Draft Report

Description and Screening of Potential Tools and Methods to Quantify Public Benefits of Water Storage Projects

Department of Water Resources

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Acronyms and Abbreviations

AAHU	average annual habitat unit
Act	The Safe, Clean, and Reliable Drinking Water Supply Act of 2012
AF	acre-foot
ASFMRA	American Society of Farm Managers and Rural Appraisers
BAWQM	Bay Area Water Quality Model
B/C	benefit-cost
BCA	Benefit Cost Analysis
BDCP	Bay Delta Conservation Plan
BUVD	Beneficial Use Values Database
CALVIN	California Value Integrated Network
CCWD	Contra Costa Water District
COFHE	California Ocean Fish Harvest Economic Model
Commission	California Water Commission
CE/ICA	cost-effectiveness/incremental cost analysis
CEQ	Council on Environmental Quality
CEQA	California Environmental Quality Act
CV	Contingent Valuation
CVP	Central Valley Project
CVPM	Central Valley Production Model
DBP	disinfection byproduct precursor
DFG	California Department of Fish and Game
DRMS	Delta Risk Management Strategy
DSM2	Delta Simulation Model II
DWR	California Department of Water Resources
EAD	Expected Annual Damage
EFT	Ecological Flows Tool

EIR/EIS	Environmental Impact Report/Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ETAW	evaporation of applied water
EWA	Environmental Water Account
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
HEP	Habitat Evaluation Procedure
I-O	input-output
ICE	Information Center for the Environment
IWR	U.S. Army Engineer Institute for Water Resources
LCRBWQM	Lower Colorado River Basin Water Quality Model
LCPSIM	Least Cost Planning Simulation Model
M&I	Municipal and Industrial
Metropolitan	Metropolitan Water District of Southern California
NED	National Economic Development
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration
NODOS	North of Delta Offstream Storage
OC	operational configuration
OMWEM	Other Municipal Water Economics Model
PFR	Preliminary Feasibility Report
P&G	The "Economics and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies" published by the U.S. Water Resources Council in 1983
PNW	present net worth
PP	Pumping Plant
Reclamation	U.S. Bureau of Reclamation
SCRB	Separable Costs-Remaining Benefits
State Water Board	California State Water Resources Control Board
SWAP	Statewide Agricultural Production (model)

SWP	State Water Project
TDS	total dissolved solids
UDV	unit day value
UEM	use-estimating model
USACE	U.S. Army Corps of Engineers
WRDA	Water Resources Development Act
WTP	Willingness to Pay

Executive Summary

Water Code §79744 requires the California Water Commission to develop and adopt, by regulation, methods for the quantification and management of public benefits associated with water storage projects by December 15, 2012.

Although this section of the Water Code will not become operative until the Safe, Clean, and Reliable Drinking Water Supply Act of 2012 is passed by voters in November 2012, this report is intended to provide research and analytical work that will enable the Commission to meet its statutory deadline if the bond is approved.

The report will also provide useful information, policy guidance, and direction that can support other possible State activities related to identifying and quantifying public benefits for water storage projects, including but not limited to other future state bonds or infrastructure investment programs.

Chapter 8 of the Safe, Clean, and Reliable Drinking Water Supply Act of 2012 (the Act) authorized the issuance of $11.14 billion of bonds, if approved by voters in 2012, of which $3 billion would be allocated

> *for public benefits associated with water storage projects that improve the operation of the state water system, are cost effective, and provide a net improvement in ecosystem and water quality conditions.*

*Projects shall be selected by the [California Water] Commission through a competitive public process that ranks potential projects based on the expected return for public investment as measured by the magnitude of the public benefits provided.*The public benefits categories defined by the Act are

(1) *Ecosystem improvements, including changing the timing of water diversions, improvement in flow conditions, temperature, or other benefits that contribute to restoration of aquatic ecosystems and native fish and wildlife, including those ecosystems and fish and wildlife in the Delta.*

(2) *Water quality improvements in the Delta, or in other river systems, that provide significant public trust resources, or that clean up and restore groundwater resources.*

(3) *Flood control benefits, including, but not limited to, increases in flood reservation space in existing reservoirs by exchange for existing or increased water storage capacity in response to the effects of changing hydrology and decreasing snow pack on California's water and flood management system.*

(4) *Emergency response, including, but not limited to, securing emergency water supplies and flows for dilution and salinity repulsion following a natural disaster or act of terrorism.*

(5) *Recreational purposes, including, but not limited to, those recreational pursuits generally associated with the outdoors.*

For the purposes of this report, public benefits are defined as the above five categories.

The Act specifies four types of eligible storage projects and requires that the California Water Commission (Commission), the California Department of Water Resources (DWR), the California Department of Fish and Game (DFG), and the State Water Resources Control Board (State Water Board)

> *develop and adopt, by regulation, methods for quantification and management of public benefits described in Section 79743 by December 15, 2012. The regulations shall include the priorities and relative environmental value of ecosystem benefits as provided by the Department of Fish and Game and the priorities and relative environmental value of water quality benefits as provided by the State Water Resources Control Board.*

Because of the requirement to adopt regulations by December 15, 2012, the Commission has initiated work to identify methods for quantification of the public benefits eligible for public funding. This work has included review by state experts and information solicited from economists in government and academia. This report, the result of that work, will be used to guide the development of regulations and economic guidelines for storage project applicants who request state bond funding for public benefits, if the bond is approved by voters in November 2012. If the bond is not approved, the water code section requirement to develop and adopt regulations will not be operative. However, it is anticipated that the work in this report will still be important for other activities in which the public benefits of water storage projects need to be quantified, identified, and evaluated.

This report is only one of the activities the Commission is or will be pursuing to prepare for evaluating requests for public funding. The Commission has also been consulting with the DFG and the State Water Board to develop priorities and relative environmental values, as specified by the Act. Results of that consultation are not included as part of this report. In addition, if the bond is approved by voters in 2012, the Commission will need to develop an overall competitive process that evaluates applications on a number of factors, including quantified public benefits, priorities and relative environmental values, and other criteria. This report does not attempt to develop such a process.

Economic Measurement of Public Benefits

The Act requires that public benefits be quantified and compared across benefit categories and projects. Projects cannot be ranked based on the magnitude of public benefits received unless this magnitude is comparable across projects. The Act requires that ecosystem improvement benefits are at least half of all public benefits, so all of the public benefit categories must use a common measure. The Act states that benefits available to private and public parties must be consistent with each party's cost share. These provisions taken together imply that public benefits should be quantified in common units that can be compared directly to costs; in other words, the public benefits should be quantified in dollar terms.

The Role of Physical Benefits

The Act suggests that economic benefits analysis is required to obtain a common denominator for comparison among public benefits and costs. However, economic quantification requires physical quantification. The economic benefits forecast for a project normally requires that physical benefits be forecast first. Also, physical quantification is generally required for cost-effectiveness tests implied by the Act.

Physical benefits are the estimated changes in production from a project; examples are acre-feet of water supply, concentrations of water quality constituents, and populations of native species that may be affected. Common physical benefit measures for each of the five benefit categories are discussed below. When physical benefit estimates are not available, economic benefits based on them cannot reliably be estimated.

For the purposes of this report, "public benefits" are the ecosystem, water quality, flood control, emergency response, and recreation benefits defined by the Act

Non-Economic Benefits

Many benefits cannot easily be quantified in monetary terms. Some cannot be valued because the physical amount of change cannot be assessed. Others cannot be valued because, even if the amount of physical change can be estimated, no reliable study or method exists to estimate the corresponding economic value. Nevertheless, all benefits should be counted, even if they cannot be expressed in physical or economic terms.

The Scope of Public Benefits

The Act defines public benefits by reference to the five benefit categories, but a number of questions have arisen regarding the scope of public benefits and whose benefits should be counted as public. Public benefits as defined could include benefits that are sometimes regarded as private benefits. For example:

- Outdoor recreation benefits are sometimes captured by private landowners and businesses such as marinas or duck clubs.
- Water quality improvements are often received by local water users.

Both of these examples may be eligible for public funding under the Act. In this report, quantification methods are described regardless of whether the benefit might be received by private or local beneficiaries rather than the California public as a whole.

Public benefits as defined could also include benefits received by people outside of California. This report recommends that the economic methods attempt to count benefits only to California residents, businesses operating in the state, and California property owners, regardless of where those property- or business owners live.

Federal Cost Sharing

The Commission will be considering public benefits that might otherwise be financed in part by the federal government. The Act does not explicitly address federal cost-sharing. Some share of costs eligible for state funding under the Act might also be eligible for funding by the federal government. The report provides information regarding potential sources of federal funds to assist the Commission and the state in working with the federal government to consider appropriate sharing of costs for public benefits.

The Role of Ecosystem Improvement

Ecosystem improvement benefits have a special place in the Act, as follows:

1. The benefits must contribute to restoration of aquatic ecosystems and native fish and wildlife, whether inside or outside of the Delta.
2. Some of the ecosystem benefits must be measurable in the Delta or its tributaries.
3. At least 50 percent of all public benefits funded by bond money authorized by the Act must be ecosystem improvement benefits.

In calculating ecosystem improvement benefits as a percent of the total public benefits, the following principles are recommended:

> *The with-without principle requires that benefits be judged by comparison of two futures—one with the project, and one without the project*

- All benefits that are directly caused by ecosystem improvements should be counted as ecosystem benefits. For example, sport fishing recreation benefits caused by the ecosystem improvement should be assigned to ecosystem improvement, not recreation.
- Benefits that are incidental to operations for water supply for ecosystem services should not count as ecosystem benefits. For example, urban water quality improvements in the Delta caused by the use of water for ecosystem improvement should be assigned to water quality benefits, not ecosystem.

Description and Screening of Economic Methods and Models

The main focus of the report is to evaluate and screen economic methods and specific models that are available to estimate the monetary value of public benefits. For each public benefit category, the available methods and models are described and screened to identify those that are appropriate and reliable.

