ECONOMIC VALUATION OF IMPACTS TO BENEFICIAL USES OF WATER QUALITY IN CALIFORNIA. PROPOSED METHODOLOGY

by

Rafael J. Maestu

A Thesis Presented to the
FACULTY OF THE GRADUATE SCHOOL
UNIVERSITY OF SOUTHERN CALIFORNIA
In Partial Fulfillment of the
Requirements for the Degree
MASTER OF ARTS
(ENVIRONMENTAL STUDIES)

December 2002

UMI Number: 1414848

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UNIVERSITY OF SOUTHERN CALIFORNIA
THE GRADUATE SCHOOL
UNIVERSITY PARK
LOS ANGELES, CALIFORNIA 90007

This thesis, written by

Rafael Javier-Maestu

under the direction of his Thesis Committee, and approved by all its members, has been presented to and accepted by the Dean of The Graduate School, in partial fulfillment of the requirements for the degree of

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Dean

Date 6 SEP 02

THESIS COMMITTEE

Chairman

DEDICATION

To my family.

ACKNOWLEDGEMENTS

I wish to thank the Los Angeles Regional Water Quality Control Board and the California State Water Resources Control Board staff for their assistance and resources in the preparation of this thesis. Without their guidance, I never could have understood the principles and regulations that protect water quality in California. My years of experience working at the Los Angeles Regional Water Quality Control Board and at the State Water Resources Control Board have been the best preparation in understanding water quality and water quantity issues.

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ABSTRACT

Regional Water Quality Basin Plans in California protect the beneficial uses of water quality. Beneficial uses of water quality provide goods and services that can be estimated in monetary terms. Assessing the economic value of beneficial uses of water quality is necessary for enforcement, as well as, for setting priorities for water quality protection and preservation. The economic theory proposes several methods to assess the monetary value of the goods and services provided by water quality. A simpler methodology must be made available to regional board staff.

In an ideal world, economic values would be defined for beneficial uses of water bodies in regional basin plans. The current state of the art in economics and water pollution science, however, is not easily applicable for watersheds in major urban areas. This study proposes a methodology for estimating the economic damages of water pollution.

PART I

INTRODUCTION

1. Purpose of the Study

The beneficial uses water quality described in California Regional Basin Plans have an economic value. This value should be recognized, identified, described, estimated and incorporated into the water quality standards.

The nature of water makes it suitable for multiple uses and purposes including consumptive and recreational uses. Water is a public good and an economic good. As an economic good, it must be managed efficiently, and, as a social and public good, some level of government intervention is required to guarantee that all the users and uses reach an adequate level of protection.

Water is a highly valued resource in California. As the population of the state continues to increase, the competing demands for this resource continue to grow. California's increasing population is a driving factor in future water management and planning. If the needs of society relative to water are to be satisfied, it is obvious that water resources must be managed wisely.

Clean water is central to Californians' quality of life. From the surfers of Santa Cruz to the sunbathers of Santa Monica, Californians look to high water quality as essential. Despite this concern, however, California's waterways are some of the most polluted in the country. Nearly 500 California lakes and rivers are considered polluted and not fit for some uses, including fishing or swimming.

(California beach closings increased 63% from 1999 to 2000) and stormwater pollution continues to dump thousands of tons of chemicals, motor oil and fecal matter into our waterways every year (Green Watchdog, 2002).

The most recent assessment of California's water quality revealed that a large percentage of waterbodies throughout the state are either impaired or in danger of becoming impaired (SWRCB, 1999). The leading sources contributing to the degradation of California's water quality are agricultural runoff, forestry activities, storm water runoff, storm sewers, and unspecified non-point sources (U.S. EPA, 2000).

In managing water resources, water quality especially should be considered for protection. Water quality affects and is affected by economic activities, public health and ecosystems. Water quality can be directly linked to value. Better water quality provides more services, therefore higher water quality equates to higher value.

Water quality and water quantity both play a significant role in the usability and availability of the resource. Water quality is often seen as one of the dimensions of a particular water demand, along with quantity, location, and timing (Gibbons, 1986). Different water uses require different availabilities of the resource, different qualities and quantities. Different water uses also result in varying degrees of water quality degradation. Therefore, quantity and quality of water must be taken into consideration in protecting and regulating water resources.

Many organizations and institutions manage water in California. It is estimated that more than 1,000 public and private agencies share responsibility for the administration of California's water resources (Goodall, 1978). Different organizations focus their role on water quality, quantity or both from the local, state and federal perspective. (See Appendix A.)

For example, in the Los Angeles region, responsibility for protecting water quality of surface and ground waters lies with a number of agencies. With many different uses and benefits, these waters are subject to local, state and federal laws and regulations. Many of the beneficial uses to be protected are described in the Los Angeles Basin Plan (Los Angeles Regional Water Quality Control Plan). In the Basin Plans the quantity and quality of water play a major role in determining the suitability of the water for the various beneficial uses.

Basin Plans describe and assign the beneficial uses of waterbodies. Basin Plans do not include a qualitative or quantitative evaluation of the beneficial uses assigned to specific waterbodies. Basin Plans do not assign values, quantitative, qualitative or monetary to the various beneficial uses of a waterbody.

However, a valuation of the existing beneficial uses of each watershed is necessary, in order for policy makers and regulators to set priorities under circumstances of scarce resources, prepare and design policies, assign resources, take enforcement actions, and assure compliance.

The purpose of this study is to discuss the need and methods available to calculate the economic value of the different beneficial uses for waterbodies described in California Regional Water Quality Control Plans. A presentation of the existing literature on water management in California and methods to calculate environmental values will be followed by a discussion of the viability of calculating the economic value of the beneficial uses of water, using a variety of methods. This study contributes to the effort of environmental protection and conservation by proposing a methodology in which available information is used to develop estimates of damage to beneficial uses derived from a reduction in water quality.

The purpose is to analyze the methods available to calculate the damage to the (economic) value of the beneficial uses described for a specific waterbody in the Regional Basin Plans, rather than calculate the total economic value of water quality.

The proposed methodology will attempt to estimate the economic damage to beneficial uses derived from pollution discharges. An estimation of damage to beneficial uses would be done in monetary terms, if possible. For enforcement purposes, the traditional focus lies in determining whether a negative impact to the economic value, a damage to beneficial uses exists or not, rather than estimating the dollar value of the damage caused by pollution.

Enforcement literature justifies the estimation and assessment of economic value of natural resources, especially for enforcement purposes (Cohen, 1999). One example is the "Polluter Pays Principle" (PPP). The Polluter Pays Principle was widely discussed in the United Nations Conference on Environment and Development held in Rio de Janeiro of Brazil in June 1992. The PPP is based on the theory that there is an opportunity cost for the users of the environment, as a sink for wastes, and that there are beneficial uses lost from the reduction in water quality. These costs are not included in the decision-making process leading to suboptimal allocation of natural resources. Therefore, to maintain economic efficiency the gainers must, at a minimum, compensate society for the value of the beneficial use lost.

Water institutions responsible for the management of water quality and water quantity, often need to assess the damage caused by a polluter to determine the compensation level that will internalize the cost maximizing the economic efficiency criteria, in which the marginal rate of substitution equals the marginal rate of transformation. The economic efficiency criteria for allocation of attributes of natural resources will be discussed in Part II.

The goal of this paper is to propose an estimation of environmental values at a local scale that will help the regulator in assessing the penalties imposed to legal and illegal polluters. Because, different amounts and types of pollutants will impact the beneficial uses of water quality in a different form for each waterbody, an explanation of the dose-damage function is required. An assessment of the impact or impairment of the beneficial uses from lower water quality must be analyzed. An identification of potential losers and winners derived from pollution control regulations must be performed, and an estimation of the total economic cost or benefit to the society must be assessed. The calculation of losses may be used to compensate individuals or the society as a whole.

The specific objectives of the study are to:

- Describe the California system of water management, water quantity and water quality.
- Indicate the importance of the economic value of the beneficial uses of water.
- Introduce the methods available to estimate economic value of beneficial uses of water quality.
- Indicate the importance of assigning values in managing the environment.
- Propose a methodology to estimate the economic value of the beneficial uses of water quality in California, based on the benefit transfer method.
- Introduce models that explain the relationships among the level of pollutants and the damage to beneficial uses. (Dose-damage relationship.)
- Make estimations of the economic value of damages to beneficial uses in the Los Angeles river watershed based on the proposed methodology.
- Identify the kind of data needed to analyze the links between beneficial uses and their value.
- Identify the services provided by an ecosystem that are of value to society, the methods that should be used to measure this value, and the terms in which they should be expressed.
- Understand how ecosystems function and how they are affected by human activity by linking water quality, the impact from pollution that reduces the value of those beneficial uses, and the chemical, biological and physical characteristics of water that support those beneficial uses.

2. Description of California's Water Quality Control System

There are many water institutions in California that regulate the quantity and quality of water. Many of their roles and responsibilities overlap, and efficiency is lost. The complexity of the system is apparent when we try to understand the roles of various Federal, State and local agencies. (See appendix A for a more extensive analysis of California water institutions.)

Water is one resource, with many uses and users, basic for life and for the sustainability of our environment. Protection and efficient use of the resource should be the main concern of our institutions. The system should look to experiences of institutions that manage the resource as one integrated system. Quality and quantity of water are directly interrelated. Both form part of the same environmental system and cannot be managed independently

Water management institutions should incorporate an integrated approach focusing on the watershed as the unit of action, and the basin for the set of priorities and the development projects. As Holly E. Stoerker recommends (in Reuss ed., 1992). "An integrated natural system approach is necessary, one that reflects the dynamic interdependence of hydrologic, ecological, and biological systems and emphasizes the relationship of water to the landscape." Water institutions in California are too fragmented and to narrowly specialized in one segment of the same process such that reaching agreement on proposed solutions, to water quantity and quality problems, is very ineffective.

Water management institutions must coordinate their efforts, and adapt their institutional structure to reach an equilibrium in water use efficiency, equity of distribution among users, quality and protecting for the environment.

Water Regulations in California are the Most Advanced in the Nation

California possesses a unique system for the protection and control of its most valuable resource. The present system of water quality control was established in 1969, with the adoption of the Porter-Cologne[1] Water Quality Control Act. Found in Division 7 of the California Water Code (CWC), the Porter-Cologne Act provides for ten water quality control agencies, the State Water resources Control Board and nine Regional Water Quality Control Boards.

The State Board sets statewide policies and develops regulations for the implementation of water quality control programs mandated by state and federal water quality statutes and regulations. The California Water Code instructs the boards to preserve and enhance water quality for present and future generations. The Regional Water Quality Control Boards (RWQCB) establish and employ their water quality protection authority through the adoption of specific Water Quality Control Plans (Basin Plans). California Basin Plans go beyond the requirements of the Clean Water Act by establishing water quality standards for both surface and ground waters. Basin Plans consider regional beneficial uses, water quality characteristics,

[1] Porter and Cologne were the authors of the Code

and water quality problems (Water Quality Control Plan, Los Angeles Region, 1994).

The California Water Code assigns the State Water Board and the nine Regional Boards to develop and establish the water quality standards, as is required in the Federal Clean Water Act (CWA), Section 131.4; "States are responsible for reviewing, establishing, and revising water quality standards..." The United States Environmental protection Agency (USEPA) has delegated to the State of California the responsibility for implementation of portions of the CWA to the State and Regional Boards, including water quality planning and control programs, such as the federal National Pollutant Discharge Elimination System (NPDES) program that regulates any discharge to navigable waters of United States (surface waters). The Code of Federal regulations (Title 40, CFR) and USEPA guidance documents provide direction for implementation of the CWA (Los Angeles Basin Plan, 1994). It is therefore the responsibility of both the State and Regional Boards to implement and manage the Clean Water Act that regulates the quality of surface waters[2]. The states, with approval of the USEPA, designate beneficial uses of their waters, the water quality standards necessary to support their use, and the amount of pollutants that may be discharged consistent with the designated uses. Water quality standards, their description and their application will be discussed in Part III.

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[2] Surface waters are considered waters of United States, Ground water is considered as water of the State of California. As a rule of thumb all waters of United States are Waters of the State, but not all waters of the State are waters of United States.

The federal Clean Water Act (CWA), passed in 1972 and amended in 1977, heralded the true beginning of the federal government's effort to reduce pollution and improve the quality of the Nation's waters. The CWA was designed to restore and maintain the chemical, physical, and biological integrity of waters of the United States (Thompson, 1999). The goal of the CWA was to make the Nation's waters fishable and swimmable by 1983. The main thrust of the 1972 act was control of point source pollution. Point sources of pollution are discrete, identifiable sources such as tanks, pipes, or ditches and are primarily associated with industries and municipal sewage plants. The CWA says wastes cannot be discharged into surface waters without a NPDES permit. The NPDES permit specifies the types and amounts of pollutants that may be discharged. Water quality is evaluated through monitoring programs run by the states. Water quality is assessed biennially and the data are submitted to the USEPA in accordance with section 305(b) of the CWA.

The NPDES program has been very successful in identifying and regulating point source dischargers, but enforcing all permit requirements remains a distant goal. USEPA 305(b) reports measure the program's progress. Nationwide controls on industrial pollution in 22 industries have reduced releases of toxic organic pollutants by 99 percent, or nearly 660,000 pounds per day, since 1972. Releases of heavy metals have been reduced by 98 percent, or 1.6 million pounds per day (Thompson, 1999).

The CWA makes several references to the estimation of the uses and the value of water quality, although it does not specify that the value of water should be determined by requiring a quantitative or qualitative evaluation. Section 131.2 of the Clean Water Act states that "Water Quality Standards, should, wherever attainable take into consideration the use and value of public water supplies, propagation of fish, shellfish and wildlife, recreation in and on the water and agricultural, industrial, and other purposes including navigation."

However, in defining water quality standards, Basin Plans in California only identify beneficial uses and not their value, as is required in section 131.2 of the CWA. Therefore, Basin Plans should include a description of the value of beneficial uses when defining water quality standards.

Section 303(c) of the federal Clean Water Act requires the state of California to establish water quality standards for a waterbody or portion thereof by designating the use or uses to be made of the water and by setting criteria necessary to protect the uses. States adopt water quality standards to protect public health or welfare, enhance the quality of water and serve the purposes of the Clean Water Act. Each Regional Board establishes the water quality standards for each waterbody in its region. The water quality standards are defined and identified in each regional Basin Plan.

The term "water quality standards" is defined in the Clean Water Act §130.2(c) and §131.3(I)[3] as:

> Water quality standards are provisions of state or federal law which consist of a designated use or uses for the waters of the United States and water quality criteria for such waters based upon such uses. Water

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[3] 40 Code of Federal regulation (CFR) Sections 130.2(c) and 131.3(I)

> quality standards are to protect public health or welfare, enhance the quality of water and the serve the purposes of the Act."

Beside the state and federal laws, several court decisions are applicable to the protection of water quality. For example, the 1983 Mono Lake Decision (National Audubon Society v. Superior Court [1983]) reaffirmed the public trust doctrine, holding that the public trust is "an affirmation of the duty of the state to protect the people's common heritage in streams, lakes, marshlands, and tidelands, surrendering that right of protection only in rare cases when the abandonment of that right is consistent with the purposes of the trust." Public trust encompasses uses of water for commerce, navigation, fisheries, and recreation. (LA Basin Plan, 1994).

3. Why is an Economic Valuation of the Beneficial Uses of Water Quality Necessary?

Beneficial uses have an economic value for society and individuals. This value is in most cases, ignored or unknown. This may lead to inadequate management decisions taken by individuals, industries and institutions.

By definition, beneficial uses of a waterbody provide goods and services of value to humans, this means they must provide a positive net present economic benefit[4] that may be estimated. The beneficial uses of water contain both a qualitative and quantitative form of value. Mere recognition that environmental values exist is insufficient, particularly when they are significantly endangered. To

[4] Who benefits and other distribution effects are not the subject of this study.

manage beneficial uses properly, their positive environmental values must be estimated. In the definition of management, we want to make clear reference to the protection and control of the different uses.

Decisions concerning the environment always involve benefits and costs, some with monetary values and some without. Ideally, decisions are made where benefits outweigh the costs. Where environmental resources are affected by the decision, monetary values need to be weighed against non-monetary values.

Benefit-cost analysis of regulations is a common method for estimating the economic impact of regulatory measures. Benefit cost analysis is used in a broad variety of circumstances, most of them related to a specific project or analysis of specific impact of a regulatory measure. Therefore, benefits and costs must be evaluated independently considering all the potential circumstances and scenarios available (Boardman et al, 1996 and Hanley and Spash, 1993).

Economic Valuation Required by Law

During the late 60's there were growing concerns regarding the adverse effects of public works projects on environmental quality. It was recognized that environmental consequences were not integrated into benefit-cost analyses and that only some aspects of economic efficiency were considered. As a result of these concerns, the US National Environmental Policy Act of 1969 (NEPA) was enacted, requiring environmental impacts to be integrated into all federally funded project planning and decision making. Environmental impacts were considered in a separate process from the economic analysis, namely, the Environmental Impact Statement process (Freeman, 1993).

The integration of projects' environmental effects into the economic analysis was introduced with the Comprehensive Environmental Response Compensation and Liability Act of 1980 or the superfund law (CERCLA, 42 U.S.C. 9601-9676 and 26 U.S.C. 4611, 4612, 4661, 4662, 4681, and 4682). This law gave government agencies the right to sue for damages to natural resources as a result of discharges of hazardous substances. The nature of this law required that environmental impact be quantified monetarily.

Following the Exxon Valdez spill in Alaska, the Oil Pollution Act of 1990 introduced damage recovery requirements to reduce oil spills (Freeman, 1993). Section 307 of the Clean Water Act (33 U.S.C. 1251 et seq.) requires USEPA to set effluent limitations for discharges of toxic pollutants to surface waters considering the application of the best available technology economically achievable (BATEA) that "will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants" [section 301(b)(2)(A).]

In 1981, President Reagan issued Executive Order 12291 requiring agencies to perform Regulatory Impact Analysis (RIA) for all proposed projects or policies that would have an impact of $100 million or more on the national economy. USEPA published guidelines in 1983 describing the application of the directives to Federal regulator agencies and summarized the requirements for RIA including the quantification of costs and benefits.

In 1993, President Clinton issued Executive Order 12866 on Regulatory Planning and Review which revoked and replaced Executive Orders 12291 and 12498. Order 12866 emphasizes the importance of accounting for potential economic benefits associated with the environment, public health and safety, as well as distributive impacts and equity (Schierow, 1994).

Economic Valuation Required for Compliance and Enforcement Purposes

Economic valuation is especially important in assuring compliance of dischargers with limits and prohibitions, by enforcing the laws and regulations that protect water quality. Economic valuation of damage to the environment is of particular relevance while taking enforcement actions. It helps the agency to justify the level of penalties, leveling the playing field among industries and regions and deterring polluters from polluting, and assists in the assessment of impacts and the impairment of those beneficial uses affected by pollution.

Estimating the value of the damage to the environment in monetary terms is required in many pieces of federal and state legislation that govern the protection of the quality of surface waters in California.

Surface waters in California are considered waters of United States and therefore subject to the jurisdiction of Federal laws. There are several federal statutes allowing for natural resource trustees to claim damages for injury to, or loss of use of natural resources. The main federal statutes are the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), the Federal Water

Pollution Control Act (Clean Water Act), the Trans-Alaska Pipeline Authorization Act (TAPAA) and the Oil Pollution Act of 1990 (OPA)[5]. Under all of these statutes, damage claims consist of three primary components: the cost of projects to restore injured natural resources, the value of lost use of resources during the injury period, and the cost of doing the assessment. CERCLA incorporates provisions for compensation of public resource values both temporarily and permanently lost as a result of toxic waste sites and hazardous materials spills. The Federal and State governments are viewed as "Trustees" that manage the public owned wildlife and fisheries on behalf of the citizens.

The State of California in the California Water Code requires that a number of factors must be considered in determining liability for violations of sections 13385 (h) and (i) (discharge of pollutants to waters of United States). Reviewing, documenting and analyzing each factor precedes the issuing of the complaint by the RWQCB Executive Officer.

California Water Code section 13385 (e), governing Administrative Civil Liability (ACL) amounts for violations subject to the CWA, requires consideration of different factors stating that:

> The regional board, the state board, or the superior court, as the case may be shall take into account the nature, circumstances, extent, and gravity of the violation or violation of the discharge, and, with respect to the violator, the ability to pay, the effect on its ability to continue its business, any voluntary cleanup efforts undertaken any prior history of violations, the degree of culpability, economic benefit or savings, whether the discharge is susceptible to cleanup or abatement, the degree of toxicity, if any resulting from the

[5] The OPA was written, in part, as a response to the EXXON Valdez oil spill.

> violation, and other matters that justice may require. **At a minimum, liability shall be assessed at a level that recovers the economic benefits, if any, derived from the acts that constitute the violation.**[6]

In addition, the recently approved State of California "Water Quality Enforcement Policy" [7] lists the factors that must be taken into consideration in the assessment of the monetary amounts of Administrative Civil Liabilities imposed for violations of the California Water Code. Among the factors to consider in the penalty assessment, the Policy pays particular attention to what it calls: the "Beneficial Use Liability". The Beneficial Use Liability is described as:

> Review the designated beneficial uses of the receiving water and determine whether the violation has resulted in any quantifiable impacts related to beneficial uses. Quantitative information may only be available for a limited number of impacts such as beach closure days, but where readily available the RWQCB should consider it. If possible, estimate the dollar value of any impacts of the violation on beneficial uses of the affected waters (California Water Quality Enforcement Policy, 2002).

The key element in incorporating the damage to the beneficial uses is really the definition of "where readily available." Therefore, basin plans should make the estimation of the damages: "readily available."

The damage to beneficial uses of water quality is difficult to estimate and therefore difficult to incorporate into the penalty calculation. The negative impact on the value of beneficial uses due to pollution is never zero, but it cannot be considered, if it is not assessed. The economic value of beneficial uses, although positive, is difficult to estimate. Regional Board staff does not have the resources or

[6] Emphasis added.
[7] The Water Quality enforcement policy was adopted during the February 19, 2002 California State Water Resources Control Board (SWRCB) meeting.

the skills to perform the estimation of the monetary values of the damages and the values are not properly described or assigned in their respective Regional Basin Plans. Therefore, the requirement of the enforcement policy to incorporate the estimation of the damages becomes a difficult task. This study attempts to facilitate the task of estimating the value of the damages by proposing a methodology for applying the benefit transfer approach and shadow prices. This allows the Regional Board staff to perform a preliminary estimation of the damages caused by pollution, by making the values of beneficial uses "readily available".

We could consider the incorporation of the dollar value of any impacts into the penalty calculation, as an innovation to enforcement and compliance of the water quality of surface waters. The incorporation of the value of the damage to the environment, or to the beneficial uses, is not common in the liability assessment. For example, the Civil Penalty policy for section 311(b) and (j) of the Clean Water Act, consider the penalty assessment to be based on the following factors:

- The seriousness of the violation or violations.
- The degree of culpability involved.
- The nature, extent, and degree of success of any efforts of the violator to minimize or mitigate the effects of the discharge.
- Any history of prior violations.
- Any other penalty for the same incident.
- Any other matters as justice may require.

- The economic impact of the penalty on the violator.
- The economic benefit to the violator, if any, resulting from the violation.

The damage to the environment among these factors is not included, although the policy is open to its consideration under "any other matters as justice may require." Again, the inclusion of the calculation of the beneficial use liability in the California State Water Resources Control Board Water Quality Enforcement Policy in the Administrative Civil Liability amount calculation is an important step to reaching the adequate level of deterrence from the regulated community.

The term "Liability" used in the California Water Code has a different meaning from the concept of "penalty". For example, the California Supreme Court has held that "liability" operates to compensate the people of the State and is not punitive [8]. So liabilities should be used to compensate the people, the users or the public in general for damages caused to beneficial uses, that may have impaired or limited the use of the assigned beneficial uses. Similar approaches can found at the federal level. For example, the civil penalty policy for sections 311(b) and (j), of the Clean Water Act[9] states that "Civil penalties reduce the likelihood of a spill by providing an incentive to the violator and to other members of the regulated community to comply with the Act's requirements, help replenish funds that are used to clean up the environment, and provide a level of playing field for businesses that meet their obligations under the law."

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[8] People ex rel. Younger v. Superior Court of Alameda County (1976) 127 Cal.Rptr. 1222, 544 P.2d 1322.

[9] Civil Penalty Policy for section 311(b)(3) and section 311(j) of the Clean Water Act. Office of Enforcement and Compliance Assurance August 1998

California Water Code recommends when possible, the estimation of the monetary value of the damage to the services and goods provided by beneficial uses (beneficial use liability) when possible, and incorporates it into the total liability amount. Knowing the economic value of the beneficial uses impacted will help to consider the gravity factor of the calculation. Knowing the value of a potential civil liability derived from exceeding the allowable limits promotes a higher level of compliance and deters dischargers from future violations. Bringing firms into compliance is the main purpose of enforcement, like monitoring programs of NPDES permits. Measuring the effectiveness of monitoring and enforcement of environmental policy in deterring individuals and firms from violating environmental laws or achieving an improved level of environmental performance, has not been the focus of many empirical studies (Cohen, 1999). In general, studies show that both increased government monitoring and increased enforcement activities result in reduced pollution and/or increased compliance (Cohen 1987, 1999).

By incorporating the beneficial use liability into the liability calculation, as required in the recently approved enforcement policy, it is expected to improve the level of deterrence and therefore contribute to protecting the beneficial uses of water quality.

Economic Valuation Required for Natural Resource Damages Compensation

Dischargers found liable for Natural Resource Damages (NRDs) face three primary damage components:

- Cost of resource restoration to baseline conditions (in some cases the acquisition of equivalent resources can be used as a substitute for restoration).
- Compensation for interim losses (that is the lost value of injured resources pending full restoration).
- The cost of the damage assessment.

In practice, the determination of compensating remedies can be quite difficult; determining appropriate levels of on-site physical restoration is complex, given the technical challenges associated with restoration and the need to estimate baseline conditions against a background of natural variability. In many cases, however, off-site restoration must also be part of the remedy. This requires some valuation-based comparison of natural resource services across different types of natural resource services. Numerous challenges are associated with this kind of comparison. Monetary valuation is one way to make such comparison.

PART II

THEORIES AND METHODS OF ECONOMIC VALUATION OF BENEFICIAL USES OF WATER QUALITY

1. Introduction to Environmental Valuation: Water Quality as an Economic Good

Environmental valuation can be defined as the procedures for valuing changes in environmental goods and services, whether or not they are traded in markets, by measuring the changes in the producer and consumer surpluses associated with these environmental goods (Tietenberg, 1992). Environmental valuation follows from the idea that effects on human welfare are the basis for deriving measures of the economic value of changes in the value of goods and services that the environment provides. This is an anthropocentric vision of the value of the environment.

Water is an economic good because it provides goods and services that have a value to humans. Water has many competing uses. Many times water is a public good and cannot be appropriated as individual property. Therefore, public intervention is required to guarantee the efficient use of the goods and services provided. The International Conference of Water and Environment (held in Dublin, Ireland in January 1992) included the following principle among the four known as the "Dublin Principles for Water:" "Water has an economic value in all its competing uses and should be recognized as an economic good" (ICWE, 1992). Following the

Dublin meeting, the first United Nations Conference on Environment and Development (held in Rio in 1992) clearly recognized that economics must play a part in efficient water management, by stating "Integrated water resources management is based on the perception of water as an integral part of the ecosystem, a natural resource, and a social and economic good…" (UN Agenda 21, Chapter 18.8).

