSW, 1998)

Public-private partnerships can take a number of forms, from assigning operation and maintenance to farmer organizations or water districts, to user charges, to volumetric or quasi-volumetric pricing at the farm level, to intersector permit transfer laws and regulations. (Perry et al., 1997) Canada has introduced "realistic water pricing" to encourage efficiency through improved technology, water conservation and reduced pressures for costly system expansion. Pricing of water is exercised mainly by provincial and local governments although the federal government exercises the policy in its own areas of jurisdiction. It is Canadian policy to "promote the use of market and market-type forces and beneficiary pays policies to achieve the most efficient long-range use of water resources, and participate with other levels of government in meeting its responsibility in a manner that recognizes the social, economic and environmental and ecological value of freshwater resources to Canadians." (Environment Canada, 2003) Programs of voluntary permit transfers, with oversight provided by the state, have been proposed with varying restrictions that minimize harm to other water users. (Eheart, 2002; Hanner et al., 2002; Goodnough, 2003)

In Mexico, water users can exchange non-tradable water rights for tradable, sellable "concessions," which are essentially allowances to use an allotted share of water. The concessions have a maturity of 30 years, and can be bought or sold freely as long as transactions do not negatively impact the water rights of others. (Thobani,

1997) A number of combinations of public-private responsibilities, authorities, rights and privileges are possible.

Cost-benefit Justification for water development projects

Notwithstanding the debate over the efficacy of pubic versus private water allocation systems, water development projects that effects water allocation are largely justified by their cost-benefit ratios.

*Benefit evaluation.* Valuation according to market price can readily be applied to water uses that are involved in the "stream of commerce" (e.g., water used to produce agricultural or silvacultural products, water used by the pulp and paper industry, or water supplied by municipalities, to name a few). For instance, 1,930,000 liters of water (509,906 gallons) is necessary for the production of one ton of cellulosic man-made fiber. Only 843,000 liters of water (222,721 gallons) is necessary for the production of organic, non-cellulosic fibers, (Gleick, 1993) Discounting all other aspects of commercial influence, the production of organic, non-cellulosic fibers is a more efficient use of water than the production of cellulosic, man-made fiber as long as the selling price of one ton of organic fiber is less than 2.28 times the sell price of one ton of man-made fiber.

However, other uses are difficult to measure in the market place (e.g., water needed to sustain the aquatic ecology, water needed to sustain hunting and fishing, water needed to assimilate waste). In some uses of water, adequate methodologies for quantifying benefits have not been developed (e.g., the value of maintaining riparian vegetative buffers). (Draper, 1997) Care should be taken not to neglect these less-easily-valued water uses simply because it is difficult to do. Additionally, equity is the other broad principle that has guided the allocation of water resources. It is more difficult to articulate a means of achieving equitable allocations than to define rules for maximizing financial returns. The essential problem is how water is valued and what objective function is used to maximize the allocation of water.

The popular definition of economics is "the science of the production and distribution of wealth ... the condition of a country, etc., as regards material prosperity." (Oxford, 1999) Under this definition, "financial" value and economic value are often considered synonymous. The value of water may then be defined, as "the maximum amount the user would be willing to pay for the use of the resource." (Briscoe, 1996) As discussed above, this function can be relatively easily determined in the case of benefits derived from commercial transactions. Of course, "willingness-to-pay" depends largely on the ability to pay, (Perry et al., 1997) bringing up issues of equity and the distribution of benefits from allocation of what many believe is public resource. (Barlow and Clarke, 2002; Dellapenna and Draper, 2002a; Draper, 2002e; Draper, 2001; Rothfeder, 2001)

Valuation of the benefits of water uses that involve commercial transactions are normally tied to market pricing of the products produced, absent government regulation. In cases where a direct correlation with commercial transactions is not possible, economists normally use "demand surveys" of the relevant stakeholders to determine the "willingness-to-pay." (Stewart et al., 2001; CALFED, 1999; Winpenny, 1997; Veeman and Veeman, 1997; Apogee, 1996) Another technique is to value water according to damages averted through specific allocation techniques. An example is the allocation of underground water. Underground water provides structure to the geologic environment. If the aquifer in question is limestone formation, excessive ground water extraction can result in subsidence of the land surface. The primary economic measure, in addition to benefits received from the withdrawals, should also include the dollar value of the cost of damage in lost property value or replacement cost for infrastructure. Likewise, reduced hydraulic pressure resulting from excessive underground water extraction can allow salt water intrusion into a coastal aquifer, causing significant damage to municipalities and industries that need adequate supplies of clean water. (National Research Council, Committee on Valuing Ground Water, 1997)

The "willingness to pay" for each of the water use categories are usually determined differently. Valuations of the benefits derived from water uses directly tied to commercial transactions are straightforward.

*Agricultural demand.* For agricultural use, local variations in rainfall, soils, and crops dictate that marginal willingness to pay by agricultural users be estimated from the unique characteristics of the market prices for the specific crops.

*Public supply.* Analysts commonly measure domestic consumers' marginal willingness to pay at the existing level of water use by using the market price consumers actually pay, providing water is not rationed and providing other market distortions, such as pricing or subsidies by a government regulatory agency, are not present. If such distortions exist, they should be factored into the valuation. Willingness-to-pay for proposed changes to a public supply system is normally determined by "demand surveys."

*Industrial demand.* Since the mix of industries selling to strictly local markets is typically similar from region to region, techniques similar to those employed for public supply are usually appropriate for estimating marginal willingness to pay for the industrial sector that sells to local markets. The same technique may be applied to the industrial sectors that sell to regional, national and/or global markets.

*Thermoelectric and nuclear power demand.* Estimation of benefits for electric power generation departs from the norm since pricing is not market-derived. Typically a government regulatory agency sets prices to reflect costs plus a "reasonable" return to the power provider. Consequently, the concept of marginal willingness to pay is not relevant in most cases. Analysts may determine benefits by using the established regulatory price per kilowatt-hour times the output of the facilities. Valuation of costs should include the cost of treating cooling waters before discharge into the receiving waters. It should be noted, however, that water withdrawn for closed water-cooling systems might be considered as 100% consumptive.

*Interbasin transfers.* The parties may analyze transfers either from the transboundary river basin system to another or from an outside basin into the transboundary river basin system using the concept of marginal willingness to pay discussed above. The parties should acknowledge, however, that such transfers, especially if they are vested for extended periods, may have unexpected and unintended disadvantages for the water users within the river basin system. The cost of basin-of-origin protection should be factored into the valuation.

*Hydropower.* Marginal willingness to pay may be set at the existing market price for peaking power determined by the electric utility. For both base and peaking power, an alternate valuation may be determined by the comparison of hydropower with alternative generating sources.

*Navigation.* Marginal willingness to pay for navigation is normally set by the marginal cost of supplying navigation when compared to other modes of transportation that are close substitutes. The marginal willingness to pay for navigation can be estimated as the price of the least-cost alternative means of transportation, adjusted for the difference in operating costs.

*Aquaculture.* The marginal willingness to pay for locally harvested aquatic food or seafood usually equals the national market price for that product. The quantity of water and, equally important, the quality of water have direct impacts on fisheries production. In principle, the marginal willingness to pay for a specified quantity or quality of water is the price of a fishery's product multiplied by the marginal product of water in the fishery.

For valuing the benefits derived from water uses not directly tied to commercial transactions, indirect techniques are required. For example, three major approaches are normally used to determining economic value of changes in recreational water quantity: (1) the "travel cost demand" model; (2) "contingent valuation" models and (3), the hedonic pricing method. Under the travel cost model, primarily used for recreational water use, economists treat "visits" to a site (or visitor days) as a measure of quantity and use the cost to travel to a site as an implicit measure of price. Valuation of water use is based on observed behavior and choices. Under the contingent valuation model, economists use questionnaires given to a representative sample of individuals involved in the water use to directly determine the benefits derived from the water use. The hedonic approach to valuation uses the relationship between the price of the land and the characteristics of the land, such as water availability, soil quality and other attributes, to explain differences in land prices. (Pierce et al., 2003; Stewart et al., 2002; CALFED, 1999; Milon et al., 1999; Winpenny, 1997; Veeman and Veeman, 1997; Apogee, 1996)

*Waste Assimilation.* The use and capacity of a water body to assimilate wastes represents a real economic value, especially in urban areas. The marginal willingness to pay may be estimated in several ways, depending on the specifics of the particular water use. In some instances, water allocation to waste assimilation can be valued in terms of wastewater treatment infrastructure foregone. Likewise, a specific water use may reduce wastewater loading and the benefit may be valued, as wastewater treatment costs foregone; water reuse programs are an example. "Demand surveys" are often used, especially for waste treatment infrastructure.

*Recreation water use.* Analysts may use several techniques to determine the marginal willingness to pay for recreation. Consumers engage in recreational activities to a point where marginal willingness to pay for recreation equals the marginal cost of participating in recreation when there are no constraints and no market distortions. One technique, the Alternative Site method, determines the marginal willingness to pay for recreation at a particular site as the additional travel cost consumers would incur to enjoy the same recreational experience at a more distant site. The second technique, the Travel Cost method, considers that consumers visiting a particular site may travel different distances to reach that site. Analysts can use this variation in travel cost statistically to estimate a marginal willingness to pay function for recreation at the site. In the Contingent Valuation method, analysts use surveys asking consumers to state their marginal willingness to pay for recreation at a particular site.

*Scenic beauty water use.* Water bodies generate amenity values independent of the benefits strictly associated with recreation. The marginal willingness to pay for local amenities may be priced according to the market premium for waterfront land. When using land values to estimate willingness to pay for amenities, the analyst should avoid double-counting recreation benefits that accrue to this segment of the population by combining estimates of land premiums with other estimates of recreation benefits.

*Environmental and ecological sustainability.* Using the concept of marginal willingness to pay is, however, of limited effectiveness in evaluating the value of environmental and ecological sustainability. In the past, the environment has been the last claimant on scarce water. (Winpenny, 1997) While many economists have proposed that a marginal willingness to pay may be estimated using techniques similar to those used for recreational demand, such techniques may be grossly inexact since the consumer in this case can be classified as the society at large. Contingent valuation has become the most widely used approach to value pubic goods. However, there are a number of problems associated with a contingent valuation study, such as: a vague or unclear description of the good, lack of key information about context and substitutes, lack of attention to ways respondents could misperceive the good, implausible or overly hypothetical scenarios (particularly with respect to provision of the good and payment for it), willingness to pay responses which cannot be predicted by the available covariates, inadequate sampling procedures, poor response rates, and sample sizes which are too small for the purpose for which they were intended. (Mitchell and Carson, 1995) The direct approach to the estimation of willingness-to-pay is to ask individuals how much they are willing to pay for a risk reduction. (Johannsson et al., 1995) It has been suggested that the damages could be approximated by the cost for reaching an environmental or ecological goal. (Dasgupta et al., 1995) Thus, if the officially stated goal is to reduce fecal coliform concentrations by thirty per cent, then one can approximate current fecal coliform damages by the cost of reaching this goal. The willingness to sacrifice some degree of environmental and ecological sustainability relates directly to the political will of the national and/or international community.

*Social costs.* These methods for measuring the economic feasibility of a project are familiar and established. However, there are no accepted measures for to assess the full social costs of constructed projects. The social costs of displacing and relocating the population that had been living in an area intended for a hydroelectric dam and reservoir may be very large. (Wescoat and White, 2003) In China, the construction of large hydroelectric dams displaced over ten million people between 1959 and 1990. In India, large dams displaced sixteen to thirty-eight million people in the same period. The World Commission on Dams determined that in many cases the number of displaced people was under-counted, that they were not properly compensated or resettled and that indigenous, low-income peoples and women were especially affected adversely. Its review shows that the true economic profitability of large dam projects remains elusive as the environmental and social costs of large dams were poorly accounted for in economic terms. (World Commission, 2000; Wescoat and White, 2003)

## Integrated water resources management and water sharing

Economic programs may affect water sharing in at least four ways. First, there may be a disparity between the individual parties with respect to their individual stages of economic development. Second, the individual parties may have adopted internal economic programs related to water allocation that may affect their ability to deliver prescribed quantities to others involved in the water sharing agreement. Third, the parties may adopt economic programs as part of the agreement itself. Finally, economic programs of an international, transboundary nature, specifically international water markets, may exist outside the water sharing agreement and beyond the control of the parties. (Draper, 2004)

*Economic disparity.* Economic disparity between the parties to the agreement present significant issues related to the environment and ecology of the shared water source as well as, potentially, to the public health of individuals who depend on those waters. This is especially the case in arid regions. Water scarcity is compounded by contamination of the water by industrial waste and sewage. Economic infrastructure that depends on adequate supplies of clean water may suffer. The contamination of the river leads to increased rates of contraction of infectious diseases, such as hepatitis-A, typhoid and cholera, borne by pathogens in feces or bacteria present in deoxygenated water. Increased levels of nitrates and phosphates may create an overabundance of plant growth, which kills fish and produces bacteria in a low oxygen system. (French, 2000) When economic disparity exists between the parties it is essential that the issue be addressed in the agreement in some fashion.

*Internal economic policies.* The most significant effect of internal economics programs and policies on the water sharing agreement would be the case where the degree of privatization of water allocation within the country affects the ability of the country to meet the obligations of the agreement. Essentially, this "compact water" cannot be marketed in the upstream state since compact water affects the volume of water available for trading in a water rights market. (Brookshire et al., 2002) How this is resolved is case specific but should be considered when the agreement is formulated,

The same issues of third party effects that are a problem with privatization within a state or country (Lund and Israel, 1995) can be extended to transboundary water sharing, especially in the upstream-downstream context. Water allocation under the agreement directly affects the economic condition of businesses, industries, and other entities that depend directly on water. But the effects may be much more far-reaching. Changing allocation of water may cause effects on retailers and service industries that support the direct water users. Allocation may affect water quality. It may affect others as the result of potential land subsidence, overdraft and well interference. Downstream governments and urban use may be effected. These secondary costs and secondary benefits frequently are often ignored because (1) they are hard to measure, (2) their measurement has been subject to great abuse in justifying various projects, (3) secondary costs to the area of origin are likely to be largely offset by secondary benefits in the locality of the new water use, and (4) changes in secondary economic activities may be, in part, transfers from other areas. The transfer of water can significantly affect third parties not directly involved in the transfer. The greatest challenge for economists analyzing the effects of the transboundary agreement may be in properly identifying the affected parties and adequately mitigating the impacts.

*Economics within the water sharing agreement.* Privatization in the transboundary non-navigational water sharing agreement context has mainly been in hydroelectric power generation sector. (ARCADIS, 2001) However, the introduction of state-sponsored water sales may develop. Noting that international water sales would become more profitable than oil sales, Moscow Mayor Yuri Luzhkov recently proposed the initiation of state-sponsored water marketing, suggesting the Ob River in Central Asia as a water source. (American Foreign Policy Council, 2002) However, it has been noted that the inclusion of water markets within the provisions of the agreement is probably inappropriate, as water markets tend to allocate all incremental water to the country with the highest marginal value with little or no equity or political consideration. (Just et al., 1997)

*International private water markets.* International private water markets have gained notoriety recently. In 1997, Nordic Water Supply Company based in Oslo, Norway, completed the first international export of water with bags when it signed a supply contract with Turkey to deliver water to northern Cyprus. (Anderson and Landry, 2003) Two New Zealand companies have indicated their intention to export water throughout Southeast Asia and other parts of the world.

International trade in water does have obstacles. Water has two characteristics that have complicated the development of large scale international water trading: bulkiness and mobility. Water can be described as a "bulk commodity," meaning that the value per unit weight of water tends to be relatively low. Trading in water would be valuable for both parties only when conducted at a very large scale. Contributing to the difficulty in trading water is its evasive nature; it is difficult to identify and measure since it flows, evaporates, seeps, oozes and transpires. Consequences of its evasive nature are problems in defining the quantities to be traded and in determining the price of water. Unless water is traded in containers or tankers, it may be difficult to determine the volume units exported or imported and the tariffs charged. (de Haan, 1997)

## 2.4 The international law of transboundary water sharing.

Most of the principles cited above are recognized as obligations of Sovereign parties when water sharing is an issue. It is important for the parties to an agreement to recognize the legal duties imposed upon them by international law and to conduct themselves accordingly in any negotiations involving sharing of water that crosses international boundaries.

### Substantiating international legal norms

International law demands that nations, in their relationships with other nations, conduct themselves according to specific standards of conduct, or legal norms. Nation-states rarely defy openly or directly generally accepted principles of international law, relying on those principles in their diplomatic exchanges. (McCaffrey , 1993) A nation not following these legal norms may be ostracized and sanctions of one sort or the other may be imposed. However, the specific international legal norms are not as easy to ascertain, as are the legal duties and obligations imposed by national laws.

International law differs fundamentally from national (domestic) law. The domestic laws of any Sovereign Party derive from a variety of sources. These sources can include a written constitution, civil codes or statutes, common law (judge-made law), religious law, tradition, and administrative regulations. The citizens are obligated to follow these laws. These sources of law do not exist in the international arena. The basic characteristic of international law is that it is consensual. A nation will usually consent to a rule only if it is in the country's best interests in terms of the long-term benefits outweighing the long-term costs. An example is the 1921 *Convention and Statute on the Regime of Navigable Waterways of International Concern, 7 LNTS 35 (1921)* (the Barcelona Convention). That convention obligated "[e]ach riparian State ... to refrain from all measures to prejudice the navigability of the (international) waterway, or reduce the facilities for navigation..." This obligation was clearly in the trading interest of the different Sovereign parties and a large number of nations signed the convention. The obligation, therefore, may be considered a legal norm.

Article 38(1), *Statute of the International Court of Justice*, (Charter of the United Nations, Statute and Rules of Court and Other Documents KZ6277.U56 1989) describes how that Court determines international legal obligations.

> *The Court, whose function is to decide in accordance with international law such disputes as are submitted to it, shall apply:*
>
> *a. International conventions, whether general or particular, establishing rules expressly recognized by the contesting states;*
>
> *b. International custom, as evidence of a general practice accepted as law;*
>
> *c. The general principles of law recognized by civilized nations;*
>
> *d. Judicial decisions and the teachings of the most highly qualified publicists of the various nations, as subsidiary means for the determination of rules of law.*

<u>Legal norms of water sharing</u>

Some obligations may readily be described as international norms, as defined in the Statute of the International Court of Justice. To cooperate and negotiate in good faith is an international legal obligation expected of all nations. A number of different international treaties, conventions and resolutions substantiate this premise. This obligation is applicable to a wide range of areas and is not limited to transboundary water sharing. The other duties cannot be satisfied without the willingness of the parties to cooperate and act in good faith efforts. The duty to prevent unreasonable harm is also an international norm that can be substantiated by a number of international documents.

Other principles, however, rely on international custom and the writings of highly qualified publicists. The United Nation's International Law Commission is an eminent example of one means of determining customary law. The Commission and other legal scholars have declared the international law of water sharing to include two other obligations: the duty of equitable utilization and the duty to exchange data and information. Enforcement of these legal norms can be, of course, problematic. (ARCADUS, 2001)

Legal evolution of shared water agreements

Water sharing agreements between or among sovereign states should conform to the legal structure of the river basin for which they are drafted. Consequently, interstate compacts within the United States need not contain some of the procedural safeguards that are necessary for international water sharing agreements. A review of both American and international law is appropriate for an understanding of the applicability of the model codes and the extent their modification may be necessary.

Within the United States, the Federal-State partnership established by the U.S. Constitution provides a stable legal relationship between the states upon which interstate conflict resolution may be based. Three categories of sovereignty arise under the constitutional powers of the federal, state and tribal governments. Under federalism, the states as sovereign entities maintain control over inland waters, with some important exceptions. These exceptions include specific legislation, such as the Clean Water Act, 33 USC. §§ 1251 *et seq* (CWA) and other legislation such as the Endangered Species Act, 16 USC §§ 1531 *et seq* (ESA), and certain legal doctrines established by the Courts. Such legislation and doctrines include federal reserved water rights that attach to federal lands in the west, federal control over navigability, and federal supremacy for federal waterpower projects. Independent of the states, Indian tribes also may assert sovereignty over certain waters as the result of the treaties the various tribes entered into with the United States. Thus, under some conditions, the state controls use of waters within its boundaries. Under other conditions, an Indian tribe may control certain waters within a state. Finally, under still other conditions, the Federal government may control certain waters within a state. Added to this "brew," the use of the waters within one state may significantly affect the manner or quantity of waters within another state. Inevitably, conflicts over use of the water develop. Significantly, the Constitution provides a mechanism for conflict resolution, and a forum for final conflict resolution exists in the U.S. Supreme Court. (Draper, 2002)

There are three significant methods of resolving interstate water allocation disputes: (1) interstate water apportionment compacts, (2) Acts of Congress, and (3) U.S. Supreme Court "original jurisdiction" suits between the states and. The first method is an agreement between the states to allocate the shared waters. The three-model water sharing agreements presented in *Model Water Sharing Agreements for the 21st Century*, (Draper, 2002a) relate primarily to the first method, interstate water apportionment compacts. The second method is an allocation of interstate waters by Congressional action. There has been but one instance in which this method of transboundary water sharing, the Boulder Canyon Project Act, ch. 42, 45 Stat. 1057 (1928). In this act, Congress authorized construction of the massive Hoover Dam on the lower mainstem of the Colorado River, and allocation of the waters of the Lower Basin, predicated on ratification of the Colorado River Compact, 45 Stat. 1057 (1928) (McDonald, 1997) In the Truckee-Carson-Pyramid Lake Water Rights Settlement Act. Title II of the Act of Oct. 27, 1990, Pub. L. No. 101-618, 104 Stat. 3289 (1990), Congress "authorized the federal purse" to help resolve water rights allocation disputes. (Grant, 2001) Other methods for Congress to affect interstate water allocation exist. Federally authorized water projects, and the resulting contracts for delivery of water to users can result in a de facto apportionment; an example is the apportioning of water stored in federal dams on the North Platte River. (Grant, 2001)

The third method of resolving interstate water allocation disputes is adjudication before the U.S. Supreme Court. It is important that the drafters understand these "original jurisdiction" suits between the states since any interstate dispute that is not resolved by compact or act of congress would be resolved by the Court, likely based on the principles of "equitable apportionment."