Benefits Analysis Fundamentals for SBX7-2

A benefits analysis for a water storage project is a forecast that extends to the end of the expected life of the project. Benefits must be estimated by reference to a forecast that does not include the project, which is called the without-project condition. This forecast shows the most likely future without the project. Normally, this forecast includes some information about water supplies and demands, existing and planned projects, and demographic and economic conditions such as population and prices. Any benefits analysis must quantify benefits by reference to the without-project condition. In general, adverse environmental effects will be mitigated as part of the project plan. If not, any public benefits should be net of these adverse effects.

Economic benefits are a measure based on willingness to pay. Some economic methods and models do not provide economic benefits as a measure.

General Types of Economic Benefits

Most economic benefits are one of three following types:

1. The willingness to pay (WTP) is the fundamental concept for estimating economic benefits. It measures the value that the beneficiaries would be willing to give up to obtain the benefit in question.
2. Avoided cost is a cost that would be incurred without the project but would be unnecessary or delayed with the project.
3. Alternative cost is the least cost of any viable way of obtaining the same physical benefit as the project.

Screened Economic Methods and Models

Economic benefit (defined as WTP, avoided cost, or alternative cost) is different than some other indicators of economic or financial conditions. Income, employment, value of production, prices, and dividends are examples of measures that are not economic benefits. Some economic methods and models do not estimate economic benefits, so they have been screened out. These include the following:

1. Input-output (I-O) models and related software, which are often used to estimate direct and indirect changes in employment and income.
2. Models that forecast growth in income, output, and employment.
3. Financial models that describe changes in costs, revenues, or cash flow to an agency.

These models can provide useful information related to benefits, but additional information and calculations are usually needed to obtain economic benefits. For example, I-O models can provide information about income, but any inference about economic benefit requires information about employment mobility and other factors that are not normally included.

Otherwise, few combinations of methods and public benefits are screened out. Some methods are described as “not likely” to be applicable, and others can only estimate a share of the total economic benefit. Models that have been reviewed but are not recommended for use in quantifying public benefits include HAZUS-MH Level 1 and the Federal Emergency Management Agency’s (FEMA’s) Benefit Cost Analysis (BCA) toolkit. The specific methods and models described are likely not exhaustive. Other tools may be appropriate.

Specific Recommendations on Economic Methods

A number of specific methods and models are described in this report, and some are recommended as the preferred method in certain circumstances. These specific methods and models would, if used appropriately, provide the quantification called for in the Act. Other methods and models may exist or be developed that also provide appropriate quantification, so long as they are described, justified, and make use of one or more of the general methods described here.

Cost-effectiveness Analysis Required

Chapter 8 of the Act requires that funds be provided for public benefits that are cost effective. This means that any project seeking public funds should demonstrate either of the following:

1. There is no alternative way of providing the project's physical public benefits.
2. The physical public benefits cannot be provided by any alternative at a cost less than the project cost.

The documentation required to address conditions 1 and 2 should include a quantification of physical benefits wherever possible. Inability to estimate physical benefits, or poor documentation of those estimates, should raise questions about whether a proposed project is ready for public funding.

Condition 1 requires a fair consideration of the feasibility of potential alternatives. Alternatives analysis should consider the full range of potential approaches to achieve the same public benefits as the project. The Commission should consider an independent evaluation of potential alternatives for any large project seeking public funds. The feasibility of alternatives should be considered under the same criteria as are used for the project, that is, the same baseline assumptions and general cost estimation procedures.

Why Avoided and Alternative Costs are Important

This report concludes that avoided cost or alternative cost will often provide the best basis for economic public benefits quantification, for the following reasons:

1. The without-project future often includes projects or programs that, with-project, can and would be cancelled or delayed.
2. The cost-effectiveness analysis should be used to identify alternatives and their costs. When the cost of any feasible alternative is less than the WTP benefit, the dollar amount of public benefit should be limited to the alternative cost amount.
3. In many cases, the WTP economic benefit will not be quantifiable, either because the benefit cannot be quantified in physical terms, or because the physical benefit cannot be monetized. Even where the WTP benefit cannot be monetized, the public benefit should still be no more than the alternative cost.

Ecosystem Improvement Methods

> *Where private markets for a public good exist, and markets are generally competitive, price should be used as the measure of willingness to pay.*

Ecosystem benefits are generally (1) avoided costs or alternative costs, (2) production of valuable goods such as fish and wildlife, or (3) a variety of ecosystem services such as water quality, aesthetics, and carbon sequestration. Under item (2), fish and wildlife have value for commercial use and recreation, and fish and wildlife have non-use values, which are the benefits people profess even though they do not intend to use the fish and wildlife in any way. In this report, water quality and recreation benefits caused by ecosystem improvements are discussed under the water quality and recreation sections, respectively.

The ecosystem improvement benefit category is perhaps the most problematic for economic quantification, primarily because few methods or models reliably forecast the physical benefits of ecosystem improvement. Most of DFG's ecosystem improvement priorities involve rare native fish and wildlife, but few if any widely accepted models exist for forecasting fish and wildlife populations or the amount of other ecosystem services provided by restored aquatic, riparian or wetland habitats.

If the physical amount of ecosystem improvement (for example, increases in fish population) can be quantified, then the WTP for this quantity should be estimated. WTP measures might be based on market prices, hedonic pricing, survey methods, or benefit transfer methods, depending on the situation. The economic value of public benefit is the lesser of the WTP or the minimum cost of any feasible alternative that provides the same level of physical benefit.

If the physical amount of improvement cannot be quantified, but some intermediate measure such as fish habitat can be quantified, then the benefits analysis should include WTP measures and the alternative cost of providing this intermediate measure. Again, the dollar amount of public benefit is the lesser of the WTP or the minimum cost of any feasible alternative.

If no intermediate measure can be quantified, but the amount of water supply to be provided by the project for ecosystem improvement can be estimated, then the alternative cost of providing this water supply should be estimated. This cost might include economic benefits of agricultural and urban water supply foregone, under the assumption that these would be the likely alternative uses of the water supply. Agricultural and urban water supply benefits can be estimated using state or local economic models, hedonic or land value estimates based on local irrigated land prices and rents, or estimates of the alternative cost of water supply, such as pumping groundwater.

If the amount of water supply provided for the ecosystem improvement is the only way to quantify the ecosystem benefit, this should raise questions about whether a proposed project is eligible for public funding. Section 79742 of the Act requires some measurable improvement. Also, there is some risk that the alternative cost approach based on the value of water supply will overstate the public benefit. For example, if ecosystem improvement water is planned for a time when it actually provides little or no benefit for fish, then the alternative cost approach likely provides a benefit estimate that is too large—the true benefit is actually near zero.

Therefore, at a minimum, any application of the alternative cost approach for intermediate goods (habitat or water supply rather than for the species population itself) should be accompanied by a biological justification for the use of water for the ecosystem improvement in the amounts and timing as proposed. Where physical benefits cannot be quantified, the significance of ecosystem outputs should still be documented in terms of their institutional, public, and/or technical importance. The following types of information should be provided:

- The type of physical benefit expected and its relationship to DFG and State Water Board priorities
- Evidence that the project will result in, at a minimum, a measureable change in the claimed public benefits

The following information could help determine whether economic benefits are important.

- The number of persons affected, and the way they are affected
- Evidence that the affected people or their representatives have an interest in the effects (i.e., they have expended time or money because of the effects)

Ecosystem improvement may include restoration of wetlands and riparian acreage. The quantification and valuation of fish and wildlife production and ecosystem services from such areas is highly complicated. Therefore, the alternative cost approach is generally recommended. The alternative cost should be the minimum cost of providing the same quantity (acreage) and quality in some other way. These other ways may include creation, restoration, or purchase and protection of acreage that would otherwise (in the without-project condition) be lost. The alternative cost might include land acquisition, landscaping and grading costs, cost of water supply, and ongoing management.

The ability of scientists to forecast physical benefits of ecosystem improvements may improve. This information could then be used to value the improvements more directly and could provide a check on the alternative cost approach. Better estimates of physical changes will also allow benefits to be valued when no viable alternative exists.

Water Quality Improvement Methods

For water quality resulting from ecosystem improvement, the avoided cost and alternative cost principles discussed in the previous sections are applicable. In many local areas, water quality improvements are planned or mandated, so avoided costs or alternative costs are appropriate ways to estimate benefits. Such costs normally take the form of an alternative treatment technology, avoided treatment costs, or the cost of obtaining alternative and cleaner supplies. In many cases, in particular where degraded groundwater is to be cleaned as contemplated by the Act, water supply from storage is used to dilute or replace poor quality supplies. If a project provides a water supply for water quality improvement, or if water supply is increased by the water quality improvement, the water supply might be valued by the alternative cost approach.

For water quality related to urban uses, two models of urban salinity costs are available; one corresponds to the southern portion of the San Francisco Bay area, and one corresponds to the south coast area in Southern California. Economic methods for quantifying the benefits of salinity improvements to agriculture are also available. For other water quality constituents, hedonic pricing, revealed preference, survey methods, and benefit transfer may all provide usable WTP estimates, depending on circumstances; however, they may provide only partial benefits estimates. Project applicants may also provide avoided costs or alternative costs based on their own estimates, if those are well documented.

Flood Damage Reduction Methods

Relative to ecosystem and water quality, flood damage reduction economic methods are well established. For simple, relatively small problems, DWR's F-RAM, a spreadsheet model, is appropriate; or methods that use the same logic and appropriate damage cost data can be used to obtain expected annual damage (EAD) estimates. For large and complex problems, either the U.S. Army Corps of Engineers' (USACE's) HEC-FDA or FEMA's HAZUS-MH, Level 2, can be used. The report describes situations in which either may be preferred.