Water is also a public good. After air, water is the natural resource that behaves most like a public good. A public good cannot be assigned clearly defined and enforceable property rights. An efficient structure of property rights that could produce efficient allocations in a well functioning market economy has four characteristics (Tietenberg, 2000):

1. Universality – All resources are privately owned, and all entitlements completely specified
2. Exclusivity – All benefits and costs accrued as a result of owning and using the resources should be accrued by the owner, and only by the owner, either directly or indirectly by sale to others.
3. Transferability – All property rights should be transferable from one owner to another in a voluntary exchange.
4. Enforceability – All property rights should be secure from involuntary seizure or encroachment by others.

These characteristics assume that an owner of a resource with a well defined property right has a powerful incentive to use resources efficiently because a decline in the value of those resources represents a personal loss. The economic value of an environmental system can be defined as the sum of the discounted present values of the flows of all goods and services provided (Freeman, 1993). Changes in environmental quality can affect individual welfare through any of the following four channels: changes in the prices they pay for goods bought in markets; changes in the prices they receive for their factors of production; changes in the quantities or qualities of nonmarketed goods (i.e. public goods); and changes in the risks individuals face (Freeman, 1993).

This part discusses the economic rationale behind environmental valuation and introduces the different methods available to estimate the value of beneficial uses of water quality.

2. Review of Economic Theories on Valuation of Environmental Resources

The Economic Concept of Value

There is no objective concept of value. Economists make assumptions about what value means to people. One of the basic premises of welfare economic is that the purpose of economic activity is to increase the well-being of the individuals who make up the society (Freeman, 1993). This anthropocentric approach to value is the basis for deriving measures of the economic value of changes in resource environmental systems.

The value of goods and services respond to a neoclassical demand function in which the quantities of goods and services consumed depend on the price, the level of income and the individual preferences. In neoclassical welfare economics, good is defined in terms of the well-being of individuals. Individual well-being can be represented by an ordinal utility function (Freeman, 1993). The basis for deriving measures of the economic value of changes in water quality is their effect on human welfare. The value of the goods and services can be assessed directly or by estimation techniques that identify the consumers' willingness to pay for the goods and services or willingness to accept compensation for the damage.

In one formulation, economic value is defined by the maximum a person is willing to pay or "WTP", for something they do not have, or the minimum a person must receive to feel fully compensated for the loss of something called willingness to accept compensation or "WTA" (Gleick *et al.*, 2002). Economists assume that benefits can be derived from the demand curve for the good or service provided by the environmental resource (Tietenberg, 1992). Total willingness to pay (WTP) is the concept we shall use to define total benefits received from a resource. Thus total benefits are equal to the area under the market demand curve from the origin to the allocation of interest (Tietenberg, 2000).

Environmental Valuation and Values

An extensive literature exists on environmental values and valuation methods. Description of environmental values can be done in qualitative or quantitative terms. Qualitative assessments of environmental values allow us to compare different resources and help us assign the adequate level of protection to each resource. Quantitative assessments allow us to justify and claim monetary remedies to pollution (penalties, liabilities or cost of clean-up). The financial or economic damage caused by pollution is often called an externality. These costs are not "internalized" in the economic decision process of an individual actor, but instead are borne by others. An economic optimum cannot be reached without including the cost of the damage to the services that the environment provides (Baumol and Oates, 1988).

But the assessment of the value of the services provided by the environment is a difficult task. Indeed assessing the value of ecological systems in monetary terms represents a challenge to economists, but not an impossible one. Robert Costanza, the founder and first president of the International Society for Ecological Economics explained: "some argue that valuation of ecosystems is either impossible or unwise, that we cannot place a value on such "intangibles" as human life, environmental aesthetics, or long term ecological benefits. But in fact we do so every day, when we set construction standards … because spending more money in construction can save lives" (Costanza *et al.*, 1991).

There are several ways of integrating environmental values into the decision making process, most of them include a quantitative (monetary and non-monetary) and/or qualitative estimate of those values. Benefits and costs, impacts and damages can be estimated in terms of a description of the environmental value affected and under other circumstances it is possible to reach estimates of monetary benefits and costs. Among environmental economists, there is an emphasis on differentiating among monetary and non-monetary values of the environment. Both are economic values and are subject to quantitative and/or qualitative assessments. The political process may incorporate the values that the environment represents to society in the political process in several ways. The following table attempts to describe the options available.

Table 1: Ways of Integrating Environmental Values Into Decisions

Ways of integrating environmental values into decisions	
Omit them	Consider only monetary values and risk taking decisions which disadvantage society
Recognize them	Make no attempt to value or integrate them into decisions
Describe them	Present a descriptive list alongside a list of monetary values
Make a qualitative comparison	Describe the non-monetary effects and compare them with the monetary. (Monetary benefits > non-monetary costs, monetary costs < non-monetary benefits)
Make a quantitative non-monetary assessment	Assess and record effects in non-monetary units
Make a quantitative monetary assessment	Evaluate in money terms as many effects as possible and integrate them in the decision. Describe and record the remaining effects.

Source: Adapted from Tietenberg, 2000.

Quantitative assessments of the environmental value of the beneficial uses can be made in non-monetary and monetary units. Biologists attempt to assess environmental amenities in terms of desirable attributes such as species diversity, community structure, and energy and nutrients flows. Using a similar criteria, the beneficial uses can be ranked. Such ranking can indicate the value of environmental attributes to society.

The economic literature identifies three basic economic functions of the environment: resource supply, waste assimilation and aesthetic commodity (Tietenberg, 2000):

Table 2: Basic Economic Functions of the Environment

• Resource supply
• Waste assimilation
• Aesthetic commodity

Source: Adapted from Tietenberg, 2000.

These three economic functions can be regarded as components of one general function of natural environments: the function of life support. In order for economic systems to be sustainable, they must be in equilibrium with the environment that supports the economic systems. Therefore, economies do not exist in isolation from the environment.

Environmental and natural resource economists attempt to estimate the value of these three basic economic functions of the environment. For example, Gibbons recommends that the value of waste assimilation of water be calculated as "either waste treatment costs foregone or downstream damages avoided." The capacity of a water body to assimilate or dilute wastes represents a real economic value when the costs of water quality effects are actually considered (Gibbons, 1986). Because each type of pollutant involves a different treatment process and has different downstream effects, the value of water for dilution will also be unique to the specific type of pollutant and to a specific location.

For our analysis of estimating the value of the beneficial uses of water, it is not possible to include the waste assimilation function because this beneficial use is not incorporated in the description of the beneficial uses. The reason for this is §131.10(a) of the Clean Water Act, in its description of the designation of uses, states; "In no case shall a State adopt waste transport or waste assimilation as a designated use for any waters of the United States." (But because the Clean Water Act only refers to the Waters of United States or surface waters, the beneficial uses of the basin plan could incorporate the waste assimilation function for ground water. Despite that, the waste assimilation function is not included as a beneficial use in the basin plan.)

Under the Porter-Cologne Act, the discharge of waste is not a right, but a privilege, subject to specific permit conditions. Therefore, the discharge of waste is not included as a beneficial use of water, even though the waste assimilation function of the environment has an economic value.

Measures of Economic Values

The economic literature distinguishes between the intrinsic value of the existence of a resource and the value derived from human use (see table 3). The total economic value of the resource will comprise the addition of both values. Use values are normally further subdivided into direct and indirect uses.

Table 3: Categories of Benefits of Water Quality

Use Benefits				**Intrinsic Benefits**	
Direct			**Indirect**	Option Value (Access to resource in the future)	Existence Value (Knowledge that services of resource exist)
Consumptive		**Non-Consumptive**	**Property Values**		
Market Benefits	**Non-Market Benefits**	Swimming	Aesthetics		
Water Supply	Recreational Fishing	Boating			
Commercial Fishing	Water Supply	Human Health	Fishing Equipment Manufacturer		
	Hunting				

Source: Author.

Use benefits: Estimating the benefits of clean water will depend upon several variables that describe the attributes of the resource and its uses. A waterbody might be used for recreational activities (such as fishing, boating, swimming, hunting, bird watching), for commercial purposes (such as industrial water supply, irrigation, municipal drinking water, and fish harvesting), or for both. Where recreational activities are created or enhanced due to water quality improvements, the public will see an increase in benefit.

Direct Uses include both consumptive and non-consumptive. Consumptive uses are distinguished from non-consumptive uses in that they exclude other uses of the same resource. For example, water is consumed when it is diverted from a waterbody for irrigation purposes. With non-consumptive uses however, the resource base remains in the same state before and after the use (e.g. swimming).

When estimating benefits, it is important to determine whether or not the resource and its uses (in this case clean water) can be considered market or non-market resources and uses (i.e., does a market exist for the resource or its use). For example, commercial fisheries have a market value reflected by monetary (financial) value of landings of a particular species. By contrast, no market exists to describe the value individuals receive from swimming or from other recreational activities related to water quality. Where market values are available, they should be used to estimate benefits. In the case of water supply, there may or may not be a market for clean water. Some water users may be required to pay for that use. For example a farmer could pay a regional water board to divert water for irrigation purposes. By contrast, a manufacturing facility using water for cooling or process water may not pay anything for the right to pump and use water from the adjacent river. For resources with no market value, a number of estimation techniques are available.

Consumptive use is frequently associated with markets and non-consumptive use is frequently associated with non-market situations. Some resources that are considered market resources, however, may be used non-consumptively (i.e. a swimmers use of a lake is not consuming any part of the water quality or quantity of the lake, even though he may be paying a fee for being able to swim in the lake).

Commercial activities that are dependent on clean water which is not directly owned are said to benefit from indirect use. Examples would be a fishing equipment manufacturer's dependence on healthy fish stocks to induce demand for its products or the dependence of property values on the pristine condition of an adjacent water body. Indirect use is also characterized by the scenic views and water enhanced recreational opportunities (camping, picnicking, bird watching) associated with the quality of water in a water body. Indirect use benefits such as enhanced property values can be estimated using the hedonic price technique.

Intrinsic Benefits: The benefits include those associated with a resource, but that are not directly related to the current use of the resource. Intrinsic benefits include both existence and option values. Existence values indicate an individual's (and society's) willingness to pay to maintain an ecological resource such as clean water for its own sake, regardless of any perceived or potential opportunity for that individual to use the water body now or in the future. Contributions of money to save endangered species demonstrate a willingness to pay for the existence of an environmental amenity despite the fact that the contributor may never use it. For example, I may gain satisfaction and I am willing to pay money for the protection of whales even though I may never see one or possess one because I like to know that they are alive and protected.

Option value is the willingness to pay for having a future opportunity to use a resource, such as clean water, in known or as yet unknown ways. Pristine habitats and wildlife refuges are often preserved under the assumption that plant or animal species may yield a potential benefit related to pharmaceuticals, genetics or the ecosystem. Option values become very important when conservation and preservation of a resource is at stake for potential future use. In our analysis of the beneficial uses of water in Los Angeles, option value would be derived from the consideration of protecting a resource based on its potential use. Intrinsic benefits are difficult to measure due to the level of uncertainty associated with these benefits.

The Damage Function: The Concept of Efficient Level of Fund Pollutants for a Specific Waterbody, Static Efficiency

Economists argue for the existence of an optimal allocation of pollution that satisfies the efficiency criteria. The question then is: What is the optimal level of pollution, that from the economic standpoint, should be allowed? The economic proposition that maximizes net benefits is such in which the marginal benefits equal the marginal costs. Since benefit is similar to damage reduction, the economic theory suggest that the efficient level of pollution is reached when the Marginal Control Cost curve intersects the marginal Damage Cost curve (Tietenberg, 1992). Therefore it is necessary to estimate the total damage cost and the marginal damage cost for every quantity of pollution emitted in order to be able to estimate the level of pollutants that maximize the total net benefits.

In the case that the pollutants discharged to the waters can be assimilated by the environment within a certain period of time (fund pollutants). In order to estimate the optimal level of pollution we will need to know something about how control costs vary with the degree of control and how the damages vary with the amount of pollution emitted.

The economic theory also suggests the shape of the two curves:

- The Marginal Damage Cost curve will probably increase more than proportionally with the increase of the level of pollutants. This hypothesis is derived from the idea that the marginal damage caused by a unit of pollution increases with the amount emitted. When small amounts of the pollutant are emitted, the marginal damage is quite small. However, when large amounts are emitted, the marginal unit can cause significantly more damage.
- The Marginal Control Cost curve. Marginal control costs commonly increase with the amount of pollutants controlled usually very slowly at first and then very steep at the end.

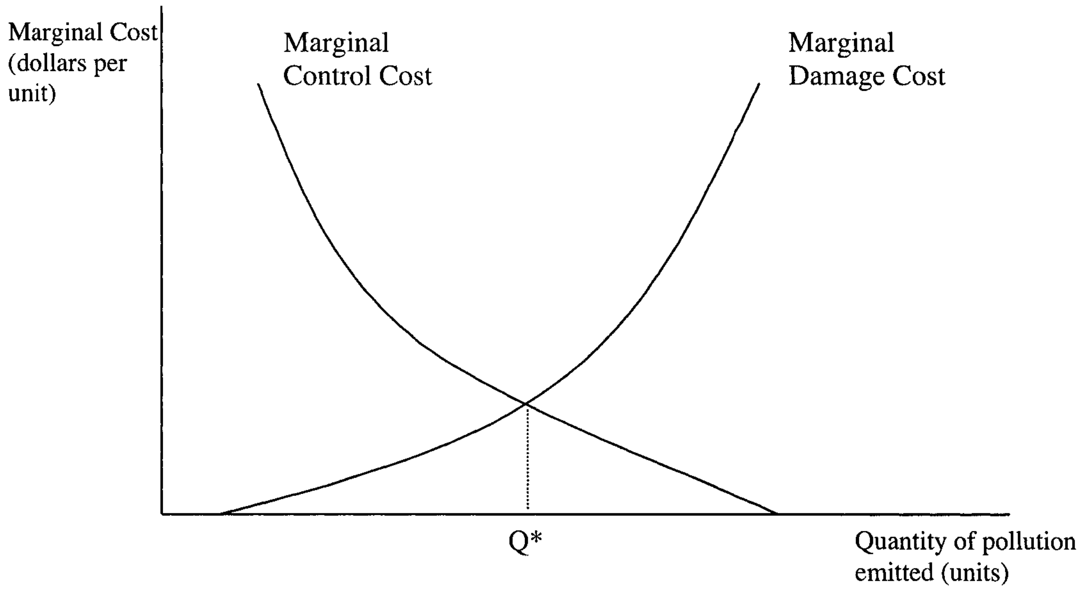

Figure 1: Marginal Cost of Pollution and Efficient Allocation of Pollutants (Source: Tietenberg, 2000.)

Where Q* represents the efficient allocation of pollutants, the point at which the damaged caused by the marginal unit of pollution is exactly equal to the marginal cost of avoiding it.

Most of the controversy that surrounds the use of economic analysis for environmental decision-making arises from the difficulty of defining and measuring the true marginal benefits and marginal costs of environmental regulation (Morgenstern, 1997, p. 41). The difficulty resides in establishing the link between different concentrations of pollution in the ecosystem and how they affect their beneficial uses. This is poorly understood and difficult to measure. Even when the level of environmental damage from various levels of pollution can be estimated (dose-response function), the economist's challenge is to determine society's willingness to pay for the beneficial uses impaired.

In most circumstances the optimal level of pollution will not be zero. This is because the marginal cost of reducing the pollution emissions to zero will be too high compared to the marginal benefits.

Economic rationality of efficient level of pollution is not directly applicable to the protection of beneficial uses of water quality in California because the policies and regulations defined in the Basin Plan already determines the optimal level of pollution allowed that protects beneficial uses. Therefore in our analysis we will be assuming that the water quality objectives and the effluent limits of permits to discharge meet the efficiency criteria.

3. Methods to Estimate the Economic Value of Natural Resources

Environmental valuation is a series of techniques that economists use to assess the economic value of market and non-market goods and services related to and dependent on the uses or states of natural resources or the quality of the environment. Environmental valuation applies the welfare economics concepts of producer and consumer surplus to issues involving natural resources and the state of the environment.

The economic value of beneficial uses of water quality, as described in California regional basin plans, cannot be inferred from water quality markets or exchanges. But it can be estimated using different evaluation methods.

The economic value of water quality is explained by economists in terms of users' willingness to pay for water quality and the opportunity cost of the use of water quality. The economic value of water must reflect the scarcity of the resource in all its attributes, therefore changes in the quantity and/or quality of water will alter the economic value of the resource.

Economists have several tools and techniques to estimate and reach an approximation of the value of goods and services provided by environmental resources. Depending on the particular type of goods and services provided by the environment, various methods are recommended. For example, the economic value of changes in health benefits or risks can be measured using a valuation tool or technique such as water market demand functions (Walker and Hoehn, 1990), averting or defensive expenditures (Abdalla *et al.*, 1992; Abdalla, 1994; Bartik, 1998; Harford, 1984; Vossler *et al.*, 1998), damages avoided (Raucher, 1986), changes in production costs (Freeman and Harrington, 1990; Holmes, 1988; Ribaudo and Hellerstein, 1992), hedonic price method (Mendelson *et al.*, 1992; Polinsky and Rubinfield, 1977; Ribaudo and Hellerstein, 1992) or stated preference methods such as the contingent valuation method or conjoint analysis (Carson and Mitchell, 1993; Caudill and Hoehn, 1992; Collins and Steinback, 1993; Edwards, 1988; Jordan and Elnagheeb, 1993; Kwak *et al.* 1997; Luzar and Cossé, 1998; McClelland *et al.*, 1992; Poe, 1993; Poe, 1998, Poe and Bishop, 1999; Powell and Allee, 1991; Powell *et al.*, 1994; Shultz and Lindsay, 1990; Stevens *et al.*, 1997; Sun *et al.*, 1992) (Bergstrom *et al.*, 2001).

A change in the water quality used for farm irrigation and drinking water for livestock may result in direct changes in the value of livestock or crops. The change in value (price) can be estimated using market demand functions for the particular goods sold in the marketplace. Changes in production costs can be estimated using estimated costs functions. Potential changes or impacts in human health or health risks can be estimated using the damages avoided approach and the stated preference methods (Bergstrom *et al.*, 2001).

Other uses directly related to water quality, such as recreational uses (fishing, hunting, parks, etc. can be estimated using the travel cost method and the stated preference method (Greenley *et al.*, 1981; Sutherland, 1982; Russell and Vaughan, 1982; Osborn and Shulstad, 1983; Smith and Desvouges, 1983; Ribaudo and Epp, 1984; Sutherland and Walsh, 1985; Mullen and Menz, 1985; Caulkins *et al.*, 1986; Bockstael *et al.*, 1987; Deesvouges *et al.*, 1987; Green and Tunstall, 1991; Loomis *et al.*, 1991; Hayes *et al.*, 1992; Magnussen, 1992; Freeman, 1995;Choe *et al.*,1996; Montgomery and Needelman, 1997; Georgiou *et al.*, 1998; Jakus *et al.*, 1998; Phaneuf *et al.*, 1998).

The effects of changes of water quality for indirect uses can be estimated using the stated preference method (Greenley *et al.*, 1981; Greenley *et al.*, 1985; Mitchell and Carson, 1985) (Bergstrom *et al.*, 2001).

The techniques and methods of environmental valuation available and used in the economic literature (Mitchell and Carson, 1989) can be classified in two main groups: Techniques that use direct methods of environmental valuation and techniques that use indirect methods to estimate the value of those goods and services.

Direct Methods

With the direct methods, preferences are revealed in observed markets and the benefit measures are directly linked with the peoples' preferences (Mitchell and Carson, 1989). Direct methods of environmental valuation are used mostly when there is a market for the goods and services subject to study and when it is possible to estimate the value using surrogate markets and simulated markets,

The range of economic valuation techniques can be encompassed under three general approaches: market (actual preference), revealed preference (surrogate market), and stated preference (simulated market). These three approaches can also be reduced to two groups of methods, the methods that estimate the value from observed behavior (actual preference and revealed preference) and methods that use surveys to elicit information about costs and benefits (stated preference or simulated markets).

Market Valuation Methods

Market valuation uses existing market prices to estimate values. Market techniques value a benefit/cost as an increase/decrease in revenue or as a decrease (increase) in costs. Some market evaluation techniques focus on the changes in productivity or income associated with economic activities and environmental changes. For example, income lost due to health problems associated with air pollution would be quantified as a cost, whereas increased income in the presence of lower reported sick days would be deemed a benefit.

- Direct estimation of the demand curve
- Market analogy method
- Intermediate good method
- The change in productivity technique
- The change in income technique. The wage differential technique.
- The replacement cost technique
- The preventive expenditure technique. The defensive expenditure method.
- The relocation cost technique

Revealed Preference Methods

Surrogate market approaches determine estimates of the value of environmental resources using the costs or revenues gained from the environmental changes themselves.

Hedonic pricing examines existing market prices to detect implicit valuation of environmental factors by consumers. Hedonic methods explores the idea that information on a public good, such as water quality, is contained in the prices and consumption levels of private goods. They assume the existence of a continuous function relating the price of a good to its attributes, called the hedonic price function. Hedonic valuation assumes that either wages or housing values reflect spatial differences in the quality of water resources. Using regression models, estimates are made regarding the value of water quality based on price differentials controlling all other characteristics.

- Using differences in asset values
- The property value technique. (Hedonic pricing.)
- The travel cost method.
- The proxy good technique.

Both the market and surrogate market approaches depend on actual market data as a basis for (indirectly) establishing nonmarket value estimates

Stated Preference Methods

Simulated market techniques rely on survey data to form estimates of economic value. Specifically, questions are included in the survey that elicit monetary values directly in the form of willingness to pay. These include:

- Contingent Valuation. The contingent valuation method can only estimate the perceived quality of the beneficial uses in the actual estate. There are problems of incomplete information as well as seasonal variations that may create divergences in the perceived quality of the beneficial uses among their users.
- The trade-off game
- Contingent ranking and contingent rating
- The priority evaluator technique

Indirect methods

Indirect methods rely on data from situations where consumers make actual market choices. Indirect observed methods involve a kind of detective work, in which clues about the values individuals place on environmental services are pieced together from the evidence that people leave behind as they respond to prices and other economic signals (Freeman, 1993; Mitchell and Carson, 1989, Tietenberg, 2000).

Indirect Methods can be classified into two main groups: Observed/indirect methods that rely on data from situations where consumers make actual market choices and Hypothetical/Indirect methods in which people is asked to respond to hypothetical markets. Among Observed/Indirect methods class are:

- The travel cost method
- The hedonic property values
- The hedonic wage values
- Avoidance expenditures

Among Hypothetical/Indirect methods are:

- Contingent ranking
- Indifference curve mapping
- Allocation games
- The priority valuation technique

Recommended Methods to Estimate the Value of Beneficial Uses of Water Quality

Some methods are most suitable for valuing water quality changes. The travel cost recreation demand models and contingent valuation survey methods are especially well suited for valuing water quality improvements at a recreation site (Smith and Desvousges, 1986).

A complete evaluation of the different beneficial uses of water quality may require the use of multiple methods. The choice of the valuation tool or technique depends on many factors including theoretical appropriateness, estimation robustness, ease of data collection, time and budget constraints, and professional judgment and preference.

Table 4: Valuation Methods Recommended for Each Beneficial Use of Water Quality

Beneficial use category	Habitat/ Ecosystem	Wetland/ Floodplain	Agriculture	Recreation	Industrial/ Municipal	Navigation	Power
Averting Behavior Approaches					X	X	
Contingent Valuation	X	X		X	X		
Conjoint Analysis /Damage Function Approaches	X	X	X	X	X	X	
Hedonic Methods	X		X	X	X		
Market Valuation	X	X	X	X	X	X	X
Opportunity Cost Methods	X			X	X		
Optimization Models	X	X	X	X	X		X
Replacement Cost Methods	X	X	X	X	X	X	X
Simulation Models	X		X	X	X		X
Travel Cost	X	X		X			
Other Methods	X	X	X	X	X	X	X

Source: University of California at Davis. Beneficial Uses Database.

Several methods can be used in the assessment of the economic value of beneficial uses of water quality as defined in California regional Basin Plans for specific segments of waterbodies. Table 4 represents the methods used by researchers to value beneficial uses of water.

Part III of the study will describe in detail the beneficial uses of water quality as defined in California Regional Basin Plans.

Use of Shadow Prices from Secondary Sources: The Benefit Transfer Method

Benefit transfer methods have been broadly used, even the United States Environmental Protection Agency (USEPA) suggests "off-the self methodologies and studies can serve as the basis for benefit-cost analysis."

Benefit transfer is not the most accurate method to estimate environmental values but it is definitely the most cost and time effective. Benefit transfer has received many criticisms but is still viewed as a valid option under specific circumstances. Often, the time and cost limitations make it difficult to develop specific studies of environmental value or damage assessment for each particular site and discharge. At the same time, there are a growing number of studies that estimate the economic value of environmental resources, their uses and the impacts from pollution. Many recent studies have been able to compile the information into databases that sort the studies by different criteria that allow the identification of studies and values that can be transferred to the study area.

It appears logical that under determined circumstances, and with appropriate adjustments the estimated values of other studies can be incorporated into the study, or assessment of the site under consideration. One drawback from the use of the benefit transfer method is the risk of producing poor quality benefit estimates that could lead to incorrect policy choices (Desvousges *et al.*, 1992).

The controversy here lies in the fact that sometimes it is better to estimate some values that are probably incorrect than no values at all. The reason for this is that in cases of civil penalties assessed to dischargers in the State of California, almost none of them included an estimation of the damage to the beneficial uses. The civil liability is supposed to compensate society from the damage done to the environment. And the assessment of liabilities includes that implicitly in the calculation, but this is not done in a clear and specific form. This may lead to cases in which, by not estimating the damage done to beneficial uses, the liability assessed is less than it should have been required otherwise. The idea is not the straightforward inclusion of the estimated value using the benefit transfer method, but to recommend a preliminary assessment of its value using the benefit transfer method and then recommend, based on the conclusions of the proposed methodology, a more detailed and specific study. But in a great portion of the civil liability cases in California a benefit transfer estimation may be a valid approximation of the true damage to society derived from the damage to the beneficial uses by discharging pollutants in exceedance of permit conditions.

There is an extensive literature in the area of benefit transfer (Cummings *et al.,* 1986; Mitchell and Carson, 1989). Benefit transfer is defined as the transfer of existing estimates of non-market values to a new study which is different from the study for which the values were originally estimated (Boyle and Bergstrom, 1992).

The benefit transfer method is the transfer of monetary valuations estimated from research studies to the policy site. The site where an existing study was conducted is referred to as the "study site", while the site that proposes to make use of the transferred values is referred to as the "policy site". The term benefit transfer was first used by Desvousges, Naughton and Parsons (1992) to describe the transfer of monetary valuations.

Benefit transfer methodology has benefits and drawbacks. Among the benefits are the low cost and shorter time. On the other side, the use of the benefit transfer may lead to meaningless information if not applied properly. Desvousges propose to transfer the estimated monetary values from the study site to the policy site following a two-step process and the following of a five step criteria to select the studies available for transfer (Desvousges *et al.,* 1992).