The basis of the "equitable apportionment" doctrine is that interstate waters should be apportioned by balancing equities. Equity (or "fairness" as opposed to "equality") is achieved by balancing the stake (or value) each party may have in utilizing the shared resource. (Grant, 2001) The factors to be analyzed to determine a "fair" allocation of water between or among the parties include:

(1) Physical and climatic conditions;
(2) Consumptive use of water;
(3) Character and rate of return flows;
(4) Extent of established uses and economies built on them;
(5) Availability of storage water;
(6) Practical effect of wasteful uses on downstream area;
(7) Damage to upstream areas compared to the benefits to downstream areas if limitations were to be imposed on the former.

It is important to. note, however, that there is no requirement that an interstate compact be based on the principles of "equitable apportionment and the states can apportion waters in any manner or procedure the party states choose. Once approved by Congress, the compact becomes federal law according to the terms of the compact. Should a dispute arise over interpretation of the compact, and the matter referred to the Supreme Court for resolution, it is doubtful the principles of "equitable apportionment" would be applied unless the compact explicitly stated that such principles formed the basis of the compact. The Court has stated "courts have no power to substitute their own notions of an 'equitable apportionment' for the apportionment chosen by Congress." [Arizona v. California, 373 U.S. 546 (1963)] Since "congressional consent transforms an interstate compact . . . into a law of the United States, . . . no court may order relief inconsistent with its expressed terms." Texas v. New Mexico, 462 U.S. 554 (1983)]. Additionally, it should be noted that, to date, no state has sued for apportionment of a water source to which that state is not riparian. (Grant, 2001)

Within the international arena, the problems with effective conflict resolution are magnified for two reasons. First, no forum for final conflict resolution of water disputes exists in relation to water sharing conflicts. The United Nations, the World

Court and the World Trade Organization (WTO), provide forums for conflict resolution in some subject matter and under certain conditions, but no forum for conclusive judgment for conflicts involving water sharing exists. Secondly, no clear standards exist in customary international law that relate to transboundary water sharing.

Under long-standing customary international law, a sovereign state had the exclusive rights to all natural resources within its boundaries. This customary rule of international law recognizes undisputed ownership of water within political boundaries. Necessarily, this rule presents the potential for serious conflict over shared water resources, especially in upstream-downstream disputes.

Over the years, various international conferences and congresses have recognized that this absolute control philosophy was not an acceptable means of resolving conflicts. However, no definitive international treaty or agreement has been ratified on a worldwide basis to change this rule. With no such global agreement in place, a legal question emerges whether this precept of customary international law remains valid or whether a series of recent international conferences and agreements have changed the law.

The first serious challenge to this customary rule of law appeared in 1966. The *Helsinki Rules on the Use of the Waters of International Rivers,* 52 I.L.A. 484 (1966) presented a consensus of the attending States that each co-riparian is entitled to "a reasonable and equitable share in the beneficial use of the waters of an international drainage basin." Since 1966, a variety of other sources of international law have presented conflicting views. The 1972 *Stockholm Declaration on the Human Environment*, 11 I.L.M. 1416 (1972) articulated the view that sovereign states have "the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction." Standing by itself, this rule could clearly supersede the customary rule of law that recognizes undisputed ownership of water within political boundaries. However, a companion declaration in this 1972 Declaration also articulated the need to protect "the sovereign right [of States] to exploit their own resources pursuant to their own environmental policies."

The *Treaty for Amazonian Cooperation,* 17 ILM 1046 (1978) proclaims "that the exclusive use and utilization of natural resources inside their own territory is a right inherent to the states' sovereignty and that its exercise will not be subject to restrictions other than those imposed by international law ..." The standards of international law were not described however. The 1992 *United Nations' Convention on the Protection and Use of Transboundary Watercourses and International Lakes,* 31 I.L.M. 1312 (1992) declared that the parties "shall take all appropriate measures to prevent, control and reduce any transboundary impact ... (and) ensure that transboundary waters are used in a reasonable and equitable way, taking into particular account their transboundary character, in the case of activities which cause or are likely to cause transboundary impact..." Oriented to European transboundary water quality, this Convention calls for "sustainable water-resources management" but does not discuss allocation of water.

In 1992 the United Nations Commission on Sustainable Development reiterated the sovereign right to exploitation of internal resources. (Report, 1992) This report, published as Agenda 21, stated to the Secretary-General that

> *States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies and have the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or areas beyond the limits of national jurisdiction.*

Clearly, without a definitive international treaty, signed and ratified by a significant number of the world's powers, current customary law concerning the non-navigational use of international watercourses is still ambiguous. Arguably, the standards for the non-navigational use of international watercourses has changed little from its position set by the customary rule of international law that recognizes undisputed ownership of water within political boundaries.

The 1998 U.N. *Convention on the Law of the Non-Navigational Uses of International Watercourses,* United Nations Document A/51/869 (1998) may end this confusion about customary law. The U.N. General Assembly approved this Convention in May 1998 by a vote of 104-3. Although it will not enter into force until ratified by 35 nations, the Convention may provide clear standards for agreements concerning the shared use of international watercourses. It will institute the standard of "equitable and reasonable utilization" for use of transboundary waters. The Convention states:

***Article 5***

*Equitable and reasonable and participation*

> *1. Watercourse States shall in their respective territories utilize an international watercourse in an equitable and reasonable manner. In particular, an international watercourse shall be used and developed by watercourse states with a view to attaining optimal and sustainable utilization thereof and benefits therefrom, taking into account the interests of the watercourse States concerned, consistent with adequate protection of the watercourse.*

*2. Watercourse States shall participate in the use, development and protection of an international watercourse in an equitable and reasonable manner. Such participation includes both the right to utilize the watercourse and the duty to cooperate in the protection and development thereof, as provided in the present convention.*

The Convention's doctrine of "equitable and reasonable utilization" is similar to, but more expansive than the U.S. Supreme Court 's doctrine of "equitable apportionment."

***Article 6***

*Factors relevant to equitable and reasonable utilization*

*1. Utilization of an international watercourse in an equitable and reasonable manner within the meaning of article 5 requires taking into account all relevant factors and circumstances, including:*

*(a) Geographic, hydrographic, hydrological, climatic, ecological and other factors of a natural character:*

*(b) The social and economic needs of the watercourse States concerned;*

*(c) The Population dependent on the watercourse in each watercourse State;*

*(d) The effects of the use or uses of the watercourses in one watercourse State on other watercourse States;*

*(e) Existing and potential uses of the watercourse;*

*(f) Conservation, protection, development and economy of use of the water resources of the watercourse and the costs of measures taken to that effect;*

*(g) The availability of alternatives, of comparable value, to a particular planned or existing use.*

*2. In the application of article 5 or paragraph 1 of this article, watercourse States concerned shall, when the need arises, enter into consultations in a spirit of cooperation.*

*3. The weight to be given to each factor is to be determined by its importance in comparison with that of other relevant factors. In determining what is a reasonable and equitable use, all relevant factors are to be considered together and a conclusion reached on the basis of the whole.*

Other significant provisions of the Convention include the requirement for all parties to "prevent the causing of significant harm to other watercourse States" (Article 7). It declares that all watercourse parties should "cooperate on the basis of sovereign equality, territorial integrity, mutual benefit and good faith in order to attain optimal utilization and adequate protection of an international watercourse" (Article 8).

One word of caution is appropriate. It has been noted that the "equitable and reasonable utilization" standards are vague and there is an absence of a neutral enforcement mechanism in the Convention. (Dellapenna, 1997a) Both points demonstrate the Convention itself cannot stand alone in resolving conflicts over shared water resources. Rather, the Convention provides should provide the standards and structure of a water sharing agreement developed for a specific watershed or river basin.

Notably, the U.N. *Convention on the Law of the Non-Navigational Uses of International Watercourses* applies only to co-riparians on international watercourses. Attention is directed to the terminology used in the *Law of the Non-Navigational Uses of International Watercourses*, especially regarding the term "equitable and reasonable utilization." Nowhere in the Convention does the term "beneficial use" appear. This term of art is used extensively in those U.S. states adhering, in whole or in part, to the Prior Appropriation water allocation doctrine. Because the term "beneficial use" raises significant policy issues, especially with regard to the classification of instream uses as valid and legally protected water uses, and because current international law uses the term "equitable and reasonable utilization" to denote those water uses that are permissive, the latter phrase is used in this Model Agreement.

The significant difference between international law and the laws of the United States is that, for the United States, the U.S. Supreme Court provides the institutional legal framework with a "court of last resort" to resolve interstate water disputes. No such forum exists for international water disputes; reliance should be placed on internationally accepted legal norms such as a ratified *Convention on the Law of Non-Navigational Uses of International Watercourses.*

**2.5 Summary.**

A number of obstacles exist in developing an effective agreement to share water resources between sovereign entities. These include conflicts in the internal water laws and policies of the parties, an incomplete knowledge of the water resource availability and demand within the shared basin, and conflicts between the internal economic policies of the parties.

To negotiate these obstacles, efficient and effective water sharing across political boundaries requires that development of the agreement follow a certain pattern. The parties should acknowledge certain standards of conduct for negotiation. The parties should assume the obligation to cooperate and negotiate in good faith and the obligation to prevent unreasonable harm to other parties. They should commit to the equitable utilization of the shared water and to the values of water resource sustainability. The parties should assume the obligation to exchange adequate data with the other parties and make a commitment to do so. The obligation to cooperate and negotiate in good faith and the obligation to prevent unreasonable harm are standards of conduct clearly mandated by international law. Since the validity of the other standards of conduct should rely on international custom and the writings of highly qualified publicists, the Sovereign parties should explicitly address those obligations in the agreement process. Negotiating the obstacles presented by conflicting economic objectives and priorities is especially difficult to overcome, in no small part because of the conflicting philosophical concepts of economic efficiency.

Once these obligations are delineated, along with a mechanism to ensure the parties embrace these obligations, the specifics of the agreement can be formulated. Significant sections of the agreement will include a mechanism to allocate the shared waters between the parties according to some objective function that includes both the economic, social, and environmental and ecological objectives of the parties. An institution should then be developed that can effectively implement the agreement at a reasonable cost without unduly infringing on individual sovereignty. Equally important, the source water needed to fulfill those objectives and the water available in the shared resource should be compared and the objectives modified as necessary to reflect the reality of the yield of the shared resource. This will require significant scientific and engineering studies to estimate the water available under normal conditions as well as conditions of drought and flood. Finally, some dispute resolution mechanism should be constituted to minimize the potential for destabilization of the agreement.

## SECTION 3

## RESOURCE ASSESSMENTS

The foundation of a water sharing agreement requires accurate and precise information about the availability of water, the quality of that water, and the demands that should be accommodated. A number of assessments should be conducted at the beginning of the formulation of the agreement. These assessments include definition of the geographical and political boundaries of the water sources to be shared and analysis of the water policies, laws and regulations of the individual parties that may conflict. An assessment of the yield of the water sources for normal conditions should be made as well as for extreme conditions of droughts and floods. An accurate accounting for existing demands and one for predicting future water demands should be made, as well as an assessment of the water quality and quantity necessary for ecological integrity. An economic impact assessment should then be made that correlates the other assessments.

From a procedural standpoint, strategies for the development of a water sharing agreement should initially proceed with the exchange of data and information between technical experts with the objective of reaching a technical consensus on both the actual and potential problems known or envisioned. Only then can alternative strategies to respond to the problems be developed. (Eaux partagées, 2002)

### 3.1 Geographical and political boundaries.

One criterion of the *Convention on the Law of the Non-Navigational Uses of International Watercourses* makes the definition of the waters to which an agreement applies a mandatory provision in the agreement. The parties should identify and document the type and geographical extent of the water resources to be subject to the agreement. This description will allow all appropriate and necessary parties within the geographic/political region to be included in the agreement and negotiation process. Only then can an investigation of any conflicts in water law and policy proceed. (Dellapenna, 1994a; Dellapenna, 1997a; Dellapenna, 1997b)

In order to formulate an effective agreement, the parties should analyze the factors that influence the water resource in question, including the climatology, physiology, geology and the interaction between underground and surface water resources. The analysis should identify pollution sources and the resulting impact on water quality. The geographic scope of the water resources to be covered by the Agreement should be sufficiently expansive to fully address all the water sharing issues involved. It is important to acknowledge that the Agreement reflects the particular circumstances and compromises reached in its formulation, and that it applies only to the waters shared between the parties. (Draper, 2002a)

The Agreement should include the total surface area of drainage throughout the Basin and include aquifers underlying the surface drainage. Some tributaries could be connected to the underlying aquifers. Some of the aquifers could be connected to more than one of the surface water basins. (Draper, 2002a)

The purposes, objectives, and scope of an agreement will weigh heavily on this assessment, delineating the parties to be included. All principal stakeholders, such as persons, institutions or governments directly affected by the shared use should be identified and included in the negotiations and the agreement, including any sovereign government having direct access to the sources of water. Both governmental and private stakeholders should have a voice in agreement formulation. The *Treaty for Amazonian Cooperation*, 17 ILM 1046 (1978), involving a balance of development and environmental protection, is a good example. Without the combined signatures of Bolivia, Brazil, Columbia, Ecuador, Guyana, Peru, Surinam and Venezuela, the agreement could not be effective.

In terms of atmospheric water, the analysis of meteorological and climatological factors should identify those sovereign powers that will be impacted. The applications of new techniques for weather modification might have effects beyond any one state's borders. (Gochis, 2001; ASCE, 2004) For instance, significant extraction of atmospheric water in western Canada may impact other provinces in Canada as well as in the United States. However, because the impact of extraction of atmospheric water may extend far distances in ever-decreasing or increasing significance, the parties should adopt some measure of "reasonable impact."

Analysis of the effect of an agreement on international organizations and multilateral and bilateral treaties should be performed. Any such impact will require these organizations or parties be joined to the agreement or consulted in a meaningful sense at the very least.

In the United States, because many water-related sovereign powers remain at the state and tribal level, these parties should be included as stakeholders, albeit not in the same way as national governments are included. An agreement to share the Floridan Aquifer, for instance, could not be completely effective without the combined signatures of Alabama, Florida, Georgia, South Carolina and, arguably, Mississippi. (USGS, 1996) Again participants should adopt some measure of "reasonable impact" to join the relevant parties in the case of underground water sharing. As in the case of international organizations and treaties, regional organizations or other special jurisdictional authorities may be affected by water sharing between states, and these authorities should also be joined. If all parties will not join in developing the agreement, the agreement should include mechanisms for dealing with the inevitable conflicts that will occur.

While private water rights holders within the various jurisdictions will not be joined as parties to the agreement, the various persons and organizations associated with the various water demands should have a voice in formulating the agreement. Although the extent of consultation with private groups will depend largely on the political nature of the governments themselves, some recognition of existing rights is required. In most situations a conflict will exist between demands for water for economic purposes and the needs of environmental and ecological protection. Water users frequently need external incentives to accept the reservation of some water for environmental and ecological protection. Unless the governmental entities involved with formulating the agreement actively seek to include the various interest groups, the effectiveness of the agreement may be compromised. (Draper, 2001)

### 3.2 Assessment of Water Laws and Policies

Different water issues will exist for the individual parties both within the state and across the state's boundaries. Each party will have developed, therefore, certain laws and policies to deal with these issues that may be at variance with the laws and policies of other parties. Comparing and contrasting the different laws to expose conflicts that may affect water sharing is essential. (Dellapenna and Draper, 2002a) Within the United States, the extent of conflicts varies not only between the states involved, but with an array of federal and tribal water rights and issues. It has been observed that current U.S. water-use policy is in such disarray that many critical interstate water basins are left "dangling under Solomon's sword." (Tarlock, 2001b) This does not make water sharing between political entities any easier.

Water Rights

Differences in law should be identified and accounted for in the agreement. By comparing and contrasting the laws of the individual parties, drafters of the agreement can identify potential conflicts and determine the areas requiring meticulous coordination. Each jurisdiction should have mechanisms to implement and enforce the laws. Knowledge of the administration and management institutions of each is necessary in order to properly administer the water sharing agreement and ensure that its provisions are enforced. Participants should review and analyze each jurisdiction's institutional mechanisms that affect any form of water management. For instance, definition of legal terms within the individual jurisdictions is a prerequisite for understanding the conflicts and similarities in their laws. Of specific concern are the definitions of "reasonable use" and/or "beneficial use" and the term "equitable."

While most jurisdictions maintain governmental control over the allocation of water and its use, the use of private water markets has been contemplated as a means to make the allocation process more efficient. The existence of such a private water market policy may result in significant differences in the way individual water rights are transferred. How water rights are lost is a concern in each jurisdiction. Each of these matters will affect the final form of the agreement. (Draper, 1997)

The analysis to compare and contrast the water laws of the different participants can be efficiently accomplished within the context of the legal theories of water law and property rights. Legal theory establishes three basic approaches to water law and property rights: common property; private property; and public property. (Freyfogle, 1999; Dellapenna, 2000; Gleick, 2000; Dellapenna and Draper, 2002a)

Although the disciplines of science and hydrology have long recognized that surface water rivers and underground water aquifers are interrelated waters, the law has not. (Eckstein, 1998; Dellapenna and Draper, 2002a; Glennon, 2002; Dellapenna, 2003a) Traditionally, the framework of water law for surface water and underground water has been separate and distinct. Rights to use surface water (rivers and streams) are generally provided under one of three water right doctrines: riparian rights, appropriative rights, and regulated riparianism. (Dellapenna, 2001b)

The Riparian Rights Doctrine is a surface water rights doctrine, typified by common law that treats water as a common resource. The doctrine, also referred to as a Doctrine of "Reasonable Use," or "Eastern Water Law," permits a landowner adjacent to a watercourse to withdraw and use the water as long as the use is "reasonable." The doctrine leaves the courts to resolve conflicting claims of right to use the common resource. Shortfalls in water availability are shared by all riparians, with courts deciding each user's share according to its reasonableness at the time of the decision.

The Appropriative Rights Doctrine is a second surface water rights doctrine treating water essentially as private property. Water is appropriated according to "first in time, first in right." The senior appropriator is one who first puts a specific amount of water to beneficial use. All others who put water to beneficial use later in time are junior appropriators. In cases of water scarcity, there is no sharing of the shortfall in water; the junior appropriator forfeits his/her water use until the senior appropriator has fully satisfied his/her appropriation. This doctrine is also referred to as "Western Water Law." (Dellapenna, 2005)

The Regulated Riparianism Doctrine is a third surface water rights doctrine that has begun to supplant common law Riparian Rights as states have recognized the need for active public management of water as the needs of large water users (e.g., commercial, municipal, industrial, agricultural) increase and begin to compete for the available water supplies. Rather than treating water as a common resource as under common law Riparian Rights, or as a private resource as under Appropriative Rights, the Regulated Riparian Rights Doctrine treats water as a public resource. The central requirement of regulated riparianism is that water users should obtain state permission (time-limited permits) to withdraw and use large amounts of water for a specific purpose. Water withdrawals above a certain threshold are required to have a permit; withdrawals below the threshold are exempted. The threshold varies from state to state.

The western doctrine of prior appropriation is premised on shortages allocated by priority schedules that provide a clear and complete risk allocation scheme in advance of the shortages. (Tarlock, 2000) The water user need not be adjacent to the water source. In contrast, riparian rights are premised on shortages being shared in "reasonable use" by all riparians. The water user normally should be adjacent to the watercourse. International water law is similar to riparian rights and normally requires the equitable sharing of transboundary water resources.

Five legal doctrines apply to underground water. (Dellapenna and Draper, 2002a; Draper, 2002d; Dellapenna, 2003b) The Absolute Dominion Doctrine allows an overlying landowner to withdraw an unlimited amount of water, unconstrained (in its purest form) by any concern about injury to another landowner. This doctrine is actually a form of the "*water as private property*" model in which each common owner has the unlimited right to capture the underground water. The Reasonable Use Doctrine for underground water requires the landowner to make "reasonable use" of water; any unreasonable use of underground water (uses that unreasonably injure adjacent landowners as determined in court) is actionable. However, the landowner may withdraw and consume the underground water for reasonable uses without regard to the effect on others. There is no sharing of the aquifer among landowners as incorporated in surface water riparianism, (Tarlock, 1989) except as a court may determine that continuing a use is unreasonable. Implicit in the doctrine is that the "reasonable use" should take place on the land itself. Under the Correlative Rights Doctrine, landowners may withdraw only their share of the underground water for "reasonable use." If there is not sufficient water available, each landowner shares in the shortfall in proportion to the amounts allocated to that landowner's use. This doctrine treats water as a common resource and resembles the common law Riparian Rights model described above. (Trelease, 1979; Tarlock, 1989) Defining and enforcing the shares is a complex and often unsatisfactory process. Two other legal doctrines of underground water have evolved. Under the Appropriative Rights Doctrine, underground water is allocated according the "first in time, first in right," as with Appropriative Rights Doctrine for surface water. It treats water as private property. Finally, a growing number of states apply their Regulated Riparian system created for surface water, or a similar system addressed specifically to underground water. Under a regulated riparian approach, underground water is allocated by a statutory system of a comprehensive water withdrawal permit system.

The distinct laws for surface water and underground water have resulted from an historical misunderstanding within the political and legal communities of the scientific nature of underground water and surface water and the interrelationship between the two. This misunderstanding often results in policies, laws, and court decisions that are inadequate and ineffective in dealing with modern water issues. Aside from a few island-nations, virtually every nation shares an underground water system with one or more countries, and virtually all underground water systems are related or linked directly to surface water resources. Underground water sharing has serious domestic and international implications. (Eckstein, 1998)

There can also be significant differences in water laws even between parties that have similar water law systems. The difference may be especially important in how certain water rights are vested by the individual internal water laws. Initial identification of vested water rights and knowledge of laws which may vest such rights in the future are necessary to prevent extremely complex water problems such as those experienced by Los Angeles as Arizona and Nevada exercise their legal rights to the waters of the Colorado River. (Dellapenna, 2001b) These differences in the definition of the type, quantity and extent of water subject to water laws can include the extent and duration of water rights, the permissible quantity of use, the timing, pattern and location of use.