Emergency Response Methods

This category is intended primarily for the benefits of stored water used to provide salinity repulsion from the Delta following a levee failure event. There has been little direct estimation of expected costs of these events, but information is available from the Delta Risk Management Strategy, and some work is being completed for DWR's Delta Flood Emergency Preparedness, Response and Recovery Project.

Again, an alternative cost approach can be useful. Without the proposed new storage project, it is likely that some other stored water would be used for salinity repulsion. Models are available that can show how the release of a large volume of stored water will increase water supply costs or water shortage costs in subsequent years. With information about the frequency of Delta levee failure events, an expected value of annual cost can be estimated; this is the cost that would be avoided by using the new storage facility instead of an existing facility.

Recreation Methods

Many economic studies exist regarding outdoor recreation in the U.S. and elsewhere, but few studies in recent years have been conducted in California. New revealed preference studies using accepted methods such as the travel cost method are recommended. Such studies may require new survey information. Benefit transfers using existing studies are also useful if the studies are similar to the project at hand. The information base is deep enough to provide usable unit values for the benefit of a recreation-day by type of activity. A consolidated information database on the amount of visitation, and models that show how visitation and benefits might be affected by a new facility, are lacking.

Market prices and hedonic pricing might also be useful, but these methods are likely to provide only a share of the benefits. Until and unless a new values and use-estimating model is developed, the use of procedures followed by the USACE Engineer Regulation (ER) 1105 (USACE, 2000) is recommended. An alternative cost approach, perhaps based on the costs of providing new recreation facilities at existing water bodies, is also required by the Act.

SECTION 1

Introduction

1.1 The SBX7-2 Legislation

The Safe, Clean, and Reliable Drinking Water Supply Act of 2012 (the Act) authorized the issuance of bonds, if approved by voters in November 2012, in the amount of $11.14 billion pursuant to the State General Obligation Bond Law to finance a safe drinking water and water supply reliability program. Chapter 8 provides that $3 billion of these funds would be allocated

> *for public benefits associated with water storage projects that improve the operation of the state water system, are cost effective, and provide a net improvement in ecosystem and water quality conditions.*

The following four types of storage projects are eligible:

1. Surface storage projects identified in the CALFED Bay-Delta Program Record of Decision
2. Groundwater storage or groundwater prevention or remediation projects that provide water storage benefits
3. Conjunctive use and reservoir reoperation projects
4. Local and regional surface storage projects that improve state water system operations and provide public benefits

The Act requires that the California Water Commission (Commission) work with the California Department of Water Resources (DWR), the California Department of Fish and Game (DFG), and the State Water Resources Control Board (State Water Board) to develop and utilize economic and noneconomic criteria to select storage projects that qualify for public funding, as follows:

> *Projects shall be selected by the Commission through a competitive public process that ranks potential projects based on the expected return for public investment as measured by the magnitude of the public benefits provided.*

The Commission, in consultation with DFG, DWR, and the State Water Board

> *shall develop and adopt, by regulation, methods for quantification and management of public benefits described in Section 79743 by December 15, 2012. The regulations shall include the priorities and relative environmental value of ecosystem benefits as provided by the Department of Fish and Game and the priorities and relative environmental value of water quality benefits as provided by the State Water Resources Control Board.*

The Commission, in anticipation of a referendum as contemplated by the Act, has initiated work to identify the methods for quantification of the public benefits eligible for public funding. This work has included review by state experts and information solicited from economists in government and academia. This report, the result of that work, will be used to guide the development of regulations and guidelines for storage project applicants who request state bond funding for public benefits if the bond is approved by voters in November 2012. This report also provides some tentative interpretation of the Act related to the definition, scope, and quantification of public benefits. This interpretation helps to clarify the potential scope of economic benefits that need to be addressed by this report.

The Commission has been consulting with the DFG and the State Water Board to develop priorities and relative environmental values, as specified by the Act. Results of that consultation are not included as part of this report. In addition, this report does not address how economic benefits would be included in the competitive process contemplated by the Act.

1.2 The Role of Economic Benefits

The Act requires that public benefits be quantified and suggests that the public benefits be quantified using a common metric. Certain ecosystem improvements must be measurable, as follows:

> *79742. A project shall not be funded pursuant to this chapter unless it provides measurable improvements to the Delta ecosystem or to the tributaries to the Delta.*

Public benefit measures must be comparable across projects, as follows:

> *Projects shall be selected…through a process that ranks potential projects based on the expected return…as measured by the magnitude of the public benefits provided.*

Public benefits must also be comparable across public benefit categories, as follows:

> *No project may be funded unless it provides ecosystem improvements that are at least 50 percent of total public benefits of the project funded under this chapter.*

The following provision also suggests that private and public benefits should have a common metric and that it should be the basis for allocating costs between private and public beneficiaries:

> *The benefits available to a party shall be consistent with that party's share of total project costs.*

Cost shares might be quantified on the basis of (1) share of storage space allocated to that benefit, (2) share of water supply provided, or (3) share of economic benefits. However, some benefits are not well represented and costs are not well allocated on the basis of item (1 or item (2. A storage facility can provide recreation, flood control, and water quality benefits even if no share of storage space or water supply is provided. Economic benefits analysis and cost allocation use dollars as the common benefit and cost metric to ensure that the ratio of benefit to cost for each beneficiary is similar.

1.3 The Scope of SBX7-2 Public Benefits

The public benefits categories defined by the Act are as follows:

(1) Ecosystem improvements, including changing the timing of water diversions, improvement in flow conditions, temperature, or other benefits that contribute to restoration of aquatic ecosystems and native fish and wildlife, including those ecosystems and fish and wildlife in the Delta.

(2) Water quality improvements in the Delta, or in other river systems, that provide significant public trust resources, or that clean up and restore groundwater resources.

(3) Flood control benefits, including, but not limited to, increases in flood reservation space in existing reservoirs by exchange for existing or increased water storage capacity in response to the effects of changing hydrology and decreasing snow pack on California's water and flood management system.

(4) Emergency response, including, but not limited to, securing emergency water supplies and flows for dilution and salinity repulsion following a natural disaster or act of terrorism.

(5) Recreational purposes, including, but not limited to, those recreational pursuits generally associated with the outdoors.

The agency team has considered several potential interpretations of the Act related to the benefits that might qualify for public funding. Following is a summary of potential qualifications:

1. Private benefits within the five categories:

   The five SBX7-2 benefit categories could include some benefits that are commonly regarded as private or local. The economics team has not categorically excluded any economic benefit within the five categories above based on whether it is received by private or local beneficiaries rather than by the public as a whole. Therefore, for the purposes of this report, the scope of "public benefits" may include any benefits identified within the five categories above, even if they may be later defined as private benefits. The economic methods will include information that can be used by the Commission to identify shares of the benefits that might be considered as private or local.

2. Public benefits that accrue outside of California:

   There will be instances when "public benefits" accrue to members of the public who are not Californians. The Commission may want to know what share of benefits accrue to Californians and what share of benefits accrue to those outside the state. The economic methods will include information to help identify the share of benefits that accrue to non-Californians.

3. Public benefits that might be financed by the federal government under federal laws:

   Some share of costs eligible for funding under the Act might also be eligible for funding by the federal government. The methods provide information regarding potential funding from federal funds to enable the Commission to better work with the federal government in considering appropriate cost shares.

4. Types of activities:

   The Act does not specify what types of benefits within the five broad categories should qualify. For recreation, the economic guidance includes methods that apply to recreation activities that directly involve public water bodies. These activities are boating, fishing, waterfowl hunting, swimming, and viewing and sightseeing, as well as camping and visiting that are directly associated with these activities.

The team has also considered the problem that certain types of public benefits might be classified in more than one public benefit type. The labeling of such benefits matters in that "ecosystem benefits" have a special meaning in SBX7-2. It is sometimes difficult to determine whether a water quality change should be regarded as an "ecosystem" benefit, a "water quality" benefit, or both. Release of stored water for the purpose of providing more natural flow and temperature downstream for special-status fish species is an ecosystem benefit. Such operations may have incidental benefits for other water users, but the primary purpose is for ecosystem benefit.

On the other hand, ecosystem improvements may provide water quality benefits. For example, riparian and wetland acreage may help cleanse water. These benefits can be hard to quantify in physical terms, but as a matter of semantics, they stem from ecosystem improvements and should probably be regarded as such. Similarly, it is recommended that recreation benefits stemming from ecosystem improvements (for example, better fishing) be classified as ecosystem benefits, not recreation.

SECTION 2

Principles of Economic Benefits

This section provides a description of the basic structure, protocols, and content of benefits analysis.

Benefits analysis is a forecast of a project's economic benefits. Several definitions and concepts are fundamental to how benefits should be calculated, and these definitions are standard practice within economics generally and within benefit-cost (B/C) analysis in particular.

Usually, benefits analysis is part of a B/C analysis. Benefits and costs (see glossary) are calculated by the difference between a future without the project, and a future with the project. The analysis is conducted for a planning horizon that usually extends from the beginning of construction to the end of the project's useful life. Normally, the useful life is measured in years. An annual time step is used to display costs and benefits for each future year until the end of the planning horizon, and costs and benefits are discounted to net present value terms using an established discount rate.

2.1 Economic Benefits Defined

The word "benefits" can mean different things in different contexts. In this document, benefits are defined consistent with standard practice for B/C analysis as the net economic value of the goods and services provided by a project or program. Normally, benefits are net of all costs except project costs.

Economic value, in turn, can be measured as the willingness to pay (WTP) by those benefiting from the goods and services. For example, Young (2005) defines economic benefit as a positive effect for which individuals are willing to pay. Similarly, the federal "Principles and Guidelines" (P&G) for evaluating water resources projects (U.S. Water Resources Council, 1983) defines the value of economic goods and services as the "willingness of users to pay for each increment of output from a plan."