The quality of the original study site and its similarity or difference to the policy site is of great importance. Areas of difference can include population size, socioeconomic characteristics and the magnitude of the change under consideration. The method used to transfer benefits can also have an effect on the quality of the results obtained for the policy site.

Applied economists have estimated a whole range of price elasticities, cross-elasticities, and income elasticities that can be used in environmental value estimation. These can be used in benefit transfer, as they are based on the responses of people to similar changes in the past, they provide an empirically grounded basis for predicting responses under similar circumstances. Some other cost benefit analysis also provide per-unit impact estimates that can be "recycled" (Boardman *et al.*, 1996).

A more sophisticated approach is presented in Desvousges et al. (1992). The goal of benefit transfer is to construct the best prediction possible for estimating the benefits of water quality improvements (in this study, it will be used to estimate the damage to beneficial uses derived from water quality reduction). The prediction equation for an individual household may be expressed as

$$E(cs/x) = f(Q_1 - Q_0, \alpha, \beta, P; \delta)$$

Where E( ) is an expected value operator; δ is a vector of parameters; cs is a compensating surplus for an improvement (reduction) in water quality from Q_0 to Q_1 (from Q_1 to Q_0); α is a vector of household characteristics such as income and household size; β is a vector of site characteristics of the river such as natural cover, size, (beneficial uses), and recreation accommodations; P is a vector of own prices and substitute implicit prices of recreation visits; and

$$X = (Q_1 - Q_0, \alpha, \beta, P)$$

Desvousges et al. assume that if the models and data are available, the transfer problem is straightforward. The benefit transfer would be simply the use of the parameters estimated of the study site (δ) to the characteristics of the policy site (Q_1-Q_0, α , β and P). Then the transfer can be conducted in a two-step process. First, we establish the market area, or the geographic area that is affected by changes in water quality. Market size determines the population size that will be used to convert benefits per household to aggregate benefits. Second, we substitute the parameter estimates and variables for each household in the estimated equation and the compensating surplus is estimated. Desvousges et al. estimate the total value of the change in water quality by multiplying the estimate value of the number of individual households by the market area.

Desvousges et al. recognize the fact that the quality of parameter estimates varies across studies and many studies do not estimate all the necessary parameters. Studies also vary in the components of user, nonuser option, and existence benefits that they attempt to measure. In order to reduce the difficulties encountered in benefit transfer, Desvousges et al. propose the following five criteria:

1. The studies used must be based on adequate data, sound economic method and correct empirical technique.
2. The magnitude of change in water quality valued at the study site should be similar to the expected change at the policy site. This may take care of the problem of the nonlinearity between willingness to pay and water quality.
3. The study must contain regression results that describe willingness to pay (or willingness to accept, depending on who holds initially the property rights). Individual characteristics have an effect on willingness to pay.
4. The study and policy sites must be similar. This requires a certain level of knowledge of the study site and the policy site. The study site model should contain regression results that describe willingness to

pay as a function of site characteristics. Study and policy sites must have similar populations.

5. In the case of being short of usable information on own prices and substitute implicit prices from the study site, the markets for the study site and policy site should be similar.

The proposed five criteria can be summarized in three aspects, a) the study sites and policy sites are similar, b) The environmental change under consideration at the policy site is similar to the proposed change at the study site, c) the socioeconomic characteristics of populations and other site details are similar. Therefore, depending on the extent to which these criteria are satisfied and the degree of accuracy needed, there is some choice as to the level of sophistication to be adopted for benefit transfer. The amount of data required and its level of aggregation is important to the cost and accuracy of the final transfer method.

Pearce et al. (1995) propose three approaches to benefit transfer:

1. Transferring mean unit values. Here the assumption is that the change in well-being experienced by the average individual at the study site is equivalent to that which will be experienced at the new site being valued. Under this approach the direct transfer can be done on a per person or per household basis. The total value of the benefit at the policy site is then obtained by multiplying the mean estimate by the size of the affected population. The problem with this approach is that individuals at the new site, for a variety of reasons may not value the recreational activities at the new

site equally to the average individual at the existing sites. This may arise from differences in terms of demographic structure, income, education, religion, ethnic groups or other socioeconomic characteristics. The direct transfer of unit values without adjustment is the least rigorous method of benefit transfer.

2. Transferring adjusted unit values. The mean unit values of the existing studies are adjusted before transferring to the policy site. They can be adjusted for any biases that are thought to exist, or they can be adjusted in order to reflect better the conditions at the new site. Reasons for adjustment include: differences in socioeconomic characteristics of households, differences in the environmental change being looked at, and differences in the availability of substitute goods and services.

   This approach generally provides a higher degree of accuracy than direct transfer and is adequate in some cases provided the variation about the mean value of each of the parameters is relatively small.

3. Transferring the demand function. In this approach, instead of transferring adjusted or unadjusted unit values, the entire demand function estimated at existing sites could be transferred to the new site. What is transferred here is the values of the estimates of the parameters of the demand function and calculated with the values of the policy site.

There are two reasons to expect that an estimate of total recreation benefits from applying an existing demand curve from a similar site is likely to yield a more unbiased estimate of total recreation site benefits than simply transferring the benefit per day. First, total recreation benefits depend both on the value per trip and on total site visitation. Second, the benefit estimates derived from either travel cost method (TCM) demand or contingent valuation method studies are often a complex function of the site characteristics, user characteristics and spatial attributes of the site relative to visitors residence (Loomis, 1992).

Of these approaches, the benefit function transfer is the most rigorous and sophisticated and therefore is more expensive and time consuming. That is why its use its limited to the availability of time resources, and number of studies for the area of study.

In summary, the use of the benefit transfer method will always require some types of adjustments. These adjustments include: conversion from nominal to real monetary units, adjustments for population size, types of use, size of resource, etc. Economic analysis must be carried out in a timely and efficient manner. Environmental valuation studies are expensive to undertake and they do not meet the timeliness criteria necessary to act accordingly when damages occur. The use of benefit transfer can reduce both the cost of research and the time required for assigning values to environmental qualities of a specific site.

The number of studies that estimate the value of the beneficial uses of water is growing, and as the number and diversity of the investigations expand, the potential for benefit transfer will expand. Many recent studies have attempted to collect and classify the estimated values and parameters from multiple sources, examples of these databases include:

- ENVALUE, the New South Wales Environment Protection Authority Envalue Study Database from the Australian Environmental Protection Agency (http://www.canri.nsw.gov.au/),
- EVRI, the Environmental Valuation Reference Inventory (EVRI) (http://www.evri.ec.gc.ca/evri/) and
- BUVD, the beneficial use value database developed by the department of agricultural and resource economics from the University of Davis. (http://buvd.ucdavis.edu/)

The Economic Analysis and Research Branch of the U.S. Environmental Protection Agency, Office of Policy Planning and Evaluation has also prepared the "Environmental Economics Database", a collection of references for natural resources and environmental amenity valuation studies collected over several years.

In summary, the purpose of any economic valuation is to perform a benefit-cost test of a specific project or to justify the expenditure of command and control measures in order to protect values that the market fails to protect. The level of intervention is therefore justified in several cases based on the fact that there is a net loss to the society derived from an economic activity that is producing a negative externality that is not being internalized (compensated) in the market place.

To keep down the costs of damage assessment, it was decided to rely on the benefits transfer approach to obtain an estimate of beneficial use damages.

PART III

THEORIES AND METHODS ESTABLISHING THE LINKS BETWEEN POLLUTION, WATER QUALITY AND BENEFICIAL USES

1. Establishing the Link Between Pollution, Water Quality and Beneficial Uses

In order to estimate the damage caused to the value of beneficial uses of water quality by pollution, we need to explain the relationships between water quality and the discharge of pollutants, and water quality and the beneficial uses supported. An essential element in estimating the benefits from water quality is an understanding of how pollution (emissions) affects the environment that humans value. This section discusses the various links between pollution, water quality, and the level of impairment of the beneficial use. Understanding these connections is central to the discussion of the damage to beneficial uses from pollution that follows.

But, we only have a limited knowledge of the interactions between humans and the environment. The understanding of the long and short run impacts to the environment is limited. We must be aware of the degree of scientific uncertainty of our comprehension of the environment. Public policy, however, requires reaching decisions about the appropriate level of use of the environmental asset and presumes the existence of solid scientific information. As Tietenberg explains; "Only when the physical consequences of various courses of action are understood can the task of weighting the costs and benefits begin. In many significant areas, we simply do not have solid scientific information or we do not fully understand the relationships between society and the environment. Making a wrong choice based on incomplete or misleading information could prove very costly." (Tietenberg, 2000).

Reducing scientific uncertainty is critical to understanding the sustainable equilibrium between economic and ecological systems. Furthermore, scientific findings must be presented in such a way that policy-makers clearly understand both the nature of the evidence and the long-term implication of their policies.

For example, estimates of the value of a salt marsh in sustaining a marine fishery must be based on knowledge of the biological and ecological links between the marsh and the exploited fish species (Lynne *et al.,* 1981). A complete description of the physical, chemical, and biological aspects of water quality, as a function of natural and man-made factors, and the technological measures available for changing water quality can easily fill extensive volumes (Kneese *et al.,* 1968). An essential element in estimating the benefits from water pollution control is an understanding of the links between pollution discharge and effects on humans or things in the environment that humans value (Kneese, 1984). Economists seek measures of values that are based on the preferences of individuals. In estimating the value of environmental and resource service flows, it is very important to understand the underlying biological and physical processes that generate those services (Freeman, 1993, p. 37). Matching the boatable, fishable, and swimmable levels of water quality with physical water quality criteria is not an easy task, nor is there complete agreement on how to do this (Carson and Mitchell, 1993).

Different models have attempted to estimate this relationship. For example, Resources for the Future has built a National Water Quality Network Model that simulates water quality changes associated with changes in effluent discharges. In the model, pollutants can be injected into the system at particular points (municipal and industrial discharges) and uniformly between them. The model then simulates the transport, degradation, and transformation processes that occur in the water body and calculates a number of water quality characteristics at any point in the system, taking account of all of the points of discharge that affect that location (Kneese, 1984).

Not only does this assist in defining the effects of existing levels of pollution on the beneficial uses, but also in identifying the impact of changes in pollution on the value of the beneficial uses. It is necessary to understand the marginal changes of value derived from marginal changes in water quality.

Our understanding of exactly how natural systems are affected by man's discharge of pollutants is still very limited (Kneese, 1968). Impacts of changes on water quality derived from wastewater effluent discharges are difficult to model accurately (Freeman, 1993).

For each type and amount of pollutants discharged an evaluation of the damage to each of the beneficial uses, the duration and the extent must be estimated. Freeman has defined the links between the pollution discharge and impact on beneficial uses as a three stage process, in which changes in the amount of pollutants lead to changes in the physical, chemical and biological characteristics of water, that then impacts the beneficial uses of water quality and their value. The last stage of the process entails an evaluation, in monetary terms, of the net changes in value of the beneficial uses.

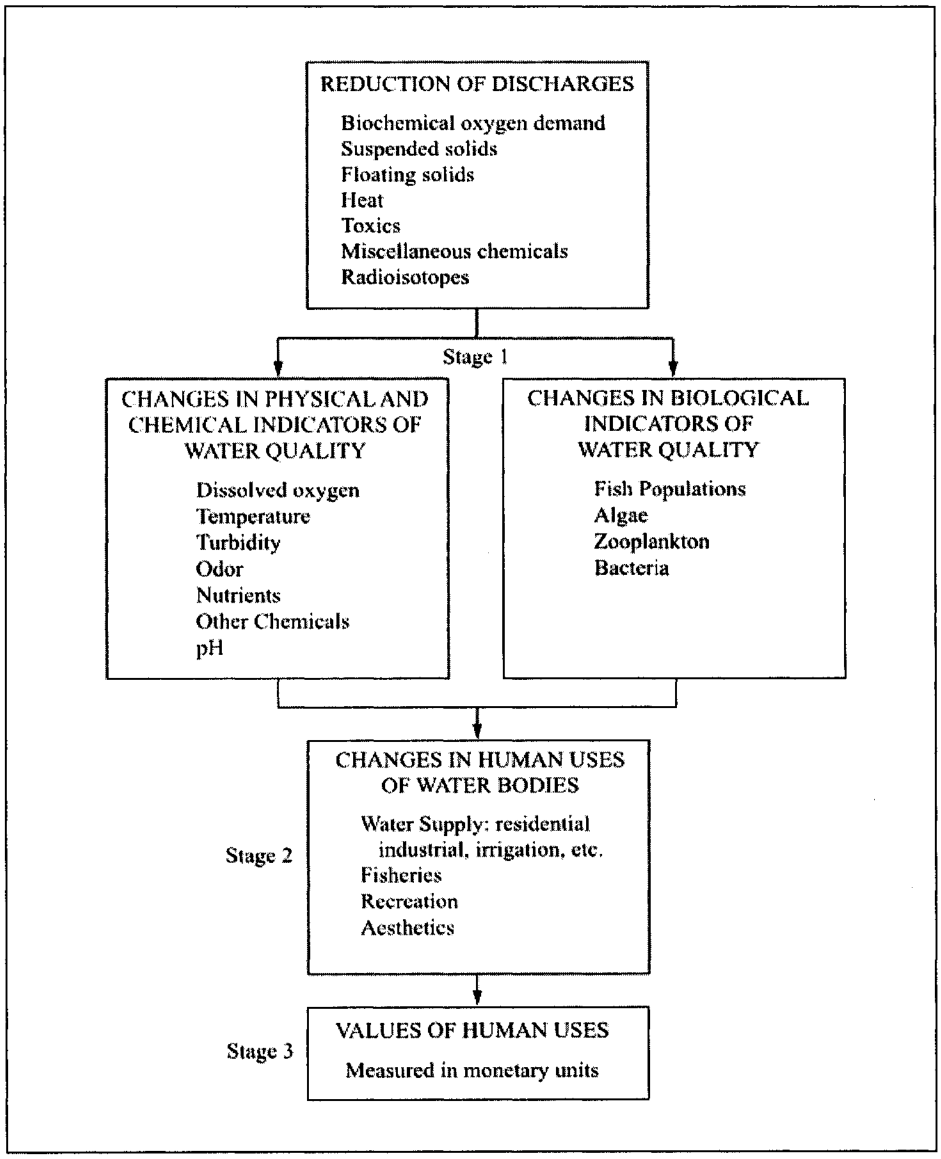

Figure 2: The Production of Benefits from Improved Ambient Water Quality (Source: Freeman, 1993.)

Dose-response methods seek a relationship between environmental quality variables and the output level of the beneficial uses provided by water quality

(Hanley and Spash, 1993). Three questions arise at this stage of the analysis: a) How do we select the parameters for describing water quality? b) How do we measure water quality? c) How do we define the functional relationship between the service flow of a waterbody (beneficial uses) and the level of water quality?

a) How Do We Select the Parameters for Describing Water Quality?

Different levels of water quality can be related to the concentration and type of pollutants in a particular waterbody. Ecological systems that interact within a watershed are often complex and difficult to define. Water quality has many components. We could describe them as the physical, biological and chemical properties of water. Different levels of water quality are required to support different beneficial uses of water. We can say then that water quality is a form of measuring the degree to which the beneficial uses are satisfied. Therefore, the level of impairment of waters is comparable to the degree of providing the beneficial uses.

Several attempts have been made to describe the factors affecting water quality. Water resource integrity is a function of a wide range of parameters, including, not only water chemistry, but also biotic factors, energy sources, habitat structure and the flow regime (Yoder and Rankin, 1995).

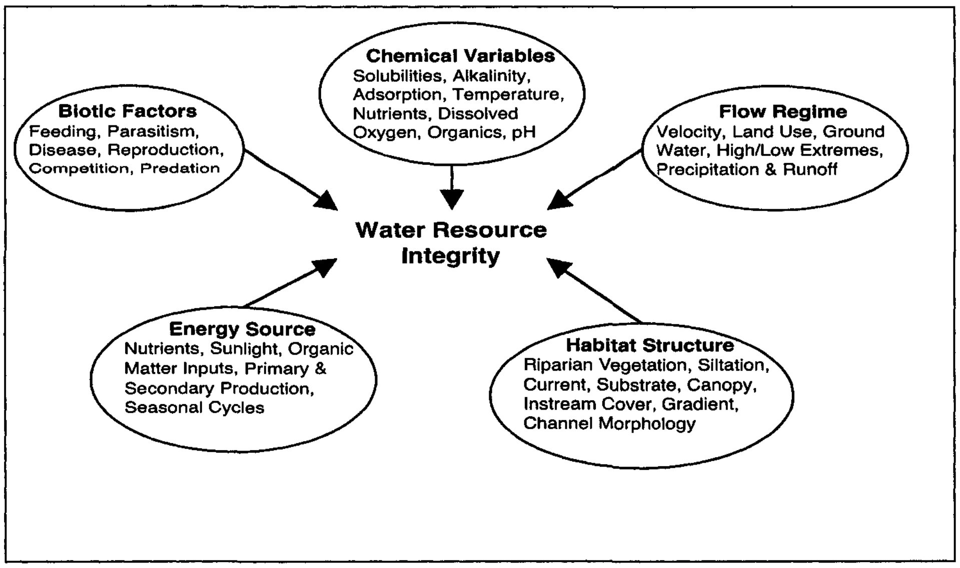

Figure 3: Factors Affecting Water Quality (Source: Yoder and Rankin, 1995.)

Each beneficial use can be supported with a different combination and concentration of pollutants. This also depends on the flow and the waterbody type. Therefore, the selection of pollutants that determine the level of water quality that protects beneficial uses should be done on a case by case basis, for each beneficial use, for each different waterbody and for each season (dry weather/wet weather).

b) How Do We Measure Water Quality?

Water quality cannot be represented by a single number of some scale, but rather is an n-dimensional vector of the relevant parameters (Freeman, 1993). But the relevant parameters that define the quality of waters are determined by the final beneficial use assigned to a particular waterbody. For example, temperature can adversely affect spawning, but it may improve the value of beneficial uses, such as water contact recreation.

Humans possess a clear perception of water quality. Unfortunately, that perception is difficult to measure in abstract terms. But we need to know if the quality of the water is good or bad, suitable or toxic for beneficial uses. We need a functional method for measuring water quality that defines and expresses the degree to which the waters are adequate for its uses.

Other classifications of water quality are directly related to the degree of support of certain beneficial uses. In this sense W. J. Vaughan, from Resources for the Future developed a water quality index, which maps the rungs of the water quality ladder back into physical water quality parameters such as dissolved oxygen which can in turn be tied to a large scale water quality model
(Carson and Mitchell, 1993).

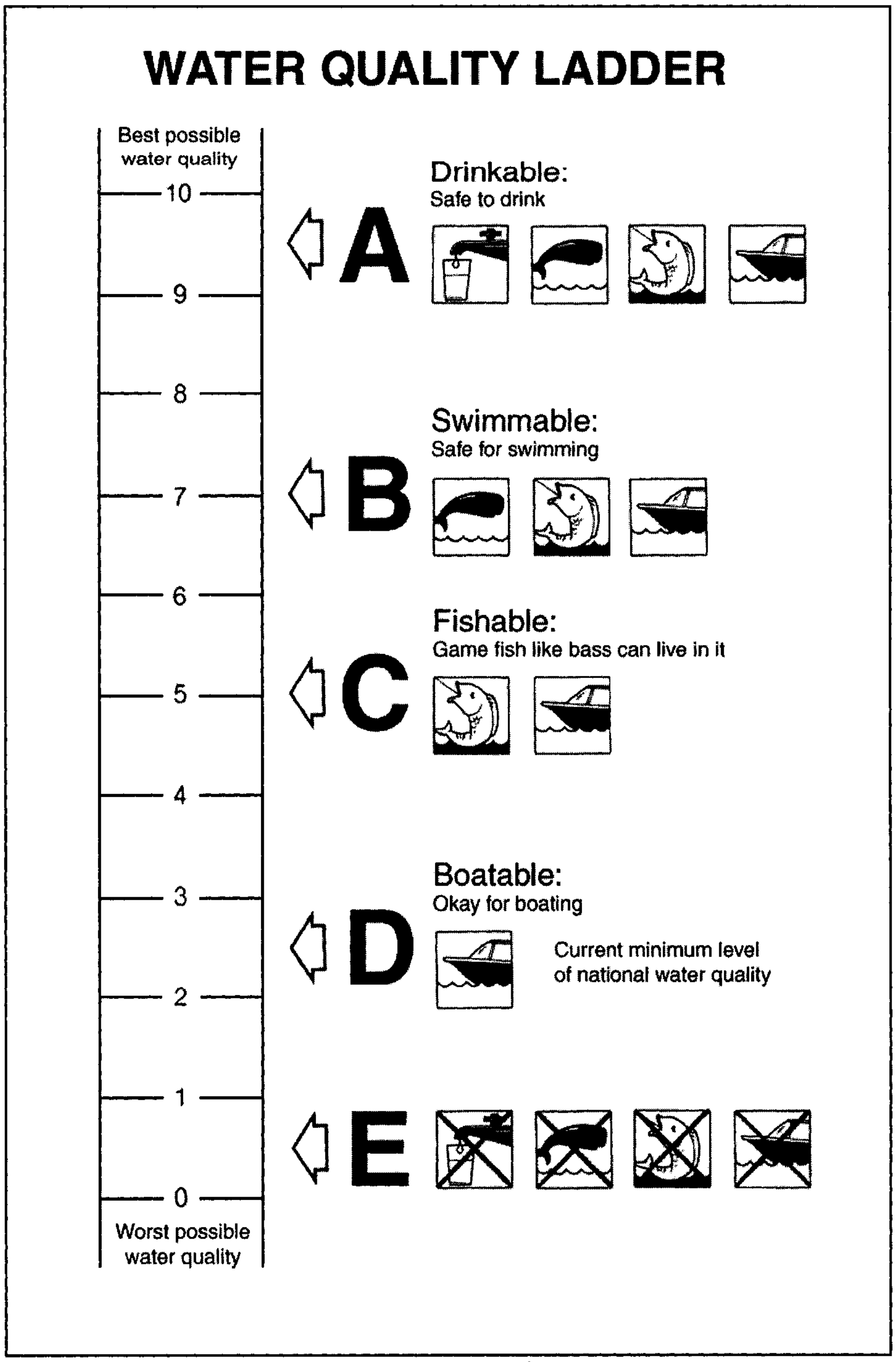

Figure 4: Water Quality Ladder (Source: Smith and Desvousges, 1986.)

This water quality index has been used by Smith and Desvousges [1986] in their Monongahela River study, and by Carson and Mitchell [1993] in their study to determine the national benefits of freshwater pollution control. The ladder proves useful in determining marginal changes in the uses from shifts in water quality and in conducting contingent valuation studies. But the water quality ladder cannot be considered a water quality index that reflects water quality with precision. It is only a good indicator of human perception of water quality.

Another attempt to define a water quality indicator is the Water Quality Index developed by California Rivers Assessment (CARA) project from the University of California Davis (http://www.ice.ucdavis.edu/newcara/). The CARA index is an index of the water quality of all the waterbodies included in the watershed. The weighting of this index is interesting because it provides an example of how difficult it is to incorporate all the variables into an overall index. The index weighs multiple factors affecting a waterbody. For each watershed it multiplies an adjusted waterbody value by the waterbody length. The adjustment of the waterbody value is factored by a weighted average of beneficial uses support (u), causes (c) and sources (s) of impairment, and the Total Maximum Daily Load (TMDL) designation (t).

$$CARAWQI = \sum \frac{(Waterbody.Values\frac{(u+c+s+t)}{4})xWaterbody.length}{\sum Total.length.of.waterbodies.in.Cara.watershed}$$

u= beneficial uses support [fully supporting=1, threatened but supporting=0.75, partially supporting=0.5, not supporting=0.25, not attainable=0]

c= causes of impairment [no recorded impairments=1, a suspected magnitude=0.75, a slight magnitude=0.5, moderate magnitude=0.25 and a high magnitude=0]

s= sources of impairment [no recorded impairments=1, a suspected magnitude=0.75, a slight magnitude=0.5, moderate magnitude=0.25 and a high magnitude=0]
t= TMDL designation status [designated=0, not designated=1]

The problem with this indicator is that the lack of spatial designation leads to a disparity in the basis for judgments across watersheds (Viers et al., 1998).

The United States Environmental Protection Agency (USEPA) Office of Water has developed an Index of Watershed Indicators that attempts to classify in simple terms the degree of water quality of specific watersheds nationwide. The index looks at a variety of indicators that point to whether rivers, lakes, streams, wetlands and coastal areas are "well" or "ailing" and whether activities on the surrounding lands that affect our waters are placing them at risk (USEPA, 1999.) Seven of the indicators used in the index are related to the condition of the aquatic resources and eight indicators are related to the vulnerability, conditions, or activities that may place stress on the resources. Those related to aquatic resources are 1) assessed rivers meeting all designated uses established by state or tribal water quality standards, 2) fish and wildlife consumption advisories, 3) indicators of source water quality for drinking water systems, 4) contaminated sediments, 5) ambient water quality data for four toxic pollutants, copper, chromium VI, nickel and zinc, 6) ambient water quality data for four conventional pollutants; ammonia, dissolved oxygen, phosphorous and pH, and 7) wetland loss index. The indicators that are related to vulnerability are 1) aquatic/wetland species at risk, 2) pollutants load discharged above permitted discharge limits for toxic pollutants, 3) pollutant loads discharged above permitted discharge limits for conventional pollutants, 4) urban runoff potential, 5) agricultural runoff potential, 6.) population change, 7) hydrologic modification, and 8) estuarine pollution susceptibility index. In the near future the index may incorporate additional indicators such as biological integrity, terrestrial condition, groundwater and air deposition. The USEPA Index of Watershed Indicators (IWI) is a more comprehensive approach to account for the biological, physical and chemical properties of water that define its quality, and is the best attempt at providing a value that can be compared across watersheds. The score ranges from 1-6. Each score has two dimensions, condition score and vulnerability.

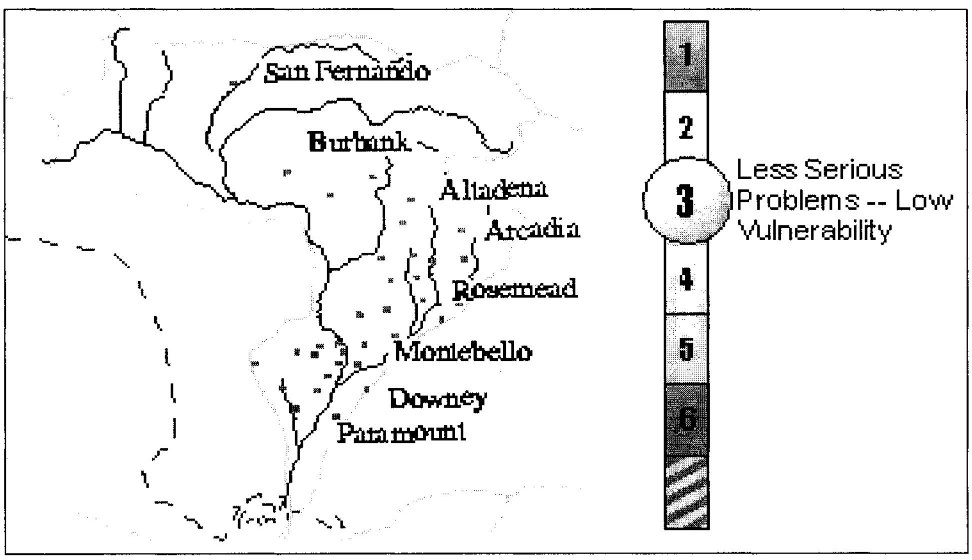

Figure 5: Index of Watershed Indicators for Los Angeles River Watershed (Source: USEPA, 1999.)