Without careful consideration when the parties to the agreement have differences in their systems of water law and property, the understanding of specific provisions in the agreement by one party may be very different than the understanding of other parties. This could quickly lead to an unenforceable agreement.

Water Policy

An assessment is also necessary of water policies that are an extension of water law but is broader in scope and less tied to the formalities of legal provisions. These policies range from specific water policies such as requirements for instream flow and safe yield to economic policies that may indirectly impact water demand. It has been suggested that eastern and western water policies have begun to converge (Kundell and Tetens, 1997) but for the foreseeable future, dramatic differences in water policy within the United States exist.

*Minimum Flow and Safe Yield.* A significant policy conflict may arise with regard to the individual party's requirements for minimum flows for surface water and safe yield for underground water (and reservoirs). Instream flow requirements can mean many things. It can be the amount of water remaining in a stream, without diversions, that is required to satisfy a particular aquatic environment (Nevada, 1999) or the flows and levels reserved from allocation in order to protect the appropriate biological, chemical and physical integrity of water sources. (Georgia Water Coalition, 2002). Required minimum flow may be defined as the minimum flow necessary to assimilate projected wastewater discharges. It can mean the streamflows required for swimming, floating a canoe, supporting fisheries, sustaining waterfowl habitat, providing downstream water supplies, assimilating wastes or generating hydroelectric power. These uses require different quantities of water at different times and at different levels of water quality. (Sherk, 2002) Other definitions set variable minimum flows that mimic natural flows. (Poff, 1997) If the individual parties to the agreement do not agree to a common definition or requirement, or at least insure the agreement accommodates the difference, significant differences will arise.

Safe yield or sustainable yield (Helweg, 2000), as applied to underground water, is usually more limited in scope. Policies of maintaining safe yield usually refers to a management concept that allows water users to pump only the amount of ground water that is replenished naturally through precipitation and surface-water seepage. (Sophocleous, 1998) As with differing policies regarding instream flow, differing policies of whether to restrict withdrawals can seriously damage the effectiveness of an agreement unless the difference is addressed in the agreement.

*Interbasin Transfer of Water.* Interbasin Transfer of Water is the transfer of water rights and/or a diversion of water (either underground water or surface water) from one drainage or hydrographic basin (the basin of origin) to another. (Nevada, 1999; Draper, 22004) As competition for limited water resources has increased, conflicts concerning interbasin water transfers have increased. (Kundell and Tetens, 1997; Draper, 2004)) One party to the agreement may have a policy of meeting water supply needs in one region by transporting abundant supply from another. (Hirji et al., 2001; Draper, 2004) This may result in negative impacts on both the environment and economy of the basin of origin that may include alteration of stream flow affecting instream uses of the water and preclusion of potential future instream and offstream uses of water that support economic activity. (GJCWPC, 2002; Draper, 2004) For purposes of water sharing, unless the receiving basin is in a common river basin whose waters are shared by the parties, interbasin transfer can reduce the available water to be shared. Clearly, policies of interbasin transfer by one party could have a significant impact on the water to be shared and, to reach an effective agreement, the interbasin policies of the respective parties should be closely analyzed. It may be necessary for the agreement to detail how and when interbasin transfers of shared waters can occur.

Various governments have imposed different criteria for interbasin transfer. Commonly, such transfers are allowed only after a showing that, among other criteria, there is no other reasonable alternative and that programs of conservations and efficiency have been implemented. (Georgia JSC, 2002; Glennon, 2002; Draper, 2004)

*Flood Control.* Flood control policies and works may also have a dramatic effect on the timing and elevation of water levels and thus may become a contentious issue between the parties. The issue should be addressed as an individual area of coordination. This provision recognizes the right of each party to make efforts to safeguard its people and economic forces from flood damages but establishes an avenue for the sharing of data on flood control efforts as well as an independent analysis of the effects of those efforts on other parties. (Draper, 2000a)

*Priority of Use. The UN Convention on the Law of the Non-Navigational Uses of International Watercourses,* United Nations Document A/51/869 (1997), advises that "(i)n the absence of agreement or custom to the contrary, no use of an international watercourse enjoys inherent priority over other uses." If sufficient water is available to meet all equitable and reasonable uses, all demands will be met and no need for prioritization exists. Even if sufficient water is available during normal conditions, restrictions on water rights during times of water shortages or dry periods should be analyzed. (Kundell and Tetens, 1997)

If sufficient water is not available, it has been recommended that a priority of allocation be established. A number of prioritization schemes have been proposed. One suggestion includes a priority list of human needs, vested water rights, and minimum instream flow for environmental and ecological protection and water quality purposes, followed by allocations that balance demands that provide maximum economic benefit with demands which have a direct influence on quality of life issues but cannot meet the economic threshold. (Sterner, 1994) The DRBC and SRBC provide priority for (1) domestic uses (drinking and bathing), (2) public safety, (3) the minimum amounts necessary for preservation of livestock and property, and thereafter attempts to balance reductions in water use so as to maximize productivity and preservation of employment, and preserve essential instream flows for water quality and biological conditions. The State of Pennsylvania prioritizes water use under drought conditions as domestic use (including drinking, bathing, cooking, laundry, livestock watering, and other uses necessary for life and health) is given priority with no regard for the amount of water left in the stream or lake after these uses are satisfied. The next priority is the public's right to navigate, followed by all nondomestic water uses. Upstream non-domestic uses, including irrigation, manufacturing, and power production, can be slowed if there is insufficient water to meet downstream domestic or navigational needs remain in its natural state may hamper development of riparian land. (Abdalla, 1997)

It can be argued, however, that a strict priority arrangement is not practical due to a number of difficulties and that a response to drought conditions actually requires balancing of various needs at the time of the drought. The difficulty with a priority scheme, at least in developed countries, is that water is normally allocated to broader sectors than the water uses listed. For instance, the problem with placing domestic uses (drinking and bathing) or human needs as top priority is that these uses do not match the reality of rapidly urbanizing society. Most domestic uses are provided water through a municipal system and it is difficult to separate out what is necessary for domestic use from the other uses of municipal supply. Once the law established domestic use as top priority, state and local regulations must develop very detailed requirements of what is and what is not allowed. For instance, municipalities must manage water use during drought emergencies by limiting or banning certain uses such as lawn watering, car washing, golf course irrigation, etc. It is difficult, however, for political and factual reasons to curtail commercial or retail use. Separating water being used within a shopping mall between the grocery store (food as a human need), the drug store (medicines as a human need?) and the clothing store, for instance is a challenge.

**3.3 Assessment of water sources.**

Establishing equitable principles and standards for managing the shared use of water between sovereign governments requires detailed knowledge of the quantity and quality of the shared water resources and a comprehensive understanding of how the use of the water resources by individual parties will affect others. (Draper, 1997; Kaya, 1998) Even more importantly, a mechanism to predict accurately future sources and demands is essential. (GJCSWPC, 2002) Such detailed knowledge is rarely available without extensive research and funding, even in the United States or other developed countries. If an effective water sharing agreement is really intended, the parties need to devote the human and financial resources necessary to develop a broad understanding of the extent and limits of the water sources available to be shared. (U.S. Army Corps of Engineers, 1995; Kundell and Tetens, 1997)

The global available annual renewable freshwater supply is estimated to be 9,000-14,000 billion cubic meters (7,300-11,400 billion acre-feet) (Rosegrant, 1997) Freshwater is, however, distributed unevenly across the globe and even across the United States. Canada has 120,000 cubic meters (97.3 acre-feet) per capita per year of renewable water resources; Kenya has 600 cubic meters (0.49 acre-feet) and Jordan, 300 cubic meters (0.24 acre-feet). The ultimate goal of the assessment of water sources is to determine whether existing or "reasonably anticipated" water sources are sufficient to meet the expected future demands. (Ryan et al., 1998) Both natural factors and human effects may change the available water available. Factors that affect water availability include "climatic variability and change, population growth that reduces per capita water availability, contamination that reduces usable water supplies, physical overuse of a stock, such as underground water overdraft, and technical factors." (Dellapenna, 1997a; Gleick, 1998; Dellapenna, 1999) The negative impact of human activities on water sources has been noted:

> *Despite the ability of stream flow to renew and self-purify, in recent decades the intensive development of industry and agriculture throughout the world, population growth, the opening of new territories, the sharp increase in water withdrawals on all continents (except most recently in the United States and parts of Europe), and the transformation of the earth's natural cover have begun to exert a significant impact on the natural fluctuations of the stream flow and the state of fresh water resources.* (Shiklomanov, 1993)

Data Collection and Uncertainty

Accurate and reliable data and information are key requirements in effective water planning and management. (Dellapenna, 1997b; Draper, 1997; Georgia JSC, 2002; Vörösmarty, 2002) Given the complexities of water resources decision, collection efforts should focus on collecting the data and information needed to support those decisions by providing input for computer models and geographic information systems used in making those decisions. Unfortunately, in many countries collection of hydrographic information has deteriorated. (Vörösmarty, 2002)

Accessibility to the data and information is equally important. Numerous national, state and local agencies collect water-related data for various purposes and manage those data using incompatible formats and systems. Many records are maintained in paper files; on microform, microfiche or microfilm; or on individual desktop computers. Demand for public access to data has skyrocketed as use of the Internet has become more commonplace. Although access to water-related data and information has improved significantly, limitations still remain. Successful development and implementation of a comprehensive, integrated data and information management system for the shared water resource will depend on the strong commitment of participating agencies and strong executive and legislative leadership. (Georgia JSC, 2002)

Predicting the future yield of shared water sources based on the historical record can result, however, in significant future problems. Future over-allocation due to an inaccurate historical record is illustrated by the 1922 Colorado River water allocation that was based on the 30 years hydrological record available at that time. Later research, based on an analysis of tree rings, determined that the amounts of water used in the allocation were abnormally high, resulting in over-allocation of the water source. (Stockton and Jacoby, 1976; Murakami, 1995)

However, even if a detailed, accurate record of the historical flow record of the shared water resource exists, there is a significant likelihood that it will not accurately predict future yields. The issue of climate change has surfaced as a potential impediment to effective long-range policies and management of water resources. (Dellapenna, 1999; Nicholls, 2000) There is now little argument that global warming will occur. (Bennett and Pendlebury, 1998; Jackson et al., 2001; NAS, 2001; RPPI, 2001) Sustainable water yields may or may not be reduced in the long-term average, but they will almost certainly be less reliable in the short term. (Sophocleous, 1998) A rapidly growing body of evidence suggests that we are entering a somewhat warmer and definitely more variable world. The American Society of Civil Engineers, in *Policy Statement 360*, dated 2004,recognized the problems associated with water resources planning and climate change:

> *The American Society of Civil Engineers (ASCE) supports continued research on global climatic change. ASCE recommends that policy makers seek the participation of the engineering community during the development and implementation of national policy and research agenda on global climatic change. Resulting programs should*

> *incorporate the principles of engineering and sustainable development.*

Climate change challenges existing water resources management practices by adding uncertainty. (Vörösmarty, 2002; IPCC, 2001) The Intergovernmental Panel on Climate Change of the World Meteorological Organization, which has predicted an increase of global average temperatures of 1.4 to 5.8° C by the end of this century, (Burns, 2000) is specific about the potential problems with lakes, streams and wetlands associated with climate change. (IPCC, 2001)

> *Globally averaged annual precipitation is projected to increase during the 21st century ... Climate change will lead to an intensification of the global hydrological cycle and can have major impacts on regional water resources, affecting both ground and surface water supply for domestic and industrial uses, irrigation, hydropower generation, navigation, instream ecosystems and water-based recreation ... The impacts of climate change will depend on the baseline condition of the water supply system and the ability of water resource managers to respond not only to climate change but also to population growth and changes in demands, technology, and economic, social and legislative condition ... Freshwater quality generally would be degraded by higher water temperatures.*

The IPCC predicts that climate change will substantially reduce available water in many of the water-scarce areas of the world, but will increase it in some other areas. (IPCC, 2001) However, even in those areas where precipitation is predicted to increase, much of the increase will occur in high-intensity events. Flood magnitude and frequency could increase in many regions as a consequence of increased frequency of heavy precipitation events, which can increase runoff in most areas as well as affect underground water recharge in some floodplains. Land-use change could exacerbate such events. (IPCC, 2001)

Although only medium confidence exists for region-specific predictions, some predictions are made with high confidence. For instance, precipitation will increase in the winter and decrease in the summer. (Hahn and Palmer, 2001) Because snowpack is very likely to decrease (NAS, 2001) and early snow melt will likely happen due to high temperatures, "peak streamflow will move from spring to winter in many areas where snowfall currently is an important component of the water balance." (IPCC, 2001; Miles, 2001; NAS, 2001) The greatest changes are likely in regions like central and Eastern Europe and the southern Rocky Mountain chain where a small temperature rise reduces snowfall substantially. The potential of climate change introduces the potential for increases of both the "drought of record" and the "flood of record" in most areas. (Berry, 1998) The significance to the areas in the Western United States that depend on snowmelt for the bulk of their water cannot be overestimated.

Other predicted effects include increased saltwater intrusion due to sea-level rise. (Jackson et al., 2001; NAS, 2001) Coastal areas that depend on underground water for municipal and industrial water supply, such as California and Georgia, will be affected. A significant challenge will be the need to protect wetlands during periods of decreased water availability. (Johnson, 1998) Significant changes in average temperature, precipitation, and soil moisture are very likely to affect demand in most sectors, especially in agricultural irrigation, forestry, and municipal use. (NAS, 2001)

Essentially, the accuracy of predictions of the future yield of shared water sources leave a significant uncertainty for development of an effective and efficient water sharing agreement. (Tarlock, 2001a) Since the effects of climate change will extend across political boundaries, the parties should recognize that the water sharing agreement may need to be adapted, even significantly adapted, as more accurate and precise predictability becomes available on those changes. (Dellapenna, 1999; Frederick and Schwartz, 1999) The U.S. Climate Change Science Program (CCSP) was established in 2002 to coordinate climate and global change research conducted in the United States. A review of the programs strategic plan by the National Academies has recommended that greater emphasis be placed on the potential changes to the water cycle. (NRC, 2004) If this recommendation is accepted, the accuracy predictions of the future yield of shared water resources should improve.

Adequate and reliable data is required for effective water sharing. What constitutes adequate and reliable data will depend both on the water sources and needs of the specific individual basins and the willingness of the parties to expend the necessary financial, human and technical resources to collect, catalog, and make the data available before an agreement is signed.

Water Supply

Surface and underground water resources are often managed as separate and distinct sources. (Eckstein, 1998; Draper, 2002b; Dellapenna, 2003b) However, such individualized management does not provide a comprehensive understanding of either the water sources or their use. In reality, however, the three components of water, surface, underground and atmospheric, are part of one hydraulic system. (Glennon, 2002) Prior to implementing transboundary water use allocation or transfer, participants should conduct a comprehensive inventory of the shared water resource. Such an assessment requires a sound historical record of the natural water cycle, to the extent it is available, as altered by human intervention. (Vorosmarty, 2002)

In most situations each component of water, whether it be surface, underground or atmospheric water, has historically been assessed and managed as separate and distinct sources from the others. However, such individualized assessments do not provide an integrated understanding of either the water sources or their use. (German Foundation, 1998; Illinois, 2001) The flows of surface waters and underground water are often closely linked and need to be studied and managed conjunctively. (Winter et al., 1998; Illinois, 2001; Glennon, 2002) This interrelationship is significant since the interface between surface waters and underground water s is often direct, with streams sometimes recharging the aquifer and sometimes gaining water from the aquifer. It is estimated that the contribution of underground water to small- and medium-sized streams is between 40 and 50 percent. (Fort, 1998) Clearly, then, the available waters should be managed conjunctively. (Hayton and Utton, 1989)

Effective water sharing agreements need to base their provisions on accurate and reliable data and information. The goal of the parties should be to collect and make available data and information that enables them to make timely, accurate and complete decisions in the development of the water sharing agreement. Successful data development depends on a strong commitment of participating parties. (DIMS, 2002)

A comprehensive assessment requires that three conditions be met. First, the parties should define the critical hydrologic conditions that frame the water sharing agreement. Second, adequate and reliable data concerning the water sources and demands should be available. Third, a shared water resource database should be developed and maintained. (Georgia JSC, 2002) Certain parameters define the framework of the agreement. The parties need to specify the extreme hydrologic events that the agreement will cover. This suggests the parties should clearly establish the quantitative measures of "normal" or "average" hydrologic conditions and establish the levels when special management for drought (dry) or flood (wet) conditions arises. The parties should also define the levels of water quality degradation they are willing to accept as a result of meeting the demands for the water.

A number of factors influence the availability of water within the shared resource. Water in its different forms moves between the atmosphere, through precipitation and condensation to rivers and streams, lakes and reservoirs, and vegetation and soils, to aquifers or oceans, returning to the atmosphere through evaporation. Any efficient management of one cannot be attained without linkages to the other, preferably dealing with both underground water and surface waters as a unitary whole. (Haddadin, 2000) The timing and amount of available water to be shared will be based on a careful analysis of this linkage. (Illinois, 2001) The timing and amount of water available for shared use is also linked to human intervention, both by the addition of supply augmentation facilities and programs, such as reservoirs and aquifer storage and recovery systems, as well as the loss of reusable water consumed by individual uses and unavailable to others. (Draper, 2002c)

The goal of collecting data and information on precipitation amounts, recharge rates and other data should be to determine the reliable available quantities of water to meet projected needs. (Illinois, 2001) The word *reliable* is emphasized because, in the absence of storage devices, the demand for water by the individual water user sectors should be reliable and consistent for extended periods of time. It is not sufficient that the statistical average yield of the water source equal the projected demand. The yield of the shared water source should be able to meet the demand under most climatologically, meteorological, and hydrological conditions.

Water utilization by one party can have serious effects on the quantity and/or quality of the water available for use by the other parties. A significant source of controversy develops when one party undertakes the construction and operation of water supply reservoirs and hydropower facilities that may dramatically lower the flow or decrease the quality in the shared water resource. Although this reduction may be limited to the initial start-up period and may be limited to a period of several years, severe economic and social impact may occur to other parties. As importantly, releases from the works should be coordinated to assure downstream users are not significantly affected in an adverse manner. In the case of water supply reservoirs this may become critical during periods of drought. In the case of hydropower dams, especially those that provide power principally during peak electrical demand, usually in the morning and early evening, the timing of release may be critical. Other parties may also be affected by significant changes resulting from interbasin transfers or increased water consumption. (Draper, 2002a; Draper, 2004) Water supply reservoirs and hydropower facilities can often also have significant biological impacts that may or may not be related to total water supply or water quality. (Bourget, 2005)

Underground and atmospheric water supply.

Conjunctive analysis, considering surface and underground water supplies together, coordinates use and storage so as to increase the total water yield over time, thereby increasing the reliability of water supply. Integrated analysis, considering water supplies and water quality together, coordinates the adequacy of the water supplies for those water uses that demand a certain level of quality. (U.S. Advisory Commission, 1991)

Failure to deal specifically with the issue of underground water withdrawal has led to litigation in the context of existing interstate compacts in the United States. It is therefore recommended that underground and atmospheric water be included within the scope of the agreement. As technology advances, use of and control of atmospheric water may also become more commonplace, (Davis, 1995; ASCE, 2004, Bomar, 2005) and consideration should be given to dealing with the potential for such use and control before it becomes established and results in unexpected interference with the provisions made for underground and surface water. (Draper, 2002a) Shared aquifers require careful evaluation because there is a general lack of detailed data. (ASCE, 2001b) The impacts of use of transboundary aquifers are subtle and widely spread geographically and often delayed in time. (Puri and Arnold, 2002)

Withdrawing water from shallow aquifers for public and domestic water supply, irrigation, and industrial uses is widespread. Withdrawing water from shallow aquifers can diminish the available surface water supply by capturing some of the underground water flow that otherwise would have discharged to surface water or by inducing flow from the surface water into the surrounding aquifer. (Winter et al., 1998) Conversely, underground water resources can be used as an effective tool to mitigate the effects of drought. Since underground water aquifers are less affected by short-term variability in climate conditions than are surface water rivers and streams, they can be artificially recharged during high water periods and utilized during low water periods. (ASCE, 2001b) However, increased use of underground water during droughts may have unanticipated effects. If an increase in underground water withdrawal is continued after the drought, a permanent and unanticipated change in the level of underground water may develop. (Alley, 1999)

Provisions in water sharing agreements of transboundary underground water aquifers should distinguish between two types of aquifers. The first type includes aquifers that are hydrologically connected to surface waters, in which a conjunctive approach may be used directly. For this type, typified by the Florida Aquifer shared by many Southeastern U.S. States where rates of aquifer recharge may be as high as 20 inches per year (Miller, 1990), the transboundary concern will be two-fold. The first concern is the transboundary effect of excessive water withdrawal by the upgradient party and its effect on the water available to the downgradient party. Second is the possible reduction in the recharge of the aquifer by developmental activities within the recharge areas by one of the parties, usually the upgradient party. Clearly, knowledge of the aquifer recharge areas is extremely important. (Dellapenna, 1997; ASCE, 2001b)

The second type of aquifer includes those with no direct surface water connection (so called "ancient" or "fossil" aquifers). In this case, typified by the Ogallala Aquifer shared by many Western U.S. States, recharge is negligible since recharge of these aquifers is normally quite slow, ranging in the tens of thousands of years. (Cummings et al., 2001a) An estimate of the magnitude and extent of the water available for use in this case cannot be made without considering the risk to future users of exhaustion of the water source, an issue of sustainability. (Donkers, 1997) A problem that is even more significant in the sharing of such an aquifer involves the controlled depletion of storage. Increased use by one party may result in, or exacerbate, existing "mining" where annual pumping exceeds natural recharge, effectively depleting the source. (Cummings et al., 1996) In some areas of the Ogallala, more than 50 percent of the predevelopment saturated zone has been dewatered. (Alley et al., 1999) The parties, however, can mitigate this issue of increased underground water "mining" by including in the water sharing agreement a requirement for more water efficient irrigation systems, incentives for the introduction of crops that use less water, and the irrigation of fewer acres by underground water in some areas because of the declining water levels. (Solley, 1997)

Quality of water supplies

The issue of water quality is also pertinent to an analysis of water resources. In many cases, providing adequate supplies of water for a particular demand is not sufficient. The need may well be adequate supplies of water at an acceptable level of quality. (Draper, 2001) The parties should recognize a level of water quality within the shared waters that will meet a number of needs. At a minimum, the shared water should maintain ecosystem integrity and preserve aquatic ecosystems, while sustaining economic growth and prosperity. (ASCE, 2001a) Integration of water quality and quantity programs is one aspect of, and is inseparable from, comprehensive, coordinated, multipurpose, basin-wide water and related resource planning and management. (Goldfarb, 1993).