Willingness-to-accept compensation is a concept similar to WTP, but it measures the value that beneficiaries would require as compensation in order to give up a benefit they currently enjoy. Willingness-to-accept can differ significantly from WTP for several reasons, and the amount is generally larger than WTP. The P&G, some federal and state policies, and most textbooks on B/C analysis recommend WTP as the way to value benefits provided by a proposed project, so it is the preferred measure in this report.

Most economic benefits occur because the with-project condition demonstrates a larger quantity of goods or services than the without-project condition. The project would provide better water quality, or more fish, or more recreation, or some environmental enhancement. In this case, the benefits analysis is best served by an estimate of the physical benefit and the WTP for that benefit.

The following examples show how consumers and producers express WTP. For consumers, net WTP for the public benefit is net of the costs that the consumers must incur. For example, if a boater is willing to pay $40 for a day on the lake and the only cost is $35 to launch at the marina, the net benefit to the boater (i.e., from the boater's perspective) is $5. This type of benefit is often called consumer surplus.

For producers, the revenue net of costs is their measure of benefit. Producer benefits are usually estimated using quantities and market prices of goods and services produced. For example, if the marina charges $35 per day for launching but it only costs the marina $15 per day to provide this service, then the producer's benefit is $20. The total net benefit of the marina to both the consumer and the producer in this example is $25 ($5 plus $20). The total benefit is the consumer's gross WTP ($40) minus the cost of providing the good ($15); again, $25.

This example illustrates several important points. Since neither WTP nor cost are equal to the $35 price, the amount paid by the consumer to the producer doesn't count. The $35 launch fee is often called a transfer payment; because the $35 fee is a cost to the consumer but is a benefit to the producer, and because both are Californians, the fee washes out.

Where private markets for the good or service exist and markets are generally competitive, (i.e., large numbers of buyers and sellers are free to buy and produce as much as they want at the market price), then WTP and marginal cost are both equal to price, and the price of the good or service should be used as the measure of WTP. All costs, including project costs and associated private costs, that are required to produce the good must also be included.

In the example above, if a perfectly competitive market existed for marinas, the boater would have the option of choosing another marina whose price would equal the consumer's net benefit of $35. In this case, WTP for the subject marina is $35, not $40. In market conditions WTP is the market price, but net benefit is the market price less the cost of providing the good, which is still $15, so the net benefit is $20, in this case.

For some of the SBX7-2 benefit types, either no markets set prices at all, or the prices in existing markets do not reflect actual benefits. Shadow pricing is a process of estimating the benefit or cost of a resource when market prices are absent or distorted. If a shadow price cannot be estimated, then a variety of techniques can be used to obtain WTP measures. These techniques are discussed below.

Avoided costs occur because the without-project future often includes projects or programs that, with-project, would be cancelled or delayed. Avoided costs are a benefit because people should be willing to pay up to the amount of the cost in order to avoid it. If the avoided project or action produces the same physical benefit as the subject project, then there is no net increase in physical benefit because of the project.

Alternative cost is the cost of providing the same physical benefit by some other means. The physical benefit is used to design alternatives for alternative cost. Logically, no one should be willing to pay more for a good than the cost of obtaining it in some other way. Therefore, WTP is generally limited to the cost of any alternative for providing the good in the same amount, time, and place. For example, if the same water could be supplied from another, less expensive source (and physical attributes of the water supply such as quality and reliability are otherwise similar), then the WTP for water from the proposed project can be no greater than the cost of the alternative source.

Suppose a drought-prone urban area appears willing to pay $1,000 per acre-foot (AF) for water to reduce shortage during dry and critical years. If a proposed project is the only feasible way to provide that water, then the benefit of the water from the proposed project is $1,000 per AF. However, if another feasible source for that same water supply could be identified at $850 per AF, then $850 becomes the economic benefit for the proposed project's supply.

Avoided costs and alternative costs differ for the following reasons:

- An avoided cost occurs in the without-project condition, whereas an alternative cost does not.
- The amount of an avoided cost is determined by the without-project condition. The amount of an alternative cost is usually calculated by designing an alternative that provides the same benefit as the project.
- The physical benefit provided by an avoided cost is not obtained with the project. The physical benefit provided by an alternative cost is obtained with the project, or with the alternative.

2.2 The With-Without Principle

The development of a realistic and defensible without-project future is one of the most important parts of a benefits analysis. The analysis should assume the most likely without-project future. The with-project future must also be reasonable in considering the most likely future for the project involving operations, costs, outputs, and prices that can be received for the outputs, as well as making assumptions about how users will respond to these prices. Where reasonable forecasts differ, or where there is uncertainty, sensitivity analysis might be used to compare economic results under different assumptions.

The with-without principle requires that the analysis utilize forecasts of factors that may influence benefits in the future. These factors include laws, population and demographics, land use plans, projects and programs expected to be operating in the future, environmental conditions, future markets and trade conditions, and anything else that may have an important influence on costs and benefits. Some factors such as population are relatively easy to forecast. Others, such as changing technology, tastes, and preferences, are not. Normally, unpredictable changes are not accounted for in long-term planning, but using sensitivity analysis regarding uncertain factors can be helpful.

B/C analysis is often done as part of a feasibility study that may be concurrent with a National Environmental Policy Act (NEPA) and/or California Environmental Quality Act (CEQA) impact analysis. This concurrent planning process can create additional considerations and constraints on the definition of the without-project condition. NEPA and CEQA analyses usually compare alternatives at a future development condition (year), but benefits analysis requires a planning horizon. The criteria for including planned projects in a NEPA or CEQA no-action condition can result in a no-action future that is different from the benefits analysis. Benefits analysis normally requires that the most likely future projects be included even if those projects do not have complete environmental documentation.

2.3 Analysis Perspective

A benefits analysis requires a definition of whose benefits are being counted. The "analysis perspective" defines the group of people whose benefits are being counted. Unless stated otherwise, this report assumes that the appropriate analysis perspective for SBX7-2 is the state of California.

One of the difficult issues the Commission may face in comparing projects is whether a local benefit is truly a statewide benefit. In some cases, a local benefit is a transfer of a benefit between one Californian and another. For example, if one region is able to obtain an allocation of water from another region of the state, the benefits of the receiving region may be offset by losses in the region of origin.

Another difficult issue involves national versus statewide benefits. The benefits received by consumers and producers in other states and nations are not necessarily benefits for Californians. Whereas some decisions about projects may consider benefits to non-Californians, this consideration may not extend to authorizing California taxpayer money to pay for those benefits.

The California accounting perspective means that public benefits obtained by non-Californians should not be counted; however, this perspective is difficult to implement in the modern global economy. Most economic data are collected according to place of residence or business, not according to citizenship. Therefore, the California accounting perspective should try to count benefits to residents, plus benefits to businesses operating in the state, plus benefits to property located in the state, regardless of the residence of their owners.

2.4 Real Versus Nominal Value of Benefits

When benefits occur over an extended period of time (the planning horizon), standard practice is to evaluate them as though there will be no inflation. Costs and benefits are expressed in real, or constant, dollar terms; both terms mean free of inflation and are expressed in terms of price levels from a recent year (e.g., "all dollar values are provided in 2010 dollars"). Real dollars are distinguished from nominal dollars—nominal means that the observed dollars reflect the general price level at the time they occur. It is important that benefit and cost evaluation consistently uses either real or nominal values throughout, including use of a real or nominal discount rate (see Section 2.5); however, standard practice is to use real dollars with a real discount rate.

For an analysis in real dollars, dollar values from past years that are used as data inputs must be adjusted for recent inflation before being used in the analysis. If the estimates are more than a few years old, the preferred approach is to obtain new data rather than to simply adjust for inflation, but this is not always possible.

In a real dollar analysis, individual components of costs or benefits should be adjusted, escalated, or de-escalated if their future unit values are expected to change in real dollar terms over the planning horizon. For example, if independent, documented projections of electricity prices indicate that they will rise faster than inflation over the planning horizon, then the increase above the underlying general inflation should be used in the real dollar analysis.

2.5 Discounting and Benefit/Cost Measures

All dollar costs and benefits over the planning horizon are discounted to the present using a predetermined discount rate. Discounting accounts for time preference.; that is, benefits occurring in the present are more valuable than the same benefits occurring in the future, all else being equal. Once all benefits and costs are discounted to the same year, they can be summed and compared.

There are numerous B/C measures, each with relative advantages, including the ratio of benefits to costs, the net benefit (discounted benefits minus discounted costs, also called present net worth [PNW]), and the annualized value of benefits minus costs. Annualized value of net benefits is calculated by simply amortizing the PNW over the planning horizon. All of these measures provide the same result of indicating whether a given project is economical. A B/C ratio greater than one, a positive PNW, or a positive annualized net benefit all indicate an economical project. However, when comparing multiple projects or alternatives, the B/C may not provide the same relative ranking as the PNW criterion or the annualized value criterion. But with a limited budget, a ranking of projects in order of their B/Cs will maximize the return to investment. Because the purpose of analysis is to allocate a limited budget, the use of B/C ratios can be generally recommended.

2.6 Double Counting

Double counting is a common problem in benefits analysis and should be avoided, but it can be difficult to identify in projects of complex operations and multiple, related products. For example, both intermediate and end products should not be valued for the same benefit type. If a project provides habitat for a species, then the analysis should not calculate both the value of the habitat and the value of the species that relies on the habitat (unless the habitat provides additional value beyond its use by the species). Also, values from different methods used to estimate the same benefit should not be aggregated.

2.7 Mitigation

Modern water storage projects normally require mitigation for any adverse effects. This report presumes that any adverse consequences of a project to public benefits are mitigated and are completely offset by the project plan. If the plan does not completely mitigate for negative effects on public benefits, then physical public benefits counted for the purposes of the Act should be net of the adverse effects.

2.8 Relationships Among Intermediate Benefits and End Product Benefits

Figure 1 is a general schematic of a typical water storage project benefits evaluation problem. A project generally has defined purposes that are promoted by operations. The analysis requires a forecast of project operations to show how storage will be allocated among uses. The operations lead to intermediate products and then to end products. Economic valuation normally seeks to value the end products, but the intermediate products may be valued if the end product cannot be quantified, or if the intermediate product could be provided by some other means in the without-project condition.