The IWI applied by USEPA reveals that 15% of the watersheds nationally have relatively good water quality, 36% have moderate problems, 22% have more serious water quality and 27% do not have enough information to be characterized.

Estimating the degree to which beneficial uses are being supported is another form of measuring water quality. This is the approach used by the Environmental Protection Agency in the preparation of the list [§303(d) list] of impaired waterbodies. The Clean Water Act requires states to list waters for which point source technology-based limits are not enough to restore and protect water quality.

Waterbodies are classified as follows:

1) Fully supporting (F)

2) Fully supporting but threatened (FT)

3) Partially supporting (P)

4) Not supporting (N)

5) Unassessed (U)

c) The Functional Relationship Between Beneficial Uses and the Level of Water Quality

Conventional water quality measures are not sufficiently comprehensive to effectively account for all relevant factors that define the level of water quality required to support the beneficial uses assigned to each waterbody. Beneficial uses and the maximum level of pollutants that each waterbody can assimilate without impairing the beneficial uses are defined in the water quality criteria set by USEPA and in each region in the water quality standards.

Water Quality Criteria: It is defined as the levels of water quality expected to render a body of water suitable for its designated use. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, industrial processes, or other beneficial uses. The US Water Quality criteria are provided by USEPA, Office of Water (304(a)) criteria, reflecting the latest scientific knowledge. They are generally applicable to waters of United States (surface waters). USEPA recommends that states use these water quality criteria as guidance in adopting water quality standards. (USEPA, 1999).

Water Quality Standards: These are the state-adopted and USEPA-approved ambient standards for waterbodies. The standards prescribe the use of the waterbody and establish the water quality criteria that must be met to protect designated uses.

In California Regional Basin Plans, water quality standards are composed of three parts:

i. Designated beneficial uses of water
ii. Water quality objectives that protect beneficial uses
iii. Implementation programs to achieve and maintain water quality objectives

Water Quality Standards = Beneficial Uses + Water Quality Objectives +Implementation Programs

Figure 6: Water Quality Standards (Source: Los Angeles Basin Plan, 1994.)

Water quality standards form a pyramidal structure of actions for the State and Regional water boards to follow. In order to protect the beneficial uses they must specify the water quality objectives and criteria for guaranteeing the protection of the potential and existing beneficial uses. At the same time, the boards must implement and design programs that guarantee the achievement of those water quality objectives. The programs materialize in the issuance of Waste Discharge Requirements (WDR), setting the maximum allowable limits, and other regulatory measures, such as the California Ocean Plan, California Toxics Rule, Total Maximum Daily Load (TMDL), California Enclosed Bays and Estuaries Plan and regional basin plans that also establish the criteria to be used in setting the effluent limits.

Basin plans contain water quality standards that are specific to surface waters and groundwater within a particular region or segment of a waterbody. The Basin Plans contain, beneficial use designations, water quality objectives and implementation programs. In summary, the regulator protects the beneficial uses of water through the establishment of water quality objectives and implementation programs.

2. Beneficial Uses

Beneficial uses are described in Section 13050(f) of the California Water Code as follows: *"Beneficial uses of waters of the state that may be protected against quality degradation include, but are not necessarily limited to, domestic, municipal, agricultural and industrial supply; power generation; recreation;*

aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves."

The regional Board Water Quality Control Plans list the specific beneficial uses established for each surface water and groundwater bodies within the region.

Surface waters are waters of United States and therefore subject to the federal Clean Water Act. Pursuant to the Water Quality Standards Regulation (40 CFR 131), states must define statewide water quality goals first by designating water uses and second by adopting water quality numeric and narrative criteria that protect the designated beneficial uses. When designating beneficial uses, States must consider the use and value of the waterbody for public water supplies, protection and propagation of fish, shellfish and wildlife, recreation in and on the water, agricultural, industrial, and other purposes including navigation. The designated use may or may not coincide with the existing use, but it cannot reflect lower water quality than the existing use (SWRCB Resolution 68-16, Antidegradation Policy). As described in the Water Quality Standards Handbook (USEPA, 1994), if the designated use of a water body is also an existing use, the designated use cannot be downgraded to one that requires less stringent water quality criteria. If, however, the designated use is not an existing use the states may, under certain circumstances, remove the designated use, create new subcategories of the use, or grant a water quality standard.

The beneficial uses described in the federal regulations are less specific than the beneficial uses described in the California Basin Plans (see appendix B.)

Regional Basin Plans identify the beneficial uses of surface, groundwater and coastal waters of waterbodies located within specific hydrological units. Waterbodies are listed multiple times if they cross-hydrologic areas or sub-area boundaries.

For surface waters, the beneficial use designations apply to all tributaries to the indicated waterbody. Beneficial uses are defined for every segment of the waterbody. A list with a description of all the beneficial uses found in California Regional Basin Plans is included in appendix B.

3. Water Quality Objectives

Section §13050 (h) of the California Water Code (CWC) defines "water quality objectives" as "the limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area."

Section §13050 (l)(1) of the CWC defines "pollution" as "an alteration of the quality of the waters of the state by waste to a degree which unreasonably affects such waters for beneficial uses, or facilities which serve such beneficial uses." Therefore, pollution occurs whenever water quality objectives are exceeded. From that point the beneficial uses are considered impaired and damage has occurred.

On the other hand, "nuisance" is defined in Porter-Cologne §13050 (m), as "anything which meets all of the following requirements 1) is injurious to health, or is indecent or offensive to the senses, or an obstruction to the free use of property, so as to interfere with the comfortable enjoyment of life or property, 2) affects at the same time an entire community or neighborhood, or any considerable number of persons, and 3) occurs during, or as a result of, the treatment or disposal of wastes." Nuisance occurs only when the three conditions are met, therefore, the occurrence of nuisance is more difficult to quantify.

Water quality objectives for every region in California are also found in their respective Water Quality Control Plans. Water quality objectives are established in the Basin Plans either for specific bodies of water, or for the protection of particular beneficial uses of surface waters or groundwaters throughout a specific basin or region.

Water quality objectives may be expressed in either numerical or narrative form. The numerical objectives values for the indicated constituents or parameters specified are those that, if reached, will provide reasonable protection for beneficial uses described for that specified body of water. The numerical limits are normally defined in parts per billion (PPB, μg/L) or parts per million (PPM mg/L) depending on the constituent, but can also be measured in many other formats (degrees Celsius, pH units, etc). An example of a numerical objective would be that the pH of the waters must be within the range of 6-8.5 pH units.

Narrative objectives describe a requirement or a prohibition, for example "waters shall not contain chemical constituents in concentrations that adversely affect beneficial uses" or "Water shall not contain taste- or odor- producing substances in concentrations that impart undesirable tastes or odors to domestic or municipal water supplies or to fish flesh or other edible products of aquatic origin, or that cause nuisance, or otherwise adversely affect beneficial uses."

Any narrative objective must be interpreted and a numerical limit selected which meets the narrative objective. The definition of the required limits that protect beneficial uses is of paramount importance, in assessing whether a particular discharge (regulated or unregulated) has caused or threatens to cause pollution. Therefore, exceeding the numerical and/or narrative objectives described in the water quality standards for the specific waterbody is sufficient to cause damage that can be estimated. The dose response function will be based on the numerical and narrative limits defined in water quality standards and in the Waste Discharge Requirements.

4. Implementation Programs

Water quality control programs instituted by state and regional water boards intend to prevent and correct conditions of water pollution and nuisance. The programs are implemented through the issuance of Waste Discharge Requirements (WDR). They set the maximum allowable limits for specific pollutants that can be discharged. The criteria to set the limits is also based on other regulatory measures such as the California Ocean Plan, California Toxics Rule, Total Maximum Daily Load (TMDL), California Enclosed Bays and Estuaries Plan and Regional Basin Plans.

Waste Discharge Requirements set the numerical and narrative limits for each discharge. Effluent limitation is defined, under 33 USC section 1362(11), as "any restriction…on quantities, rates, and concentrations of chemical, physical, biological, and other constituents which are discharged from point sources…"

Through the issuance of waste discharge requirements (permits), water quality monitoring and reporting programs, and other enforceable orders, the state and regional boards implement the statewide and regional water quality control plans, policies for water quality control, and water quality regulations. Permits are specific to the type of program, for example dischargers to surface waters require an "national pollution discharge elimination system" (NPDES) permit, dischargers of water to land require a Chapter 15 and Non chapter 15 permit (groundwater), etc. Permits include provisions, prohibitions and requirements.

Numerical water quality effluent limitations, established in permits, may be used to assess damages to beneficial uses from discharges of pollutants above the required effluent limit. The beneficial uses of a waterbody can be considered impaired when pollutants are discharged concentrations equal to or greater than these effluent limitations.

PART IV

PROPOSED METHODOLOGY TO ESTIMATE THE ECONOMIC DAMAGE TO BENEFICIAL USES OF WATER QUALITY

1. A Model of Valuation of Beneficial Uses of Water Quality

a) Introduction

In previous parts of this study we have stated that economic valuation of natural resources is necessary for the protection of the beneficial uses of water quality. This study contributes to this effort by proposing a methodology for improving the way in which available information is used to estimate the economic value of beneficial uses of water quality. This framework may provide a basis for the testing of the method proposed, if resources and needs became available.

An estimation of the damages to the value of beneficial uses from pollution must be done within an underlying theoretical model. The model must include a sound understanding of the underlying biological, chemical and physical processes by which environmental and resource service flows are generated.

Part II introduced the methods available to estimate economic values of beneficial uses of water quality. Part III described the relationship between the level of pollution, water quality and beneficial uses. This part presents a model that links the damaged caused by pollution to the economic valuation of those damages.

b) Assumptions

Any model that attempts to explain the functional relationships among variables must start with stating the assumptions on which the theoretical model is based.

Assumptions:

- The first assumption is that the proposed model is not measuring the value of water quality. What the model attempts to measure is the value of the damage to beneficial uses of water quality from pollution.
- The model assumes that damages to water quality are temporary, and therefore, no permanent loss or degradation of water quality is assumed. Damages will last a specified period of time. Therefore, discounting will not be required. The model will not be applicable to permanent damages to beneficial uses of water quality.
- The economically efficient level of pollution for a specific waterbody is defined in Waste Discharge Requirements (WDR). Therefore, we are assuming that WDR takes into consideration all of the discharges of pollutants to a specific waterbody. The underlying implication is that there is a Total Maximum Daily Load (TMDL) assigned for each waterbody that protects its beneficial uses.
- In cases of scientific uncertainty of the pollution/impact to beneficial use relationships, the study assumes that an exceedance of the effluent limits set up in Waste Discharge Requirements will totally damage

the value of certain beneficial uses. Therefore, no linear relationship is assumed; any exceedance of permit limits will reduce the value of beneficial uses to zero.

- There are no emission trading permits for pollutants.
- There is no scientific uncertainty on the level of pollution that protects beneficial uses. The adequate degree of certainty eliminates the need for risk management or risk assessment. Water quality standards will protect beneficial uses.
- We know the relationship between physical and biological changes in environmental and resource systems and the changes in well-being and values realized by the people affected by these changes.
- The beneficial uses of water quality meet all criteria for public goods.
- There is no market for goods and services provided by the beneficial uses.
- The value function is a simple aggregation of individuals' values.
- Designated beneficial uses of a waterbody are indeed the existing uses.
- The value of each beneficial use is known based on a certain unit that can be transferred for each reach of a waterbody.

c) Total Economic Value of Beneficial Uses of Water Quality for a Waterbody

The total economic value of a segment or reach of a waterbody is equal to the sum of the values of the individual beneficial uses for each segment. Then, for segment i of the waterbody the total economic value (TEV) is equal to the sum of the value of the individual beneficial uses for that segment of the waterbody.

$$TEV = \sum_{1}^{n} VBU$$

Where VBU is the value that each "n" individual derives from beneficial uses provided by water quality.

Then the total economic value for a particular waterbody would be the sum of all the existing beneficial use values. This is expressed as:

$$TEV_j = \sum_{i=1}^{i=n} (Bu_i)$$

TEV_j = Total economic value of the beneficial uses of waterbody j

Bu_i = value of the ith beneficial use of waterbody j

Beneficial uses of a particular watershed or waterbody are defined and assigned for each of the reaches of segments of the river. Therefore, in our calculation we should separate each one of the reaches or segments[10] of the river.

[10] A segment of the river is a reach of a river that has similar beneficial uses and properties. It can be defined as small as needed, but for practical purposes and simplicity it should be limited.

Symbolically, we could express the total economic value as:

$$TEV = \sum_{j=1}^{m} \sum_{i=1}^{n} (Bu_i)$$

Here, "m" is the total number of segments in which the river is divided and "n" the total number of beneficial uses.

The value of beneficial uses will be calculated based on the value of the goods and services that the beneficial uses generate. Therefore, the VBU is a function of the value of the vector of "l" goods and services[11] (VG) that the different beneficial uses provide.

$$VBU = \sum_{1}^{n} \sum_{1}^{l} VG$$

d) How to Value Goods and Services Provided by Beneficial Uses of Water Quality

The value of goods and services respond to a neoclassical demand function in which the quantities of goods and services consumed depend on the price, the level of income and the individual preferences. In neoclassical welfare economics, good is defined in terms of the well-being of individuals. Individual well being can be represented by a ordinal utility function (Freeman, 1993). The basis for deriving measures of the economic value of changes in water quality is their effect on human welfare. The value of the goods and services can be assessed directly or by estimation techniques that identify consumers' willingness to pay for the goods and

[11] Economists often mean "goods and services" when they say only "goods." We also use this convention.

services or willingness to accept compensation for the damage. The individual willingness to pay for goods and services will be calculated using the benefit transfer method. Then, a unit price is applied to the physical measure (miles of reach, etc) to convert it to monetary terms.

e) Water Quality and the Value of Beneficial Uses Relationship

The value of the beneficial uses of a waterbody can then be estimated for each specified level of water quality. Changes in water quality will lead to changes in the quality of the goods and services provided and therefore will reduce the value of those services and the willingness to pay for the same amount of goods and services for a similar utility level and income. It is assumed that the value function is a simple aggregation of the individual values. The value of each good provided by a beneficial use is a function not only of water quality, but of other factors, such as the prices of other goods and services consumed.

Next, we can establish that the value of goods and services provided by the beneficial uses of water quality will depend up on, among other things, the level of water quality that supports those beneficial uses.

VG=f(WQ, OTH)

Where:

$$\frac{dVG}{dWQ} \geq 0$$

Where, OTH will be a vector of other factors. We can expect a direct relationship between water quality and the value provided by goods and services of beneficial uses. Therefore, increases in water quality will increase the economic value of the goods and services provided by beneficial uses. Following the same rationality, reductions in water quality will impact the value of those uses negatively.

f) The Value of a Flow of Goods or Services Versus a Stock

One of the assumptions is that in estimating the damage to beneficial uses of water quality we are only taking into consideration the flow pollutants and not the stock pollutants.

The reason for this can be explained as follows. If the present value of the beneficial uses of a waterbody is B (B= PV (Σ B')), a stock, then the value of those beneficial uses today (a flow) would be the yield generated by those uses. The yield could be estimated by multiplying B by the risk free average rate of return. B x (i) = X, with X being the annual benefit derived from all the beneficial uses of the waterbody.

Therefore, the value of the negative externality of the impairment of the beneficial uses of the environment could be calculated as follows:

((B x (i)) / 365) * Days impacted * % Damage to beneficial uses= Value of damage

The optimal penalty level that assures the adequate level of compliance can be calculated by dividing the monetary value of damage by the probability of the violation being detected and penalties assessed and enforced (Becker, 1968).

g) The Damage Function to Beneficial Uses from Pollution

Once we have determined the value of the beneficial uses under a level of water quality that protects those beneficial uses, then we can determine a damage function to the value of beneficial uses based on the concentration of pollutants in the receiving waters and the amount discharged. In this usage, the "damage" terminology requires that some "clean" state or reference point be identified. We will assume that the state of water quality meets the criteria set in the water quality standards to protect beneficial uses.

For example, changes in the level of pollutants in a waterbody will modify the overall water quality. Changes in water quality alter the diversity of microorganisms, fish, or flora and fauna and can noticeably change the local ecological habitat. The magnitude of the technical effects depends on specific waterbody characteristics, the nature of the pollutant being discharged, and the extent of the damage. For example, river depth, flow rate, and riverbed geology will influence the technical effects of changing the designated uses of a river to include a warm water fishery (Smith et al., 1986).

Therefore, we can define that the level of water quality is a function of, among others, the concentration of pollutants.

WQ=f(POLLUTANTS, OTH)

Here, OTH is a vector of other factors. In cases of impairment of any of the beneficial uses, the potential value of the beneficial use may be reduced based on some type of index or indicator of degree of impairment. The value of each beneficial use would be a function of the degree of impairment and water quality. We could use a scale of zero to one for the assessment values, one being best. For each reported beneficial use, for each reach of the river, a score was given based on its level of support: fully supporting received a 1.0, threatened, but supporting, received a 0.75, partially supporting received a 0.50, not supporting received a 0.25, and not attainable received a 0.0. These scores were then averaged to determine a relative score for support of beneficial uses. For causes and sources of impairment, each record was given a score based on the magnitude of impairment; no recorded impairment received a score of 1.0, a suspected magnitude received a 0.75, a slight magnitude received a 0.5, moderate magnitude received a 0.25, and a high magnitude received a score of 0.0.

No numerical index of water quality exists in the form of binary (0-1) assessment of the actual capacity of a waterbody to satisfy the beneficial uses (some or all) that are defined in the basin plan. This could be accomplished with the use of estimates that will help us to assess the attainability of the water quality objectives. This could be in the form of a simple, yes-no analysis or a percentage (i.e. the water quality objectives are obtained by 50% impaired waters, or 100% for excellent waters), or in the form of a poor-fair-good-excellent evaluation. For the case in which the waters are not impaired or impacted by pollution, the water quality allow for the full use of beneficial uses assigned. In this case, the water quality index (WQI) would have a value of 1. If the waters are impaired (i.e. the waterbody is included in the 303(d) list), then the water quality index would be below 1, indicating that the quality of the waters are not providing full support for all beneficial uses.

Once we know the water quality index for each reach of the waterbody, we could derive the level of impairment for each of the beneficial uses. For example, beneficial uses related to drinking water would require a very high water quality index before the level of water quality loses the level required to support that beneficial use. On the contrary, other beneficial uses may be supported with a much lower degree of water quality or WQI. These values are known and can be derived from different studies that describe the physical biological and chemical properties of water that support beneficial uses. Symbolically, we could incorporate the support level for the beneficial use in each waterbody as follows:

$$TEV = \sum_{j=1}^{m} \sum_{i=1}^{n} \left(Bu_i \times WQI_j \times BUI_i \right)$$

WQIj = Is the Water Quality Index of the j reach of the waterbody

BUIi = Is the Beneficial Use Index, and reflects the sensitivity of a particular beneficial use to the WQI. It multiplies the impact. A very sensitive beneficial use to the WQI would have a high BUI. The beneficial use index should also specify the level of WQI that would not allow the support of the beneficial use.

The TEV of a particular waterbody would be expressed in monetary terms. The value of each beneficial use would be assigned based on other studies that estimate the beneficial use. The set of relationships represented is almost totally non-economic in nature because it involves a variety of physical and biological processes.

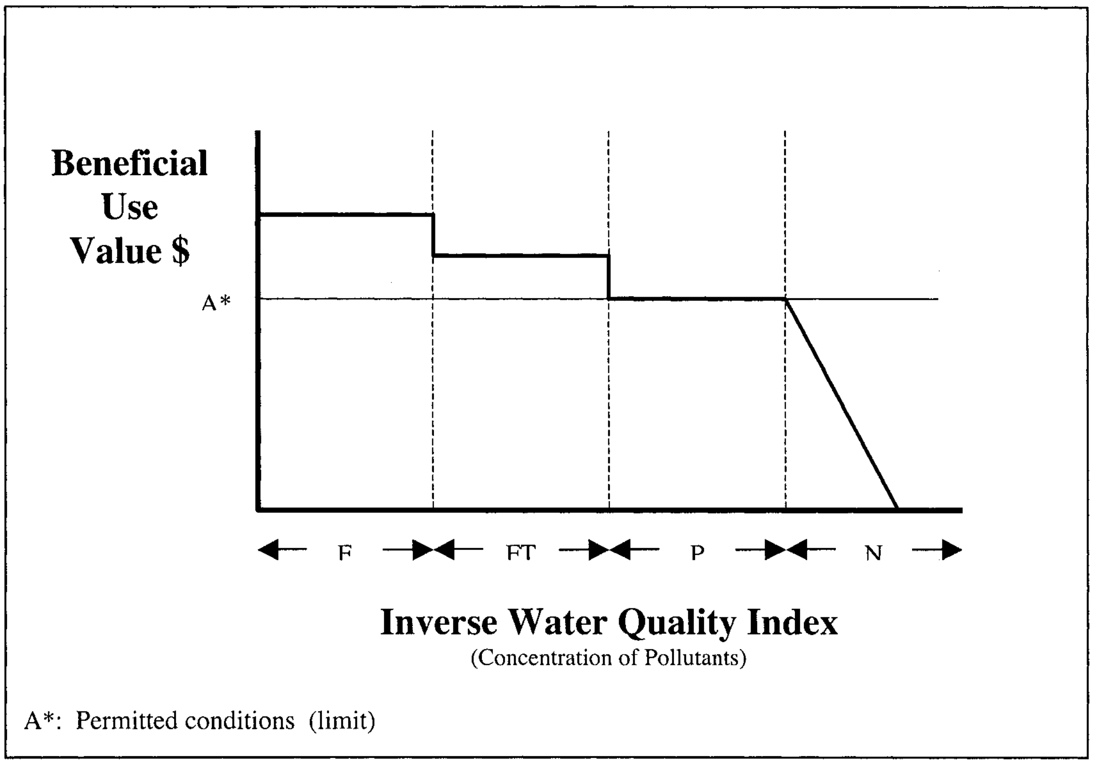

Figure 7: Trade Off Between Water Quality and Value of a Beneficial Use: Case 1 (Source: Author.)

Figure 7 represents the linear relationship between the level of water quality, represented by an inverse water quality index and the value of beneficial uses

The water quality index is represented here, by the level of support of beneficial uses from water quality. Changes in water quality can be from 1. Fully Supporting (F) to Fully Supporting but Threatened (FT), 2. (FT)to Partially Supporting (P), 3. (P) to Non Supporting (N).

Figure 7 represents a linear relationship between the level of support of the beneficial use and the value of the beneficial use after the water quality standard, that protects water quality, is exceeded, or after the level of pollutants that impair the beneficial use is exceeded (N zone in figure). This linear relationship is difficult to estimate but the value will not be reduced drastically to zero once the water quality reaches the zone "N" of impaired waters. For testing our model we will assume a relationship as described in figure 9.

2. Recommended Steps to Apply the Proposed Model

The total economic value of a waterbody can be defined as the sum of each of the values of all beneficial uses assigned to each reach of the waterbody. Beneficial uses are defined and assigned in each regional basin plan and their values are determined by several factors. The final value of each beneficial use will reflect reductions or enhancements depending on the quality of the waters. The definition and measurement of water quality and the link between water quality and beneficial uses must be identified to reach a method for calculating any values.

The literature reviewed recommends following certain steps, in estimating the economic damage of pollution. For example, Freeman recommends “An analysis of the value of a resource or of the benefits of an environmental or resource policy change must begin with a description of the resource flow or some measure of environmental quality. This description requires choices about what attributes or characteristics of the resource-environmental service are important” (Freeman, 1993, p. 34).

Tietenberg (2000) is even more specific in describing the steps required. When assessing damage caused by pollution, Tietenberg recommends the evaluator follow a specific methodology that includes all the following elements. Because pollution can damage natural resources and values in multiple ways, assessing the magnitude of the damage requires (1) identifying the affected categories, (2) estimating the physical relationship between the pollutant emissions (including natural resources) and the damage caused to affected categories, (3) estimating responses by the affected parties toward averting or migrating some portion of the damage, and (4) placing a monetary value on the physical damages. Each step is often difficult to accomplish (Tietenberg, 2000).

Figure 8 represents the four steps that this study proposes to estimate damages to beneficial uses of water quality from pollution.

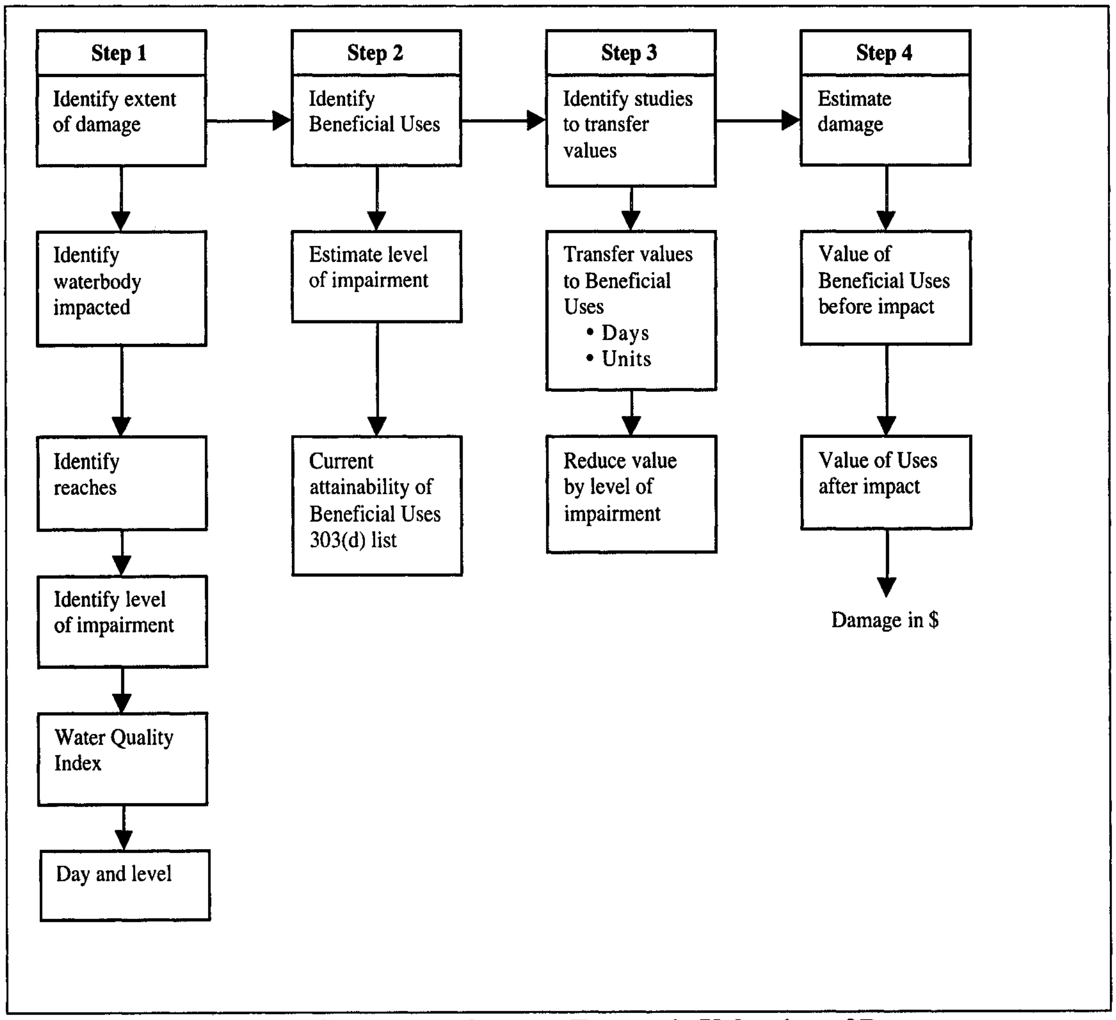

Figure 8: Recommended Steps to Perform an Economic Valuation of Damage to Beneficial Uses from Discharges of Fund Pollutants to Surface Waters (Source: Author.)