Surface and underground water may be degraded by a variety of factors. Major problems affecting the quality of these water resources arise, for instance, from inadequate domestic sewage treatment, inadequate controls on the discharge of industrial waste and effluent, the diversion of waters resulting in insufficient water to assimilate waste, the loss and destruction of catchment areas, the improper locating of industrial plants, deforestation, and poor agricultural practices that cause leaching of nutrients and pesticides. (Draper, 2002a) In coastal regions, saltwater intrusion can nullify the underground water supply as a viable water source to meet the needs of agricultural irrigation and municipal water supply. (State of Georgia, 1997)

Poor quality water imposes risks that the parties should recognize as a common threat. There is, for instance, the potential health risk to the population that uses the water for domestic purposes. If the available water does not meet the minimum standards for certain industrial purposes, there is the risk that economic growth will be impaired. Also, there is the risk that quality degradation will have a severe impact on long-term sustainability. Therefore, integration of water quality and quantity is essential. (Ahlander, 1994) The UN *Convention on the Law of the Non-Navigational Uses of International Watercourses,* United Nations Document A/51/869 (1997), establishes the criterion that "*(w)atercourse States shall, individually and, where appropriate, jointly, protect and preserve the ecosystems of international watercourses.*"

Within the United States, the Clean Water Act provides a baseline for surface water quality programs, but the same cannot be said of underground water. Treaties between Canada and the United States and between Mexico and the United States have established water quality norms in North America. (Killgore and Eaton, 1995) Similar norms exist for the European Union and the Amazon Basin. (Draper, 2002a; ASCE. 2001a) However, in many other regions of the world, water quality criteria are not prescribed.

Water supply augmentation

Water augmentation projects and programs are techniques to change the timing and/or quantity of water available for use. Examples of effective water augmentation techniques include surface water reservoirs, aquifer storage and recovery, precipitation enhancement, interbasin transfer, evaporation suppression, desalination and wastewater reclamation and reuse. (Keyes, 1977)

Reservoirs can significantly augment water supply in areas or periods of water scarcity. Therefore, the parties may need to assess both existing dams and potential construction of new dams. With regard to existing reservoirs, almost half the world's large reservoirs have been built exclusively or primarily for irrigation. An estimated 30% to 40% of the 268 million hectares (662 million acres) of irrigated lands worldwide rely on dams. Dams are estimated to contribute at most to 12% to 16% of world food production. (World Commission, 2000) However, in addition to growing demand for municipal water supply, a combination of social pressures is emerging with the potential to shift the operational priorities of reservoirs significantly in the near future between, among others, hydropower and water supply. (McMahon and Farmer, 2002) However, reallocation of reservoir storage by one party may cause unintended consequences on the quantity, timing, and quality of water available to the other Party. One of the specific risks associated with reservoirs is degraded water quality, resulting from increased levels of mercury pollution early in the post-construction life of the reservoir. Another potential effect that may have detrimental effect on long-term water supply availability is the tendency of reservoirs to emit greenhouse gases, carbon dioxide, and methane, adding to the projected increase in climate change. (Pielou, 1998)

Recreation has also developed into a significant competing purpose with other traditional uses, at least for reservoirs in the United States. Both lake and river recreation has been noted as a significant national resource and public benefit, making an important contribution to local, state and national economies. However, recreation at federal lakes has not heretofore been treated as a priority, or as an equal with other reservoir uses, even if designated as an authorized purpose. (National RLSC, 1999)

As water scarcity continues to grow and needs change, reallocation of the purposes of reservoirs mounts. While reallocation often considers changes in purpose from hydropower to municipal use in the United States (McMahon and Farmer, 2002), in other areas reallocation from irrigation to industrial use might be appropriate.

Construction of new reservoirs by one party can also significantly affect the quantity, timing and quality of other parties, especially downstream parties. A large number of aquatic and ecosystem impacts exist that should be considered, including the impacts of reservoirs and flow modifications on terrestrial ecosystems and biodiversity, the emission of greenhouse gases associated with reservoirs, and the accumulation of pollutants. The impacts of altering the natural flood cycle on downstream floodplains and the impacts of reservoirs on fisheries in the upstream, reservoir and downstream areas can be significant. The cumulative impacts of a series of reservoirs on a river system should be carefully considered. (World Commission, 2000)

Aquifer storage and recovery (ASR) is the storage of water in aquifers during times when water is plentiful, and recovery of the water during times when it is needed. Proponents claim that this technique provides a cost-effective solution to many of the world's water management needs, storing water during times of flood or when water is plentiful and quality is good, and recovering it later during emergencies or times of water shortage, or when water quality from the surface water source may be poor. Large water volumes can be stored deep underground, reducing or eliminating the need to construct large and expensive surface reservoirs. In many cases, the storage zones are aquifers that have experienced long term declines in water levels due to heavy pumping to meet increasing urban and agricultural water needs. Underground water levels can then be restored if adequate water is recharged. (Aquifer Forum, 2002) The primary benefits include significant cost savings from not having to construct expensive surface reservoirs. Potential disadvantages include lowering water quality due to mixing higher and lower quality water sources. From the shared water perspective, a good understanding of the regional hydrogeologic framework is essential in order to assess the regional costs and benefits of any proposed regional ASR systems. (NRC, 2001) The identification and protection of the sources of aquifer recharge is essential. (ASCE, 2001b)

Artificially induced precipitation is another water supply augmentation technique that, if harmfully practiced by one party, may affect the water available to the other party. The moisture suspended in the atmosphere is a natural resource. It has been estimated that only about 2% to 3% of the moisture in the atmosphere falls as natural precipitation. (Colorado, 2002) Techniques to artificially increase precipitation have become increasingly more viable. (Kahan, et al, 1995; Keyes, 2005)

For effective water sharing, an understanding of the potential effects of such an inducement both within and outside of the shared resource in question is necessary. (ASCE, 2004) A number of economic, environmental and ecological, social, and legal factors determine the acceptability of a cloud seeding program. (Reinking, et al, 1995: Davis, 1995) A considerable amount of research has been conducted in the western United States on the potential environmental and ecological impacts of cloud seeding projects. (Reinking, et al' Keyes, 2005) Some of the more common concerns that could be addressed included toxicity of seeding materials (i.e., silver iodide), extension of the snowmelt in higher elevations, and increases in soil erosion. Published results from these projects indicate no significant impact from winter or summer projects. While there appears to be little effect at the scale that has been studied in the immediate areas downwind (Daniel B. Stephens & Associates, 2002), research of the effects of significant precipitation enhancement to precipitation at the downstream regional level have not been reported. The parties to any agreement should recognize that the effects of artificially induced precipitation might extend beyond the borders of the party boundaries, depending on the scale of the program to augment precipitation. Any party that augments precipitation within the Basin might be entitled to full and exclusive use of additional water supplies resulting from such augmentation, if those supplies can be effectively measured, notwithstanding any other standard of allocation set forth in the agreement as long as the downwind party is satisfied the augmentation will not affect precipitation elsewhere in the shared water resource. (Draper, 2002a)

Interbasin transfer of water, long a fixture in the Western United States, is an increasingly significant water augmentation technique in Eastern states. In the international arena, Canada has passed legislation widely prohibiting inter-basin transfers. Interbasin transfer with the Great Lakes as the basin of origin has been increasingly controversial, as the Great Lakes states and provinces seek to define what might or might not be considered acceptable inter-basin transfers. (Draper, 2004)

Interbasin transfer of water involves the withdrawal, diversion, or pumping of surface water from one river basin or the withdrawal of underground water from a point located within or beneath one river basin and release of all or any part of the water into a river basin different from the basin of origin. (Draper, 2004) The transfer of water to outside the boundaries of a river basin has impacts on the water and other resources in the basin of origin and the receiving basin. Such impacts differ from those caused by uses of water within the same basin because the non-consumed water may not be returned to the stream from which it is taken for further use in that river basin. (Georgia JSC, 2002) In a favorably configured basin that is well managed, most water supplies can be utilized a number of times as the water is withdrawn, used, and the non-consumed water returned after treatment to the original water source. Water transferred by interbasin transfer is essentially fully consumed and unable for further use by those downstream in the basin of origin.

The parties should consider three aspects of interbasin transfer. The first is interbasin transfer to another basin outside of the boundaries of the shared water resource. Such a transfer by one party will diminish the water available to some downstream parties by the elimination of returned flows into the shared basin of origin. The second aspect is transfer of water from a watershed within the shared water basin to another watershed within the shared water basin. Such a transfer will definitely affect the water available to the downstream users in the watershed of origin parties. The third aspect is a transfer of water into the shared water basin. In this case, an importation of water from outside the basin may be excluded from the provisions set forth elsewhere in the agreement, and the party importing such water should have the right to full and complete use and consumption of such imported water, as determined by the party's internal laws. (Draper, 2002; Draper, 2004) However, water quality issues may be significant. It has been claimed that interbasin transfers are not a "supply augmentation" but a reallocation that can be characterized as changes in use. (Hall and Meral, 2002)

Other water augmentation techniques include water reuse and desalination of seawater and brackish underground water. (El-Nasser, 2001; NMWRRI, 2004) Water reuse involves water reclamation, the treatment of wastewater to make it reusable for other applications such as irrigation, industrial cooling, washing, and specific environmental and ecological purposes. (BACMNG, 2002) In most cases, water reuse, for cultural and public health reasons, cannot be used for municipal supply. However, by using reclaimed water for irrigated agriculture or industry, it can reduce the demands on present and future water supplies. (El-Nasser, 2001) The primary concern for the parties to a water sharing agreement is the scale and scope of water reuse by one of the parties, especially the upstream party. Since any reuse will result in some percentage of the water being consumed and unavailable for further use downstream, the potential exists that this water augmentation technique, while augmenting the upstream party's available water, may reduce the water available to downstream users if such reuse is at a large enough scale. Desalination is an expensive augmentation technique, at least under current technology. In Toronto, the cost of traditional surface water withdrawal is approximately $0.87 per cubic meter while desalination costs are approximately $8.00 per cubic meter. (Zimmerman, 2002) A primary reason for this cost differential has been reported as the concentrate disposal techniques used. (Hightower, 2004) This suggests that significant engineering advances must be made before the technique reaches its full potential. As desalination technology advances, the technique will become a viable option, especially in those areas that experience increasing costs for water. (NMWRRI, 2004)

### 3.4 Assessment of water demands.

The need for water reaches into all aspects of human life. The very existence of life requires adequate supplies of clean water. Estimates for the human need for water to sustain a minimum acceptable quality of life range from 50 liters per day to 100 liters per day (Gleick, 1996; Falkenmark and Lindh, 1973) Food production for the world's expanding population depends largely on irrigation. Agriculture demand is estimated to account for 60 – 80% of water consumption worldwide. (Postel, 1993; Hinrichsen et al., 2001; Rothfeder, 2001; Barlow and Clarke, 2002) It requires almost 1,100 cubic meters of water to grow the food for one person's nutritious but low-meat diet for a year. (de Villiers, 2000) Beyond survival, adequate supplies of clean water are required for economic prosperity. (Draper, 2001) Water needs in the economic sector can be enormous. It requires almost 543,000 liters (143,000 gallons) to produce one ton of paper (Gleick, 1993) and over 150,000 (40,000 gallons) to produce an automobile. (Barlow and Clark, 2002; Gleick, 1993) Global water withdrawal and use by industry has been estimated at 22% of withdrawals. (World Bank, 2001) Water is important for other aspects of the quality of life for the human species, as well. The demands for good public health, recreation, and a sustainable environment depend largely on adequate amounts of instream water being available. (Draper, 2001) Forty percent of the world's population and over 90% of the people in the United States depend on waters shared with other states or countries to fulfill their water needs and demands. (International Network, 2002; Sea River, 2002; Draper, 2003)

Consumptive Use

Effective water planning and management, whether for interstate water sharing or intrastate water management purposes, should distinguish between water withdrawal and water consumption. (Alber and Smith, 2001; Draper, 2002c) It is the efficient allocation of water for consumptive use that presents the greatest challenge to water sharing. (Draper, 2002a; 2002c)

For surface water, demands are usually classified as consumptive when they remove water from the water source, and the water is not returned to the source for reuse by others downstream. (Gleick, 2002; Draper, 2002c; Minnesota DNR, 2002; USGS, 2002a)) The major effect on the watercourse is a reduction in the quantity of flow. The actual amount of water consumption varies both by type of demand and within general categories by particular demands. (Shiklomanov, 1993) For underground water, the classification of consumptive use is more complicated. Some water used for irrigation, for instance, may infiltrate back into the aquifer; this is especially true where the edge of the aquifer lies close to the surface. This clearly is non-consumptive return flow. On the other hand, some water may flow not back into the aquifer but flow to a surface source and be available for surface water users downstream. Thus the definition of "consumptive use" is problematic.

The United States Geologic Survey's definition of consumptive use (USGS, 2002a) is quite specific:

> **Consumptive use**--that part of water withdrawn that is evaporated, transpired by plants, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate water environment. Also referred to as water consumed

The Minnesota Department of Natural Resources definition (Minnesota DNR, 2002) is somewhat different, being oriented towards the effect on reuse of the water:

> **Consumptive use** is defined as water withdrawn that is not directly returned to its original source. Under this definition, all ground water withdrawals are consumptive unless the water is returned to the aquifer from which it was obtained. Surface water withdrawals are considered consumptive if the water is not directly returned to the source so that it is available for immediate further use.

The difficulty with this definition is that by designating underground water withdrawal as consumptive unless the water is returned to the aquifer from which it is withdrawn, the definition does not consider whether reuse of the water is possible. A better definition, at least for water sharing purposes, would be as follows:

> **Consumptive use** is defined as that portion of the water withdrawn from the shared resource that is not available for use to meet water needs immediately downstream or in the immediate area down gradient, either because water is not discharged (by return flow) into a water source at or near the point of withdrawal or because the biological, chemical or physical quality of the water is sufficiently impaired to prevent further use.

Under this definition, if the water is withdrawn from a surface source and a portion of the water is discharged after use into the same or nearby shared surface water resource, that portion discharged is non-consumptive. If water is withdrawn from an underground water source and a portion of the water is discharged after use into the shared surface water resource, that portion discharged is non-consumptive. If, however, any portion of the withdrawal is not discharged into a shared water source at or near the point of withdrawal, that use is consumptive. Water that is withdrawn from a water source for interbasin transfer and released into a stream or river not part of the shared waters would be considered 100% consumptive. (Draper, 2004) However, the discharge from the interbasin use may be considered non-consumptive if it is returned to the basin-of-origin.

Although highly dependent on how data is collected and what assumptions are made in defining consumptive use, the regional difference in water consumption within a specific country may be significant in Table 3-1.

Table 3-1
Regional Differences in Water Consumption

| | Water Consumption (%) | |
|---|---|---|
| | Western U.S.* | Coastal GA** |
| (1) Domestic/Commercial | 23.2 | 18.3 |
| (2) Irrigation/Livestock | 53.6 | 95.8 |
| (3) Industrial/Mining | 31.2 | 1.9 |
| (4) Thermoelectric/nuclear Power | 5.8 | 3.2 |

* Solley, 1997
**Alber and Smith. 2001

Water use can also be consumptive without lowering the quantity of water in the water source. Water can be consumed, that is, made unfit for further reuse, because the biological, chemical or physical quality of the water may be sufficiently impaired to prevent further use. Biological impairment depends on the specific habitat under consideration. Biologically, water serves as host to aquatic ecosystems that are easily disrupted by polluted and/or an inadequate supply of waters. (Falkenmark, 1997) Certain species cannot adapt to changes in the surrounding flora and fauna or biologic food source. Chemical impairment can develop by a variety of pollutants introduced by upstream or up-gradient water uses; mercury, phosphorous and nitrogen pollution usually predominate. Unregulated underground water withdrawals near the coast can result in saltwater intrusion. Chemical impairment can also occur when specific levels of naturally occurring chemical compounds, which may have long-term effects on reproduction, feeding, physiology or metabolism, are not maintained. (Draper, 2002a) Physical impairment often results from turbidity and sediment loads, which increase to unacceptable levels due to land run-off and shoreline erosion, pollution, re-suspension of bottom sediments, dredging operations, or during high periods of fresh-water input from rivers and streams. (Minnesota DNR, 2002) Sediment from erosion can impair further use by damaging mechanical systems associated with, for instance, industrial cooling or public water supply treatment processes.

Elevated temperatures can have significant negative effects on environmental and ecological sustainability and wastewater assimilation functions. The amount of oxygen dissolved in surface waters is probably the single most important measure of habitat quality. Temperature affects the concentration of dissolved oxygen (DO) since warmer water cannot dissolve as much oxygen as colder water. (Minnesota DNR, 2002) This dissolved oxygen problem is often the result of wastewater discharges with temperatures above ambient temperature and heat loads from power plants. (CWI, 2000)

The importance of classifying water uses according to their consumptive effect cannot be overemphasized. (Dellapenna, 1997; Jackson et al., 2001; Draper, 2002c) When water use is largely non-consumptive, a significant portion of the water withdrawn is returned to the water source and is available for use by other water users downstream and by the environment.

An extreme example of the potential negative effects of excessive consumptive use is the Aral Sea Basin in Central Asia. Large river diversions for irrigation have caused the sea to shrink more than three quarters in volume and fifteen meters in depth over the past four decades. The shoreline of the Aral Sea has retreated 120 km in places, and a commercial fishery, which once landed 45,000 tons of fish a year and employed 60,000 people, has disappeared. Salinity tripled from 1960 to 1990, and the water that remains is now saltier than the oceans. (Jackson et al., 2001; de Villiers, 2000) Another example is Lake Chad in Africa, once the sixth largest freshwater lake in the world. Over the past three decades, its surface area has shrunk over 90%, from 25,000 square kilometers (9,652 square miles) in 1960 to 2,000 square kilometers (772 square miles) in 1990, as it and its tributaries have served as the sole water source for over 11 million people. (Hinrichsen et al., 2001)

Water demands

Various government and non-government agencies, both worldwide and in the United States, record water demand data, at varying times and locations. Unfortunately, there exists no standard format for reporting existing and predicted future demands. Different agencies use different categories with which to report water demands. For instance, the formats in which many estimates of global water demand are reported categorize water demands according to whether the demand is for Agricultural use, Domestic use or Industrial use. (Alcamo, 2000; NWF, 2001; Gleick. 2002) The demands are usually measured in cubic kilometers ($km^3$) per annum. However, others at the global scale may use the terms household, Domestic/Commercial, Municipal, Public Supply or some combination in place of Domestic use. (Postel. 1998; Cosgrove and Rijsberman, 2000; Jackson et al., 2001; Rosegrant et al., 2002) Electrical or Thermoelectric cooling may be an additional category. (Gleick, 1993) A separate category for Reservoir consumption (from evaporation) is sometimes included. These differences make direct comparison of different predictions difficult. (Shiklomanov, 1993; Cosgrove and Rijsberman, 2000; Jackson et al., 2001) In the United States, the unit of measure is normally million gallons per day (MGD). Water use in the U.S. has been reported in eight categories; Domestic, Commercial, Irrigation, Livestock, Industrial, Mining, Public Supply and Thermoelectric. (USGS, 1998) It has also been reported in four categories: Agricultural, Domestic, Industrial and Thermoelectric. (Fort, 1998; Washington Water Watch, 2002) Other variations exist.

In order to adequately compare and contrast different reports and predictions of water demands, this discussion considers the following categories of water use: Agricultural, Industrial, Public Supply and Electric Power Generation. A fifth category, Interbasin Transfer, is also proposed since such transfers can have a significant consumptive effect on water sharing. The units of measure are $km^3$/day and MGD. (See Table 3-2.)

A consideration for the magnitude of water use around the globe is enlightening. In the year 1995, the human population withdrew approximately 3,800-3,900 $km^3$ (1.00–1.03 billion gallons). (Rosegrant and Cai, 2003; Cosegrove and Rijsberman, 2000; Alcamo et al., 2000) This is equivalent to approximately 10.5 $km^3$/day (2,077,000 MGD) for offstream uses. Based on a definition similar to that of the U.S.G.S., the average consumption rate was 46%. (Rosegrant et al., 2002; Alcamo et al., 2000; Shiklomanov, 1998b) Industrialized countries withdrew approximately 3.0 $km^3$/day (790,000 MGD), with a 38% consumptive rate, and developing counties withdrew 7.5 $km^3$/day (1,980,000 MGD) with a 49% consumptive rate. (Rosegrant and Cai, 2002) By 2025, the average global water withdrawal is forecast to be 12.5 $km^3$/day (3,300,000 MGD), with an approximate 56% consumptive rate. (Raskin et al., 1998; Shiklomanov, 1998b; Alcamo et al., 2000; Rosegrant et al., 2002)

Large quantities of water are used in North America and these quantities are expected to increase. However, comparison of North American use is difficult because the withdrawals for the different nations are not collected in a consistent time frame. In 1995, withdrawals in the United States have been estimated as 1.29 $km^3$/day (341,000 MGD), with a 29% consumptive rate. (USGS, 1998) It has been estimated that 2025 withdrawal will increase 9.3%, with an average consumptive rate of 32%. (Shiklomanov, 1999) In 1996, Canadian withdrawals have been estimated as 0.12 $km^3$/day (32,530 MGD), with an average 11% consumptive rate. (Statistics Canada, 200) Withdrawals in 2025 are predicted to increase 31.1% and have an average consumptive rate of 21%. (Cross, 2001; Shiklomanov, 1999) For 1991, withdrawals in Mexico have been estimated as 0.25 $km^3$/day (66,118 MGD), with an average 11% consumptive rate. (UNEP, 1997) Withdrawals in 2025 are predicted to increase 22.4% and have an average consumptive rate of 50%. (Shiklomanov, 1999) (See Table 3-2) Water uses can be subdivided into those that remove water from the watercourse or aquifer for use, designated offstream uses, and those that use the water without removing it, designated instream use.