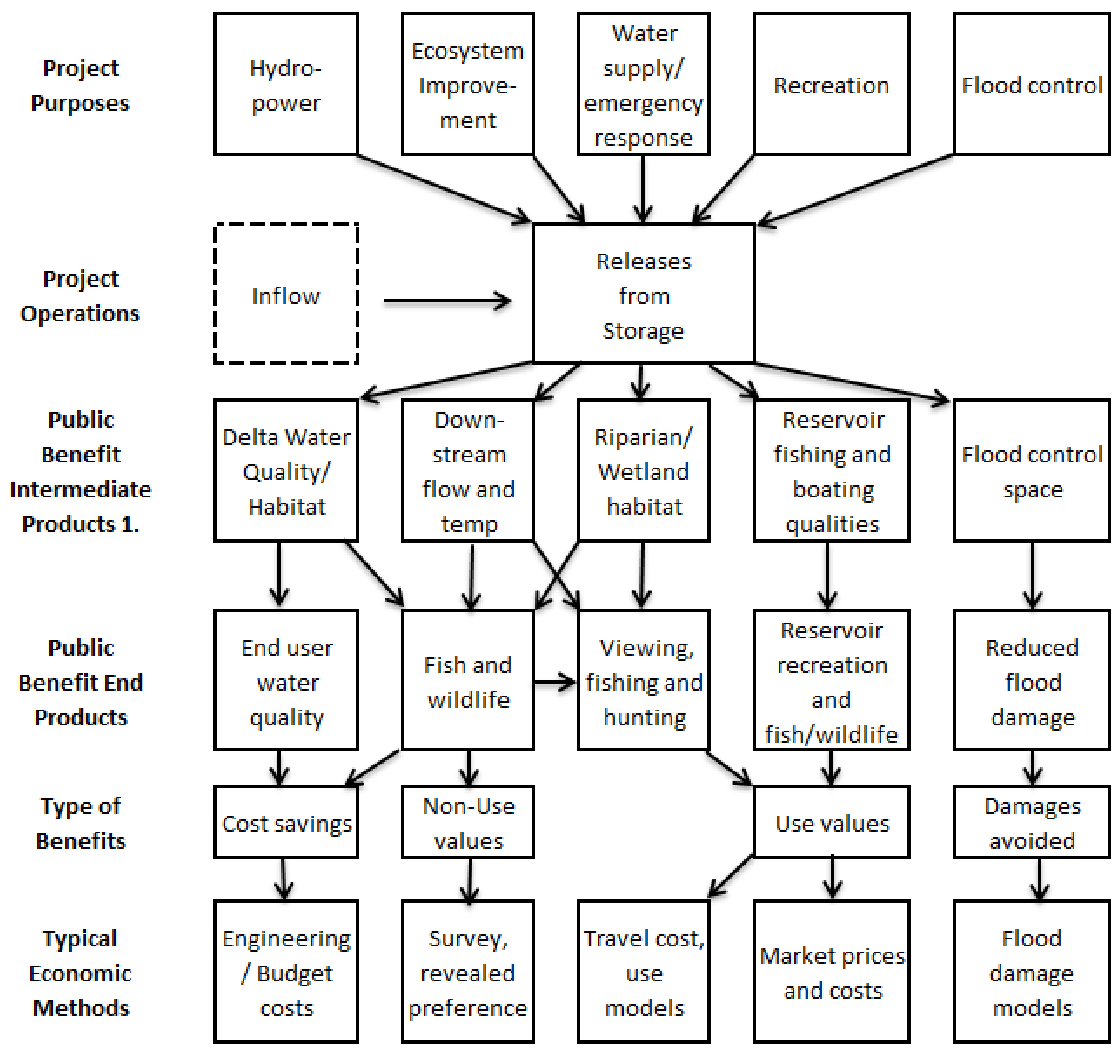

FIGURE 1
Relationship Among Project Purposes, Operations, and Public Benefits
SBX7-2 Economic Methods

SECTION 3

Guidance Documents for Benefit-Cost Analysis

Although numerous documents provide general direction for B/C analysis, relatively few are required to be used for benefits analysis of water resource projects. Four of these documents are discussed briefly below.

U.S. Water Resources Council. 1983. Economics and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G). March.

The P&G is perhaps the most cited and used economic guidance for water-related projects. It was developed to apply to water-related projects of the Bureau of Reclamation (Reclamation), U.S. Army Corps of Engineers (USACE), Tennessee Valley Authority, and the U.S. Department of Agriculture's Natural Resources Conservation Service under the Water Resources Development Act (WRDA) of 1974 (Pub. L. 93-251). Consistency with the P&G is critical for any water project that seeks federal cost-sharing participation.

The P&G covers water supply (both municipal and industrial (M&I) and irrigation uses), flood damage reduction, navigation, hydropower, and recreation. Water quality, ecosystem restoration, and emergency response are not directly addressed, although urban water quality is discussed within urban water supply and emergency response is discussed within flood damage.

In the 2007 Water Resources Development Act (U.S. Congress, 2007), Section 2031, Congress directed the Secretary of the Army to revise the P&G. During the process of revising the P&G, lead responsibility was reassigned to the Council on Environmental Quality (CEQ). The CEQ released its "Proposed National Objectives, Principles and Standards for Water and Related Resources Implementation Studies" in December 2009. The proposed changes to the national economic development (NED) accounts included a minimum B/C ratio of 1.5.

The Obama administration's description of proposed changes states the following:

> The revised Principles and Standards include a number of important changes that modernize the current approach to water resources development in this country, which include:
>
> > Achieving Co-Equal Goals: While the 1983 standards emphasized economic development alone, the new approach calls for development of water resources projects based on sound science that maximize net national economic, environmental, and social benefits.
> >
> > Considering Monetary and Non-Monetary Benefits: The revised Principles and Standards will consider both monetary and non-monetary benefits to justify and select a project that has the greatest net benefits—regardless of whether those benefits are monetary or non-monetary.

> Avoiding the Unwise Use of Floodplains: The decision to modify water resources and floodplains will be based on evaluations of the services gained and lost by such an action. Only those actions that provide a net benefit will be further pursued or recommended for construction. For the first time such evaluations must give full and equal consideration to nonstructural approaches that can solve the flooding problem without adversely impacting floodplain functions.
>
> Increasing Transparency and "Good Government" Results: The revised Principles and Standards are intended to promote the transparency of the planning and implementation process for water resource development projects in this country. (The White House, 2011)

A review of the 2009 proposed changes to the P&G (NRC, 2011) found that

> the 2009 proposed revisions lack clarity and consistency in several respects. One weakness is that the distinctions and relations among "objectives," "principles," and "standards" are not clear. The 2009 proposed revisions also exhibit ambiguity in identifying the federal agencies, programs, studies, and projects to which they will be applied. Another weakness is that the planning principles and steps presented in the document are not fully consistent and lack sufficient coherence in defining a process for planning or implementation. For these reasons, detailed advice on specific planning procedures at this point would be premature. As CEQ proceeds with further revisions to the P&G document, clarification and specification in these areas will be necessary.

Given this review, it is unclear how the P&G might change. The Commission should monitor this situation over time to better understand if benefits methods, and the responsibilities of federal partners, might change.

California Department of Water Resources. 2008. Economic Analysis Guidebook. State of California. The Resources Agency. January.

The state's Economic Analysis Guidebook (DWR, 2008a) states: "Because of its considerable water management partnerships with the federal government, DWR has a policy that all economic analyses conducted for its internal use on programs and projects be fundamentally consistent with the P&G. . .. It is also DWR policy to adopt, maintain, and periodically update its own Economics Analysis Guidebook, which is consistent with the P&G but can also incorporate innovative methods and tools when appropriate."

State policy for B/C analysis has differed from federal policy in several ways. First, the state's analysis perspective focuses on California, and some costs and benefits to the nation may not apply for California. Second, the state has used a discount rate of 6 percent, whereas the federal government uses a rate for investment in water resources projects that changes annually based on the cost of federal borrowing. Other than these specific differences, DWR intends that its B/C analyses will be consistent with the P&G.

DWR has used the guidebook as a basis for economic evaluations required in recent proposals for grant funding from the state. Proposals from local water suppliers and other agencies for Integrated Regional Water Management and Stormwater Flood Management grants require such economic analysis. Guidelines for these grant programs provide specific instructions and calculation templates for applicants to follow.

State Water Resources Control Board. 2011. Guidelines for Preparing Economic Analysis for Water Recycling Projects (De Souza et al, 2011)

This recent guidebook, although designed for water recycling projects, provides some useful information and ideas related to surface storage. In particular, it gives useful information related to the nexus between financial and economic analysis, and useful summaries of benefits information are provided in the appendices. For example, Appendix B in particular provides summaries of U.S. studies regarding the value of water quality and ecosystem improvements and recreation.

U.S. Department of the Army. 2000. Planning guidance notebook. Engineer Regulation 1105-2-100. Washington, D.C. April.

This document, which is based on the P&G, gives guidance for projects that provide flood damage reduction, ecosystem restoration, and recreation. In addition, some of the guidance for storm damage reduction might apply to emergency response. Also, guidance is provided where water quality and recreation result from ecosystem restoration.

Guidance for estimating most benefits is provided in Appendix E, Civil Works Missions and Evaluation Procedures. Appendix D, Economic and Social Considerations, provides guidance for “other direct benefits” that “are the incidental effects of a project that increase economic efficiency.”

In the discussion below, Engineer Regulation 1105 (ER-1105) (USACE, 2000) is given much attention because it is the most detailed implementation document for the P&G. It has been used extensively around the nation, and methods should be acceptable to federal partners in California.

U.S. Bureau of Reclamation Economic Guidebook.