Step 1: Identify Extent of Damage (Who, What, Where, When)

A single effluent discharge may contain many substances that affect water quality. When these substances enter the waterway, they affect water quality in many different ways. In order to properly identify the extent of damage, we will need to identify and describe:

- The waterbody impacted,

- The reaches or segments of the waterbody impacted,
- The water quality for the waterbody prior to the damage,
- The extent of damage including: type of pollutants discharged, amount (mass loading) or concentration of pollutants discharged, number of days, that exceeded the limits, location of the discharge, reaches or segments of waterbody impacted, and level of impact, miles of river impacted, number of days of damage (we assume that the damage is not permanent and occurring during a short period of time, as the pollutants get diluted with the river flow, otherwise discounting will be required), beneficial uses impacted and level of impact to beneficial uses. Was the beneficial use already impaired? Is the level of impact progressive to the level of pollutants or drastic?

Step 2: Identify Beneficial Uses Affected and the Level of Impairment of Each Beneficial Use for the Amount of Pollutants Discharged

We need to identify first the services that the beneficial uses of water quality provide to society. The first requirement to estimate economic value is the definition of the beneficial uses, the estimation of its existence for every specific waterbody and the designation of the beneficial uses for each specific waterbody and segment of the waterbody. Other complications derive from the establishing specific values and definitions and categorizing the "existing uses" and "designated uses." For simplification purposes its assumed that designated uses will correspond with the existing uses.

The process starts with an identification of the beneficial uses assigned to a specified waterbody. The beneficial uses would need to be estimated individually for each reach of the waterbody. Beneficial uses are just defined as existing, potential or not assigned for each reach of a particular waterbody and may be classified based on the level of water quality that supports the beneficial use. In order to estimate the level of water quality that supports the beneficial uses, we will be using the water quality index developed by US EPA Region 9 introduced in Part III. Once the beneficial uses have been identified and designated we may be able to estimate their economic value using the benefit transfer methodology.

Step 3: Application of the Benefit-Transfer Methodology to Estimate Value of Beneficial Uses

By defining the goods and services that the beneficial uses of water quality provide, we will be able to recommend the use of the most appropriate valuation techniques for every case of water quality pollution and beneficial use impaired. A list of techniques available for each beneficial use was introduced in Part II.

To lower the costs of damage assessment, it was decided to rely on the benefits transfer approach to obtain an estimate of beneficial use damages.

The benefit-transfer method: Borrowing of an estimate of economic value of the consequences of a similar project or policy that has been implemented. A benefit transfer is the application of monetary values obtained from a particular non-market goods analysis to an alternative or secondary policy decision setting.

In this study, the benefit-transfer method is used to estimate the value of the beneficial uses of the quality of the waters described in the basin plans. The application of the benefit transfer method requires two steps; first, we need to identify studies that can be transfer to our policy site; second, we need to transfer the values from the study site to the policy site.

Step 4: Estimate the Value of the Damage in Monetary Terms

The damage caused to beneficial uses will be the difference between the value of the beneficial uses ex-ante (the value before the damage occurs) and the value ex-post (the value after the damage occurs).

4.1 Value of Beneficial Uses Ex-ante

The value of the beneficial uses ex-ante will be the sum of the monetary values of all existing beneficial uses for each specific reach of the waterbody, as identified using the benefit transfer method.

4.2 Value of Beneficial Uses Ex-post

The value of the beneficial uses ex-post would be the value of the existing beneficial for each reach of the Los Angeles River after a discharge event that damages the water quality that supports beneficial uses. Changes in water quality can be from 1. Fully Supporting (F) to Fully Supporting but Threatened (FT), 2. (FT)to Partially Supporting (P), 3. (P) to Non Supporting (N).

Figure 9 is a graphical representation of the changes in value of a beneficial use for different levels of water quality. This representation assumes that after the pollution level reaches the zone of "Non Supporting" then the value of the beneficial uses is reduced drastically to zero. This is the assumption that we will apply in the next part of this study.

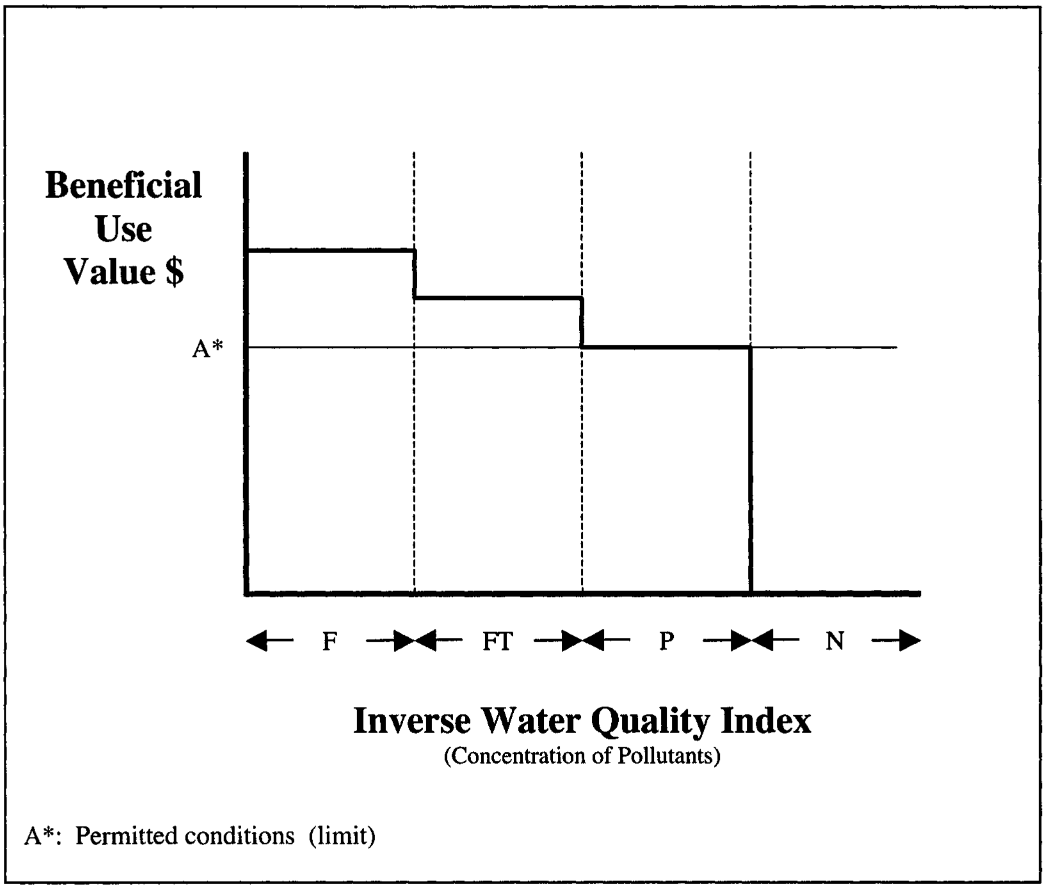

Figure 9: Trade Off Between Water Quality and Value of a Beneficial Use: Case 2 (Source: Author.)

PART V

TESTING THE PROPOSED METHODOLOGY. ASSESSING DAMAGES TO BENEFICIAL USES OF LOS ANGELES RIVER WATERSHED

1. Introduction: Testing the Proposed Model. Why the Evaluation of the Beneficial Uses of the Los Angeles River Watershed

This part will present the application of the methodology presented in the previous parts to estimate the damage to the economic value of beneficial uses using a case study of the Los Angeles River. We will be using information available that may allow us to perform an estimation of the damages to beneficial uses. Due to limited resources, this study may not allow for a total estimation of the value of beneficial uses, but it will point out a direction for further research.

To test the proposed model, the Los Angeles River has been selected for its physical characteristics and because it covers an urban area subject to multiple sources of pollution (point and non-point sources). The Los Angeles River also has many users and uses and is located in a city that lacks public parks. The Los Angeles River was also selected based on the number of studies available and the personal experience of the author. Due to the unique characteristics of the Los Angeles River, applying the model to other rivers may require a different approach.

Los Angeles River is unique in how it has been modified dramatically by man from its natural state. Under a rationale of flood control, the natural watercourse was significantly modified and the bed of the river was lined in concrete over more than 80% of its length. Its natural values were ignored and erased in order to protect human lives and the value of properties, allowing for the growth of one of the most populated cities in the world. The river was considered, then, only as a liability and not as a potential asset for the society and for the environment. The river has been seen as a problem in itself and the beneficial uses that it provided or could provide were ignored. This consideration led to the lining of the river and the destruction of beneficial uses that went unidentified.

Still, the Los Angeles River continues to be ignored by citizens, many of whom have never seen or would not recognize the river. It is a concrete channel that is commonly thought to only provide flood management service. The river flow used to be very small for most of the year, following the precipitation pattern for Southern California Region. It was originally mostly a dry creek that overflowed during storm events. The uneven flow regime of Los Angeles River has changed as well. With the importation of water from other regions, such as the Owens Valley, the Colorado River and Northern California, the river now has a steady flow during most of the year. That also represents a major change in the original ecosystem.

The river has been detached from its natural values. Still, many interest groups [12] are trying to revitalize the use and values of the actual river in his present condition. These values are described in many studies, as in the definition of beneficial uses in the Los Angeles Region Basin Plan or in other studies and projects

[12] Diverse groups and organizations are dedicated to the study and protection of the Los Angeles River such as Friends of Los Angeles River, Los Angeles River Watershed Council, etc.

(Saint et al., 1993; Trim, 2000; Danza, 1994). But, none of the studies and work visited have attempted to use economic analysis to estimate the value that society attributes to those beneficial uses related to water quality, and therefore none of the studies have attempted to calculate society's willingness to pay to protect the beneficial uses from pollution damage. The calculation of the value of the damages, in monetary terms, would help in estimating the cost to society when the beneficial uses are impaired or lost.

In order to properly evaluate the beneficial uses assigned to the Los Angeles River waters, we must define the physical, chemical and biological attributes of the river. It is also necessary to determine the existing beneficial uses and break them down into small components or attributes that could be compared and identified allowing the transfer of economic value estimation from other studies under similar circumstances. Lastly, it is necessary to estimate the current level of water quality that supports beneficial uses. The level of water quality depends upon the chemical, biological and physical characteristics of each reach of the river under current and optimal conditions of water quality. This analysis uses the description and determination of the reaches of the Los Angeles River defined in the Los Angeles Region Basin Plan. Other more detailed descriptions of the reaches of the river from sources such as documents that develop the Total Maximum Daily Load standards for the Los Angeles River will be included.

The major issues of concern in the watershed include: 1) protection and enhancement of fish and wildlife habitat, 2) removal of exotic vegetation, 3) enhancement of recreational areas, 4) attaining a balance between water reclamation and minimum flows to support habitat, 5) management of storm water quality, 6) assessment of other nonpoint sources including horse stables, golf courses, and septic systems, 7) pollution from contaminated ground water, 8) groundwater recharge with reclaimed water, 9) contamination of ground water by volatile organic compounds, 10) leakage of MTBE from underground storage tanks, 11) groundwater contamination with heavy metals, particularly hexavalent chromium, and 12) contaminated sediments within the Los Angeles River estuary. Some of these issues are only indirectly related to water quality, but are those identified by stakeholder groups (LARWQCB, 2000).

2. Steps to Assess the Potential Impact Derived from Pollution to the Value of Beneficial Uses of Water Quality

In the previous part, certain steps were identified that are recommended while assessing damages to water quality. Each step will be applied for the case of the Los Angeles River. In each step we will identify the information necessary and present, as an example, the information obtained from available resources.

Step 1: The Waterbody of Study

The description of the waterbody and its water quality relies on studies produced by the Los Angeles Regional Water Quality Control Board and are publicly available.

To describe waterbodies, the Los Angeles Regional Board uses the classification system developed by the California Department of Water Resources, which separates surface waters into hydrologic units, areas and sub areas. Ground waters are divided into major groundwater basins.

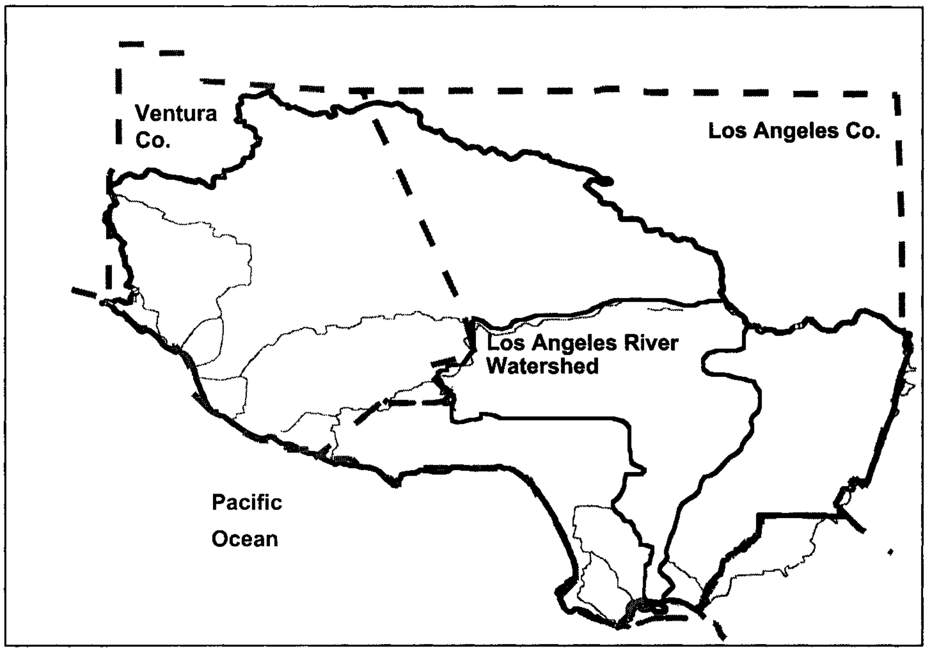

Figure 10: Los Angeles River Watershed (Source: Regional Water Quality Control Board, Los Angeles.)

A watershed "is the land area that drains into a stream; the watershed for a major river may encompass a number of smaller watersheds that ultimately combine at a common point" (USEPA, 2002). The Basin Plan defines the beneficial uses for specific waterbodies, but lacks the definition of a waterbody. For the purpose of this study it is assumed that the Basin Plan refers to a waterbody as a watershed for surface waters, and a basin for groundwater, for coastal features, to beaches, estuaries, wetlands, lagoons, harbors, marinas, islands and other public areas.

Step 1A: Identify and Describe Waterbody Impacted

The Los Angeles River is located in Los Angeles county and flows 51 miles from the western end of the San Fernando valley to the Pacific Ocean at Long Beach. The Los Angeles River watershed drains approximately 834 square miles, including the Rio Hondo's 132 square mile drainage area (Los Angeles River Master Plan, 1996). Approximately 35% (324 square miles) of the watershed, primarily the upper watershed, is forest or open space. These areas are primarily within the headwaters of the Los Angeles River in the Santa Monica, Santa Susana, and San Gabriel Mountains. Approximately 33% of the land use can be categorized as residential, 5% as industrial, and 5% as retail or commercial. Most of the area devoted to these more urban uses is found in the lower portions of the watershed.

A number of lakes, including Peck Lake, Echo Lake, and Lincoln Lake, are part of the watershed. Most of the River is lined with concrete for flood control purposes. However, portions remain unlined and in relatively natural condition, supporting riparian vegetation, fish and wildlife. Many species of fish are found in the river, including a federally endangered species, the Santa Ana sucker, and two state species of special concern, the Santa Ana Speckled Dace and the Arroyo Chub.

The headwaters of the river can be found to the north in the San Gabriel Mountains and to the south in the Simi Hills and the Santa Monica Mountains. The river flows through the San Fernando Valley, passes through the Glendale Narrows, past downtown and out to the Los Angeles Coastal Plain to its estuary and finally into Queensway Bay in the Los Angeles Harbor.

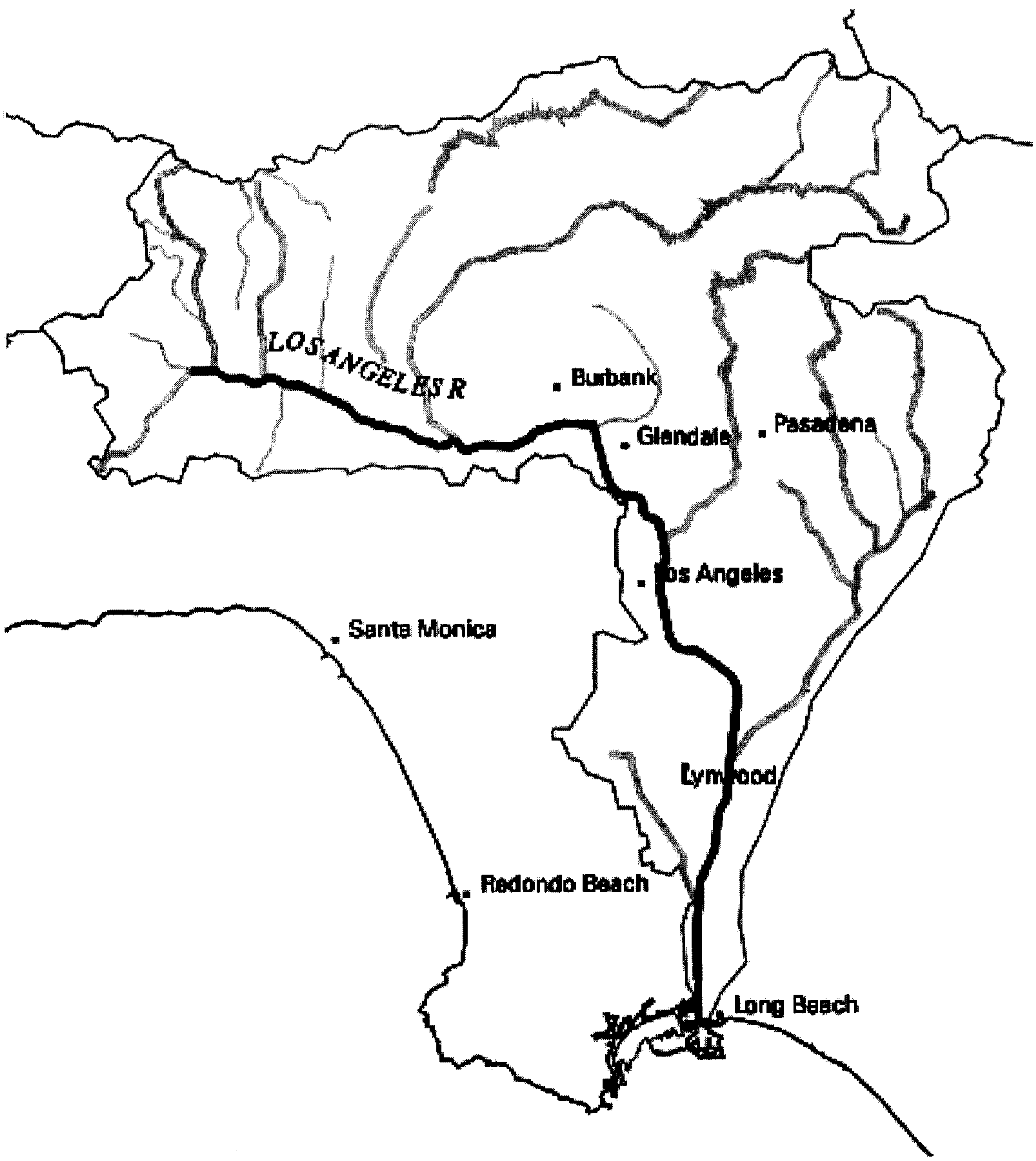

Figure 11: Los Angeles River Basin (Source: Information Center for the Environment, UC Davis.)

The 3-mile long estuary extends to about 700 feet upstream of the Pacific Coast Highway near Willow Street where the bottom width is 470 feet (Los Angeles Regional Basin Plan, 1994). Figure 11 is a geographical representation of the Los Angeles River basin. The natural hydrology of the river and many of its tributaries have been altered for flood control purposes, including channelization of much of the river and construction of flood control reservoirs. Most of the main stem of the Los Angeles River is lined with concrete, and most tributaries are lined with concrete for most or all of their lengths.

During dry weather, most of the flow in the Los Angeles River is comprised of wastewater effluent from three Publicly Owned Treatment Works (POTWs) in the Los Angeles Region watershed. For most years, the monthly average discharge in the river is approximately equal to the sum of the measured effluent from the Tillman, Los Angeles/Glendale, and Burbank POTWs. During periods of storm runoff, however, the river's flow is dramatically greater, upwards of two to three orders of magnitude. In dry-weather months, such as February through December 1997, the POTW monthly average discharges together equaled 80% to 100% of the monthly average flow in the river. In months with major rain events, such as February through May 1998, the POTW monthly average discharges together were less than 30% of the monthly average flow in the river.

Los Angeles River Watershed is subject to a high degree of variable precipitation from the dry season to the wet season and from one year to another as represented in Figure 12.

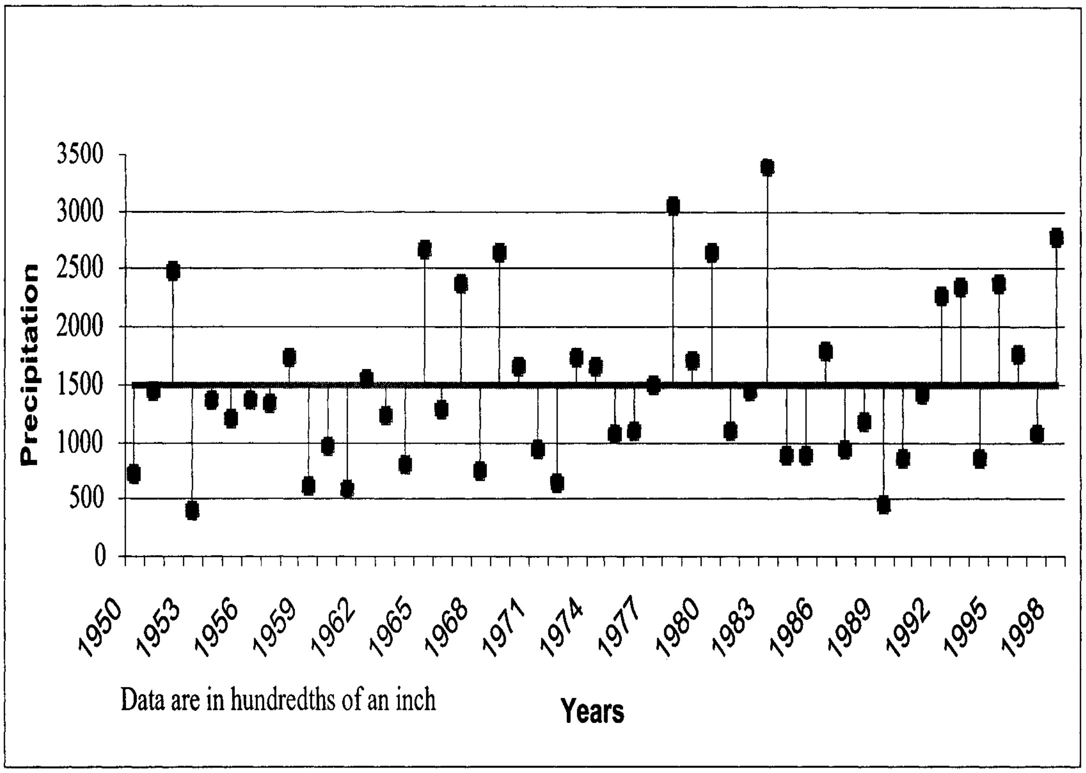

Figure 12: Average Yearly Precipitation in Los Angeles Region
(Source: Adapted from National Oceanographic and Atmospheric Administration.)

The high river flows during the wet season originate as storm runoff both from the large areas of undeveloped open space in the mountains of the tributaries' headwaters, and from the equally large urban land uses in the flat low-lying areas of the watershed. Rainfall in the headwaters flows rapidly because the watershed and stream channels for the most part are steep. In the urban areas, about 5,000 miles of storm drains in the watershed convey urban runoff to the Los Angeles River. The storm drains are designed to move stormwater flow rapidly and efficiently through the system. In effect, the watershed produces storm flow in the river with a sharply peaked hydrograph, where flow increases quite rapidly after the beginning of rain events in the watershed, and declines rapidly after rainfall ceases. Figure 13 shows a hydrograph of the Los Angeles River daily mean streamflow.

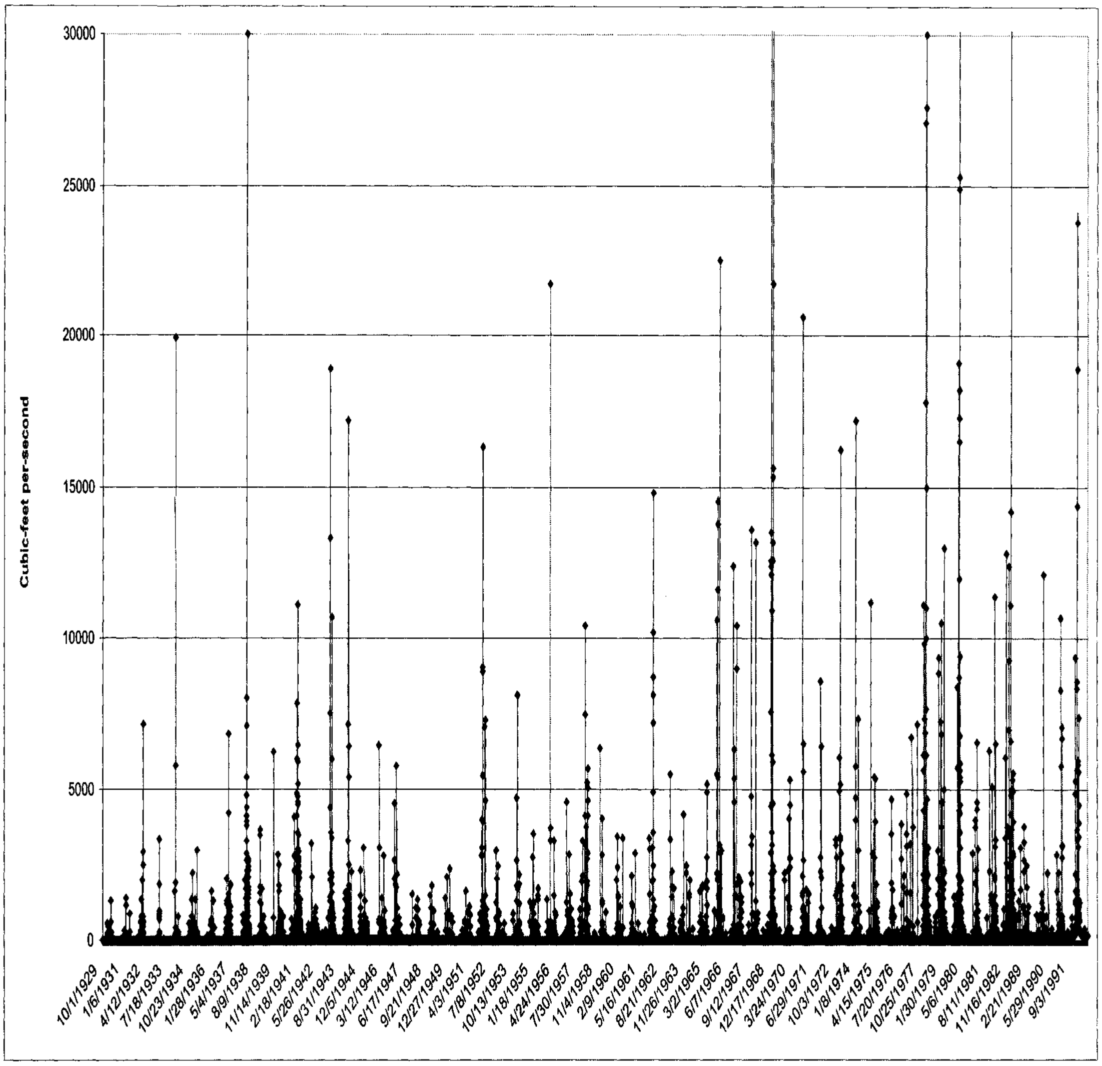

Figure 13: Los Angeles Daily Mean Streamflow 1929-1992, in cubic-feet per-second (Source: Adapted from National Oceanographic and Atmospheric Administration.)