Table 3-2

Year 1995 Estimated Consumptive Water Use: Global & North America.

| | Water Use | | |
|---|---|---|---|
| Resolution | Consumptive $km^3$/day | MGD ($10^3$) | Rate (%) |
| Global | 10.5 | 2,770 | 46 |
| United States | 1.29 | 341 | 29 |
| Canada [1] | 0.12 | 33 | 19 |
| Mexico [2] | 0.25 | 66 | 11 |
| | 2025 Predicted Water Use | | |
| Global | 12.5 | 3,300 | 56 |
| United States | 1.41 | 373 | 32 |
| Canada | 0.16 | 43 | 21 |
| Mexico | 0.31 | 81 | 50 |

[1] Year 1996 data [2] Year 1991 data

Data from Shiklomanov, 1999

## Offstream Water Uses

Direct water withdrawals from surface or underground sources for offstream uses are divided into five specific general categories: Agricultural, Industrial, Public Supply, Thermoelectric, Interbasin Transfer. (See Tables 3-3 and3-4)

*Agriculture*, primarily irrigation withdrawals, account for the largest offstream use, both globally and in North America. In 1995, worldwide irrigation consumption has been estimated as 8.45 $km^3$/day (2,230,000 MGD), approximately 80% of total global water consumption. (Rosegrant and Cai. 2002) In Asia, water withdrawals for irrigation account for 86% of consumption, compared to 49% in North and Central America and 38% in Europe. Rice growing in particular is a high water consumptive use; rice requires almost 7,650 cubic meters of water per hectare while wheat consumes 4,000 cubic meters per hectare, (Riceweb, 2003) Predictions for agricultural usage for 2025 are mixed, ranging to a high of 8.74 $km^3$/day (2,310,000 MGD) (Gleick, 1997; Shiklomanov, 1999) The average consumptive rate in 2025 is predicted to be 71%. (Shiklomanov, 1999)

In 1995, water withdrawals for agriculture in the United States have been estimated as 0.51 $km^3$/day (134,000 MGD). The average consumptive use for agriculture is almost 61%. Approximately 37% of withdrawals for irrigation purposes were from underground water sources and 63% were from surface water sources. It is important, however, to recognize that withdrawals for irrigation are seasonal and periodic, and not continuous like the water withdrawals needed for industrial production. (Cummings et al., 2001) Consequently, unless this anomaly is considered, a serious over-estimation of the water demands of agriculture may arise. (USGS, 1998) Livestock use is also included in the Agricultural use category. This use includes water for livestock, feed lots, dairies, fish farms and other farm demands not associated with irrigation. In 1995, water withdrawals for livestock uses in the United States have been estimated as 0.021 $km^3$/day (5,490 MGD), less than 2% of all freshwater withdrawals. Fifty-nine percent (59%) of withdrawals were from surface sources and 41% from underground sources. Although average consumptive use was 58% of the total, consumption rates in the various regions vary widely, from nearly 100% in Texas-Gulf and Souris-Red-Rainy regions to 4% in the Pacific Northwest. (USGS, 1998) Agricultural usage in the United States for Year 1995 has been estimated as 0.53 $km^3$/day (139,490 MGD) with an average consumptive rate of 61%. Agricultural usage in the continental United States for 2025 has been predicted to be 0.57 $km^3$/day (150,940 MGD) with an average consumptive rate of 57%. (Shiklomanov, 1999)

Agricultural withdrawals in Canada have been reported for Year 1995 as being 0.013 $km^3$/day (3,355 MGD) with an average consumption rate of 74%. (Statistics Canada, 2002) Predictions for 2025 estimate that agricultural usage in Canada and Alaska will increase 53% to approximately 0.0199 $km^3$/day (5,257 MGD) with an average consumptive rate of 79%. (Shiklomanov, 1999) Agricultural withdrawals in Mexico have been reported for Year 1991 as 86% of the total withdrawals, or about 0.215 $km^3$/day (56,800 MGD). (UNEP, 1997) By 2025, if there is little change to the ratio between domestic, industry, and agriculture, agriculture withdrawals will exceed 0.267 $km^3$/day (70,540 MGD). (Shiklomanov, 1999)

*Industrial demands* include process water for industrial, manufacturing and mining purposes. Internationally, the water demands for thermoelectric power generation cooling are included as a part of industrial demand. (Kemp-Benedict et al., 2002) In the United States, the water demands for thermoelectric power generation cooling are reported separately. (USGS, 1998) Worldwide industrial demand accounts for approximately 2.06 $km^3$/day (540,000 MGD) with an average consumptive rate of 11%. Predictions for global industrial usage show a 64% increase to 3.21 $km^3$/day (848,800 MGD) in 2025, with an average consumptive rate of 14%. (Shiklomanov, 1999)

In the United States, 1995 water withdrawals for industrial purposes, not including water demands associated with mining and thermoelectric power generation, totaled 0.106 $km^3$/day (28,000 MGD). Consumptive rates averaged 15%, although certain western regions, notably the Rio Grande and Lower Colorado, had consumptive rates above 50%. The larger industrial users, primarily in the Mississippi River Basin and East, had consumptive rates between 10% and 14%. (USGS, 1998) Mining use is included within industrial demand for this analysis. Mining use includes water for extraction of underground natural resources such as minerals, ores, and energy sources. Coal, crude petroleum and natural gas extraction is included in this category. In1995, U.S. freshwater withdrawal for mining uses was estimated as 2,560 MGD, with an average consumptive rate of 30%. However, consumptive rates vary widely among various regions, with the Texas-Gulf, Great Basin, and California regions having consumptive rates over 96%. Prediction for industrial use for 2025 in the continental United States, including mining, shows a 5.6% increase with an average consumptive rate of 6%. (Shiklomanov, 1999)

Industrial withdrawals in Canada in 1996 have been estimated as 0.039 $km^3$/day (10,390 MGD) with an average consumptive rate of 9%. (Statistics Canada, 2002) Industrial demands in Canada and Alaska in 2025 are projected to rise 32%. In 1991, industrial use in Mexico has been estimated as 8% of total use, or 0.020 $km^3$/day (5,284 MGD). (UNEP, 1997) By 2025, if there is little change to the ratio between domestic, industry, and agriculture, industrial withdrawals will exceed 0.025 $km^3$/day (6,560 MGD). (Shiklomanov, 1999)

*Public supply* includes water provided by public water supply utilities for public functions, including domestic and commercial uses. Domestic use includes household uses such as drinking, food preparation, bathing, washing clothes and dishes, flushing toilets, and watering of lawns and gardens. Globally, 1995 domestic per capita withdrawals varied from a high of 240 cubic meters in the United States to only 11 cubic meters in Sub-Saharan Africa, a level that is just over one-half of the 20 cubic meters per capita estimated to be required to meet the most basic human needs. (Rosegrant, 1997; Gleick, 1996) 1995 worldwide public supply water withdrawals have been estimated as 0.94 $km^3$/day (2489,000 MGD) with a consumptive rate of 15%. It has been predicted that 2025 water needs for public supply will increase 76% but that consumptive use will drop to just over12%. (Shiklomanov, 1999)

In the United States, 1995 withdrawals for public supply purposes have been estimated as 0.16 $km^3$/day (41,700 MGD). Sixty-three percent (63%) of the withdrawals were from surface sources and the remainder from underground sources. Overall consumptive use was just over 19%. (USGS, 1998) Public supply withdrawals in 2023 are predicted to rise 18% with a consumptive rate of 16%. (Shiklomanov, 1999) In 1996, public supply withdrawals in Canada have been estimated a 0.011 $km^3$/day (2,839 MGD) with an average consumptive rate of 11.4%. (Statistics Canada, 2002) Withdrawals for 2025 have been predicted to increase 20% with an average consumptive rate of 15%. In Mexico, 1991 withdrawals for public supply were 0.015 $km^3$/day (3,963 MGD) with an increase of 55% by 2025. (Shiklomanov, 1999)

Table 3-3

Year 1995 Estimated Offstream Water Use: Global & North America.

(Compiled from data sources described in text)

| | $Km^3$/day | MGD | Consumptive Rate |
|---|---|---|---|
| Agricultural | | | |
| Canada | 0.013 | 3,355 | 74 |
| Mexico | 0.215 | 56,800 | 86 |
| U.S. | 0.51 | 134,000 | 61 |
| Global | 8.45 | 2,230,000 | 80 |
| Industrial | | | |
| Canada | 0.039 | 10,390 | 9 |
| Mexico | 0.020 | 5,284 | - |
| U.S. | 0.106 | 28,000 | 15 |
| Global | 2.06 | 540,000 | 11 |
| Public Supply | | | |
| Canada | 0.011 | 2,839 | 11 |
| Mexico | 0.015 | 3,960 | - |
| U.S. | 0.16 | 41,700 | 19 |
| Global | 0.94 | 2,489,000 | 15 |
| Thermoelectric | | | |
| Canada* | 0.080 | 21,120 | - |
| Mexico** | 0.030 | 7,926 | - |
| U.S. | 0.50 | 132,000 | 3 |
| Global | - | - | - |

* Estimation for Canada & Alaska (1995)
** Estimation for Mexico & Latin America (1991)
\- Data Unavailable

*Thermoelectric power demands* include water for the generation of electric power with fossil fuel, nuclear materials, or geothermal energy. The water use is primarily for cooling purposes. When used for evaporative cooling purposes, the consumption rate for water quantity purposes is less than 3% of the water removed from the water source. However, water use for thermoelectric power is primarily used for cooling purposes and has thermal effects on the returned water that may cause significant water quality concerns for reuse in the immediate vicinity of the discharge. Farther downstream, once the heat effect has dissipated, reuse normally is possible. Water withdrawn for closed water-cooling systems, however, may be considered as 100% consumptive. Globally, water withdrawals for thermoelectric power are reported as a part of industrial demands. In 1995, freshwater withdrawals for thermoelectric purposes in the United States were 0.50 $km^3$/day (132,000 MGD) (USGS, 1998)

Table 3-4

2025 Predicted Offstream Water Use & Consumptive Rate
(Compiled from data sources described in text)

| | $Km^3$/day | MGD | Consumptive Rate |
|---|---|---|---|
| Agricultural | | | |
| Canada | 0.012 | 5,260 | 79 |
| Mexico | 0.267 | 70,540 | - |
| U.S. | 0.57 | 150,940 | 57 |
| Global | 8.74 | 2,310,000 | 71 |
| Industrial | | | |
| Canada | 0.51 | 13,600 | - |
| Mexico | 0.025 | 6,560 | - |
| U.S. | 0.112 | 29,570 | 6 |
| Global | 3.21 | 848,800 | 14 |
| Public Supply | | | |
| Canada | 0.013 | 3,490 | 15 |
| Mexico | 0.019 | 4,920 | - |
| U.S. | 0.190 | 49,990 | 16 |
| Global | 1.65 | 437,090 | 12 |
| Thermoelectric | | | |
| Canada* | 0.100 | 26,335 | - |
| Mexico** | 0.049 | 12,840 | - |
| U.S. | 0.543 | 143,350 | - |
| Global | - | - | - |

* Estimation for Canada & Alaska
** Estimation for Mexico & Latin America
\- Data Unavailable

The demand is projected to increase 8.6% by 2025. Thermoelectric power requirements for Canada and Alaska in 1995 were estimated as 0.08 $km^3$/day (21,120 MGD) while demand is expected to rise 24.6% by 2025. Thermoelectric power demands in Mexico and Central America in 1995 have been estimated as 0.030 $km^3$/day (7,926 MGD) with an increase of 62% by 2025. (Shiklomanov, 1999)

*Interbasin Transfer* (IBT) is an indirect water use that has special effects on water sharing. Under normal conditions, IBT is a consumptive demand on the waters available to users in the basin-of-origin. Unless the receiving basin's return flows are discharged back to the basin-of-origin, this demand consumes 100% of the withdrawals and may significantly reduce the future availability of water. In the case of the shared water resources, this becomes critical. Any water removed from the shared resource for use in another basin will not be available for further use by downstream parties unless the return flows from the receiving basin are back into the basin of origin. Although measurement of interbasin transfer has been made published for specific local or regional cases such as the Great Lakes and the Colorado River apportionments, no national, regional or global comparisons of the amounts of interbasin transfer has been made to date.

<u>Instream Water Uses</u>

Instream uses are divided into five specific general categories: hydropower, navigation, protection of human health by dilution of pollutants, recreation and environmental and ecological sustainability. (Jackson et al., 2001) These instream uses require water to remain in the watercourse in order to achieve the goals of their specific instream activity. Consequently, they compete with offstream uses, especially under conditions of water scarcity. Consideration should also be given to including reservoir evaporation as an instream use. While evaporation losses from reservoirs are not directly an instream use, the effect is a loss of water for downstream use. Water is stored for a variety of purposes, ranging from further instream use such as recreation, providing water to generate hydropower when needed, and providing storage for further offstream uses.

*Hydroelectric power* generation uses waterpower to generate electricity. When water moves through the turbines in a single pass, accurate estimates of the water used can be made by flow measurements and gate openings. At pumped-storage facilities, the estimate may be less accurate. Pumped-storage facilities are those that generate electricity during peak-load periods by using water that has been pumped to reservoirs at higher elevation during off-peak periods.

*Navigation* is an instream use that has immediate economic consequences if adequate water is unavailable to maintain an adequate channel depth. (U.S. Army, 2003) Its economic importance derives from its effectiveness in shipping bulk quantities of materials at a low cost. On U. S, waterways in 1996, over 620 million tons of coal, grain and oil and oil products were shipped by inland navigation. Over 80% of the nation's grain export, valued at over $25 billion, is shipped by barge.

(Maritime, 2003) The impact of inland water transportation on the economy of the State of Arkansas alone has been estimated as $811 million. (Nachtmann, 2002) The impact of recreational boating in a navigable watercourse is also significant. In the State of Maryland, it has been estimated that recreational boating contributed $356 million in personal income and $980 million in yearly economic activity, measured in 1993 dollars. (Chuck et al., 2000) On the European continent, the 25,000-km network of navigable canals and rivers provide the most efficient and reliable method of transporting goods. The major industrial areas in Europe depend on waterways that link them to parts of the North, the Baltic, the Black, and the Mediterranean Seas and the Atlantic Ocean. (Lyda, 2001)

*Protection of human health* demands adequate supplies of clean water. Globally, almost 34,000 deaths occur daily from water-borne diseases. In developing countries, 80% of illnesses are water-related. (Environment Canada, 2003; International, 2003) Such waterborne diseases include cholera, typhoid, bacillary dysentery, polio, meningitis, hepatitis A & E, and diarrhea among others. (Gleick, 2001; International, 2003) Other than fecal-oral diseases, the most important category of water related disease is water related insect vector. Malaria, filariasis, yellow fever, and dengue fever are all classified as water related diseases because their vectors breed in water. Malaria alone kills an estimated 1-2 million people annually and there are up to half a billion new cases every year, second only to diarrheal and respiratory infections. (Kjellen and McGranahan, 1997) Industrialized nations are increasingly at risk from water-related diseases that may increasingly be imported by travelers and visitors to these countries and from diseases that may establish themselves. (Gleick, 2001) Growing threats to the environmental and ecological integrity of the world's watersheds come from rising populations, water pollution, deforestation, withdrawals of water for irrigation and municipal water supply and the regulation of water flows resulting from the construction of large reservoirs. (WCD, 2000)

One of the most significant water resource issues facing the various states within the United States is Total Maximum Daily Load (TMDL) compliance, which derives from the Federal Clean Water Act, 33 U.S.C. §§ 1251 *et seq* (CWA), requiring that states identify waters not meeting water quality standards and develop specific plans to bring the waters into compliance. While discharge from point sources, i.e., specific pipes and devices that discharge pollutants at a specific point, are regulated and should treat discharges to meet TMDL compliance, other sources of pollution (non-point sources) are not so regulated. These other sources, often erosion and sediment particles to which are attached various pollutants, are not treated. Unless strict local regulations are effective in sediment and erosion control, dilution of these non-point pollutants can be accomplished only with sufficient quantities of water in the watercourse. The exact quantification of what sufficient quantities of water are required to meet TMDL requirements remains a much-debated question and is, in many respects, requires a site-specific examination of the existing and potential future pollutant loads. (NDEP, 1994; USGS, 2002b; USEPA, 2003)

In many regions outside of the United States, such standards do not exist, however. In this case, the parties should consider establishing biological, health, physical and chemical quality criteria for all significant water bodies in the shared water resource to continually improve water quality where necessary. The parties should establish minimum standards both for discharge of effluents and for receiving waters and institute standards for land use management such as limits on agrochemical use, deforestation, and wasteful irrigation practices. (ASCE, 2001a) Such rational land use standards should prevent land degradation, erosion and siltation of lakes and other water bodies. (Draper, 2002a)

*Recreation, and environmental and ecological sustainability* are two separate water demands but they are closely related since, in most cases, both uses depend on adequate supplies of clean water remaining in the watercourse. They are related because they are both instream uses that are related since, in most instances, water-based recreation is based on a sustainable environment and ecological systems. Hunting and fishing depend on a stable population of game animals or birds, or game fish. The two uses often compete, however, with respect to water quality. If recreational use unreasonably pollutes the watercourse, through the discharge of heavy metals, or oil and gas from boat engines, or introduced species are predatory for instance, environmental and ecological sustainability becomes threatened.

Environmental and ecologically sustainable use of water is a fundamental element of sound water resources management. Environmental and ecological flow requirements are important components of water use and they should be incorporated in allocation procedures. (WCD, 2000; Hirji and Ibekk, 2001) Watersheds, aquifers, and wetlands provide natural storage besides serving other functions. (Hirji and Ibekk, 2001) It is emphasized that a goal of ecosystem sustainability is necessary for more than purely aesthetic or philosophical reasons. Economic prosperity as well as adequate public health depends on a healthy environment as does significant industrial and commercial activities. Recreational activities depend on adequate supplies of water and a healthy environment. Hunting and fishing are among the largest recreational activities and both depend on clean water. One-tenth of the total world fish yield is caught on inland waters, not including subsistence fishing. (Covich, 1996) Environmental and ecological degradation of water resources exacts its own costs in human terms. Degraded watersheds and recharge areas result in reduced and unreliable water supply. Destabilized wetlands result in uncertain food supplies and altered hydrological and ecological functions. Declining productivity of commercial and subsistence game animals and birds, fish, shellfish, or waterfowl populations carries economic costs and severely affects indigenous peoples and fishing communities. Likewise, recreation and tourism may diminish. If wetlands are no longer available to provide storm-surge protection, local and downstream areas may sustain more frequent and severe flood damage. Underground water recharge patterns may be altered. To safeguard the productivity of water resources, it is essential to protect watersheds, recharge areas, and ecosystems from irreversible degradation.

*Reservoir evaporation* is an important by-product of reservoir storage that should be considered. Evaporation from reservoirs is a significant indirect consumptive used of water. Water may be stored in surface reservoirs for further direct use, such as agriculture, industry, public supply, navigation, or thermoelectric cooling purposes, and for hydroelectric power generation. Globally, it is estimated that reservoir evaporation in 1995 was 0.52 $km^3$/day (137,400 MGD) with a predicted increase of 43.1% by 2025. In the United States, reservoir evaporation for 1995 is estimated as 0.06 $km^3$/day (15,860 MGD) with a predicted increase of 11% by 2025. Reservoir evaporation in Canada and Alaska in1995 has been estimated as 0.013 $km^3$/day (3,435 MGD) with an expected increase of 46% by 2025. Reservoir consumptive losses for Mexico and Central America in 1995 have been estimated as 0.010 $km^3$/day (2,642 MGD) with an increase of 94% by 2025. (Shiklomanov, 1999)

## 3.5 Summary

Effective water sharing is based on the ability to allocate reliable, or consistent, supplies of source water to fulfill the existing and future demands of the parties. Therefore, the parties should identify and document the type and geographical extent of the water resources to be subject to the agreement. This description will allow all appropriate and necessary parties within the geographic/political region to be included in the agreement and negotiation process. It will also allow an analysis of the different water laws and policies of the parties to expose conflicts that may affect water sharing.

Having defined the hydrogeographic boundaries of the shared water resources, the parties may proceed to develop an accurate estimation of water supplies of sufficient quality that may be reliably available to meet the geographic and temporal demands within the shared water resources. Identification of existing demands for the shared waters is essential to enable estimates of future water demands. As with the assessment of water sources, it is important that the parties devote the human and financial resources to determine existing as well as future demands within the context of the agreement. This determination should not only estimate the timing, quantity and quality of the various water demands, it should also determine the amount of water the individual uses may return to the water source for use by others downstream or down gradient.