Reclamation maintains economic guidance based on the P&G for internal use (Technical Workgroup, 2010). This report references some important parts of this guidance. However, the guidebook is a working document. Any potential users should contact Reclamation to obtain current guidance.

SECTION 4

Description of Economic Methods and Models

This section provides a detailed description of economic methods for each of the SBX7-2 benefit categories. Economic methods in this document include both (1) techniques for estimating benefits that have general acceptance in the economics profession and numerous applications in the United States, and (2) existing models developed or modified for use in California. For each benefit category, some example applications are provided, if available. An application is the use of a method or model for a specific project or location.

Economic methods generally take physical quantities of goods and services as inputs and place a value on the quantities. If a project's outputs have potential to affect prices, then a supply-demand framework may be required to solve price and quantity simultaneously.

Economic models are formalized sets of calculations that employ one or more of the economic methods. Economic models generally include a database of economic and physical information, a set of calculations, and a standardized output. For example, flood damage reduction models include structural damage estimates and values per structure. Water quality models often include some calculations of water quality units and use of unit economic values. Models vary in how much they allow the user to customize data and, in some cases, calculations.

Note that the potential acceptance of a method does not imply that any application of such a method would be acceptable. Methods can be implemented well or implemented poorly; models can be applied appropriately or inappropriately. Screening criteria are developed in the next section that provide minimum standards for judging whether a method is appropriate to use.

4.1 Methods and Models that do not Estimate Economic Benefits

Some economic models and methods have been pre-screened and are not discussed in detail in this report because they do not provide economic benefits as a measure. However, data used in the pre-screened economic models and resulting output might be useful in generating benefit estimates.

Methods that provide economic measures that are not benefits include the following:

1. **Input-output (I-O) models and related software.** I-O models provide measures including output, value added, income, and employment associated with regional economic growth that are not economic benefits. I-O does not account for opportunity costs or re-employment opportunities for resources. Project impacts on output, value added, income, and employment may represent a reallocation of resources within the state and not a net increase in a cost or benefit.

Several model packages such as IMPLAN or REMI provide inter-industry sales and expenditure data. Some of the data provided by I-O models might be useful for benefits estimates. Such data may include sales levels, proprietor and wage incomes, and margins, but any economic benefits associated with these measures would need to be calculated using additional information. This would not be a commonly accepted use of I-O models, so it is not recommended.

2. **Models that forecast economic growth.** Similarly, some models forecast economic growth in terms of value of output, income, and employment. As with I-O models, these measures are not economic benefits. Project impacts to economic growth may represent a reallocation of resources within the state and are not viewed as a net increase. Similar to I-O models, economic forecasts cannot be used for benefits estimation although they may provide helpful information.

3. **Financial models that describe changes in costs, revenues, or cash flow to an agency.** These models are generally not appropriate for estimating the economic benefits of a project. Agency rate structures are often characterized by average-cost pricing and are constrained by existing contracts and laws. More importantly, they are designed to represent costs and revenues from the agency's perspective, not the state's perspective. Financial models can be important for estimating some components of the with-project condition such as water prices.

4.2 General Methods

The general methods below might apply to any of the five benefit categories. Note that any one application could involve a combination of methods, such as some use of market prices with other information.

This section introduces the concepts of use values and non-use values. Use values are associated with personal interaction with a good. Use values include consumptive use (e.g., harvest) and non-consumptive use (e.g., wildlife viewing). Non-use values are benefits that people obtain even though they have no intent of ever using a resource. For example, many people profess to value rare species even though they may never harvest or see them.

4.2.1 Avoided Cost or Avoided Damage

Project benefits often take the form of avoided costs. Avoided cost or damage methods apply if there are costs or damages in the without-project condition that will be avoided with the project. The clearest example is a cost that is already being paid but, with the project, would be eliminated. If a project brings in higher quality water supply, for example, the beneficiary might be able to reduce or eliminate some existing water or wastewater treatment costs. Another example is when a local agency is required by law or court order to remedy some problem and has a plan to do that, but the proposed project would allow the agency to avoid proceeding with that plan[1]. In a third case, the project may allow a planned

[1] Some textbooks consider this second case an example of an alternative cost. Whether it is called an avoided cost or an alternative cost does not matter to the bottom line, so long as the avoided (alternative) cost is estimated and used properly.

project to be reduced in size or delayed. Delay of a cost is an economic benefit because of discounting.

Cost savings are subject to the same qualifications regarding observed prices and competitive markets that apply when measuring WTP benefits. If the market prices associated with costs are not similar to prices that would result from competitive markets, then some adjustment to the cost estimates may be warranted.

Common types of avoided costs for the five SBX7-2 benefits are shown in Table 1.

TABLE 1
Common Types Of Avoided Costs For Water Storage Projects
SBX7-2 Economic Methods

Benefit Type	Examples of Avoided Costs
Ecosystem	Ecosystem water or habitat that must be provided by other means; regulatory compliance costs
Water Quality	Water treatment costs; alternative supplies used for blending; salinity damages to water infrastructure, plumbing, and appliances; health costs; regulatory compliance costs
Flood Damage Reduction	Avoided damage to structures and contents, roads, and other infrastructure; avoided injuries and fatalities; emergency response and public assistance costs; lost use of facilities and infrastructure
Emergency Response	Costs of emergency water supplies; local costs from reduced quality of exports
Recreation	Costs of providing recreation at other projects; crowding costs

4.2.2 Alternative Cost

California should not be willing to pay more for public benefits than the cost of obtaining the same public benefits by some other means. In B/C analysis, a benefit is limited to the total cost of an alternative project that provides the same level of physical benefits as the proposed project. This is as another way of saying that the proposed project must be cost-effective.

The use of alternative cost methods are supported when the following conditions are present:

1. One or more viable project alternatives exist that are significantly different from the proposed project and could provide the same level of physical benefit.
2. The alternative cost is less than the WTP for the physical benefit. That is, even though the alternative project is not included in the without-project condition, from an economic perspective it should be included.
3. If reasons or indications are given that "something should or likely will be done" even without the project, then the alternative cost approach is supported. In this case, the distinction between avoided cost and alternative cost is blurred, but the result is the same in terms of cost savings and economic benefit.

Cost-effectiveness appears to be required by SBX7-2. Section 79740(b) of the Act requires that public funds under the Act are for "the commission for public benefits associated with water storage projects that . . . are cost effective. . ." This suggests that project alternatives should be identified, if possible, and that their costs should be estimated. If any alternative provides at least as much physical benefit as the project at a lower cost, then the project should not be selected under SBX7-2. This result is the same as if the alternative cost is recognized in a B/C analysis.

Some benefits are inherently difficult to estimate using a WTP approach, and the alternative cost method can be used in these cases. However, condition 2 above states that the alternative cost should be used only when it is less than the WTP. Therefore, an alternative cost analysis should be accompanied by evidence that the physical benefit would be sufficient to justify the alternative cost—that is, that the WTP benefit, if it were estimated, would likely be larger than the alternative cost.

The application of alternative cost principles becomes more complicated when avoided costs are also involved. Additional alternative cost benefits (more than the avoided cost) might be claimed, but only to the extent that the net physical benefit with project exceeds that benefit without-project. The single-purpose alternatives and the WTP benefit should be sized to provide the difference in the level of physical benefit between the with- versus without-project condition, not simply the entire benefit provided by the subject project.

For example, suppose that a subject project would reduce salinity by 20 total dissolved solids (TDS) units and recreation would be increased by 50 visitor-days. The project would allow a smaller planned project to be avoided. The avoided project would have cost $1,000, and it would provide 5 TDS units and 10 visitor-days. The subject project then has an avoided cost-type benefit of $1,000, and it can claim additional physical benefit for the remaining increment not provided by the avoided project: 15 (20 minus 5) TDS units and 40 (50 minus 10) visitor-days.

Identifying a viable alternative that can provide the same level of benefit (condition 1 above) can be difficult, especially when the proposed project provides a very large physical benefit or a complex, even unique, mix of benefits. In some cases, the proposed project may be the only viable way to provide the specific timing and location of a benefit. In these cases, alternative cost alone will not be a sufficient method.

4.2.3 Market Prices

Market price techniques in this context refer to the use of market price as the measure of gross WTP per unit for the public good. Market price techniques can often be applied to estimate use values, but not non-use values. Market prices should be used to value goods that are sold in competitive markets.

In some cases, economic demand and supply functions, where quantity demanded and supplied are a function of price, can be estimated and used to show how the project will change price and WTP. Market price information can be used in a variety of more complicated statistical, simulation, and optimization methods to derive benefits. For producers, the method of residual returns is often used to estimate producer benefits. Residual returns are the market value of goods produced minus the market cost of resources required.

Often, either market prices must be adjusted to reflect a variety of non-competitive conditions, or observed values are adjusted to consider the accounting perspective. Also, any method may require that benefits are net of costs (but not project costs, which are counted separately). Costs are generally measured using market prices. However, the same concerns pertain to prices involved in costs; if prices are not determined by competitive markets, then some adjustment may be advised.

4.2.4 Hedonic Pricing and Land Value Methods

Hedonic pricing refers to techniques that use observed market prices to estimate the value of specific attributes of a good or service. In the case of public benefits, real estate values can sometimes be used to estimate at least some of the value of the public benefit. The prices of real estate and information about the public benefits attributes of the real estate can be used to infer the value of the attributes. The method is appropriate where an important share of the public benefit is captured by landowners and where the benefit for these lands is large enough to be measurable by comparison to similar lands that do not enjoy the public benefit.

A hedonic price equation is estimated using statistical methods from a cross-section of sales and attribute data for properties in a given property market. The hedonic price equation calculates a property's price as a function of its attributes. These attributes may include variables such as presence or amount of ecosystem services or recreational amenities, water quality measures, amount of waterfront, or incidence of flood damage. Coefficients in the hedonic price equation can be used to estimate the share of property value attributable to the public benefit.