The damage caused by discharges of pollutants; therefore, needs to account for differences in flow occurring between wet and dry seasons. For differences between storm runoff and periods of no runoff, both during wet seasons and dry seasons, and for differences in the relative contributions from point sources and urban runoff. The variability of the river streamflow can be explained as shown below in Table 5.

Table 5: Los Angeles River Streamflow Statistics

Los Angeles River streamflow statistics 1929-1992 (units in cubic-feet per-second)	
Mean	223
Standard Error	9.57
Median	30
Mode	12
Standard Deviation	1393
Sample Variance	1941949
Kurtosis	521
Skewness	19.27
Range	55000
Minimum	0
Maximum	55000
Sum	4728687
Count	21184
Confidence Level(95.0%)	18.76

Source: Adapted from United States Geological Survey.

The maximum value of the historical streamflow since 1929 is 55,000 cubic feet per second (ft^3/s). Although the mean number is quite high, at 223.21 ft^3/s, the mode and median values are much lower, 12 ft^3/s and 30 ft^3/s respectively[13].

For a 133 year flood the US Army Corps of Engineers has calculated a discharge of 175,000 ft^3/s for the river where it enters Queensway Bay (Simons et al., 1997).

[13] Information on precipitation can be accessed through the federal National Oceanographic and Atmospheric Administration (NOAA) web page at http://www.noaa.gov/. Information on the streamflow of the river can be accessed from the United States Geological Survey (USGS) at http://water.usgs.gov/.

Step 1B: Identify and Describe the Reaches of the Waterbody

Any potential discharge of pollution to any point within a waterbody will damage the water quality downstream from the discharge point. Also, beneficial uses are assigned to specific reaches of a waterbody. Therefore, in order to estimate the damage to beneficial uses, it is necessary to describe and identify the physical, chemical and biological characteristics of each reach of the waterbody. The Basin Plan divides the Los Angeles River into different segments or reaches in order to assign beneficial uses to the water quality of the river.

The Los Angeles Regional Basin Plan defines two reaches for the Los Angeles River as the Upper Watershed, above Figueroa street, and the Lower Watershed, between Figueroa Street and Los Angeles River Estuary (Willow Street), including Rio Hondo below Santa Ana Freeway. Other waterbodies within the watershed include the Rio Hondo (above Santa Ana Freeway), Santa Anita Creek (above the Santa Anita spreading grounds), Eaton Creek (above Eaton Dam), Arroyo Seco (above the spreading grounds), Big Tujunga Creek (above Hansen Dam), and Pacoima Wash (above the Pacoima spreading grounds).

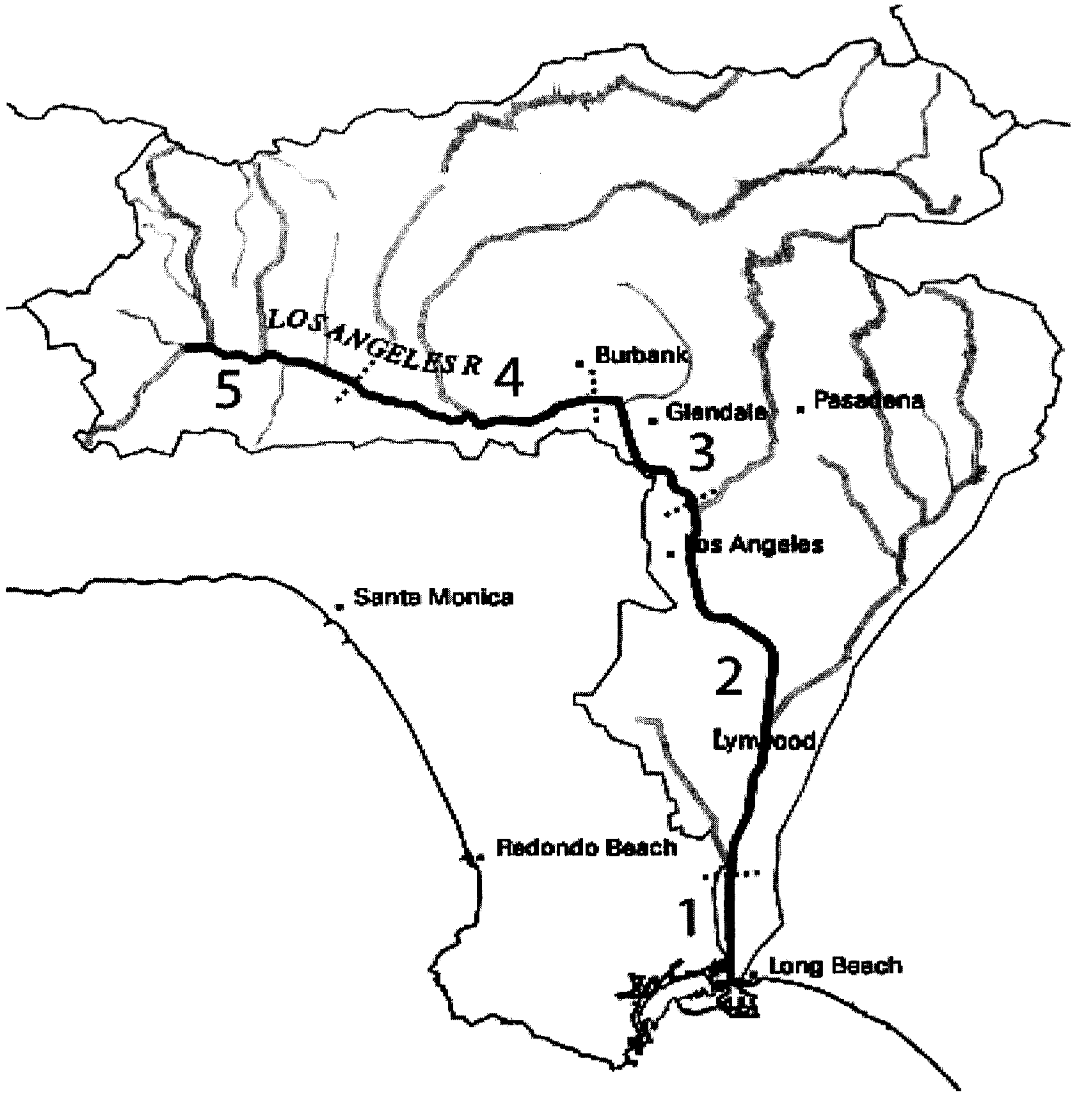

Figure 14: Five Identified Reaches of Los Angeles River (Source: Los Angeles Regional Basin Plan.)

Five reaches of the Los Angeles River have been defined, excluding the tributaries, reaches one and two correspond to the Lower Watershed and reaches three to five, correspond to the Upper Watershed (see Figure 14).

Reach 1: From San Pedro Estuary to Carson Street (2.01 miles)

Compton Creek is the last large tributary to the system, entering the Los Angeles River at mile six. Compton Creek is channelized for most of its 8.5 mile length. The tidal portion of the Los Angeles River begins in Long Beach at Willow Street (mile 3) and runs approximately three miles before joining with Queensway Bay located between the Port of Long Beach and the city of Long Beach. In this reach, the channel has a soft bottom with concrete-lined sides. Sandbars accumulate in this portion of the river where tidal influence is limited.

Reach 2: Carson Street to Figueroa Street (19.37 miles)

The first major tributary below the Narrows is Arroyo Seco (mile 24), which drains areas of Pasadena and portions of the Angeles National Forest in the San Gabriel Mountains. The 10-mile length of the Arroyo below Devils Gate Dam to the Los Angeles River is channelized, and is listed for algae.

The Rio Hondo is a channelized tributary and joins the Los Angeles River at mile 10. The Rio Hondo and its tributaries drain a large area in the western portion of the watershed. Flow in the Rio Hondo is managed by the County Sanitation Districts of Los Angeles County (CSDLAC). At the Whittier Narrows the Rio Hondo and the adjacent San Gabriel River both enter a large spreading grounds, managed by the County Sanitation Districts of Los Angeles County (CSDLAC). Flow from the two rivers intermingles during storm events, producing substantial flows in the Los Angeles River downstream of the spreading grounds. During other periods, especially during dry weather, virtually all the water in Rio Hondo goes to groundwater recharge, so little or no flow exits the spreading grounds into the Los Angeles River. Rio Hondo is listed for ammonia both at the spreading grounds and downstream, in the reach from the Santa Ana Freeway to the Los Angeles River confluence.

Reach 3: Figueroa Street to Riverside Dr. (7.24 miles)

Further downstream, where the Los Angeles River continues flowing east in the San Fernando Valley, Burbank Western Channel and Verdugo Wash enter at mile 30 and mile 28 respectively. Both are channelized streams which drain the Verdugo Mountains. The Western Channel is listed for multiple nitrogen-related effects below the point where it receives flow from the Burbank Water Reclamation Plant, a POTW with a design capacity of 9 million gallons per day (mgd). Average monthly flows from this POTW in the period 1995 to 2000 were about 4 mgd, or about 6 ft^3/s.

At the eastern end of the San Fernando Valley, the Los Angeles River turns south at the eastern end of the Hollywood Hills and flows through Griffith Park and Elysian Park through an area known as the Glendale Narrows. This area is fed by natural springs during periods of high groundwater. The river is channelized and the sides are lined with concrete, but the river bottom in this area is unlined because the water table is high and groundwater routinely discharges into the channel, in varying volumes depending on the level of the water table. In the unlined channel, the bottom is a mixture of soft sediments, boulders and cobbles, allowing riparian vegetation to grow, providing habitats for birds, benthic invertebrate fauna and fish.

The Los Angeles/Glendale Water Reclamation Plant, operated by the City of Los Angeles, is a 20-mgd POTW which discharges into the Los Angeles River in the Narrows at mile 29. The monthly average effluent discharge in the period 1995 to 2000 from this plant area was approximately 13 mgd, or 19 ft^3/s.

Reach 4: Riverside Dr. to Sepulveda Dam (11.84 miles)

Below the Sepulveda Basin, Pacoima Wash and Tujunga Wash enter the Los Angeles River. Both tributaries drain portions of the Angeles National Forest in the San Gabriel Mountains. Pacoima Wash is channelized below Lopez Dam to the Los Angeles River. None of this reach is listed for nitrogen or related effects. Tujunga Wash is listed for the 10-mile reach below Hansen Dam. It is entirely channelized in this reach. Some of the discharge from Hansen Dam is diverted to spreading grounds for groundwater recharge, but most of the flow enters the channelized portion of the stream.

Reach 5: Above Sepulveda Flood Control Basin (8.1 miles)

The main stem of the Los Angeles River begins by definition at the confluence of Arroyo Calabasas, which drains the northeastern portion of the Santa Monica Mountains and Bell Creek, which drains the Simi Hills, at mile 55 (i.e. 55 miles upstream of San Pedro Bay). The river flows east from its origin along the southern edge of the San Fernando Valley. In this region, the Los Angeles River receives flow from Browns Canyon, Aliso Creek and Bull Creek, and non-listed tributaries which drain the Santa Susana Mountains. The lower portions of Arroyo

Calabasas and Bell Creek are channelized. Browns Canyon, Aliso Creek and Bull Creek are completely channelized.

The river enters the Sepulveda Basin at mile 41. The Basin is a 2,150-acre open space designed to collect floodwaters during major storms. Because the area is periodically inundated, it remains in a natural or semi-natural condition and supports a variety of low-intensity land uses. Sepulveda Basin and Glendale Narrows supports various beneficial uses. The Sepulveda Basin and Glendale Narrows support the WILD designation. The Sepulveda Basin supports the water contact recreation (REC1) beneficial use. The D.C. Tillman Wastewater Reclamation Plant, a POTW operated by the City of Los Angeles, discharges directly into the Los Angeles River within the basin and also via two lakes in the Sepulveda Basin that are used for recreational and wildlife habitat. The POTW has a capacity of 80 mgd and contributes a substantial flow to the Los Angeles River. The average monthly flow for the period 1995 to 2000 was approximately 53 mgd (i.e. 80 cubic feet per second (ft^3/s)). During periods of storm runoff, POTW flow is a small proportion of the total flow in the river at this point. At other times, the discharge from Tillman constitutes a large proportion of the flow in the river. The 1998 California 303(d) list and TMDL priority schedule describes the man made Sepulveda Basin as an additional reach to the waterbody.

Step 1C: Identify and Describe the Quality of Waters Prior to Damage

The Water Quality Control Plan for Los Angeles Region (Basin Plan) sets standards to protect the waters of Los Angeles River. The standards consist of the designated beneficial uses of the waters, narrative and numeric objectives to protect those uses, and the State's Antidegradation Policy.

In determining the quality of waters of the Los Angeles River we will be using the 305(b) and 303(d) reports submitted by the State Board to USEPA. These reports describe the extent to which waters are meeting water quality standards. Under Section 303(d), states must identify waters that are not meeting water quality standards, submit a list to USEPA of those impaired waters, and develop Total Maximum Daily Loads (TMDL) for them.

Water Quality Problems and Issues

Pollutants from dense clusters of residential, industrial, and other urban activities have impaired water quality in the middle and lower watershed. Adding to this complex mixture of pollutant sources, in particular pollutants associated with urban and stormwater runoff, is the high number of point source permits (LARWQCB, 2000).

The majority of the LA River Watershed is considered impaired due to a variety of point and nonpoint sources. The 1998 303(d) list implicates pH, ammonia, a number of metals, coliform, trash, scum, algae, oil, chlorpyrifos, as well as, other pesticides and volatile organics in the impairment. Some of these constituents are of concern throughout the length of the river, while others are of concern only in certain reaches (see chart below). Impairment may be due to water column exceedances, excessive sediment levels of pollutants, or bioaccumulation of pollutants. The beneficial uses threatened or impaired by degraded water quality are aquatic life (WARM, WET, MAR, SPWN, SHELL, MIGR), recreation (REC1, REC2), groundwater recharge (GWR), and municipal water supply (MUN) (see appendix B for a description of codes of beneficial uses).

Table 6: Miles of Segments of the Los Angeles River and Tributaries Listed as Impaired for Nitrogen, pH, or Eutrophic Effects

Listed Waterbody Segment	Miles: By Reason for Impairment				
	Ammonia	Nitrogen	Odors	Scum/ Foam	pH
5. Los Angeles River (at Sepulveda Basin)	1.9	1.9	1.9	1.9	
4. Los Angeles River (from Sepulveda Dam to Sepulveda Dr.)	11.8	11.8	11.8	11.8	
3. Los Angeles River (from Riverside Dr to Figueroa St.)	7.2	7.2	7.2	7.2	
2. Los Angeles River (from Figueroa St. to Carson St.)	19.4	19.4	19.4	19.4	
1. Los Angeles River (From Carson St. to estuary)	2.0	2.0		2.0	2.0
Total miles affected	42.3	42.3	40.3	42.3	2.0

Source: USEPA 303(d) list.

Table 7: Examples of Typical Data Ranges, Which Led to the Listings Under the 303 (d) List

Impairments	Applicable Objective/Criteria	Typical Data Ranges Resulting in Impairment	303(d) Listed Waters/Reaches
Ammonia	Basin Plan numeric objective: varies depending on pH and temperature but the general range is 0.53 - 2.7 mg/l of total ammonia (at average pH and temp.) in waters designated as WARM to protect against chronic toxicity and 2.3 - 28.0 mg/l to protect against acute toxicity	ND - 34.9 mg/l (mean of 10.7 ± 4.8)	Los Angeles River Reach 5 (within Sepulveda Basin) Los Angeles River Reach 4 (Sepulveda Dam to Riverside Dr.) Los Angeles River Reach 3 (Riverside Dr. to Figueroa St.) Los Angeles River Reach 2 (Figueroa St. to u/s Carson St.) Los Angeles River Reach 1(u/s Carson St. to estuary)
Nutrients (algae)	Basin Plan numeric objective: nitrates-N + nitrites-N not greater than 10 mg/l	0.2 - 14.5 mg/l (mean of 2.7 ± 3.2)	Los Angeles River Reach 5 (within Sepulveda Basin) Los Angeles River Reach 4 (Sepulveda Dam to Riverside Dr.) Los Angeles River Reach 3 (Riverside Dr. to Figueroa St.) Los Angeles River Reach 2 (Figueroa St. to u/s Carson St.) Los Angeles River Reach 1(u/s Carson St. to estuary)
pH	Basin Plan numeric objective: 6.5 - 8.5 pH units	7.0 - 10.6 pH units (mean of 9.2 ± 0.9)	Los Angeles River Reach 1(u/s Carson St. to estuary)

Source: USEPA 303(d) list.

General Pollutants

The Los Angeles River (lower reach) is identified in the 303(d) list as impaired, not meeting the standards for pH, Ammonia, Lead, Coliform, Trash, Scum/Foam-unnatural, Nutrients (Algae), Total Dissolved Solids (TDS) and turbidity.

Nitrogen Compounds

Analysis indicates that six of the beneficial uses, WARM, WILD, MUN, GWR, REC1, and REC2 are the most sensitive to nitrogen compounds and related effects (low dissolved oxygen, low pH, and excessive algal biomass), such that protecting those uses will serve to protect all related effects also.

Dissolved Oxygen

Sampling at the mouth of Los Angeles River in November 1990, February 1991 and July 1994, showed levels of Dissolved Oxygen (DO) of bottom ranged from 2.7 mg/l (temp. 19.1 C) in the fall to 11.4 mg/l (temp. 21.8 C) in the summer. Surface water DO ranged from 4.1 mg/L (temp. 19.2 C) in the fall to 11.6 mg/l (temp. 22 C) in the summer.

Potential Sources of pollution

The Los Angeles Regional Water Quality Control Board has identified point and non-point sources of pollution, as well as naturally occurring pollutants, as the causes of the level of impairment of water quality in Los Angeles River watershed. Among other potential sources of pollution, the Regional Board lists the following: Publicly Owned Treatment Works (POTW), industrial discharges, septic systems, landfills, non-point sources like horse stables and golf courses, illegal trash dumping and cross contamination between surface water and groundwater (LARWQCB, 2000).

Dischargers to the LA River

The Regional Water Quality Control Board regulates the discharge of 216 Million Gallons a day from 7 major dischargers, 30 minor dischargers and 110 dischargers regulated under a general permit. The 7 major dischargers discharge almost 50% of the daily discharge flow to the surface waters of the river.

Water Quality Classification

The 303(d) list classifies the level of support of the beneficial uses of each reach of the river based on the level of water quality. The classification has 4 categories: (F) fully supporting, (FT) supporting but threatened, (P) partially supporting, (N) not supporting. Some of the beneficial uses have not been related to water quality, or its level of support has not yet been assessed, in those cases they are classified as (U) unassessed.

Step 1D: Describe and Analyze the Extent of Damage

The following information will be necessary to assess the scale and extent of the potential damage to beneficial uses for exceedances of effluent limitations.

- Type of pollutants discharged
- Amount (mass loading) or concentration of pollutants discharged
- Number of days, that exceeded the limits

- Location of the discharge
- Reaches or segments of waterbody impacted, and level of impact
- Miles of river impacted
- Number of days of damage (the damage is assumed not to be permanent and occurring during a short period of time, as the pollutants get diluted with the river flow, otherwise discounting will be required)
- Beneficial uses impacted and
- Level of impact to beneficial uses (Was the beneficial use already impaired? Is the level of impact progressive to the level of pollutants or drastic?)

The information required to perform the calculation should be available on a case-by-case basis.

Step 2: Identification and Evaluation of the Beneficial Uses of Los Angeles River

The Basin Plan for the Los Angeles Regional Board (1994) defines 14 beneficial uses for the Los Angeles River. Table 8 describes these uses, and identifies them as existing (E), potential (P), or intermittent (I). All beneficial uses must be protected without any specified priority.

Beneficial uses of water quality are assigned to reaches of the Los Angeles River. The basin plan does not assign a quantitative or qualitative value to these uses.

Beneficial uses are just defined as existing, potential or intermittent. In the description of the beneficial uses, there is no reference to any qualitative and/or quantitative estimation of the value of those beneficial uses. A beneficial use is defined and graded the same regardless of its location and value. This approach may lead to erroneous conclusions. For example, the Basin Plan for Sisar Creek (Santa Clara River Watershed) designates more beneficial uses than the Los Angeles River despite differences in their uses and their benefits.

The beneficial uses described and assigned to the Los Angeles River in the Los Angeles Region Basin Plan were estimated based on a study performed by Fullerton University (Saint et al., 1993). During the preparation of the Los Angeles Region Water Quality Basin Plan, evaluations of every waterbody and studies were conducted to assign beneficial uses to specific segments of waterbodies. Several institutions, including universities and government organizations participated in the evaluation of the beneficial uses[14].

An existing use designation for warm freshwater habitat (WARM) and wildlife habitat (WILD) applies over much of the mainstream and Compton Creek in the lower part of the watershed. The WARM designation applies as a potential use to the remaining listed tributaries. The Wildlife use designation (WILD) is for the protection of fish and wildlife. This use applies to much of the mainstream of the Los

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[14] During the preparation of the Basin Plan, the Regional Board contracted with the California Department of Water Resources for a study of beneficial uses and objectives for the upper Santa Clara River and a similar study of the beneficial uses and objectives the Piru, Sespe, and Santa Paula Hydrologic areas of the Santa Clara River. In addition, the Regional Board contracted with Dr. Prem Saint of California State University at Fullerton to survey and research beneficial uses of all waterbodies throughout the Region.

Angeles River, as an intermittent use in Rio Hondo, and as a potential use in the remainder of the tributaries. Water quality objectives developed for the protection of fish and wildlife are applicable to the reaches with the WARM and WILD designations.

Water quality objectives apply to waters with the municipal and domestic water supply use (MUN) and ground water recharge (GWR). The MUN use designation applies to all reaches in the Los Angeles River watershed. This is based on statewide policy that all surface and ground waters of the state be considered suitable, or potentially suitable, for municipal or domestic water supply (State Water Resources Control Board, 1988).

Recreational uses for body contact (REC1) and secondary contact (REC2) apply to almost all the listed river segments and tributaries as existing, potential or intermittent. These uses apply even though the Los Angeles Department of Public Works (LADPW) prohibits access to the Los Angeles River and the concrete-channelized areas of Tujunga, Verdugo, Burbank Western Channel, Arroyo Seco, and Rio Hondo. Despite the prohibition of access, people are still observed using the Los Angeles River for recreational purposes. Objectives designed to protect human health (e.g., bacterial objectives) and the aesthetic quality of the resource (e.g., visual, tastes and odors) are appropriate to protect recreational uses of the river.

Table number 8 describes the beneficial uses for each reach of the Los Angeles River with an assessment of the level of water quality that supports the beneficial use.

Table 8: Beneficial Uses in Listed Reaches of the Los Angeles River

Beneficial Use	Reach 1		Reach 2		Reach 3		Reach 4		Reach 5		Reach 6	
MUN	P_1	FT	P_1	FT	P_1	FT	P_1	FT	P_1	FT	P_1	N
GWR	E	U	E	U	E	U	E	U	E	U	E	U
REC1	E_2	N	E_2	N	E_2	N	E_2	N	E_2	N	E_2	N
REC2	E	N	E	N	E	N	E	N	E	N	E	N
WILD	E		E		E		E		E		E	
WARM	E	N	E	N	E	N	E	N	E	N	E	F
SHELL	P_2	N	P_2	N								
RARE	E		E									
MIGR	P	N	P	N								
SPWN	P	N	P	N								
WET					E	N	E	N	E	N	E	F
MAR	E	N	E	N								
IND	P	U	P	U	P	U	P	U	P	U	P	U
PROC	P	U	P	U								

Source: Adapted from Los Angeles Basin Plan.
1. Use may be reviewed by SWRCB, MUN designations under SB 88-63 and RB 89-03; 2. Use restricted by Los Angeles County Department of Public Works. (E): Existing Beneficial Use. (P): Potential Beneficial Use. (F): Fully Supporting. (FT): Fully Supporting, but Threatened. (P): Partially Supporting. (N): Not Supporting. (U): Unassessed.

A detailed description of the beneficial uses of Los Angeles River can be found in appendix D. This level of description of the value of beneficial uses is necessary in order to understand the attributes of the beneficial uses that can be transferred from other studies.

The level of impairment is also necessary in order to estimate the real economic value (and not the potential) of the beneficial uses in their current situation. Every two years, the State Water Resources Control Board submits a report to U.S. Environmental Protection Agency on the State of California water quality, pursuant to section 305(b) of the Federal Clean Water Act. This report is called the California 305(b) report.

Assessment of the quality of the surface waters is based upon the extent to which beneficial uses have been, or are threatened to be, impaired. The classification of water quality upon the level of support of each assigned beneficial use can be four types; Fully Supporting (F), Fully Supporting but threatened (FT), Partially Supporting (P) and Not Supporting (N).