# SECTION 4

# ADMINISTRATION OF AGREEMENTS

The importance of the administration and institutional provisions of the agreement cannot be overemphasized. The effectiveness of any agreement or law depends on how effectively it is administered and how rigorously its provisions are enforced. These institutional provisions involve far more than just hydrologic or engineering management of the water resources in question. They also involve establishing procedures to manage complicated coordination among a number of private and public institutions, addressing critical social issues, and responding to complex environmental and sustainability needs. The institutional provisions should provide for effective mechanisms for cooperation, coordination, and communications. These provisions should also establish a structure that resolves conflicts in a timely and cost-effective manner. While no single model or approach to cooperation is appropriate for all or even most situations, (Berlin, 1998) certain standards are appropriate for any water sharing institution.

## 4.1 The Challenge

Proper administration and management of shared water resources requires reconciling a variety of different issues. Political issues are an important consideration. State and local government water management agencies may disagree among themselves on specific provisions since the different agencies respond to different constituencies and interest groups that often diverge with respect to water needs. Not only may political issues divide agencies, constituencies and interest groups horizontally (e.g., state agencies for agriculture, environmental and ecological protection, and industry and trade may disagree), but vertically as well, (i.e., national, state, and local agencies may disagree). The administrative and institutional provisions should also address geographical issues that refer to the scale of the agreement: river basin, national sub-divisions, national, regional or global. There is little disagreement among experts that the appropriate administrative entity for international water sharing is the river basin. (Gooch et al., 2002) Environmental and ecological issues should address integrated analysis of water, as well as biological and wildlife issues. Functional issues focus on consideration of diverse water use applications, such as urban water supply, wastewater management, navigation, and irrigation. (Kliot and Shmuedli, 2001)

Since basins throughout the world exhibit a wide range of existing water resource issues and management institutions, no single type of coordinating institution is appropriate for all. (Eaux partagées, 2002) Without question, the specific water resource problem at hand should drive the institutional design. Water resource problems are customarily defined through the political process, but once the water resource problem has been defined, certain principles and practices guide institutional design to ensure that the solution to the problem is effective and permanent. A critical need is the active support and long-term commitment on the part of top-level political leaders and representatives involved in the establishment of such an institution. (Kliot and Shmuedli, 2001)

### 4.2 The historical record of international water sharing institutions.

Typically in the international context, water sharing agreements will empower a joint agency that consists of national sections, each of which obtains funding from within its own government to cover the internal office, staff, printing, travel and other administrative expenses. (Hayton and Utton, 1989; Dellapenna, 1994b; Killgore and Eaton, 1995) Two different model institutions are highlighted.

The *Treaty between the United States and Great Britain relating to Boundary Waters*, 36 Stat. 2451 (1909), between Canada and the United States, has been offered as a good model for international water sharing agreement. (Nile Management Roundtable, 2001) This model provides excellent "cooperation and coordination" capabilities that provide an umbrella under which agreements for specific projects may be created. The Treaty manages transboundary water sharing issues across and along the longest undefended boundary between two countries in the world. (Draper, 2002) The Treaty established the International Joint Commission (IJC) whose mission is to prevent or resolve disputes by resolving issues between the two countries over boundary and transboundary waters and making recommendations about their management. Its authority is limited to boundary waters themselves, not to tributaries or waters lying wholly within one of the nations. (Canadian Commissioner, 2000) However, the Treaty provides a forum for subsidiary agreements that relate to a specific geographical area or specific problem. It sets forth a process and an administering body for future decision-making with regard to issues of the defined transboundary water resources. It has been used over the past nine decades to successfully resolve over 95% of the issues addressed under its jurisdiction. Key organizational features include six Commissioners (three from each country) who make decisions by consensus, supported by small staffs in both countries and by boards and task forces comprised of equal members from each country serving in their personal and professional capacity rather than as representatives of their country or organization and operating based on joint fact-finding and consensus.

At the other extreme is the *Agreement for Cooperation for the Sustainable Development of the Mekong River Basin,* 34 ILM 864 (1995) that evolved from the 1957 adoption of the *Statute of the Committee of Coordination of Investigations of the Lower Mekong Basin* by the four lower riparian states of Cambodia, Laos, Thailand, and the Republic of South Vietnam. The Agreement's original purpose was cooperation and coordination with the intent of enlarging its mandate to encompass the development of tributaries and possibly mainstream projects. Due to the political instabilities over the ensuing decades, it was not until 1995 that the *Mekong Agreement for Cooperation for the Sustainable Development of the Mekong*

*River Basin* was signed. The Agreement created the Mekong River Commission, composed of three permanent bodies; the Council, the Joint Committee, and the Secretariat. (Radosevich and Olson, 1999) The Council membership includes one member from each riparian state at the ministerial and cabinet level who is authorized to make policy decisions on behalf of his/her government. The Joint Committee membership includes one member from each riparian state that performs technical decision making for the Commission. It oversees implementation of the policies and decisions of the Council, and supervises the Secretariat. Sub-committees of the Joint Committee focus on three critical areas: the basin development plan, water allocation and water quality. The Secretariat provides technical and administrative services to the Council and Joint Committee. A non-riparian CEO recommended by the Joint Committee and approved by the Council directs the Secretariat. Multilateral and bilateral donor agencies, primarily the United Nations Development Programme and the World Bank, provide grant funding for almost all of the MRC program and project costs; administrative costs are apportioned among member states. (Radosevich and Olson, 1999; Draper, 2002)

International water sharing agreements display large differences in administration due to different purposes, political influences, hydrology, and economic conditions, among others factors. However, it has been noted that the successful agreement between Israel and Jordan to share the Jordan River is due, in large part, to the establishment of a joint agency, the Joint Water Committee that provides a forum for ongoing communications between the two parties. (Dellapenna, 1994a; Dellapenna, 1997a; McCaffrey, 1997) That being said, simply providing a forum for ongoing communications by itself does not result in optimum water sharing. (Albert, 2000) A survey of the water sharing agreements in force in Africa suggests that three other principles, in addition to providing for a joint agency, are important for effective agreement to share international waters. First, agreements should be multi-purpose rather than single purpose. Second, there should be shared financial responsibility and adequate funding for administration and enforcement. Finally, those agreements with joint research initiatives within the agreement, with the implied financial responsibility, seem to be more successful. This same study concluded that the principle problems to be faced when developing a joint agency for water sharing included (1) an over-politicization of the institutions; (2) the tendency for proliferation of institutions that lead to duplications and increased financial requirements; (3) the distortion of economic needs with perceived political needs; (4) over-centralization of institutions and the stifling pf public initiatives; and (5) financial mismanagement (Okidi, 1997)

A different analysis of nine international water sharing agreements has noted, however, that a formal multi-purpose joint development agency by itself will not ensure the effectiveness of a water sharing agreement. Other organizational principles should be applied to the formation of the administrative mechanism developed in the agreement. The Ganges has been noted as exemplifying the shortcomings of any unwillingness to cooperate in the whole basin. (Kliot et al., 1998)

A recent study in Europe has reported similar criteria for effective water sharing agreements. This study listed five minimum requirements for the administration of a water sharing agreement. (1) The agreement should provide for an Assembly (similar to a commission or council), composed of members appointed by the States and associated authorities, which elects its President, who may alternate between the members of each State. (2) A Board of Trustees to oversee the administration and enforcement of the agreement on a regular basis should be appointed. (3) A dispute resolution mechanism should be included. (4) The institution should include the formation of various working groups directed at the principle purposes of the agreement and the groups should meet periodically in places set out in the agreement. (5) A permanent secretariat (commission or council) is essential. The agreement should set forth the role of each component of the structure as well as the rules for decision-making such as unanimity, majority, or qualified majority. (Eaux partagee, 2002) These criteria find support in a previous study of the Mekong River Agreement. (MRC Case Study, 1999)

**4.3 The historical record of American water sharing institutions.**

Within the United States, four institutional models have been used for interstate water sharing. The predominate administrative mechanism for action or coordination of interstate rivers and streams has been the Interstate Compact, a water sharing agreement between states without active federal participation, or federal participation at the technical level only. (Grant, 1998) A second mechanism is the Federal-Interstate Compact, an agreement between states that includes active federal participation. (Dellapenna, 1998) A third form, Federal Administration of shared waters without specific state involvement, has been used in two instances. (USCOE, 1999) Finally, a fourth mechanism, the Title II River Basin Planning Commission, was introduced beginning in 1965 but federal funding ended in 1981. (Wade et al., 1994) The model is presently in disfavor because it failed to achieve their objectives in the past, primarily because of reluctance by the states and federal agencies to provide sufficient authority to the river basin commissions to accomplish their missions. (Eisel and Aiken, 1997)

*Interstate compacts* administer the shared waters according to agreement between the riparian states. These water sharing mechanisms are contracts between the states themselves. Unless the agreement is so inconsequential that it does not encroach upon federal authority, the compact should have the consent of the U.S. Congress. (*Virginia v. Tennessee*, 148 U.S. 503 (1893); Sundeen and Runyon, 1998) The federal government, while not a signatory, may assist the states in the development and operation of the compact. The decision-making is normally made with a commission whose members are usually the state governors or their representatives with each state having one vote. The rules of decision typically require unanimity. While the federal government does not have voting powers in the operational decisions of the compact, it has veto power where federal interests exist. An interstate compact is a contract enforceable in the U.S. Supreme Court by specific performance and by damage awards. (DuMar, 1990; McCormick, 1994; Dellapenna, 1998)

While an interstate compact may serve a "wide range of functions, (USCOE, 1999), usually the purpose of the compact is very specific since the formation of the compact occurs only when the need exists for urgent solution to a specific problem. Normally, interstate compacts do not create mechanisms for the actual management of water sources or for allocation of water among particular users. (Tarlock, 1994; Dellapenna, 1998) Rather, the agreement allocates the shared water between and among the states that then allocate water to specific uses and users. It has been noted that the effectiveness of interstate compacts, at least with regard to drought, is "predicated on having well-publicized plans and rules for planning purposes." (Walker et al., 1991) Although there are exceptions, the determination of whether an interstate compact formed under water scarcity conditions is successful or not seems to turn on whether the compact provides an active mechanism for compact administration and whether a dispute resolution mechanism exists.

Among interstate compacts that have no active administration, the 1943 Republican River Compact is a good example. The Compact originally provided only that "(i)t shall be the duty of the three states to administer the compact." Such an absence of active administration proved unworkable. The states subsequently found it necessary to create a Republican River Compact Administration to manage compact issues. (McCormick, 1994a) Since no dispute resolution mechanism exists within the compact, it would appear that absent an informal agreement among the parties the only recourse is the U.S. Supreme Court. The most significant issue relates to underground water pumping and its effect on river flows but the issue was not explicitly addressed in the Compact. (McCormick, 1994a) A similar situation of no active compact administration exists with the ongoing dispute between Alabama, Florida and Georgia. A compact has been signed and ratified by each state pending an agreement on an allocation formula for the Apalachicola-Chattahoochee-Flint Rivers. Although the compact creates a commission of the three governors, neither an active administrative mechanism nor a dispute resolution mechanism exists. The 1923 South Platte Compact likewise established no administrative or dispute resolution mechanism and has the potential for protracted litigation since irrigation demand exceeds supply.

The 1955 Bear River Compact is similar, having no active administration or dispute resolution mechanism, although the fact that unanimity is not the rule in decision-making minimizes disputes. Also, the Compact explicitly contained a provision requiring review and possible revision at no less than 20-year intervals. The success of this compact can be traced to these compact characteristics and the fact that the compact is limited to division of rights to flowing water and storage among users.

*Federal-interstate compacts* are similar to interstate compacts with the exception that the water sharing agreement is between the riparian states themselves and the federal government, in equal partnership. The exercise of federal powers is subject to the terms and conditions of the compact and the authority of any compact-created commission or agency. (Wade et al., 1994; Dellapenna, 1998; Dellapenna, 2001b) Two instances of the federal-interstate compact exist; the *Delaware River Basin Compact, Pub. L. No. 87-328, 75 Stat. 688 (1961)* and the *Susquehanna River Basin Compact, Pub. L. No. 91-575, 84 Stat. 1509 (1970.)* These compacts provide for multi-jurisdictional commissions to manage water sources with authority to allocate water among particular users during times of shortage. (Dellapenna, 1998; Dellapenna, 2001b) In granting its consent to these compacts, Congress included reservations to prevent impairment of future exercise of federal power and avoid future limitations on congressional power to pass laws inconsistent with the provisions of either compact. (USCOE, 1999)

The Delaware River Basin Compact involves the states of Delaware, New Jersey, New York, and Pennsylvania and the Susquehanna River Basin Compact involves New York, Maryland, and Pennsylvania. Each compact creates a regional entity composed of the governor of each of the involved states and one member appointed by the President of the United States. Each member is entitled to one vote and no action may be taken unless a majority is present and votes in favor of the proposal. The jurisdiction of the commissions is limited to the geographical boundaries of the basins. The compacts provide the commissions with regulatory authority and responsibilities relating to water supply, pollution control, flood protection, watershed management, recreation, hydroelectric power, regulation of withdrawals and diversions, intergovernmental relations, capital financing, and planning and budgeting. The commission can regulate individual water users within the basins if necessary to accomplish their responsibilities. The compacts provide the commissions with power to allocate the waters of the basins among the signatory states, and to impose conditions, obligations, and release requirements. (Wade et al., 1994; Dellapenna, 1998; Dellapenna, 2001a) A unique feature is the compacts' power to allocate the waters of the basin among the signatory states in accordance with the Supreme Court's doctrine of equitable apportionment. (Muys, 2001)

Analysis of the federal-interstate model suggests that it can be very effective in maximizing the benefits of the waters of the basin when all parties are in agreement. According to some commentators, however, several issues have limited the full potential of the DRBC. These issues relate primarily to the lack of a sufficiently strong commitment by the federal representative and the federal agencies to the compact objectives, as well as non-compliance by the federal government regarding its financial commitment. (Muy, 2001) Because no DRBC provision provides the commission with alternate means to generate sufficient operating funds, this lack of federal funding has a significant impact on the effectiveness of the compact. (Bush, 2004)

This model does require the individual parties to cede a significant amount of their authority and control (some would say their sovereignty) over internal waters to decision makers who are not directly accountable to the state governments, possibly making the development of individual economic and environmental and ecological plans and programs difficult.

*Federal Administration* of river basins provides management of shared waters without state participation. Two instances of this model have been applied in the United States. These instances are the extensive federal management of the Tennessee River and of the Colorado River. The Tennessee Valley Authority was created as a federal regional agency to operate a basin-wide system of dams and reservoirs in order to (1) control flooding along the Tennessee River and its major tributaries, (2) maintain navigation depths on rivers, and (3) generate power. (16 U.S.C.S. § 831c) Its mandate has since been broadened to include pollution control and provision of recreational opportunities. (Freeman and Lesesne, 1980) The Authority is governed by a board of directors, composed of three members appointed to overlapping nine-year terms by the President, with confirmation by the Senate. The board of directors appoints a general manager who operates as the administrative head of the corporate agency, with general policy direction supplied by the board. (16 U.S.C.S. § 831c) The TVA is structured hierarchically, with the board of directors over the office of general manager, which in turn oversees seven offices: general counsel, agricultural and chemical development, power, engineering design and construction, natural resources, community development and management services. The powers given to the TVA are considerable, in keeping with their mandate for planning and operations of navigation, flood control, and hydropower facilities as well as responsibilities for water quality and multipurpose reservoir operations. (Freeman and Lesesne, 1980) Essentially, the Authority provides comprehensive water management of the entire river basin without state involvement (other than political). (16 U.S.C.S. § 831c (1991))

The second form of exclusively federal management of interstate water resources is the single federal administrator, used for allocation of the waters of the Colorado River Basin. The U.S. Secretary of the Interior on a yearly basis allocates the waters of the Colorado River to the states riparian states as stipulated in the Colorado River Basin Project Act of 1956 and the Colorado Project Act of 1968 as well as the Colorado River Compact. (Anderson, 2002) The Bureau of Reclamation is the federal agency that manages the allocation program. (Carter and Morehouse, 2001) The Bureau operates eight dams on the Lower Colorado River and bases the allocation on a reservoir routing analysis of the discharge from two federal projects, the Glen Canyon Dam and Hoover Dam. The allocation to the states is based on (1) the amount of water already in storage, (2) the anticipated releases for various uses such as hydroelectric power generation, and (3) the need to equalize storage behind the two dams. (Carter and Morehouse, 2001) The Colorado River Basin states and other stakeholders are consulted. (Anderson, 2002) The Lower Basin is essentially managed according to strict adherence to inflexible rules, due primarily to continuing tensions among the three Lower Basin States and because portions of the river below Lake Mead are relatively heavily populated. (Pagano et al., 1999) Within the Upper Colorado Basin, however, the Bureau operates the reservoirs under an adaptive management approach that emphasizes monitoring the effects of allocations on the environment, followed by adjustments to reflect the findings of such monitoring.

Analysis of this single federal administrator model suggests that it does not lead to efficient and equitable resource allocation since it does not provide for appropriate representation and participation of all major affected interests. It does not facilitate communication and bargaining between states in order to adopt and implement operating rules which resolve conflict. (Lord et al., 1995)

*Title II River basin planning commissions* provide passive management of shared waters under authority of Congress. River basin planning commissions were established under the authority of Title II of the *Water Resources Planning Act of 1965*. Pub. L. 89-80, 79 Stat. 244 (1965 and subsequently repealed in 1981.) (Executive Order no. 12319, September 30, 1981) Although no longer authorized, lessons may be learned from a consideration of the strengths and weaknesses of the Title II model.

The 1965 Act established the Water Resources Council composed of the Secretary of the Interior, the Secretary of Agriculture, the Secretary of the Army, the Secretary of Health, Education, and Welfare, and the Chairman of the Federal Power Commission. It also established planning commissions composed of Federal and state representatives with equal voting power for the Missouri, New England, Great Lakes, Ohio, Columbia, and Upper Mississippi Regions or River basins. The Council was tasked with, among other things, reviewing plans from comprehensive regional or river basin commissions and establishing the principles, standards, and procedures for federal participants in those plans. The river basin planning commissions were responsible for coordinating ~~of~~ federal, state, interstate, local, and nongovernmental plans for development of a comprehensive plan for all federal, state, interstate, local, and nongovernmental development of water and related land resources. The Commissions were tasked with the development of recommendations for long-range schedules of priorities for data collection and analysis, and planning for specific projects, and undertaking studies of water necessary in the preparation of the comprehensive plan.

The chairman for each river basin commission was appointed by the President of the United States to serve as the representative of the federal government and coordinator for federal members of the commission. Commissioners included one member appointed by each state, one member appointed by any interstate agency created by an interstate compact with jurisdiction in the area, a representative for native American tribes within the region or basin, and an international representative, when appropriate. Commission actions required the consensus of all members. Significantly, however, its decisions were not binding to the participants. This necessarily hindered the effectiveness of the model.

The Commission's authority was limited primarily to passive powers: planning, internal administrative and operational functions. The planning functions of the Title

II Commissions varied although most included preparing and updating a comprehensive plan for water and related land resources development within the basin. (USCOE, 1999) For example, the New England Commission focused on power plant siting, coastal zone coordination, and non-structural flood control while the Upper Mississippi Commission was specifically oriented towards navigation improvements, among other elements. (Michel, 1990) Commission expenses were shared between federal and state members. Each commission recommended what portion of expenses should be borne by the federal government, subject to approval by the Water Resources Council. The Commissions were responsible for apportioning the remainder of the commission's expenses between the various members. (Michel, 1990) The Water Resources Planning Act also authorized appropriations for the Council and for financial assistance to the states in the form of grants to assist states to participate in the development of comprehensive water and related land resources plans. The basis for allotments to the states included evaluation of several factors, including population, land area, the need for comprehensive water and related land resources planning programs, and the financial need of the respective states. (Mitchell, 1990) As noted, this model was abandoned in 1981 by U.S. Presidential Executive Order.

### 4.4 Organizational design principles.

The design of the institution should consider each of the following characteristics.

<u>Interdisciplinary Analysis.</u>

Regardless of the institutional framework, it is clear that no single discipline -- neither law, nor economics, nor engineering -- will provide all of the answers for resolving water disputes. (Wolf, 1998; Draper, 2001)

<u>Legal basis</u>.

The institution should possess adequate legal authority to cope with the problem. (Dellapenna, 1994a; Dellapenna, 1994b; Dellapenna, 1998; Eheart, 2002) In the United States, the legal basis of interstate compacts, including ratification by state legislators and consent by the U.S. Congress, provides legitimacy for the institution as it fulfills its responsibilities and authorities. In the international arena, legitimacy may be established by the acknowledgement of and consent to the agreement by the national governments and by any regional government involved.

<u>Political validity and equitable participation</u>.

The institution should be validated by a political consensus among the parties involved as well as the non-government organizations representing the various private stakeholders. (Kakebeeke et al., 2000) "The issue with many water institutions is their failure to adequately address issues of equity." (Gleick, 1998) The institutional provisions should be constructed through a "bottoms up" planning process that includes the balancing of the interests of all possible stakeholders. It should be able to assure equitable treatment of all interests involved with or impacted by the agreement. Mechanisms should exist for equitable participation, including participation by politically weak stakeholders, and consideration of ecosystems and future generations.

Financial Viability.

The agreement, or the cooperating parties themselves, should provide financial capability to perform the authorities and responsibilities outlined in the agreement. (ARCADUS, 2001; Berlin, 1998) The role of the private sector, or public-private partnerships, should be considered when appropriate. (ARCADUS, 2001; Draper, 2001) This is especially critical when a disparity in the financial capabilities of the individual parties exists. Unequal financial resources available for data collection, hydrologic modeling, human resources, and other items may destroy the effectiveness of the agreement. It may be necessary for one Party to subsidize another or the institution itself could be charged with data collection, financed as appropriately befits the needs and benefits accruing to the individual parties.

Implementation and enforcement competence.

The institution should be structured to ensure that implementation of the agreement is feasible, efficient, and effective. The parties should provide the means for resolving intra- and interagency, intra- and interstate, and international conflicts. At the political level, policy decision-making mechanisms should be included in the agreement that satisfy, or at least acknowledge, all political viewpoints associated with the potential problems. At the environmental and functional levels, the institution should possess management capacity and institutional culture consistent with problem solving. (Dellapenna, 1994a; Dellapenna, 1994b)

Stakeholder Involvement.