Hedonic pricing techniques can be used to derive the portion of total use values obtained by property owners who enjoy the attribute. Additional use values and non-use values usually apply for people who do not receive the property-related benefit. Their benefits must be estimated separately, taking care not to double-count benefits. For example, using an alternative cost method to estimate the public benefit and then adding the property-related benefit from a hedonic pricing study would constitute double-counting.

Land value methods use the difference in value of lands with and without an amenity to infer the value of water supply. The method is often applied to estimate the benefit of irrigation water. A sample of land prices for lands with and without water supply is required. Land value methods might have potential for some public benefits—for example, the value of land with good quality water as compared to land with poor quality water, or the value of land with or without flood protection.

Hedonic pricing and land value methods are both based on land prices. Land prices reflect expected benefits to be obtained from the land in the future. These expectations, and the resulting land values, could be biased. Both methods provide the value of an attribute or amenity in net present value terms. Amortization must be used to infer the implied annual value.

Some authors note that the hedonic pricing approach and land value approach are actually the same in that they seek to isolate the value of an attribute of land, but that the hedonic pricing approach should be preferred on a statistical basis and because it can isolate the values of multiple attributes (Young, 2005). That is, the land value approach will be biased if there are differences between the irrigated and non-irrigated land samples other than the availability of water. For example, lands with better soils are usually chosen to receive water from an irrigation project, so their higher value reflects both water supply and soil quality differences.

4.2.5 Other Revealed Preference

Revealed preference methods use observed behavior, but not market purchases of the good itself, to infer WTP. Travel cost models value recreation use based on distance travelled; more distance travelled implies a higher WTP. Votes for an initiative that raises taxes to fund public benefits imply WTP. Voluntary contributions to environmental causes or to the provision of public benefits suggest WTP. Preferences are also revealed by behaviors that seek to avert, avoid, or insure against damages or costs. Examples include purchases of bottled water, home water filters, and flood insurance. The costs of such behaviors indicate WTP. Revealed preference methods can be used for use and non-use values, but some people may never act on their non-use values; for example, they may never give to environmental charities even though they value endangered species.

4.2.6 Survey-based Methods

Survey-based methods seek to estimate WTP by using questionnaires. Contingent valuation (CV) uses a questionnaire to ask people if they would be willing to pay, and how much they would pay, for some hypothetical improvements. WTP can also be derived from questions regarding whether the respondent would vote for a measure that would increase taxes to finance specified improvements. Conjoint analysis asks individuals about attributes of goods and uses rankings to infer value.

CV and survey methods are contested methods in economics. It is clear that survey methods must be carefully designed to avoid bias. Survey-based methods may be used for use and non-use values and may be important for obtaining information on amount of use where data are not routinely collected. In particular, much recreation use is not counted through sales, so surveys are often used to count visitors, determine their characteristics, and build use-estimating or travel cost models.

4.2.7 Benefit Transfer

Benefit transfer is the technique of interpolating or extrapolating benefit estimates from studies done for other similar locations or resources and then applying those values to the proposed project. The term has been most widely applied to transfer of results from survey-based methods, but the same procedures and problems generally apply for other methods as well.

Benefit transfer usually invokes many issues involving comparability. The available benefit estimate may need to be adjusted for differences in time, location, and quantities and qualities between the original benefit estimate and the subject project, including size, productivity, aesthetics, inflation, location, and demographic differences. Benefit transfer has great potential for error, but it is often used because it is inexpensive or because no other information is available.

4.3 Existing Models

Each existing model applies to only one SBX7-2 public benefit category with the exception of flood damage reduction models, which may have applications for emergency response.

The models used for ecosystem improvement are the following:

- USACE cost-effectiveness analysis
- California Ocean Fish Harvest Economic (COFHE) model

The models used for water quality are the following:

- Lower Colorado River Basin Water Quality Model (LCRBWQM)
- Bay Area Water Quality Model (BAWQM)

The models used for flood damage reduction are the following:

- HEC-FDA and HEC-FIA
- HAZUS-MH
- FEMA Benefit Cost Analysis (BCA) toolkit
- Flood Rapid Assessment Methodology (F-RAM)

The models used for recreation are USACE Unit Day value models.

Discussions of the five SBX7-2 benefit categories are provided below. Background for each category is intended to show the general approach and protocols. Then, specific benefits methods are addressed.

Also discussed are models that may provide avoided or alternative cost information for more than one of the public benefits categories, as follows:

- Least Cost Planning Simulation Model (LCPSIM)
- California Value Integrated Network (CALVIN)
- Other Municipal Water Economic Model (OMWEM)
- Metropolitan Water District of Southern California's (Metropolitan's) IRPSIM and other agency-specific water cost models
- Central Valley Production Model (CVPM) and Statewide Agricultural Production (SWAP) model. These models are discussed after information for the five benefits categories is presented.

4.4 Ecosystem Improvement

In California, the important types of ecosystem improvements are expected to be Delta water supply or other Delta habitat alterations that improve native species, riverine, floodplain, and riparian habitat downstream of water storage facilities, as well as use of delivered supplies to improve wetlands and wildlife refuge areas. Stored water might be used to affect riverine flow and temperature or to provide water supply to increase wetland or riparian areas. Many ecosystem improvements are intended to help endangered species, especially Delta smelt, winter-run and spring-run Chinook salmon, and steelhead trout.

4.4.1 Background

Ecosystem benefits can include water quality and recreation benefits. The valuation of these benefits is discussed under those headings. The other ecosystem improvement benefits, discussed in this section, are primarily (1) the production of commercial products such as fish, (2) the non-use values for fish and wildlife and natural habitats and features, and (3) avoided and alternative costs. Other possible physical benefits of ecosystem improvements, including air quality and carbon sequestration, may apply.

The U.S. Environmental Protection Agency (EPA) Science Advisory Board provided recommendation about ecosystem valuation (SAB, 2009). This report is heavily focused on non-use values as opposed to use values, avoided cost, or alternative cost. The report notes that "Valuation of ecological systems and services is important in national rule makings, where executive orders often require cost-benefit analyses and several statutes require weighing of benefits and costs."

This report describes and illustrates how EPA can use an "expanded and integrated approach" to ecological valuation. To date, EPA has primarily sought to measure economic benefits. This report concludes that information based on some other concepts of value may also be useful. It is primarily concerned with EPA decision making processes, which do not include water storage projects. Still, this report may be influential in guiding ecosystem valuation research and procedures in the near future.

The 1983 P&G did not specifically address ecosystem improvements. Environmental protection and restoration was added as a potential federal project purpose in later legislation. However, this purpose is now important for many projects investigated by USACE and Reclamation.

4.4.2 Monetary Quantification Methods

Ecosystem benefits, especially non-use values, have proven very difficult to value in monetary terms. Ecosystem services provided by water often involve multiple attributes and species, each with its own physical and economic quantification problems. Increases in populations of valuable species would be a desirable measure in California, but few reliable methods to estimate populations are available. Also, even if the physical benefit could be estimated, the value or "price" to place on forecast population or habitat increases is also uncertain. When the amount of physical benefit is highly uncertain, it may be appropriate to quantify an intermediate good such as amount of habitat or water supply.

4.4.2.1 Avoided Cost or Avoided Damage Methods

Avoided cost methods are appropriate for ecosystem benefits when the physical benefit is planned in the without-project condition. The physical benefit may be planned because of an existing program. For example, some refuge water supply is currently obtained by leasing water from agricultural use. The economic benefit of new refuge supplies would be the net value of agricultural production enabled because these transfers are no longer required. Sometimes, avoided costs can be justified by a mandate. For example, the Endangered Species Act mandates that a particular species be recovered. If the species must be recovered, then the actions and costs required for recovery should be part of the without-project future. If some recovery can be provided by the project, then some of the without-project recovery costs might be avoided.

This line of reasoning fails if (1) no funding is provided for the recovery actions, so they would not be implemented without-project, or (2) the recovery plan is uncertain to provide species recovery, so that the project might still be needed in addition to the recovery plan.

Even if the avoided cost approach is not valid, recovery plans and related implementation plans might provide useful cost information for an alternative cost approach to estimate benefits estimation. National Oceanic and Atmospheric Administration, National Marine Fisheries Service (2009) provides some useful cost estimates for recovery measures for Central Valley salmon and steelhead; Priority 1 recovery actions are described in Chapter 6, and potential costs are described in Chapter 8, Table 8-2. In some cases, objectives could be accomplished with new surface storage projects, and the potential costs as suggested by the recovery plans could be avoided. For example, Action 1.5.5 would change water management in the Yolo Bypass at a cost of $10 million; this action might be accomplished using new upstream storage instead.

4.4.2.2 Alternative Cost Methods

Alternative cost methods should be used when at least one viable alternative exists for providing the same physical benefits as the project, and when the WTP benefit of the improvement is expected to be larger than the alternative cost of achieving the physical benefit. In addition, the case for use of alternative cost is improved if "something must be done" even without the proposed project.

There has been a trend away from quantifying ecosystem benefits in dollar terms using WTP methods. Current USACE analysis principles are based on cost effectiveness, which requires alternative cost measures. The USACE procedures are discussed below under "Ecosystem Valuation Models."

Alternative cost methods are often used to value intermediate ecosystem products such as land or water because the methods for estimating WTP benefits for final products such as endangered fish and water quality are controversial. Without measured WTP benefits, the use of alternative cost as a benefit implicitly assumes that the WTP benefit is larger. When the WTP benefit cannot be measured, an alternative cost analysis should be accompanied by other evidence that the physical benefit would be sufficient to justify the alternative cost.

Active markets exist for water supply, and markets for wetlands and other habitat types provide usable prices. In some cases, the project ecosystem water supply is or could be provided using some other supply; however, this supply is or could be providing benefits for agricultural and urban water users. In this case, the benefit of use by the agricultural and urban users that is foregone because of the ecosystem use may be a measure of benefit. Several physical and economic models that are commonly used to estimate changes in agricultural and urban water deliveries and the benefits of these deliveries are discussed below. These models can be used to value ecosystem supply as long as the conditions for alternative cost valuation hold. For areas not covered by these models, the land rent or price method described later in this section might be used to value the water supply.