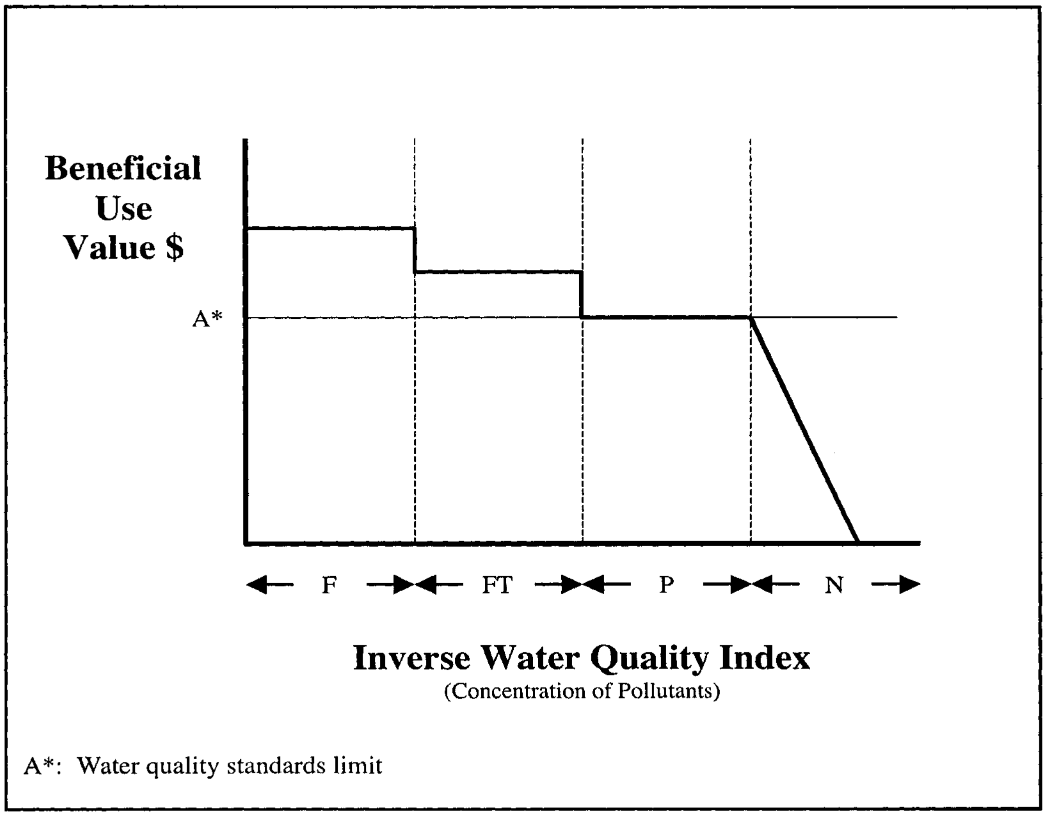

Figure 15: Beneficial Use Value and Water Quality Relationship (Source: Author.)

Figure 15 represents the relationship between the level of beneficial use support and the level of water quality index.

The economic value of the beneficial use, measured in monetary terms, can also be represented in the graph, as it is a function of the level of support of the beneficial use. The degree, and the relationship between water quality and beneficial use value needs to be established.

STEP 3: Application of the Benefit Transfer Method in the Calculation of the Value of the Beneficial Uses of Los Angeles River

Step 3A: Identify Studies to Transfer Values

The determination of the value of beneficial uses must be made on a case by case basis. It will differ for every watershed, waterbody and season. In the application of the benefit transfer method we may follow the five step process proposed by Desvouges et al. (1992). The criteria proposed can be summarized in three aspects: a) the study sites and policy sites are similar, b) the environmental change under consideration at the policy site is similar to the proposed change at the study site, and c) the socioeconomic characteristics of populations and other site details are similar.

In order to identify studies to transfer values, we can use available databases that compile multiple evaluation studies, sorted and filtered by the criteria selected. The criteria to be used will be the waterbody type, the beneficial uses impacted and the degree and type of pollution. Examples of databases to collect information are ENVALUE, EVRI and Beneficial Use Values Database, introduced in Part II.

Step 3B: Transfer values from study site to policy site

Once available studies have been selected and identified and the values to be applied to the policy site have been properly adjusted, we will need to transfer the values to the policy site.

In order to transfer values from study site to policy site, we can follow one of the three approaches proposed by Pearce et al. (1995): 1) transferring mean unit values, 2) transferring adjusted unit values or, 3) transferring the demand function, as explained in part II.

The transfer of the unit values may require some type of adjustment for time comparisons as well as location, price indexes, cost of living, population, competitive beneficial uses, etc. These adjustments may require a high degree of understanding in the economics field.

STEP 4: Estimate Damage Value in Monetary Terms

In order to estimate the damage caused by the discharge of flow pollutants into the Los Angeles River, we need to compare the value ex-ante the damage was caused and the value ex-post. The difference between the value ex-ante and the value ex-post will be the value of the damage that the discharger must compensate society.

Step 4A: Value of Beneficial Uses Ex-ante

The value of the beneficial uses ex-ante will be the sum of the monetary values of all existing beneficial uses for each specific reach of the waterbody, as identified using the benefit transfer method. For our case study of Los Angeles River this study has not identified adequate studies to transfer to the policy site, and therefore the author was not able to estimate the value of beneficial uses ex-ante using the benefit transfer method.

Step 4B: Value of Beneficial Uses Ex-post

The value of the beneficial uses ex-post would be the value of the existing beneficial for each reach of the Los Angeles River after a discharge event that damages the water quality that supports beneficial uses. Changes in water quality can be from 1. Fully Supporting (F) to Fully Supporting but Threatened (FT), 2. (FT) to Partially Supporting (P), 3. (P) to Non Supporting (N).

The highest level of damage to beneficial uses will be from (P) to (N), in which the value of beneficial use is lost for the duration of the damage. This damage can be assumed to be proportional to the damage or to be an all-or-nothing relationship, in which after exceeding a certain level of pollution the value of the beneficial uses is zero and the impact of the damage to beneficial uses derived from exceeding water quality standards or limits is maximum. This assumption, in its simplicity, may lead to controversies and a more defined water quality and beneficial use relationship needs to be established.

A graphical representation of this controversy is presented in Figures 15 and 16. In Figure number 15, we assumed that the value of beneficial uses would decrease proportionally to the decrease in water quality after the water quality standard for each beneficial use or the limit for each pollutant would have been exceeded. Figure number 16 represents a relationship that assumes that the value of beneficial uses would be zero after the water quality standard for each beneficial use or the limit for each pollutant would have been exceeded. This approach simplifies the estimation of damage although it may be too simple.

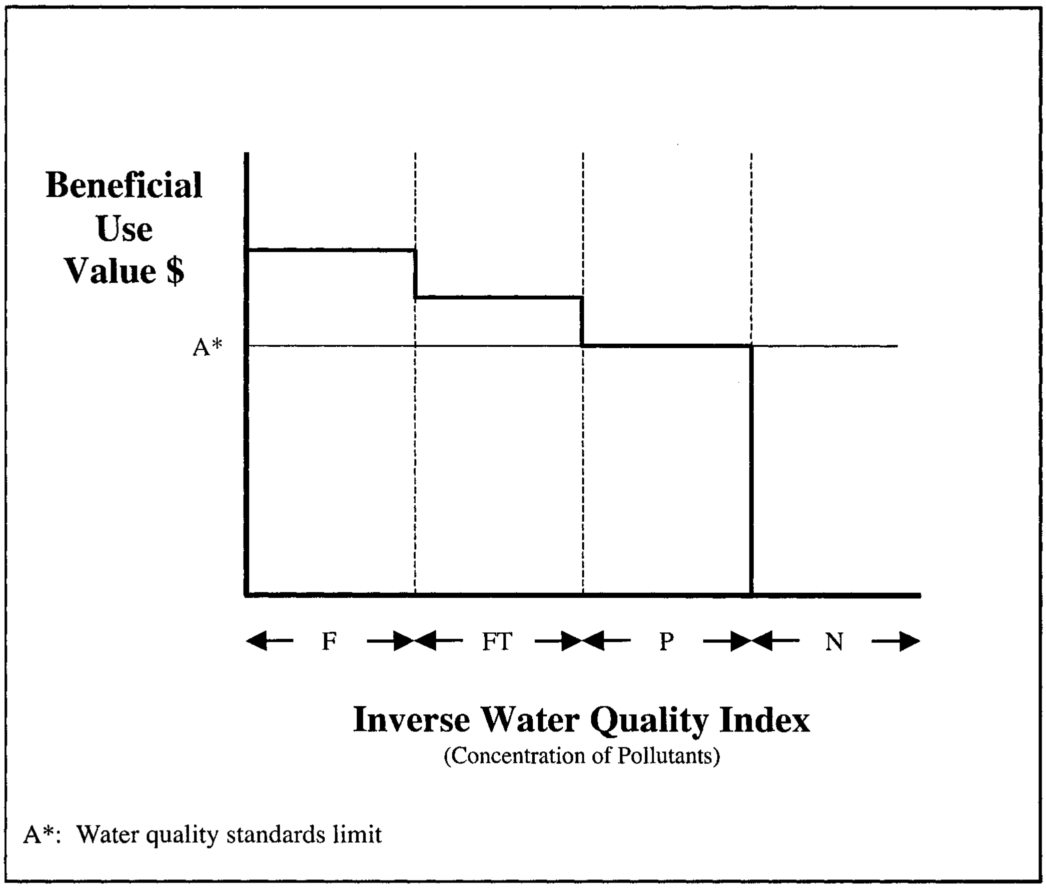

Figure 16: Beneficial Use Value and Water Quality Relationship Assuming Full Degradation of Beneficial Uses after Exceeding Water Quality Standards Limit (Source: Author.)

PART VI

CONCLUDING REMARKS

Water quality protection in California is managed at a regional level by, among other agencies, the California Regional Water Quality Control Boards. The Regional Boards define the beneficial uses of water quality to be protected, and the level of water quality necessary to protect those beneficial uses.

One of the responsibilities of the Regional Boards is compliance assurance and enforcement of the Federal Clean Water Act and the California Water Code as well as the permits issued by the Board and Regional Basin Plan and other plans and policies issued by the State Board and other state agencies. The recently approved "State Water Quality Enforcement Policy" requests the economic calculation of the damages to beneficial uses derived from pollution in the assessment of the penalty amount in Administrative Civil Liability cases.

But performing this calculation in each Administrative Civil Liability case may be a difficult and expensive process that Regional Board staff may not be able to accomplish without specific direction and guidelines. A four-step process to estimate the economic value of the damages to beneficial uses of water quality is presented and a case study is used to test the availability of the information to perform this type of calculation. The case study illustrates the difficulties to apply the proposed methodology.

The process requires a profound understanding of the interrelations among beneficial uses and type and amount of pollutants for every specific waterbody. A damage function that relates damage to beneficial uses and pollution level is required in order to assess the level of impairment to beneficial uses from a specific level of pollution. This damage function will vary depending on many variables, such as the flow of the waterbody at the time of discharge, the waterbody impacted, the time of the year, other simultaneous discharges, the type and amount of pollutants etc. The definition of the damage function must be done on a case-by-case basis.

Once the damage is being defined and certain assumptions have been stated, we need to incorporate in the analysis the estimation of the economic value of that damage in monetary terms. There are multiple methods to estimate the value of natural resources, and the value of the goods and services provided. Water quality can be considered a public good since it exhibits consumption indivisibilities and is fully accessible to all. Therefore, the same methods that can be used to estimate the value of public goods can be applied to the estimation of the value of the beneficial uses of water quality. Most of the valuation studies are expensive and timely to perform, that is why the literature recommends, when accuracy is not a priority, the use of the benefit transfer approach in estimating the economic value of the beneficial uses.

There are several problems derived with the transferability of values from study sites to policy sites. These problems can be summarized as the identification of the right study. Even then, the solution is not straightforward. There are several databases that provide values derived from many studies for multiple regions, environmental and social conditions. There are not many studies that assess beneficial uses of water quality, as they are defined in Regional Water Quality Control Plans. Therefore, the transfer of the values becomes a much more complicated process.

In conclusion, the assessment of damages to beneficial uses of water quality is not a straightforward process and requires the knowledge of multiple scientific areas, from understanding the physical, chemical and biological process that characterize water quality to understanding the basic principles in economics that assess value of goods and services. These represent a challenge that requires future research.

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APPENDIX A

WATER INSTITUTIONS IN CALIFORNIA

California Water Management System

Water quality and water quantity are the two primary characteristics of water. The attributes of water, quantity and quality, are both deeply link to each other. However, the institutions that manage the resource are several with main focus on either the quality or quantity aspect of water. This appendix attempts to describe the institutional management system that regulates the quantity and quality of water in California.

California's history has been characterized by bitter competition for scarce water resources. The history of California in the twentieth century is the story of a state inventing itself with water. The first state and federal water development programs, concerned primarily with flood control, drainage, navigation and the reclamation of swamps and marshlands which were focused on the management of the abundance of water. The modern management system is focused primarily on managing the scarcity of water. The administrative and regulatory structure of water in California and the United States is complex and diverse. There are hundreds of organizations designed to deal with problems ranging from local water supply and soil conservation issues to regional and national water planning.

Water law and institutions have evolved to fit the demands of a growing population and a thirsty agricultural economy. The riparian principle derived from the English "Common Law" entitles property of water to the land adjacent to a source of water. By making the law of waters a part of the rights of private property ownership, the riparian doctrine denied any role for the concept of a common public interest in the overall development of the state's water resources. Water, under the laws of California in the nineteenth century, was a private resource for private exploitation. Therefore in the first stage environmental concerns were not taken into account.

California Water

The fundamental water problem in California is not lack of water but, temporal and spatial imbalances between times and locations. The problem of temporal distribution is accentuated by the fact that water demands typically are low during the winter months and peak during the summer periods (like other Mediterranean climates.) Spatially is also unbalanced with the two thirds of the supplies in the north but two thirds of the demands in the south region. Historically, these imbalances have been overcome by construction of dams and canals, but this solution is no longer viable without a considerable environmental damage. Better allocation of water and more efficient use is now the only way possible to balance the supplies and demands for water. This is the area where water institutions should play a main role. But is the institutional framework the most adequate to guarantee the amount of water in quantity and quality required?

Surface water accounts for 77% of the developed water supply and groundwater for the remaining 23%. The development of surface supplies has been carried out by the federal government, the state of California and by numerous water agencies. The Central Valley project (1940), constructed by the U.S. Bureau of Reclamation, and the State Water Project (1970) supply water to irrigation and to urban users in the south. On the other side the demand for water is dominated by irrigated agriculture with 80% of water use, being the rest consumed in urban areas and in industry. Today the growing demand for water in agriculture has stopped as the acreage for irrigation has stopped or diminished. On the other, side the growing population expected to double in California in the next 30 years will increase the demand for water in urban areas.

The status quo of water rights based on previous uses must adapt to this new situation of growing urban demand. Therefore mechanisms should be implemented to guarantee the efficient allocation. Institutions should play a mayor role in the whole process, and many advocate implementation of water markets as a solution. My questions are: are water institutions in California prepared for this tendency? May we lose something in the process? How can we guarantee that no environmental damage will occur?

Water Institutions as a Key Element for Environmental Policy

Social decisions about resource allocation are made and executed through institutions and organizations. Generally, an institution is a set of rules relating an environment to desired outcomes. Institutions can be consciously designed based on the notion of minimizing social cost (Hurwicz, 1993).

Water is always at the top of California's political agenda. California's water system is physically and institutionally complex. The states water supplies are allocated and new sources planned through a convoluted set of laws, regulations, and procedures.

The design and implementation of environmental policies relies on the development of institutions that will be able to manage the resource efficiently with criteria like sustainability and equity. Institutions have been developed in most cases to protect the interests of the groups that they represent. At the federal level to apply the laws and regulations set by the Federal Government, at the state level to comply with stringent regulations, and at the local level to assure that their interests on quantity and quality are respected and guaranteed.

Water institutions are the crucial mechanism in the process of water planning and management. Therefore their roles and functions are the key in the process of allocation scarce water resources.

Analysis of Water Institutions in California

From the legal to the economic perspective, passing by the description of the historical development process all the literature reviewed tries to explain in one way or another the complex process of institutions formation and development. It is important to emphasize that not all literature takes into account the environmental issues related to water institutions, ignoring this key part of water management and focussing on the more pragmatic approaches based mostly on the economic, engineering or the legal aspects of water management.

Anderson in his suggestive book titled, "Water crisis, ending the policy drought" dedicates one chapter to explain the evolution of water institutions from a historical perspective. He states that "people produce the institutions, or rules of the game, that govern their behavior", as if the institutions are created by groups of interests to set the basic rules needed to manage water resources. He defends the system of property rights because it is the best system to maximize the effort and to enforce the laws and regulations. Then institutions evolve as the economic and demographic characteristics of the region or State change. He describes the evolution of the Riparian rights system in California, from the system of appropriation of water due to the needs of mining to the more accurate needs of water for agricultural use and for urban supply. The law that evolved in the west reflected the greater relative scarcity of water in the region, a system of water law evolved, which: (1) granted to the first appropriator an exclusive right to the water and granted water rights to later appropriators on the condition that prior rights were met, (2) permitted the diversion of water from the stream so that it could be used on nonriparian lands; (3) forced the appropriator of water to forfeit his right if the water was not used; and (4) allowed for the transfer and exchange of rights in water between individuals. Private institutions were developed to capture and deliver the water to where it was needed, Anderson points out the role of the private development as the main impetuous discarding the role of large federal projects.

Blomquist focused his studies on the management of groundwater resources in Southern California. He explains how California water users were able to protect and allocate underground water supplies despite rapidly growing demand for scarce water resources. He demonstrates how people who are self-governing can solve complex and important environmental problems without the need for centralized direction. What is required is an enabling institutional environment, defending the principles of self-governance. Groundwater serves two-thirds of the state's residents and provides about one-third of all the water used in southern California. A great variety of local governance structures have been created to design and implement management programs for many of the groundwater basins in the State, becoming a system which is primarily managed at a local level. He mentions the causes of conflicts over groundwater management due to the difficulty to define limits to overexploitation and the need to develop water institutions based on the area covered by the basin. He explains the development and success of some groundwater management institutions like the Raymond Basin (Los Angeles), that was created in an attempt to solve the problems created by overdrafting. Also, he explains the principal role that the Division of Water Resources played in the conception, design and constitution of institutional arrangements to resolve the overdraft. The Raymond Basin Management Board was created in 1945, becoming the watermaster for the Raymond Basin. The Raymond basin water producers are managing the basin through a self-governing and self-financing system they developed themselves. With a high degree of compliance and cooperation among users. The governance system in Raymond Basin does not exist in a vacuum but is embedded in, and connected with, other water resource organizations and governance systems. The Southern District office of the Department of Water Resources already collects, analyzes, and publishes most of the data needed to manage the basin. The county Department of Public Works operates flood control and water spreading grounds in the basin and provides information on storm flows and spreading operations. Other Municipal Water Districts like the city of Pasadena are member agencies. The governance structure of the Raymond Basin provides the decision-making framework for establishing the basin management program. The program consists of a fixed safe yield operation with pumping limitations, transferable decree rights, voluntary adjustment of pumping patterns, voluntary water spreading by parties in exchange for pumping credits, one experimental program for storing water in the basin, and importation of water supplies to meet additional needs. Each party must pay its own water production, importation, and spreading costs. Therefore the basin is managed to reach the maximum efficiency based on the interests of the users. The management of groundwater with these kinds of institutions will meet the criteria of efficiency and equity based on the participation of all the users in the decision making process. Blomquist does not mention the potential use of these institutions in the management of surface water. In the rest of the book, he describes the water management of every groundwater basin in Southern California. He recommends an evaluation of these institutions based on criteria of compliance, effectiveness, efficiency in administration, efficiency in resource use, equity and adaptability.

Joe S. Bain in Thomas Campbell ed. in early 1968 tries to compare the efficiency in resource development and management of local, state and federal agencies in Northern California. He proposes a system for measuring performance of institutions based on the role that they play in each area. He explains historical and structural reasons for differentials in efficiency between water agencies (local), and state and federal institutions. In order to analyze the performance of the institutions, he explain different levels of decisions in the allocation of the resources. (1) allocation among different types of use, such as irrigation, urban water, power, support of navigation, saline repulsion, in-stream recreational use...(2) allocation among times of use, involving interseasonal or interannual transfers, (3) allocation among places of use, interbasin and long interbasin transfers of water, but also more local patterns of water distribution within subregions or individual river basins, (4) allocation among customer-members of particular local water agencies, and among the lands of these constituents. He proposes that the Federal and State Agencies should manage the first three levels of allocation whereas the last one should be the responsibility of local water agencies. Examples of local agencies that he mentions are irrigation districts and some municipalities and private electric utility companies. As the large federal and state wholesales producers, he mentions the Bureau of Reclamation, the Corps of Engineers, and the California Department of Water Resources.

In Dinar et al. (1995) the management of water resources through laws and Institutions is deeply analyzed. Water disputes and conflict resolution in different parts of the world is explained. Bargaining, negotiation and mediation as well as the formations of coalitions, collective action and cooperation are also analyzed. Then some authors focus their attention on the design of water markets and other types of institutional arrangements. But markets are not always the best solution for the most efficient allocation of resources and this is due to the fact that it loses some other criteria like equity and protection of the environment. They describe management at federal and local levels, and consider the relationship of state and federal management institutions.

It is important to discuss more deeply the chapter in Dinar written by Howit and Vaux, on competing demands for California's scarce water. They explain that: "the history of water in California has been driven largely by political and economic coalitions seeking to secure government aid in financing and operating water development projects (...). These coalitions, were formed because: (1) water was scarce, (2) a single water supply project could serve many users, (3) significant economies of scale could be realized in such projects, and (4) inexpensive water supplies, for which there was intense competition, sometimes could be acquired through generous government subsidies". Therefore the process of coalitions among institutions is the center of the policy evolution. More future water coalitions among institutions at local and state levels are contemplated. The developments of these coalitions are derived from three reasons: First there are sharply higher unit cost of water because remaining dam sites are economically inferior to previously developed damn sites. Second, political priorities have changed. Support for western water development is no longer widespread and unquestioned (environmental concerns). Third, scarcity has intensified as new claims to undeveloped flows for environmental purposes have restricted the potential for developing additional water supplies. The hypothesis of his work is based on the idea that as economic interdependencies between groups shift, the resulting coalitions supporting major water policy thrusts also shift. To illustrate this he defines three stages in California's water development; government development (1920-70), arrested development (1970-82) and supply reallocation (1982-91). The first stages were characterized by a) coalitions of agricultural and urban water users, b) officials in public agencies and c) elected representatives committed to supporting and promoting water supply projects (the golden triangle). Over the past 15 years this system has evolved towards a system based more heavily on market regulations. Different coalitions should be developed. Projections of joint supply costs of the operating water market point to changes in water coalitions in the future. The shift is from an urban/agricultural development coalition confronting environmental objections to an urban/environmental coalition pressing for the reallocation of agricultural supplies. He mentions the difficulties that the agricultural sector will have in recognizing these environmental values. "If agricultural water users can demonstrate the joint costs and benefit advantages with environmental amenities such as open space and wildlife habitat, then some environmental/agricultural coalitions also are likely". More coalitions may occur by pressures for transfer and trade of water in California.

David A. Theriaque in Dzurik ed. Explain the role of water law in the allocation of resources at federal and state level. Explains the concepts of riparian rights and prior appropriation. In the United States, legislation concerning water supply and water quality is administered by governmental agencies at the federal, state and local level. At federal level water resources management and program preparation have been historically the responsibility of cabinet-level departments, principally the Departments of Interior, Agriculture and Defense. Defines the necessity for Federal reserved water rights, describes the federal legislation regarding water management and environmental protection. The Water Resources Control Act of 1986, authorized numerous water projects. Regarding to the environmental protection at Federal level we have The Clean Water Act of 1977 and his additional sections, the Water Quality Act of 1987, the Safe Drinking Water Act of 1974, and the Resource Conservation and Recovery Act of 1976. At state level, most agencies are the counterparts of federal agencies.

The report published by the Task Committee on Federal Policies in Water Resources Planning, explains the responsibilities at all levels of the American federal system of government. This report published in 1985 is a severe critique of the distribution of the responsibilities among the water institutions at all levels. They say that at the federal level there is no common and effective planning mechanism in support of legislative needs. There is little in the existing structure or procedures which clearly defines the nature and extent of the federal interest in the nation's waters. There is no national strategy which (a) sets forth minimum goals to be met, (b) provides adequate definition of the responsibility to be exercised at different governmental levels and (c) provides adequate intergovernmental involvement. They propose the establishment of an independent Water Resources Board at the national level., that will be able to set standards and guidelines, and the determination of objectives in water management at the federal level. They criticize the adequacy of the existing structure at the federal level, claiming that is not adequate to the needs and demands of today's water resources. This is due to: (a) there is no coordinated national water policy, (b) there is no effective planning mechanism in support of legislative concerns, (c) intergovernmental mechanisms are somewhat in disarray and quite inconsistent when viewed nationwide and (d) there is no definition on the federal interest in the nation's waters. They recommended the creation of alternative divisions of responsibilities and organizational structures that will help to solve this situation.

Goodall, in his book published in 1978 dedicates one whole chapter to the institutional setting of California Water. He points out the increasing competition for California's Waters between agrarian and urban use and between large-scale and family-size farming. He explains how water distribution has influenced urban development in California and has fostered the growth of two political systems in rural California. One located in the eastern side of San Joaquin Valley and Sacramento Valley, is characterized by one-person one-vote institutions and large scale corporate agriculture. He explains the development of Irrigation Districts[15] that constructed, paid and administered water impoundment and water delivery systems. Size of farms in this area were relatively small. On the other side in western and south areas of San Joaquin, agriculture was developed later and is in the hands of large scale non resident entities. The Institution that characterize this area is the California Water District[16], in this organizations voting is weighted by property; each voter may cast one vote for each dollar's worth of land. He classifies Water institutions in California by type of enabling act, by type of governing body, by indicators of citizen involvement and by geographic locale. He enumerate the water institutions responsible for every area of concern related to water management, he mentions agencies at federal and state level as well as local agencies. He describes the 17 classes of special districts with water utility functions. He ends with 20 categories of water districts.

Hartman and Seastone from Resources for the Future, propose an evaluation criteria for water organizations. "Evaluation of an institutional system requires measurement of the degree to which the system performs function in accord with community goals". One function will then be the allocation of resources efficiently. He divides his study in the analysis of two types of institutions in terms of the efficiency of their allocative function: the law and its implementing procedures; and the rules governing the internal and external operation of various kinds of

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[15] Irrigation Districts were authorized by the Wright Act of 1887
[16] A special district first authorized by the legislature in 1913.

collectives. He proposes the likely consequences of changing the actual system of property rights that will lead in a more effective system of market allocation.

Rory O'Brien (1992) in his dissertation does not mention the important role that water institutions play in the distribution of water resources in California. He explains the development of water policy with Lindblom theory of incrementalism.

In all the literature that we just reviewed, nobody has attempted to evaluate the institutions in California and their adequacy to solve the problems related to efficiency, equity and environmental issues, and even less which agency has attempt to incorporate economic values to the use of water.

From self-governance to promoting market mechanisms for the allocation of resources, through the possibility of the creation of a Institution that regulates the whole process, from the creation of coalitions, the literature presents a wide range of solutions or options based on the information that was most available at their time.

Description of California Water Institutions

Federal

The Department of Interior (DOI) is the main cabinet-level body in charge of the nations water resources. Within the DOI we have the following institutions:

- *U.S. Geological Survey*; is responsible for financing water resources research at universities and various institutes. Prepares technical reports on new and existing water management practices and techniques and is responsible for monitoring and collecting data for the nation's ground and surface water supplies

- *Federal Bureau of Reclamation*; is responsible for monitoring and developing appropriate irrigation and agricultural land reclamation projects in the western states.
- *Office of Water Research and Technology.* Supervises the nation's water quality and quantity; reserarches controls for the quality and quantity of groundwater and surface water, conservation techniques and technologies, protection of fragile water ecosystems, and water management planning. (environmental agency)
- Water and Power Resources Service. Develops and manages water and power resources in the western states. Projects include flood control, river regulation, outdoor recreation, fish and wildlife enhancement, and water-quality improvement.