A top-down administrative mechanism is not conducive to effective water allocation and all relevant stakeholders should be involved in the decision-making process. (Olem and Duda, 1995; Fort, 1998; Bandaragoda, 2000; Kakebeeke et al., 2000; Lubell, 2000; Planning and Management Consultants, 2000; Planning, 2000; World Commission on Dams, 2000; Gooch et al., 2002) These stakeholders should include governmental and non-governmental organizations as well as private stakeholders. (Fort, 1998; German, 1998; Barlow and Clarke, 2002) Public education programs should be developed to create awareness, shape public attitudes, and drive behavior change. (Bandaragoda, 2000; CWI, 2000; Glicken, 2000; Draper, 2001)

Adaptability

Just as the agreement itself should be adaptable to conform to changing economic, hydrologic, environmental and ecological conditions, so should the institutional framework to administer the agreement be adaptable to changing institutional needs. (Draper, 1997; Bandaragoda, 2000; Draper, 2002)

### 4.5 Choices in institutional design.

The choice of institutional framework requires detailed consideration. The long-term success of commissions should be based on the careful design of management structures that provide for effective planning and management, allow administrators and technical staff to operate efficiently, and are cost-effective. (Dellapenna, 1994a; Dellapenna, 1994b; German, 1998)

Purpose and objectives,

The purpose and objectives of the institution itself should be clearly and effectively defined and described since they will determine the powers assigned to and authorized for the institution. They may involve either passive or "soft" administration of the agreement, or they may involve active or "hard" management. (Derthick, 1974; Teclaff, 1987)

Passive administrative objectives are those that require little or no substantive decision-making by the institution. Such activities include, but are not limited to collecting, correlating and reporting data and information, maintaining records, advising decision-makers, providing independent research and/or analysis, coordinating and cooperating in studies, and investigation of alleged violations.

In addition to these passive management objectives, active administrative objectives include those activities involving substantive decision-making. Such activities include, but are not limited to planning, developing projects, operating and maintaining facilities, formulating and implementing regulations, and taking remedial action for violations.

Rules of decision

The rules of decision include the membership of the decision-making body, the levels of decision-making and, when appropriate, the voting rules. The agreement should carefully define membership in the substantive decision-making bodies. (Dellapenna, 1994a; Dellapenna 1994b) Normally the agreement will designate specific representatives of the signatory parties who may modify and interpret the agreement itself. The nature of the membership and/or representatives will change depending on the purpose and scope of the agreement. The model water sharing agreements provide typical examples.

The agreement should also describe when unanimity, consensus or majority voting is applicable. ((Dellapenna, 1994a; Dellapenna 1994b; McCormick, 1994b) The agreement may delegate other substantive decisions to the institution designed to manage the agreement. The rules of decision should provide for adequate consideration of the interests of all stakeholders. (Roll and Lopman, 2001) Several options exist for the voting process for decision-makers. Many existing water sharing agreements provide for making decisions informally through consensus. Discussions during the consensus-building process often prevent disputes that might arise from lack of information or misunderstandings. Rules that require unanimity effectively give one party a veto in any decisions, but unanimous voting may be the only politically feasible option for certain decisions. Decisions requiring non-unanimous votes can be extremely effective for non-politically sensitive decisions or those involving technical matters. The rules of decision can call for a simple majority or some higher percentage. (Dellapenna, 1994a)

Powers and duties

The agreement should describe in detail the powers authorized for and the duties assigned to the institution. In addition to the concern for whether the institution will have a passive or active management style, the agreement should clearly specify the "affirmative" or "restrictive" nature of the powers that should be considered. (Dellapenna, 1994a; Eaux partagee, 2002) Affirmative powers are those that are proactive in their effect on water resources users, such as arbitration of disputes, emergency response, modifying outdated policies, implementing new agreements, stream-lining permitting processes, and innovating conservation measures. Restrictive powers are those that have negative impacts on users, such as taxation and user fees. Technical support by agencies within the governmental structure of the individual parties may be utilized as appropriate. (Dellapenna, 1994a; German, 1998)

Accountability and Responsiveness

The agreement should provide for accountability and responsiveness, including accountability to decision-makers, water resource users and the general public. Except in rare cases, internal meetings should be open to the public and, the agreement should establish full disclosure provisions and require publishing of all institutional records. The institution should respond to the concerns of all interest groups.

Compliance

The water sharing agreement should have "the clout to enforce its mandates." (Dellapenna, 1997a) At least in the international arena, the respective national governments normally perform this function, (Hayton and Utton, 1989) and most water sharing agreements do not even require the monitoring of compliance. (van Edig et al., 2001; Kakebeeke et al., 2000) Consequently, the agreement should provide for a compliance review procedure for the purpose of ensuring effective compliance with the agreement on transboundary waters in a manner that avoids complexity, confrontation, is transparent, and that provides the parties with the right to make decisions relating to the compliance verification and control. Such a compliance review may be informal or it may be a formal Compliance Review Committee established in the agreement. (Kakebeeke et al., 2000)

Dispute resolution

Disputes will inevitably arise as an agreement is implemented and enforced. (Dellapenna, 1994a; McCormick, 1994a; Bandaragoda, 2000) They may involve differences in interpretation of the agreement's provisions or non-compliance with the agreement itself. The disputes may also arise because of changing conditions that alter the effectiveness of the agreement for one or more of the parties. Therefore, the institutional provisions should provide for a process to resolve disputes quickly and effectively. (Hayton and Utton, 1989; ASCE, 2001a) The mechanism should emphasize a streamlined process of dispute resolution that minimizes costly, time-consuming litigation.

The parties should consider non-judicial conflict resolutions as use of the courts in most instances holds significant disadvantages. Judges are generalists who are, in most cases, dependent on the testimony and evidence presented to them. The judicial process, with its manifold procedural safeguards, is normally too slow for effective natural resources management. Judicial decrees are often retrospective, geographically limited and quite fact-specific. Unlike administrative agencies, courts, by their very nature, do not provide prospective, uniform regulations of general applicability. Courts often lack the ability to consistently monitor and evaluate solutions they have devised. (Goldfarb, 1993)

Alternative dispute resolution (ADR) processes are non-judicial dispute resolution techniques that are designed to resolve disputes as quickly as possible and at the lowest cost to the parties involved. (Fort, 1998; Dellapenna, 2003a) The process consists of a successive series of techniques that become increasingly time-consuming and expensive. (Hayton and Utton, 1989) These processes include four techniques; negotiation, mediation, arbitration and litigation. With each successive step, the parties spend more time and more money for a result over which the parties have less and less control. (Draper, 2002a)

Negotiation is a process in which the conflicting parties engage in face-to-face discussions to develop a mutually satisfactory agreement on the issues or problems at hand. No outside, independent Party or individual is involved. If negotiations between the parties themselves are not effective, the process evolves into mediation. (ASCE, 2001a; Draper, 2002a)

Mediation is the intervention of a "third Party" in a dispute between two other parties in an attempt to reconcile their differences, usually upon the request of the parties. The qualifications of the mediator should include knowledge, experience and background in the water resource issues themselves as well as an understanding and background in the legal issues involved. Mediation typically moves through three stages. The mediator identifies and develops a factual discussion of the disputed and undisputed issues with the parties, both individually and collectively. The purpose is to assure that all parties understand the strengths and weaknesses of their case and the perceived weaknesses and strengths of the opposing parties. The mediator then explores with the parties their goals, objectives and interests, attempting to create alternative solutions to their perceived concerns. Often, this portion of the process also involves discussions with the parties individually and collectively. Finally, after the mediator intervenes, the parties themselves may then reassume a negotiating posture and possibly agree on a mutually acceptable alternative solution, or they may proceed to arbitration. (ASCE, 2001a; Draper, 2002a)

Arbitration is an informal trial, with the parties choosing the judge and employing a process that has a less formal evidentiary process. Arbitration differs from mediation only in the rules of decision as to the solution chosen to resolve the dispute. Whereas the mediator seeks to persuade the parties to agree on a mutually acceptable solution, the parties agree to allow the arbitrator to make decisions that are binding on the parties. (ASCE, 2001a; Draper, 2002a)

In the case where a dispute cannot be resolved within a prescribed time period, either through good faith negotiations or independent dispute resolution, the agreement should designate a specific legal forum to resolve the dispute. (World Commission on Dams, 2000) In the United States, the federal court system provides the forum. (Draper, 1997) In the international context, the forum might be a fact-finding commission as detailed in Article 33 of the *UN Convention on the Law of the Non- Navigational Uses of International Watercourses* or the International Court of Justice. (World Commission on Dams, 2000)

In creating an effective institution to administer a water sharing agreement, the choices depend on several questions. It depends on whether the agreement is single-purpose or multi-purpose. The agreement determines whether the administration of the agreement will be active or passive. Finally, effectiveness of the institution depends whether the parties are willing to surrender a degree of sovereignty in the interest of efficient use of the water resource.

### 4.6 Model water sharing agreements

The sequence in developing water sharing agreements is straightforward. First the assessments are conducted. Second a value is placed on the various uses to which the water may be used. Third, the goals to be achieved have been determined and strategies to reach those goals developed. Fourth, the general framework for administration is developed. Once these four steps are completed, the parties are prepared to develop a written agreement that codifies how the water shall be allocated. Depending upon the degree to which the parties are willing submit to joint management of the shared resource and the level of efficient use of the resource they are willing to accept, they may choose the appropriate allocation strategy. Commensurate with the chosen strategy, the parties should establish an appropriate institution to manage or administer the allocation, including effective dispute resolution mechanisms.

Once the agreement has been signed and ratified, the parties should develop an institutional mechanism that will assess adequacy of data used, the values and goals established by the agreement, and progress toward achieving goals followed by modification of the agreement as appropriate.

In a companion EWRI/ASCE publication, *Model Water Sharing Agreements for the 21$^{st}$ Century*, (Draper, 2002) three model transboundary agreements have been developed to serve as a framework for individual agreements. These agreements are structured according to the willingness of the parties to accede to the principles outlined above and the degree of sovereignty over water resources the parties are willing to renounce in order to make transboundary water use efficient. A summary of each model is provided below.

Model A: Water Sharing Agreement (Cooperation and Coordination).

*Model A*, the Agreement for Coordination and Cooperation in the Management of Shared Water Resources, provides a reference to be used by States to facilitate the exchange of data and other information pertinent to independent water planning and development by the respective parties. In many situations involving the sharing of water between, along, and across political borders, the parties are not prepared to relinquish their sovereign rights and duties over the waters within their boundaries but acknowledge that effective management of those resources cannot be accomplished without significant cooperation and coordination. This model transboundary agreement is designed to provide a mechanism for coordination and cooperative that insures each Party is aware of the existing quantity and quality of water available for use as well as the activities and plans of the other Party that may impact on that availability. It provides a means for exchanging boundary water-related information, including hydrologic data and information on proposed projects that may affect extraterritorial waters. This "cooperation/coordination" model makes clear provision for Sovereign parties to adequately protect their individual interests while resolving, as effectively as possible, transboundary water issues and conflicts.

This Model Agreement is partly based on the *Treaty between the United States and Great Britain relating to Boundary Waters*, 36 Stat. 2451 (1909). Certain provisions of this Treaty are, however, inappropriate for inclusion in water sharing agreements for other water basins. Modifications and revisions to the Treaty have therefore been made to a number of provisions before inclusion in the Model Agreement. These modifications allow Model A to be sufficiently flexible for use on both an interstate and international scale and in a variety of geopolitical settings. These modifications and revisions resulted from an evaluation of a number of successful water sharing agreements as well as manuscripts; treatises and other studies published by experts and learned scholars.

International agreements provided significant assistance in developing policies and provisions that are science-based and which reflect the globalization of water policy planning. From a policy standpoint, this Model Agreement for Coordination and Cooperation in the Management of Shared Water Resources conforms to the *United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses*, United Nations Document A/51/869 (1997), for which the United States voted as part of the 104-3 vote in the General Assembly. It has not yet been ratified by the requisite states, including the United States.

The Convention recommends the establishment of the dual criteria of "equitable and reasonable utilization" of the water resources and the need to "exchange data and consult on the possible effects of planned measures on the condition" of the water resource. This Model Agreement, as well as other international agreements, is relevant to interstate agreements because of what it offers as guiding principles for the peaceful resolution of water disputes. Much international study has been concentrated on developing successful water sharing agreements and the states within the United States can profit from these studies.

Model B: Water Sharing Agreement (Limited Purpose).

*Model B*, the Limited Purpose Agreement for the Shared Use of Transboundary Water Resources document, is designed for those situations in which the parties wish to maintain control of most aspects of their internal water development but recognize either the need to resolve existing or potential conflict or the need to establish direct coordination or management over a specific water development project a particular water source, or a particular water management function. Essentially, this model is oriented towards purposes that are limited in scope and narrowly drawn. The limited purpose goals may vary from simple allocation of water from a particular water source to other matters such as pollution control of a specific water body. Model B establishes an agreement for the joint development of specific water resources projects, the management of which may require more than simple coordination and cooperation. However, the joint development is strictly limited to the specific development project rather than being a comprehensive program that is expansive in nature. This model agreement therefore presents a number of illustrative provisions, not all of which may be appropriate for use in a given case. The provisions set out in *Model Water Sharing Agreements for the 21st Century*, (Draper, ed. 2002) can serve as guidelines based on similar provisions found in existing water-sharing agreements in the United States.

Model C: Water Sharing Agreement (Comprehensive Management).

*Model C*, the Comprehensive Water Management Agreement, provides a model for comprehensive planning and management of shared water resources. This Model Agreement is based on the concept that the most efficient and effective allocation of shared water resources can be achieved only through management on a watershed basis, because the water resources and the associated riparian lands are an integrated whole whose interrelation requires integrated management to achieve optimal use especially during periods of drought. Such integrated management requires creation of a separate management entity to which the parties will cede specified decision-making authority.

The agreement is extensive and considers all aspects of the management of the water resources of a particular basin. In addition to seeking optimal use of the waters of the particular basin, the objectives of this comprehensive, integrated agreement seek to achieve an equitable allocation among all parties to the agreement. It proposes that each Party restrict practices to the equitable and reasonable use of water while making sufficient data available to the other parties to verify equitable and reasonable use.

The model is partly based on the structure and organization of the *Delaware River Basin Compact* (DRBC), Pub. L. 87-328, 75 Stat. 688 (1961), and its amendments. This Compact has been extraordinarily successful in resolving interstate conflicts over the water rights and water management of the Delaware River Basin between and among the States of New York, Pennsylvania, New Jersey, and Delaware. Based on the success of the agreement, a companion agreement was made for the Susquehanna River, the *Susquehanna River Basin Compact*, Pub. L. No. 91-575, 84 Stat. 1509 (1970).

Certain provisions of the DRBC are, however, inappropriate for inclusion in the water sharing agreements formulated for other water basins. The reasons for their inapplicability may be the result of differing geophysical or climatic/meteorological differences, differing geopolitical systems or differences in purposes and scopes of the agreement. Therefore, significant modification and revision to the DRBC were made in this Model Agreement order to make the model agreement sufficiently flexible for use on both an interstate and international scale and in a variety of geopolitical settings. Certain sections that are basin-specific have been eliminated. These modifications and revisions resulted from an evaluation of a number of successful water sharing agreements as well as monographs, treatises and other studies published by experts and learned scholars.

International agreements provided significant assistance in developing policies and provisions that are science-based and which reflect the globalization of water policy planning. From a policy standpoint, the Model Comprehensive Water Management Agreement adheres to the *United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses*, United Nations Document A/51/869 (1998). This Convention attempts to set standards for all international agreements involving the shared use of transboundary water resources. It specifically establishes the dual criteria of "equitable and reasonable utilization" of the water resources and the need to "exchange data and consult on the possible effects of planned measures on the condition" of the water resource. This agreement, as well as other international agreements (e.g., EWRI/ASCE Standard 33-01, *Comprehensive Transboundary International Water Quality Management Agreement*), is relevant to interstate agreements because of what it offers as guiding principles for the peaceful resolution of water disputes. Much international study has been concentrated on developing successful water sharing agreements and the states within the United States can profit from this study.

**4.7 Summary.**

The importance of the administration and institutional provisions of the agreement cannot be overemphasized. Without effective administration, implementation of the agreement will falter and enforcement of its provisions will be limited. Without an effective institutional framework, the parties will spend much of their time and resources in dispute resolution rather than effective water management.

The effectiveness of any agreement or law depends on how effectively it is administered and how rigorously its provisions are enforced. These institutional provisions will involve far more than just engineering management of the water resources in question. They also involve establishing procedures to manage complicated coordination among a number of private and public institutions, addressing critical social issues, and responding to complex environmental and ecological sustainability needs. The institutional provisions should provide for effective mechanisms for cooperation, coordination, and communications.

In a companion EWRI/ASCE publication, *Model Water Sharing Agreements for the 21st Century*, (Draper, 2002) three model transboundary agreements have been developed to serve as a framework for individual agreements. These agreements are structured according to the willingness of the parties to accede to the principles outlined above and the degree to which the parties are willing to submit to joint management in order to make transboundary water use efficient. The models are developed to serve as templates within which the unique characteristics of the shared water resource as well as the specific political, economic and social objectives of the parties may be blended.

Model A, the Agreement for Coordination and Cooperation in the Management of Shared Water Resources, provides a reference to be used by States to facilitate the exchange of data and other information pertinent to independent water planning and development by the respective parties. Model B, the Limited Purpose Agreement for the Shared Use of Transboundary Water Resources document, is designed for those situations in which the parties wish to maintain control of most aspects of their internal water development but recognize either the need to resolve existing or potential conflict or the need to establish direct coordination or management over a specific water development project a particular water source, or a particular water management function. Model C, the Comprehensive Water Management Agreement, provides a model for comprehensive planning and management of shared water resources and it was the pre-standard document used to develop ASCE/EWRI Standard 33-01. (ASCE, 2001a)

# SECTION 5

# WATER ALLOCATION STRATEGIES

The choice of how the shared waters are allocated between the parties will determine the success of the agreement. Although the variation among allocation strategies for effective water sharing may be large in theory, historical experience has demonstrated that the number of successful strategies is limited. The historical record shows that distinct allocation strategies have been applied to allocating surface, underground, and atmospheric water. Few examples exist of allocation strategies that combine surface, underground and atmospheric waters.

## 5.1 Strategies for allocating water.

The objective of water allocation should be to provide adequate supplies of quality water for the various instream and offstream water needs of the various political units sharing the basin, while preserving the hydrological, biological and chemical elements of the ecological functioning. The allocation should evaluate and accommodate the social, environmental, and cultural as well as the economic issues that may affect the agreement. (Fort, 1998; Dellapenna, 2003a) It should apportion the water justly and fairly and should minimize the potential for conflict. Ideally, allocation should consolidate the analysis of water availability and demand at the sub-basin level, where quantity, quality and sustainability can be integrated. (ASCE, 2001a) Consideration of the consumptive uses of the shared resource, not solely the water withdrawals, is important (Kliot at al, 2001) and some have advocated allocation of consumptive use as the appropriate method of allocation. (Draper, 2002c) Although economic benefits have not been explicitly used in allocating transboundary water, economic principles have helped guide transboundary water sharing agreements. (Hamner and Wolf, 1998) Proposals have been made to introduce the sharing of economic, environmental, ecological and social benefits as the primary basis for cost sharing, thus creating incentives for cost efficiency. (Berlin, 1998; ASCE, 2001a)

Conceptually, the purpose of water allocation is to allocate the risk of water scarcity among the parties. One risk to be allocated is the risk of a water shortage during drought conditions. Another risk to be allocated is the risk of a shortage in water that might be needed for future economic growth and intergenerational quality of life. In allocating water, the parties are actually determining to what extent each party will bear these risks. Allocation strategies should also take into account the possibility of a "political shortfall;" that is, a shortfall created not by a physical shortage of water but by some social or political factor such as new regulations that reduces the quantity actually available for use. (McCormick, 1994a)

Surface water

Although the specific manner of allocating water can vary according to a variety of influences, most can be classified as either flow or storage allocation. Choice of the method depends on what the parties want to accomplish and how they want to divide the risk of shortage. (McCormick, 1994a; Kenney, 1995)

*Priority of particular demand.* This allocation strategy sets priorities by type of use rather than by user location within the water basin, and provides certain quantitative limitations on those priorities. This method can be considered more economically efficient since it allocates water on basis of value rather than location of use and care should be taken that new uses are not foreclosed because old uses have consumed the resource. This allocation requires accurate forecasting of the future values of differing uses of water. The allocation of the risk of shortage is apportioned among types of users rather than hydrogeographic areas. Lower-value uses, with lower priorities, bear the burden in a period of shortage. If the parties are willing to view the basin as an integral whole, this allocation strategy provides a mechanism to integrate the mechanics and economic planning of water use. The approach allows potential optimization of the economic value of water allocation, although the issue of environmental, ecological, social and cultural demand is still problematic. Compacts adopting this strategy in whole or in part include *Costilla Creek Compact*, 60 Stat. 246 (1946); amended 77 Stat. 350 (1963); *Bell Fourche Compact*, 58 Stat. 94 (1944); *Kansas-Nebraska Big Blue River Compact*, 86 Stat. 193 (1972); and *Klamath River Basin Compact*, 71 Stat. 497 (1957).