The Department of Agriculture deals with water resources planning and development through the Soil Conservation Service (irrigation and flood control), Forest Service, Agricultural Research Service, and Economic Research Service.

The Department of Defense:

- U.S. Army Corps of Engineers (COE), is the nation's oldest water resource agency. It deals mainly with water resources through the construction and maintenance of physical structures located on the navigable waters of U.S. . One of main responsibilities is flood control.

The Environmental Protection Agency (EPA), is the foremost federal agency with respect to water quality. It administers the Clean Water Act and has major responsibilities in pollution control enforcement and in funding and managing municipal sewage treatment plants

- Federal Energy Regulatory Commission
- Cabinet Council on Natural Resources and the Environment
- Resources Agency

Office of the Secretary for Resources; coordinates the state's comments on federal projects relating to water development, flood control, soil conservation, and activities of the U.S. Army Corps of Engineers and the Federal Energy Regulatory Commission. Also issues guidelines for implementation of the California Environmental Quality Act (CEQA) which requires environmental impact reports to be prepared for state or local government action that affect the environment

State

The state of California have agencies that are in many ways the counterparts of federal agencies because the states either elect to or are required to manage many of the federal programs. The state of California stands as one of the more developed states, with its own department of Water Resources. California developed its own water plan, constructed several large projects and influenced the development of others.

- *State Water Resources Control Board (SWRCB);* together with the nine regional water quality control boards, the SWRCB regulates California's water resources; has responsibility for water rights, and pollution control. The State Board directs regional boards to plan and enforce water quality standards within their boundaries.

- *Departments of water resources*
- *Water Rights Law Review Commission (SWRCB)*
- Office of Water Recycling; Created by executive order in 1977; coordinates water reclamation work among the various state, local, and federal agencies concerned, with a view of greatly increasing recycling of water for irrigation, firefighting and other purposes.

A number of federal-state commissions, committees, and councils have been established in order to coordinate their activities.

Local, Regional, County

Local water resources legislation is usually implemented through municipal and county water authorities or districts and deals primarily with drainage, water supply, or wastewater treatment. Much local water management is a result of federal and state delegation of powers. Most municipalities in California have their own water treatment or management authorities, and many areas implement some type of water supply agreement to assure provision of sufficient quantities of water.

- Water Districts; The Water District is assigned the rights to protect the region against adverse fiscal or environmental outcomes from transfers that "unreasonably affect the economy of the area from which the water is being transferred".

- Metropolitan Water District (MWD), is the agency responsible for the distribution of water in the Southern California region. Is the largest water agency in the world, servicing 225 communities and an estimated 17 million residential users. Has 27 member agencies. A 51 member's board governs it. The board can set water rates and raise taxes without voter approval[17]. The MWD can contract for state water projects supplies as well as developing resources of its own.

Private Sector and Other Organizations

There are many other groups that have responsibilities or influence over the development of water resources policy and the execution of water resources planning.

Environmental groups such as the Sierra Club, the National Wildlife Federation and the National Resources Defense Council influence water resource planning by either developing publicly supported positions, or by taking action in courts to restrain activities.

Professional groups such as the American Society of Civil Engineers, the American Water Resources Association, etc, represent those active in the execution of water resources policy and programs. User groups seek to influence federal and state legislation, they include the local agencies and water conservation districts.

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[17] Metropolitan Water District Act of 1928

The private sector is also involved in the management of water resources, for example Western Water Company, based in Sand Diego owns many water rights and is traded in the NASDAQ.

Conclusion

The development of California water institutions is being a political process that is based on their historical needs and geographic conditions. This slow process of development of regulations and institutions can be best explained with the Charles A. Lindblom (1959) theory of Incrementalism. "policy making typically is part of a political process in which the only feasible political change is that which changes social states by relative small steps". All the frame of the institutional structure of water management in California is being based in developing previous institutions to provide with the solutions needed at any point in time. The baggage that the historical evolution has over present institutions in California is very strong and may result in lack of flexibility and adaptability to new changes and reforms needed to increase efficiency.

Also we have to explain the role that federal institutions impose over local and state water institutions that are at the end of the chain of command the real players in the water management process. In this sense the actual institutional setting at federal level also is being reflected at state level due to the fact that many institutions in California are just a replica of the same institutions at the federal level. This Top-Bottom approach of management of water resources is combined with a

Bottom-Up one in which local and regional organization pushes for the defense of their interest. We have to recognize the high political power of farmers in the decision making process as well as the so-called "Water Barons"[18]. Lobbying becomes very important in the whole process of policymaking, and new groups and organizations are gaining participation like environmental groups and urban users and municipalities.

Many groups and economic interests compete for the scarce California water resources. More now than ever before the interests lead to the development of speculation. For example the group of real state developers, corporate agribusiness interests, and water purveyors called "water barons".

Water institutions have evolved to represent the interest of local groups as well as the interests of national and state interests. These interests had in many situations collided to each other and some kind of mechanism to solve differences has been developed. In many cases the institutions created focus only on one aspect of the process. Some Institutions focus only in quantity and pay little attention to other aspects like efficiency, equity or environmental problems, other institutions center their role in protecting the rights of their members. But none of the institutions regulate the system in order to make it achieve the principles of efficiency, equity and protection of the environment at the same time.

The American political system is based on multiple centers of power , each competing for control and dominance with respect to policy issues of concern to

[18] Group of real state developers, corporate agri-business interests, and water purveyors.

them. In this process there is no single dominant elite, but rather numerous power centers concerned about public issues and having different internal processes. This process of autonomy in achieving their goals is a complex and slow process that in maximizing participation risk lose efficiency in the global management system.

We have seen that there are many water institutions in California, many of their roles and responsibilities overlap, and efficiency is lost in gaining participation. The whole system became very complex when we try to understand the whole process as an integrate process that includes the Federal, the State and the local level.

Water is one resource, with many uses and users. Basic for life, for all kinds of life and for the sustainability of our environment. Protect and use more efficient the resource should be the main concern of our institutions. The system should look to experiences of institutions that manage the resource as one integrate system. Quality and quantity are both part of the same thing, and we can not understand both of them without the global environment that regenerates the whole system.

That is why that we should look to the development of institutions based on the management of the resources from an integrate approach. Based on the watershed as the unit of action, and as the basin for the set of priorities and development projects. As Holly E. Stoerker recommends (in Reuss ed.) “An Integrated Natural System Approach is Necessary”, one that reflects the dynamic interdependence of hydrologic, ecological, and biological systems and emphasizes the relationship of water to the landscape”. So far the institutions in California are too fragmented and to specialize in one part of the same process that the agreement on the efficiency of the solutions proposed is very ineffective. But the process must be incremental, using the actual institutional structure to add the elements necessary to reach the three equilibrium's at the same time; in efficiency in water use, in equity, in quality and in protecting the environment.

APPENDIX B

DESCRIPTION OF BENEFICIAL USES IN CALIFORNIA REGIONAL WATER QUALITY CONTROL PLANS

The California Beneficial Use Designation

Section 13240 of the California Water Code require regional boards to prepare and update basin plans that include the water quality standards to protect the beneficial uses of water.

California regional Basin Plans, then, define beneficial uses of waters for every waterbody. These Beneficial uses are described according to the actual and potential use that can be obtain derived from the quality of the surface and ground waters. Some of the beneficial uses can be considered a public good, and therefore the preservation of its beneficial uses can only be achieve with the intervention of public institutions and we could consider the existence of a market failure in which the negative externalities are not being internalized.

Basin Plans in California identify twenty-four different beneficial uses. These beneficial uses are designated following these criteria:

- Existing beneficial uses: those beneficial uses that have been attained for a waterbody on, or after, November 28, 1975.
- Intermittent beneficial uses: those beneficial uses of streams that have intermittent flows, as is typical of many streams in southern California

- Potential beneficial uses: referring to the potential future designation of a waterbody as a exiting beneficial use.

The following is a table of the beneficial uses described in California Basin Plans and the related economic functions of the beneficial use.

Table 9: Beneficial Use Description and Its Economic Function

Beneficial Uses	Economic Function of Beneficial Use
Municipal and Domestic Supply (MUN): Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.	1. Resource Supply
Agricultural Supply (AGR): Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock, watering, or support of vegetation for range grazing.	1. Resource Supply
Industrial Process Supply (PROC): Uses of water for industrial activities that depend primarily on water quality.	1. Resource Supply
Industrial Service Supply (IND): Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well re-pressurization.	1. Resource Supply 2. Waste Assimilation
Ground Water Recharge (GWR): Uses of water for natural or artificial recharge of ground water for purposes of future extraction maintenance of water quality, or halting of saltwater intrusion into freshwater aquifers.	1. Resource Supply 2. Waste Assimilation
Freshwater Replenishment (FRSH): Uses of water for natural or artificial maintenance of surface water quantity or quality (e.g. salinity).	1. Resource Supply 2. Waste Assimilation
Navigation (NAV): Uses of water for shipping, travel, or other transportation by private, military, or commercial vessels.	1. Resource Supply 2. Waste Assimilation 3. Aesthetic Commodity
Hydropower Generation (POW): Uses of water for hydropower generation.	1. Resource Supply

Table 9: Beneficial Use Description and Its Economic Function (Continued)

Water Contact Recreation (REC-1): Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs.	3. Aesthetic Commodity
Non-contact Water Recreation (REC-2): Uses of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.	3. Aesthetic Commodity
Commercial and Sport Fishing (COMM): Uses of water for commercial or recreational collection of fish, shellfish, or other organisms including, but not limited to, uses involving organisms intended for human consumption or bait purposes.	1. Resource Supply 3. Aesthetic Commodity
Aquaculture (AQUA): Uses of water for aquaculture or mar culture operations including, but not limited to, propagation, cultivation, maintenance, or harvesting of aquatic plants and animals for human consumption or bait purposes.	1. Resource Supply 3. Aesthetic Commodity
Warm Freshwater Habitat (WARM): Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.	1. Resource Supply 2. Waste Assimilation 3. Aesthetic Commodity
Cold Freshwater Habitat (COLD): Uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.	1. Resource Supply 2. Waste Assimilation 3. Aesthetic Commodity
Inland Saline Water Habitat (SAL): Uses of water that support inland saline water ecosystems including, but not limited to, preservation or enhancement of aquatic saline habitats, vegetation, fish, or wildlife, including invertebrates.	1. Resource Supply 2. Waste Assimilation 3. Aesthetic Commodity

Table 9: Beneficial Use Description and Its Economic Function (Continued)

Estuarine Habitat (EST): Uses of water that support wetland ecosystems including, but not limited to, preservation or enhancement of wetland habitats, vegetation, fish, shellfish, or wildlife (e.g. estuarine mammals, waterfowl, shorebirds).	1. Resource Supply 2. Waste Assimilation 3. Aesthetic Commodity
Wetland Habitat (WET): Uses of water that support wetland ecosystems, including, but not limited to, preservation or enhancement of wetland habitats, vegetation, fish, shellfish or wildlife, and other unique wetland functions which enhance water quality, such as providing flood and erosion control, stream bank stabilization, and filtration and purification of naturally occurring contaminants.	1. Resource Supply 2. Waste Assimilation 3. Aesthetic Commodity
Marine Habitat (MAR): Uses of water that support marine ecosystems including, but not limited to, preservation or enhancement of marine habitats, vegetation such as kelp, fish, shellfish, or wildlife (e.g., marine mammals, shorebirds).	1. Resource Supply 2. Waste Assimilation 3. Aesthetic Commodity
Wildlife Habitat (WILD): Uses of water that support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.	1. Resource Supply 2. Waste Assimilation 3. Aesthetic Commodity
Preservation of Biological Habitats (BIOL): Uses of water that support designated areas or habitats, such as Areas of Special Biological Significance (ASBS), established refuges, parks, sanctuaries, ecological reserves, or other areas where the preservation or enhancement of natural resource requires special protection.	2. Waste Assimilation 3. Aesthetic Commodity
Rare, Threatened, or Endangered Species (RARE): Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plants or animal species established under state or federal laws as rare, threatened, or endangered.	2. Waste Assimilation 3. Aesthetic Commodity
Migration of Aquatic Organisms (MIGR): Uses of water that support habitats necessary for migration, acclimatization between fresh and salt water, or other temporary activities by aquatic organisms, such as anadromous fish.	1. Resource Supply 2. Waste Assimilation 3. Aesthetic Commodity

Table 9: Beneficial Use Description and Its Economic Function (Continued)

Spawning, Reproduction, and/or Early Development (SPWN): Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.	1. Resource Supply 3. Aesthetic Commodity
Shellfish Harvesting (SHELL): Uses of water that support habitats suitable for the collection of filter-feeding shellfish (e.g., clams, oysters, and mussels) for human consumption, commercial, or sport purposes.	1. Resource Supply 2. Waste Assimilation 3. Aesthetic Commodity

Source: Author adapted from Los Angeles Basin Plan.

It is important to point out, especially when we are trying to apply the benefit transfer methodology in the estimation of economic value, that the California Beneficial Use designation is broader than the USEPA beneficial categories as outlined below:

Table 10: USEPA Designated Use and Equivalent Beneficial Use Category

USEPA Designated Use Categories	Equivalent California Beneficial Use Category
Fish Consumption	Ocean Commercial Sport Fishing
Shellfishing	Shellfish Harvesting
Aquatic Life Support	Warm Freshwater Habitat Cold Freshwater Habitat Fresh Water Replacement Areas of Special Biological Significance Marine Habitat Fish Spawning Fish Migration Rare & Endangered species Wildlife habitat Saline Water Habitat
Swimming	Water Contact Recreation
Secondary Contact	Non-Contact recreation
Drinking Water Supply	Municipal & Domestic supply
Agriculture	Agricultural Supply

Source: USEPA 303(d)list.

The description of these beneficial uses does not include a specific judgment or assessment of the quality and value of these uses. Is Shellfish Harvesting a priority to protect? Is its beneficial use threatened? The logic behind it is that, the definition of these beneficial uses has the mere purpose of being descriptive and informative. They are just categories of value and therefore they are not intend to incorporate any assessment of priority and/or value. There is no need for a ranking in terms of value, or protection for these beneficial uses because in order to do so they must be linked to a specific spatial area.

APPENDIX C

INSTITUTIONS MANAGING THE WATER QUALITY OF LOS ANGELES RIVER

The 51-mile length of the Los Angeles River flows through 13 cities and nine Los Angeles County City Council Districts. Many different institutions at local, state and federal level are responsible for the management and conservation of the river resources.

The two main institutions responsible for the operation and maintenance of the river are:

- Los Angeles County Department of Public Works and,
- U.S. Army Corps of Engineers

Other institutions with responsibilities over the protection of the beneficial uses of the river include:

- Los Angeles County Board of Supervisors
- Los Angeles County Department of Parks and Recreation
- Los Angeles County Mosquito Abatement District
- Los Angeles County Metropolitan Administration Authority
- California Department of Transportation
- California department of Fish and Game
- California Coastal Commission
- California Department of Water Resources

- California Regional Water Quality Control Board
- Southern California Regional Rail Authority
- State Lands Commission
- U.S. Environmental Protection Agency
- Federal Emergency Management Agency (FEMA)
- U.S. Fish and Wildlife Service

Stakeholder Groups

Los Angeles/San Gabriel Rivers Watershed Council: The group was formed in 1995 following a large watershed conference held in the area which served as a springboard. The Council has a board of directors and became incorporated as a nonprofit organization in 1996. The group is tracking watershed activities, but has primarily focused on flood control issues in the Los Angeles River as well as opportunities to create greenbelts and restore habitat. Three committees have been formed recently: water resources, water quality, and multi-use projects. The Council's goal is to help facilitate a process to preserve, restore, and enhance all aspects of the two watersheds. Preparation of a watershed management plan by this group is underway. This group is coordinating with other groups to seek Proposition 13 funding. Generally one staff person attends these monthly council as well as monthly board of directors meetings. More information about this group may be found at their website http://www.lasgriverswatershed.org/.

Los Angeles Basin Contaminated Sediment Task Force: Contaminated dredged material disposal is a major issue in the Los Angeles Region due to its large commercial ports and the several major marina complexes and small vessel harbors. Queensway Bay, at the mouth of the watershed, receives a large sediment load that impacts recreational uses. The U.S. Army Corps of Engineers frequently conducts maintenance dredging to remove accumulated sediments from this area. The need for a long-term management strategy for dealing with contaminated sediments in the Los Angeles area has been identified and the Task Force will prepare this strategy. Representatives on the Task Force include a number of federal and state agencies as well as port and environmental group representatives.

APPENDIX D

DESCRIPTION OF BENEFICIAL USES OF LOS ANGELES RIVER

On June 13, 1994 the California Regional Water Quality Control Board, Los Angeles Region adopted the Water Quality Control Plan (Basin Plan). The plan considers regional beneficial uses of water, water quality characteristics, and water quality problems in Los Angeles Region.

The description of beneficial uses of Los Angeles River described under this appendix relies mostly on other studies (Trim, 2000; Saint et al., 1993; California Regional Water Quality Control Board, Region 4. 2000; California Regional Water Quality Control Board, Region 4. 2002; California Regional Water Quality Control Board, Region 4., 1994; Gumprecht, 2001; Gottlieb et al. 2001; Los Angeles River Master plan, 1996.) The following is a list and a description of the beneficial uses of water quality of Los Angeles River as assessed in various studies, these studies are publicly available and constitute an example on the type of data available for this type of study.

The Los Angeles River is assigned the following beneficial uses:

MUN (Municipal and domestic supply): Historically, artesian wells and springs provided drinking water for the City of Los Angeles in the 19th and 20th centuries (Coastal Conservancy). As a result of the passage of the Proposition 65 the state adopted the Sources of Drinking Water Policy in 1988, the 1994 Los Angeles

Region Basin plan included all surface waters of the region, except estuaries as designated "existing" or "potential" MUN.

Examples of the MUN use occur in waterbodies in the Pasadena area. Prior to 1993 water was diverted from Arroyo Seco and Eaton Canyon for municipal use, or for spreading or irrigation. Millard Creek, for example, was used for MUN until 1978 when the Department of Health Services declared that flows were no longer usable as surface water. Since then surface waters in the area gas been used for groundwater recharge.

Other examples of actual uses of the surface waters of Los Angeles rivers for Municipal use include a study conducted for the Los Angeles County of Public Works. The proposed study was to capture water from the Los Angeles River and create a freshwater reservoir for either non-potable or for drinking water uses after previous treatment. The study was called the Shoreline Reservoir Concept, the idea was to capture water from Los Angeles river and create a 100,000 acre-feet freshwater reservoir (using an inflatable dam) in the Los Angeles Harbor, the project has not yet been implemented, but it demonstrates support for a MUN beneficial use designation should conditions in the Los Angeles River quality change in the future (Los Angeles County Department of Public Works, 1993.)

GWR (Groundwater recharge): The Los Angeles County Department of Public Works and other entities operate an extensive system of spreading basins in the Los Angeles area. These area were originally included in the 1975 Basin Plan. In the 1994 Basin Plan update, the groundwater recharge designation was updated to include incidental recharge in all soft bottom areas that are known as recharge zones for the different groundwater basins.

NAV (Navigation): The beneficial use of navigation has been established for the Los Angeles River estuary only.

COMM (Commercial and Sport Fishing): The COMM beneficial use has been established for the Los Angeles River estuary only. Most of the use of the Los Angeles River estuary for boating and fishing is due to recreational users entering from the harbor. The Catalina Landing is off the mouth of the Los Angeles River in Queensway Bay. Sport fishing, primarily for live bait occurs in the Los Angeles/Long Beach Harbor area (Los Angeles Basin Plan, 1994.)

REC-1 (Water Contact Recreation): IN preparation of the 1975 Basin Plan, it was anticipated that most, if not all, of the flood control channels in Los Angeles watershed would be opened to the public. Horseback riding, cycling and hiking was allowed in many channels including the soft bottom trapezoidal channels of the Los Angeles River. As was stated in the 1975 Basin Plan, "The Los Angeles County Board of Supervisors, in response to the need for more recreation areas within the Los Angeles Basin, has issued statements to the effect that public access should be permitted as much as possible in all flood control channels. It is conceivable that facilities will be constructed or installed to permit public entrance to even the concrete-lined rectangular channels for cycling and other activities. ... Rec-1 will become a future beneficial use where presently only Rec-2 is enjoyed." (Los Angeles Basin Plan, 1975).

More recently, homeless people, and others, come in direct contact with the rivers' waters for bathing and other purposes. There are a number of homeless encampments under bridges. People cut holes in the fences and enter the river system in the Glendale Narrows section (Los Angeles County, 1996) and elsewhere, especially in the soft bottom areas.

REC-2 (Non-contact Water Recreation): Although there are currently posted signs intended to keep humans out of the concrete lined channel areas, many people ignore the signs and the following activities have been observed: bird watching, jogging, hiking, soccer playing (on the wide channel bottom), and bicycling. There are at least 12 miles of public trails along the Los Angeles River that are used for walking, jogging, bicycling and horseback riding. Near Griffith Park, equestrian riders use earthen ramps that provide access to the bottom of the river and low-water river crossings (Los Angeles County, 1996.)

In addition, the forest is heavily used for recreational purposes and as was stated in their 1987 management plan, the Forest Service has under-built for water-based recreation, particularly streamside and near developed reservoir facilities (US Forest Service, 1987). Presumably more recreational use is planned.

MAR (Marine Habitat)/EST (Estuarine Habitat): The MAR use reflects the area were estuarine influence occurs. These areas of tidal influence have a brackish regime due to a blending of fresh and salt water that supports a different habitat than upstream freshwater areas. The estuaries of the Los Angeles Rivers was upgraded to the EST status during the 1994 Basin Plan update process because the

Estuarine Habitat uses was added by the State at that time. The State added beneficial use categories in order to better delineate different habitats (Saint et al., 1993.)

WARM (Warm Freshwater Habitat)/COLD (Cold Freshwater Habitat)/WILD (Wildlife Habitat): There are a number of different studies that describe the wildlife, cold water and warm water habitat usage in the Los Angeles River watershed.

The Angeles National Forest supports 216 species of birds, 60 species of mammals, 16 species of reptiles, 36 species of amphibians, and 17 species of fish most of which are dependent on riparian zones for foraging, breeding and protection. The only four species of true freshwater native fish remaining in the forest area are the Santa Ana sucker, arroyo chub, speckled dace and the Unarmored Threespine Stickleback (US Department of Agriculture, 1987).

The nine-mile stretch of the Los Angeles River from Atlantic Avenue to the ocean has some of the most abundant bird life in the river system and includes roosting and feeding habitat. The birds particularly feed where the algae grows in the warm shallow water flowing over the concrete channel. Dominguez Gap Spreading Grounds supports wildlife (Los Angeles River Master plan, 1996.)

Fishponds and trout ponds were proposed as part of the Los Angeles River Master Plan but the ideas were not given a ranking. Extensive willow forest has been identified at the western end of Hansen Basin (Woods, 1999.) The US Fish and

Wildlife Service has conducted surveys of fish, mammals, amphibians, and birds in Hansen Basins (1996) Tujunga Wash (1996), and Sepulveda Basin (1985-86).

In Glendale Narrows, there are abundant birds, ducks, frogs and other animals in the dense vegetation (Los Angeles River Master plan, 1996.) and there is habitat suitable for urban mammals such as squirrels, and opossums in local areas. Expected fish species in the lower river are those found in Queensway Bay and include northern anchovy, and California halibut. In areas with more salinity variation, top smelt, long jaw mud suckers and diamond turbots are found.

Mollusk population, though dramatically reduced since channelization of the Los Angeles River, includes a few snails and other species. Of the seven endemic species originally in the river, only three the arroyo chub, Santa Ana sucker, and Santa Ana speckled dace, still exist in large numbers. Fish decline is attributed to poor water quality and lack of refuge during high flows due to channelization. Four introduced species are common: fathead minnow, goldfish, mosquito fish, and tilapia. Nineteen of the original 33 species of amphibians still are present in the Los Angles River area. Within the river are western toad, Pacific treefrog, bullfrog, and two-striped garter snake (Woods, 1999.)

RARE (Rare, Threatened, or Endangered Species): A number of waterbodies in the Los Angeles watershed have rare and endangered communities, plants, or animals. Many of these designations were incorporated in the 1975 Basin Plan and updated in 1994 based on the California Department of Fish and Game.

Additional information about potential RARE use designation includes information from a variety of recent reports. Seven sensitive species of wildlife have been identified as having the potential to occur in the Los Angeles River (Los Angeles River Master plan, 1996) area including the monarch butterfly, San Diego horned lizard, brown pelican, California least tern, least Bell's vireo, western yellow-billed cuckoo, and tri-colored blackbird. Three sensitive species are in addition found at Sepulveda Basin: ferrunginous hawk, prairie falcon, and the arroyo chub (Los Angeles River Master plan, 1996). In Big Tujunga Wash 43 sensitive species are found including "listed" slender-horned spineflower, Nevin's barberry, and California red-legged frog. At Los Angeles River mouth the following listed species were found: California brown pelican, California least tern, and the American peregrine falcon (Woods, 1999.)

In the Angeles National Forest, endangered species include: Bald Eagle, California Condor, Least Bell's Vireo, and Unarmored Threespine Stickleback. Threatened species include Swainson's Hawk, Mojave Ground Squirrel. The Peregrine Falcon (endangered) historically nested in the forest and the Forest Service has been trying to reintroduce the species (United States Department of Agriculture, 1997.)

BIOL (Preservation of Biological Habitats): This use is not currently designated for either watershed because the Regional Board (in the 1994 update) limited the application of the BIOL use to areas legally defined as Areas of Special Biological Significance (specific areas that have been designated by the state). In

1993, California State, Fullerton, researchers recommended an extension of this beneficial use to include additional areas that have unique ecological features. This use could be applied to a number of special reserves and refuges as well as certain areas with valuable plant communities.

MIGR (Migration of Aquatic Organisms)/SPWN (Spawning, Reproduction, and/or Early Development): These uses apply to high quality habitat areas or areas of transition between fresh and salt water (for migration to cold water fisheries). Currently these uses are "existing" for both the Los Angeles River estuaries and potential for the lowest reach of the Los Angeles River. In addition, the SPWN use is "existing" for certain high quality stretches in the upper watersheds where cold water fisheries exist.

SHELL (Shellfish Harvesting): Currently this use is designated as "potential" for the Los Angeles River estuary.

WET (Wetland Habitat): Wetland designations were added in the 1994 Basin Plan update. These new wetland beneficial uses were recommended by California State University, Fullerton researchers. More recently, in the Los Angeles River system, wetlands have been identified and profiled by the Coastal Conservancy at Tujunga Wash, Hansen Dam, Sepulveda Basin, Upper Arroyo Seco, Glendale Narrows, Whittier Narrows, Dominguez Gap, Willow Street, and Los Angeles River Mouth. The following areas have the potential for enhanced wetland function: Upper Bull Creek, Cahuenga spreading grounds, Lower Arroyo Seco Park, Taylor Yard (adjacent to Los Angeles River), Hazard Park (tributary to Los Angeles river), DeForst Park (adjacent to lower Los Angeles River), Victoria Park (tributary to Dominguez Channel), Harbor Park (Woods, 1999.)