*Storage Limitations.* A storage limitation strategy limits the amount of water that an upstream entity may impound annually, seasonally, or other time period basis. It may be combined with some other method of allocation. A storage limitation strategy has several advantages. It is relatively easy to administer and it allows conservation of upstream water and storage for use at different seasons. Its disadvantages arise from its simplicity. The method does not by itself specify limits on consumption or depletion, and withdrawals downstream from reservoirs are not necessarily controlled. With regard to risk allocation, the downstream Party assumes the majority of the risk because stream flow may not be sufficient to do more than fill upstream reservoirs. Adding users upstream may further diminish flow available downstream. Finally, the downstream Party assumes the risk of shortage during prolonged periods of drought or during flood control operations. Compacts adopting this strategy in whole or in part include *Rio Grande Compact of 1938*, 53 Stat. 785, 938; *Arkansas River Compact*, 63 Stat. 145 (1949); *Arkansas River Basin Compact of 1965*, 80 Stat. 1409 (1966); *Canadian River Compact*, 66 Stat. 74 (1952); *Bear River Compact*, 72 Stat. 38 (1955), amended 94 Stat. 4, Art. XIII (2) (1980); *Kansas-Nebraska Big Blue River Compact*, 86 Stat. 193 (1972); and *Upper Niobrara River Compact*, 83 Stat. 86, Art. V (1969)

*Guaranteed quantity at a point.* Using this strategy, a guaranteed quantity is to be delivered at certain points. The upstream party guarantees that a fixed amount of water will pass a certain point every year or other time period. This method's advantage is that it is relatively simple to administer. However, it requires accurate knowledge of flow history at the various reference points. The risk of water shortage falls upon the upstream parties, which guarantee the minimum flow, although the upstream parties may also obtain benefit of extra water in periods when stream flow exceeds the base amount. To modify the division of risk, the parties may agree to divide any surplus over a specified minimum flow so that both upstream and downstream parties share part of the surplus. Alternatively the risk assumed by the upstream party may be lessened by limiting what it should do to insure the minimum flow. Compacts adopting this strategy in whole or in part include *Colorado River Compact*, approved 45 Stat. 1057 (1928); *Rio Grande Compact of 1938*, 53 Stat. 785, 938; *Arkansas River Basin Compact of 1965*, 80 Stat. 1409 (1966); *Bear River Compact*, 72 Stat. 38 (1955), amended 94 Stat. 4, Art. XIII (2) (1980); *South Platte River Compact*, 44 Stat. 195 (1923); *Sabine River Compact*, 68 Stat. 690 (1953); and *Colorado River Compact*, approved 45 Stat. 1057 (1928).

*Percentage of flow.* With this strategy, the parties allocate water by either a fixed percentage or a formula based on different flow levels. Each participant is entitled to take its specified percentage of the flow. This strategy's significant advantage is that the parties share any surplus or deficit, and it is relatively easy to administer once data is available. Certain disadvantages also exist, however. The method requires more complex administration. Gauging stations should be established at agreed-upon points to determine the amounts being withdrawn and the starting amounts available. If existing allocations are not grandfathered, those existing rights may be impaired if the allocated percentage results in insufficient water for those rights. In some jurisdictions, this could result in legal "takings" claims. This strategy should include provisions for instream flow maintenance, which may result in less usable water than the strict percentages might indicate. The method is, however, relatively benign with regard to risk allocation as each Party shares in surplus or deficit in proportion to its allocated percentage. Compacts adopting this strategy in whole or in part include *Upper Colorado River Basin Compact*, 63 Stat. 31 (1949); *La Plata River Compact*, 43 Stat. 796 (1925); *Yellowstone River Compact,* 65 Stat. 663 (1950); *Snake River Compact*, 64 Stat. 29 (1949); *Red River Compact*, 94 Stat. 3305 (1980); *Belle Fourche River Compact*, 58 Stat. 94 (1944).

*Hydrologic models.* As a complement in choosing the appropriate allocation strategy, the parties may find it helpful to use hydrologic modeling of the shared water resource. In this allocation technique, the parties develop a model to explain the flow of the river and allocate water according to differences in flow under different precipitation regimes. Parties share water according to schedules derived from the model. For rivers with great flow variability, the model can provide a system that takes variation of precipitation into account and can apportion the flow based on conditions in particular areas. The method may also appear to be more scientifically valid than others. However, the uncertainty of modeling poses a significant risk that the model is inaccurate, in which case the allocation will not accomplish what the parties intended. By using the method, the parties may divide risk of shortage any way they see fit, but the likely result is a division designed to reflect local, rather than basin-wide, variations in natural conditions. Compacts adopting this strategy in whole or in part include *Pecos River Compact*, 63 Stat. 159 (1948); and *Republican River Compact*, 57 Stat. 86 (1943);

*Comprehensive Basin Management.* In this strategy, an independent commission, under supervision and policy control of the states involved, provides comprehensive basin-wide watershed management by protecting water quality, resolving interstate water disputes without costly litigation, allocating and conserving water, managing river flow, and providing numerous other services to the signatory parties. The independent commission will usually manage surface water quality, including both point and nonpoint sources of pollution; ground and surface water quantity, including water demands, water withdrawals, water allocations, water conservation, and protected areas; drought management; and in-stream flow management. (Delaware River Basin Commission, 2003) This strategy applies equally as a underground water allocation strategy or as a strategy to integrate surface and underground water. Underground water management has also been included in this strategy in some agreements. Compacts adopting this strategy include the *Delaware River Basin Compact* (DRBC), Pub. L. 87-328, 75 Stat. 688 (1961); and the *Susquehanna River Basin Compact*, Pub. L. No. 91-575, 84 Stat. 1509 (1970).

Underground water

In most cases, underground water allocation should be included in any water allocation strategy because of the hydrologic connection between underground and surface water. (Hayton and Utton, 1989) Until recent years, however, little attention was given to underground water and its conjunctive use with surface water, although it is very much an active issue in the development of water resources agreements in the Near East. (Dellapenna, 1994a; Dellapenna, 1997a; Dellapenna, 1997b) International law on transboundary underground water sharing is weak and poorly codified. (World Bank UNDP, 1995) "International competence over aquifers divided by the [U.S.-Mexico] frontier is largely undefined; it is fair to say that the legal and institutional situation is chaotic." (Utton and Atkinson 1979)

The unintended consequences of underground water withdrawals by one party on the other party are a special consideration. Excessive or unregulated underground water withdrawals by one party may deplete a jointly used aquifer and result in aquifer depletion that impacts the other party. Dewatering of wetlands within the shared river basin is a threat as is reduction of flows in streams, (Cherry and Badr, 1998) especially during drought periods. Land subsidence and degradation of water quality may result. In coastal areas, saltwater intrusion may disrupt water supplies for industrial and municipal uses.

*Maximum withdrawal rate.* This type of allocation strategy does not divide the water itself, but limits the rates of extraction by the parties. The significant advantage of this strategy is that it controls the rate of mining of underground water and may prevent one Party from depleting the aquifer before the other can make use of it. However, because no division of the water itself occurs, this method encourages each party to withdraw water before the other does. Consequently, the "maximum" rate becomes the actual withdrawal rate. This disadvantage will not arise if the withdrawal rates are less than or equal to the recharge rate. With regard to risk allocation, each party risks losing the opportunity to use the water unless it pumps at the maximum rate. (McCormick, 1994a) Maximum underground water withdrawal limits has developed in the 1973 addendum of 1944 *Treaty Between the United States and Mexico. Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande*, Treaty Series 994: 59, Stat.1219

*Planned Depletion.* Planned depletion is an economic strategy that has been proposed in which water is withdrawn from the aquifer at whatever rate is necessary to support economic efficiency as long as it is cost-efficient to do so without regard to the recharge rate of the aquifer. Under the strategy, once it is no longer cost-efficient to withdraw the water, other, unspecified, alternatives should be found. (Cummings, 1996) In a case where recharge is limited or nonexistent, the parties could agree that the underground water source is, in effect, a nonrenewable resource and divide the aquifer itself in terms of total withdrawal over a period of time. This method's significant advantage is that the parties need not compete against each other to be first to withdraw, at least to the extent noted in the previous paragraph. However, the parties may have an incentive to withdraw water as rapidly as possible to guard against the possibility that the estimate of the recoverable quantity is incorrect and to avoid having to pump the deeper water after the other parties have removed the shallower resources. By using this method, the parties each assume the risk that the estimate of resources is wrong and the last one to pump may either lose water or face increased cost. (McCormick, 1994; Hayton and Utton, 1989) Because this strategy is the antithesis of sustainability and would appear to embody the problems associated with the "tragedy of the commons," such a strategy over the long-term is ill advised.

*Hydrologic models.* Conceptually identical to hydrologic models for surface water allocation among the parties, this strategy involves modeling the inflow-outflow hydrogeologic characteristics of the aquifer and allocating water on an annual, seasonal or other time-based period. Parties share water according to schedules derived from the model. This technique is appropriate, however, only for those aquifers, such as the Floridan Aquifer in the southeastern United States that have relatively quick recharge. The method may be considered as being based on "sound science" although modeling poses a significant risk of being inaccurate. By using the method, the parties may divide risk of shortage any way they see fit, but the likely result is a division designed to reflect local, rather than basin-wide, variations in natural conditions.

*Comprehensive Basin Management.* This strategy uses the same principles and procedures as the similar model used for surface water.

Atmospheric Water

As a starting point for atmospheric water strategies, Policy Statement 275 of the American Society of Civil Engineers is instructive.

> *The American Society of Civil Engineers (ASCE) supports and encourages the protection and prudent development of atmospheric water (also known as "weather modification" or "cloud seeding") for beneficial uses. Sustained support for atmospheric water data collection, research and operational programs, and the careful evaluations of such efforts including the assessment of extra-area and long-term environmental effects, is essential for prudent development. ASCE recommends that the results and findings of all atmospheric water-management programs and projects be freely disseminated to the professional community, appropriate water managers and to the public.* (ASCE, 2003a)

ASCE developed materials providing guidance in the use of atmospheric water-management technology with weather modification organizations and recognizes that continued development of atmospheric water- management technology is essential. (Kahn, et al., 1995; ASCE, 2004) However, the essential difficulty in drafting a water sharing agreement with respect to atmospheric moisture is in determining whether precipitation inducement efforts by one party are actually responsible for any particular quantity of precipitation falling within the river basin.

*Payer Benefits.* In this strategy, the party that induces the precipitation may receive full credit for all such induced water supplies, up to a certain maximum amount. Thus, the party paying for the inducement efforts would receive the full benefit of that investment, encouraging further efforts to enhance precipitation. This method's disadvantage is that estimation of the additional increment of available water could be inaccurate. Risk is allocated solely to the party seeking to augment water supplies, as are the benefits. Any party that attempts to augment precipitation within the basin obtains the full benefit of those efforts, but also bears the entire cost. (Davis, 1995; Bomar, 2005)

*Undifferentiated Rainfall.* This strategy treats all induced precipitation the same as naturally occurring precipitation. The method then allocates water according to existing separate surface or underground water rights. Therefore, no dispute can occur over whether the precipitation was induced or not. Usually collective or governmental corporations as beneficiaries share the costs and benefits of inducing precipitation in proportion to their expected benefits. However, this method reduces the incentive to augment precipitation because the benefits of such investments are not allocated directly or proportionally to those who assumed the costs and risks. Rather, the benefits are spread among all parties and may require further allocation with another surface water allocation strategy. (Davis, 1995; ASCE, 2004)

Integrating surface, underground, and atmospheric water allocation

The realities of the hydrologic cycle suggest that any agreement should acknowledge the link between underground, surface, and atmospheric water. (Tsur, 1997; Hirji and Ibrekk, 2001; Dellapenna, 2003)

When the parties know and understand the connections between atmospheric, underground and surface water, they can make informed decisions on the allocation of risk. In these circumstances, the parties can treat hydrologically connected surface and underground water as if they were a single source. Problems arise, however, when the connections are unknown or when the assumed connection is wrong. Agreements should consider which Party has the risk of shortage in these circumstances. Some of the surface allocation methods avoid this problem, but these are not necessarily the best solutions in all circumstances. For example, underground water use may be unimportant when the agreement guarantees delivery of a given quantity at a specified point or when the quantity is guaranteed by the priority of a particular demand. Incorporating atmospheric water may cause additional uncertainty since there is likely a problem in proving that weather inducement efforts caused a particular increase in water quantity and then showing the location of that quantity within the hydrologic cycle of only one basin.

Allocating water resulting from supply augmentation

The construction of instream and offstream reservoirs, underground water storage, wastewater reuse, and diversions from outside the basin can augment local supplies. (Keyes, 1977; Hayton and Utton, 1989; Cherry and Badr, 1998; Asheesh, 2001) Water sharing agreements should contain provisions that determine how additional supplies are to be allocated. In addition, the parties may consider the equity of existing conservation programs and past expenditures on supply augmentation in the initial allocation negotiation.

Conservation measures can help provide additional supplies of water locally and modifies availability elsewhere in a river basin. (Draper, 2002) At the time of negotiating an agreement, the parties should consider whether their existing conservation programs are equal in scope. This may or may not be a major factor in the negotiation, depending on how the parties treat increased supplies from new conservation measures. In general, the party paying the cost of implementing a conservation practice should benefit from the increased supply. This principle would allow one party to pay for another party's conservation measures and receive additional allocation as a result.

**5.2 Adaptive management.**

Water sharing agreements should be formulated with built-in flexibility and need to allow for modifications in the role of these institutions over time to meet changing conditions and to address emerging issues. (Berlin, 1998) Such changing conditions may be the result of natural events, such as diminishing rainfall over a long period of time, or because of social factors, such as increased development in one part of a basin with demand greater than what was originally anticipated. (McCormick, 1994a) Adaptive management strategies might include: changing water allocation rules, increasing water use efficiency and long-term aspects such as crop breeding and selection of plants to exploit possible differences in rainfall, temperature and carbon dioxide concentrations. (Fort, 1998; Hassall et al., 1998). At the very least, provisions should be included in the agreement for periodic review. (Muys, 1971)

Adaptive management emerged in mid-1960s as a response to need for not just looking at the impact of decisions but also actually using science to help guide decision-making. (Light, 2002) Adaptive management of water sharing is essentially the application of the scientific method to the inherently complex and divergent goals and objectives of the parties. The scientific method is a process by which hypotheses on the nature of a physical event is developed from historical observations. The hypotheses are then tested against new observations of the event and the hypotheses altered as necessary to accommodate the new observations. By using this flexible model, the parties may establish specific objectives and develop hypotheses on the expected outcomes of the water sharing agreement. Monitoring programs may then be used to test whether existing management approaches are achieving those outcomes, and then agreement altered depending on the monitoring results. The key features of carrying out adaptive management in the natural resource context are (1) establishing the mutually agreed-upon objectives and outcomes water sharing agreement, (2) proposing a management regime designed to achieve the desired objectives; (3) developing hypotheses and experiments to test whether the proposed management regime is in fact achieving the objectives; (4) setting up monitoring and testing programs to carry out the experiments and test the hypotheses "on the ground;" and (5) adjusting the management regime in response to the information received from the monitoring and testing, if the outcomes turn out not to be as desired. (Neuman, 2001) An adaptive approach requires: flexible, adaptive policies (not rigid and locked-in policies); integrated approaches (rather than piecemeal approaches); planning and management for learning (not just for economic gains or social products); and experimentation and monitoring to test policies and identify necessary changes and responses (Hollings, 1978; Coleman, 1998)

Adaptive management techniques are increasingly being used, especially for environmental programs such as the *Cooperative Agreement for Platte River Research and Other Efforts Relating to Endangered Species Habitats Along the Central Platte River,* between Nebraska, and Wyoming and the Department of the Interior (Strickland et al., 2002). The 2000 National Marine Fisheries Service Federal Columbia River Power System (FCRPS) biological opinion uses adaptive management to specify a combination of improvements at federal dams, coupled with an offsite mitigation program to increase survival in other life stages. (Toole, 2002) Adaptive management is used to achieve the objectives of the CALFED Ecosystem Restoration Program Strategic Plan: (1) achieve recovery and increase populations of native species, (2) rehabilitate natural processes to favor native species with minimum ongoing intervention, (3) maintain and enhance populations of selected species for harvest, and (4) protect or restore functional habitat types throughout the watershed. (Cavello et al., 2002)

The technique may be expanded to consider more than environmental and ecological objectives. An adaptive management project for the Klamath River Basin by the USDA in has been undertaken by the U.S. Department of Agriculture. The objectives of the project include (1) decreasing the amount of water needed for agricultural, (2) increasing water storage, (3) improving water quality, and (4) developing fish and wildlife habitat. (USDA, 2003) The number of such programs is growing and includes major federally managed processes on the Everglades in Florida, the operation of the Colorado River Storage Project (especially Glen Canyon Dam) in Arizona, and the multi-state cooperative programs on the Rio Grande and Platte River Basins. (Dwyer, 2001)

### 5.3 Summary.

A large number of different water sharing strategies exists in theory. However, as the historical record reveals only a few general methodologies have been actually used. These methodologies are generally separated according to whether they apply to surface, underground, or atmospheric water. For surface water, six strategies have been applied in water sharing agreements: (1) priorities of use are set according to specific water demands, such as agricultural or municipal; (2) limitations are placed on water storage by upstream parties; (3) delivery of a specific quantity of water by the upstream party is mandated at a particular location on the shared resource; (4) the shared resource is divided among the parties according to a certain percentage of the flow; (5) hydrologic modeling of the outflows of the shared water is used to explain the flow of the river and to allocate water according to differences in flow under different precipitation regimes; and (6) comprehensive basin management in which an independent commission, under supervision and policy control of the states involved, allocates water according to a predetermined objective function.

Four strategies have been used that relate to underground water: (1) maximum withdrawal rates that limit the rates of extraction by the parties; (2) a strategy of planned depletion, an economic strategy in which water is withdrawn from the aquifer at whatever rate is necessary to support economic efficiency as long as it is cost-efficient to do so without regard to the recharge rate of the aquifer; (3) the hydrologic modeling as done for surface water; and (4) comprehensive basinwide management. Strategies for atmospheric water sharing include (1) allocation of additional flows resulting from induced precipitation in which the benefits accrue to the party that funds the precipitation inducement, and (2) a strategy that treats all induced precipitation the same as naturally occurring precipitation. In most respects, however, the realities of the hydrologic cycle suggest that any agreement should acknowledge the link between underground, surface, and atmospheric water. All agreements should adopt the principles of adaptive management.

## APPENDIX 1

## GLOSSARY

**Allocation**: the act of distributing water by allotting or apportioning a share of the resource among users according to a rational plan or program.

**Aquaculture**: the commercial raising of fish.

**Aquifer**: a subsurface, water bearing, geologic formation from which significant quantities of water may be extracted.

**Atmospheric Water:** all available moisture above the surface of the earth, including ground and water surface and all forms of precipitation but not including water projecting from irrigation systems.

**Beneficial use**: water use that has value. This value can be derived economically, as in the use of water to produce some financial benefit, or the use has been specifically acknowledged by the political process as having public value, as in wetland replenishment for ecological reasons.

**Climatology**: the study of the earth's atmosphere over extended periods of time.

**Consumptive use** is defined as that portion of the water withdrawn from the shared resource that is not available for use to meet water needs immediately downstream or in the immediate area down gradient, either because water is not discharged (by return flow) into a water source at or near the point of withdrawal or because the biological, chemical or physical quality of the water is sufficiently impaired to prevent further use.

**Depletion**: withdrawal of water from an aquifer at a rate faster than its recharge rate.

**Drought**: condition of abnormal water scarcity in a specific area, resulting from natural conditions.

**Ecology**: scientific study of the interrelationships of plants, animals, and the environment.

**Environment**: the surroundings of an individual organism or a community of organisms, ranging up to the entire biosphere, the zone of Earth that is able to sustain life.

**Equitable**: fair; just; according to the principles of justice. An equitable settlement of a dispute is fair to both sides.

**Extraction of atmospheric water**: removal of water from the atmosphere; precipitation induced by non-natural causes.

**Flood**: inundation of normally dry land resulting from the rising and overflowing of a body of water.

**Geology**: study of the composition of Earth materials and the various geological processes in order to locate and exploit Earth's mineral resources.

**Hydrology**: The study of water moving over and through the land and its temporary storage on or within the ground.

**Instream use**: use that does not withdraw water from the watercourse. Examples include navigation, generation of hydroelectric power, maintenance of water quality, provision for fish and wildlife habitat, and fulfillment of aesthetic goals.

**Integrated**: coordinated.

**Integrated water resources management:** a water management process that integrates the assessment, management, protection, and utilization of all water resources within a basin to meet the needs of humans on a sustainable basis but still protect the integrity of the resource and its associated ecosystems.

**Interbasin transfer**: transfer of quantities of water from one water basin to another.

**Interstate compacts**: agreements between or among sovereign political entities.

**Legal duty**: legal obligation

**Meteorology**: study of the Earth's atmosphere and the variations in temperature and moisture patterns that produce different weather conditions.

**Nonconsumptive use**: use that either does not withdraw water from the water source (see instream use) or that returns a portion of the water to its point of origin after use.

**Obligation**: activity or conduct a person is bound to do or bound not to do; a moral of legal duty. Penalties may be imposed upon people who fail in their obligations.

**Physiology**: the branch of biology dealing with the functions of living organisms and their components.

**Political entities**: sovereign government, or any political sub-division thereof.

**Reasonable use**: rational use of water which may have an effect on the quantity or quality of watercourse but which does not cause unreasonably harm to another's reasonable use.

**Riparian**: being geographically adjacent to a watercourse.

**Runoff**: water from precipitation that moves across the surface; the difference between precipitation rate and evapotranspiration and infiltration rates.

**Safe yield**: the condition in an aquifer in which the withdrawal rate equals the rate the water replenishment by natural means.

**Sovereign**: an independent entity that governs itself.

**Spatial**: having to do with geographical space.

**States**: usually a sovereign nation; may be a sovereign political sub-division of a nation organized on a federal system.

**Surface water**: water existing on the surface of the earth, as streams, rivers, ponds or lakes.

**Sustainable**: condition that will endure for the foreseeable future, absent some unexpected event.

**Temporal:** having to do with time, such as the time of day, month, or season.

**Transboundary**: moving across or along political boundary separating two or more sovereign governments.

**Underground water:** water contained within an aquifer.

**Waste assimilation**: dilution of effluents from sewage by water.

**Water demands and uses**: activities that use water to fulfill their purpose.

# APPENDIX 2

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