4.4.2.3 Market Prices

Many ecosystem services have value because they are inputs in a production process or they are end-user products that are bought and sold in reasonably competitive markets. For non-listed fish such as fall run Chinook salmon in California, use benefits are primarily commercial and recreational fishing. For commercial fishing, ER-1105 provides this guidance:

> Estimate the harvest of the exploited stocks. Estimate the seasonally corrected current price of the harvested species and the total cost of harvesting in each of the relevant years if a plan is undertaken. Calculate the ex-vessel value of the harvest (output) for each alternative plan and for the without plan condition. Determine the harvesting costs, for the level of catch (output) identified by each alternative plan and the without plan condition. Compute the benefit as the value of the change in harvest less the change in harvesting cost from the without plan condition to the with plan condition. (USACE, 2000)

4.4.2.4 Hedonic Pricing and Land Value Methods

Hedonic pricing methods can be used to estimate the share of ecosystem benefits obtained by local property owners. These benefits are generally attributed to use values and aesthetics. Hedonic pricing cannot be used to value ecosystem improvements where benefits are obtained by people far from the improvement. The method is most applicable where most of the benefit is captured by private waterfront properties, and existing land values can provide information about how such benefits affect land prices.

The value of irrigated land as compared to dryland can be used to estimate the alternative cost for ecosystem water supply under the assumption that the ecosystem water could otherwise be obtained by purchasing or leasing irrigated land and transferring the available water to the ecosystem purpose. The method is potentially useful for small regions because water rental and sales markets may be limited, but irrigated land markets are often more competitive.

An example is provided in Section 4.4.4.7 below.

4.4.2.5 Other Revealed Preference

Revealed preference methods can be used for certain ecosystem benefits. Recreation and water quality benefits are discussed in their respective sections. The method requires that individuals will be aware of the benefits they will receive. This is sometimes not the case when benefits distributed over a large population mean that the improvement per capita is very small.

4.4.2.6 Survey-based Methods

Survey-based methods for ecosystem benefits are widely used in economics, primarily because ecosystem values often have multiple attributes and a large non-use component. Few other methods are available to estimate non-use values. A number of California applications are discussed below.

Reclamation's Economic Guidance does not mention non-use values as part of the value of fish and wildlife, nor does it suggest use of survey-based methods. Fish and wildlife values include commercial, recreational, or non-consumptive use. USACE guidance specifically does not allow use of survey-based methods for ecosystem values. Non-use values are not mentioned as a category of benefits.

4.4.2.7 Benefit Transfer

Benefit transfer methods are often used for ecosystem valuation. The Beneficial Use Values Database (BUVD), maintained at the University of California Davis, provides many studies that might be used for benefit transfer. A useful discussion of benefit transfer methods is also provided in Ghermandi et al (2008).

The Benefit Transfer and Use Estimating Model Toolkit (Toolkit) is another resource. The Toolkit is available through the Agricultural and Resource Economics Department, Colorado State University. The Toolkit consists of several spreadsheet tables, templates, and models that estimate values for wildlife recreation, common wildlife habitats, and threatened and endangered species. Technical documentation provides guidance selecting appropriate benefit transfer methods and visitor use estimating models (UEMs). Benefit transfer examples are also included in the technical documentation.

The spreadsheet tables, templates, and models include the following

- Use values for fish and wildlife
- Use values per day of hunting, fishing, and viewing
- Use and non-use values per acre of habitat
- Use and non-use values per household of threatened and endangered species

The use and non-use values include average values, databases of the individual studies, and meta analysis equations to tailor the benefit transfer to specific study sites.

Visitor UEMs for hunting, fishing, and wildlife viewing are available for National Wildlife Refuges, Wildlife Management Areas, and private, state, and federal lands in California. The visitor use estimates can be used with values per visitor day to undertake recreation benefit transfer studies.

4.4.3 Ecosystem Valuation Models

4.4.3.1 USACE Cost-effectiveness and Incremental Cost Procedures

The USACE uses cost-effectiveness and incremental cost procedures to value ecosystem improvement, as explained in the following passage from ER-1105 (USACE, 2000):

> Ecosystem restoration alternatives are also evaluated on the basis of cost effectiveness and incremental cost analyses. First, it must be shown through cost effectiveness analysis that an alternative restoration plan's output cannot be produced more cost effectively by another alternative. "Cost effective" means that, for a given level of non-monetary output, no other plan costs less, and no other plan yields more output for less money.
>
> The subset of cost effective plans are examined sequentially (by increasing scale and increment of output) to ascertain which plans are most efficient in the production of environmental benefits. Those most efficient plans have the lowest incremental costs per unit of output.

> Usually, the incremental analysis by itself will not point to the selection of any single plan. The results of the incremental analysis must be synthesized with other decision-making criteria (for example, significance of outputs, acceptability, completeness, effectiveness, risk and uncertainty, reasonableness of costs) to help the planning team select and recommend a particular plan.

There are a number of ways of conducting cost-effectiveness/incremental cost analysis (CE/ICA), thereby determining which plans are cost effective and, from the set of cost-effective plans, identifying those plans that are most efficient in production.

These methods are reported in the following documents:

- IWR Report 94-PS-2, Cost Effectiveness Analysis for Environmental Planning: Nine EASY Steps
- IWR Report 95-R-1, Evaluation of Environmental Investments Procedures Manual Interim: Cost Effectiveness and Incremental Cost Analyses
- IWR Report 98-R-1, Making More Informed Decisions in Your Watershed When Dollars Aren't Enough

Two software packages are also available from the U.S. Army Engineer Institute for Water Resources (IWR) Web site at http://www.wrsc.usace.army.mil/iwr. Under this procedure, outputs are not valued in monetary terms. Rather, a qualitative approach to valuing outputs is prescribed as follows:

> Because of the challenge of dealing with non-monetized benefits, the concept of significance of outputs plays an important role in ecosystem restoration evaluation… information on the significance of ecosystem outputs will help determine whether the proposed environmental investment is worth its cost and whether a particular alternative should be recommended. Statements of significance provide qualitative information to help decision-makers evaluate whether the value of the resources of any given restoration alternative are worth the costs incurred to produce them. The significance of restoration outputs should be recognized in terms of institutional, public, and/or technical importance.

Detailed procedures for determining and describing the significance of environmental resource(s), including a hypothetical restoration study example and sample significance statements, are found in IWR Report 97-R-4, "Resource Significance Protocol for Environmental Project Planning" (USACE, 1997).

4.4.3.2 California Ocean Fish Harvester Economic Model

The COFHE model is a "customized impact assessment model built on the IMPLAN impact assessment system" (Hackett, 2009). Commercial fisheries cost data obtained through surveys and revenue data from the DFG were used to develop a customized IMPLAN model for each operational configuration (OC). The OCs include individual counties, regions, and the state as a whole.

The model can be used to estimate the economic impacts related to a change in California's commercial fisheries. A proposed project could impact fisheries, affecting regional economies that include commercial fishing. Although regional economic impacts should not be used directly to estimate public benefits, output from the COFHE model could help estimate changes in value of fish production and direct costs that can be used to estimate increased net revenues in the commercial fishing sector.

4.4.4 California Applications

4.4.4.1 NODOS PFR Fall Run Salmon Commercial Catch

The North of Delta Offstream Storage (NODOS) Preliminary Feasibility Report (PFR) estimated commercial and recreational use benefits for fall run salmon. SALMOD (see Appendix A) was used to develop estimates of the percent increase in the fall run Chinook salmon population. Pacific Fisheries Management Council keeps records on commercial catch and value of commercial catch (PFMC, 2006a). Catch was allocated between commercial and recreational catch and escapement. Using this approach, the combined commercial and recreational value of catch associated with each escaping fall-run adult was estimated to be about $105.

4.4.4.2 EWA Pricing Analysis

Ecosystem valuation of non-use values for storage projects in California has relied on avoided cost and alternative cost measures. In particular, water dedicated for other environmental purposes has been valued using an alternative cost approach.

The Common Assumptions process developed methods and data for CALFED Surface Storage evaluations. The Environmental Water Account (EWA) Pricing Analysis was developed to help the Common Assumptions process estimate prices for water acquired for environmental purposes. The analysis first focused on a review of water transfer price data and price information in other studies, and provided the following data:

- A summary of existing data on water acquisition and transfer prices in the Central Valley
- A summary of results from other studies on the value of water in Central Valley agriculture
- A statistical analysis and projection of water acquisition prices for EWA

The draft report recommended that "in the interim period before the Plan Formulation modeling package is available, any use of EWA water prices in the analysis of surface storage projects [should] use the projected EWA water transfer prices as developed in this report."

The "Draft Addendum to the Report on Environmental Water Account Price Estimation" (Mann and Hatchett, 2006a) provided a sensitivity analysis that estimated the marginal value of irrigation water to agriculture over a range of land fallowing scenarios. The report used the CVPM to estimate the lost net returns to agriculture if EWA water were purchased and the land fallowed. The analysis focused on water transfers made available for the EWA by temporary, one-year fallowing of irrigated agricultural land within the Central Valley. The "shadow prices" that came from CVPM results were interpreted as the minimum price that agricultural users would accept to sell water and take land out of production. The analysis of opportunity cost was made by reducing transferrable surface water supplies used for irrigation in eligible source regions while holding groundwater fixed.

Table 2 provides water opportunity costs recently recommended from this information.

TABLE 2
Example Economic Opportunity Costs Of Water For Recent Surface Storage Evaluations, In 2007 Dollars Per Acre-Foot
SBX7-2 Economic Methods

	2004 Condition				2020 Condition			
	North of Delta		South of Delta*		North of Delta		South of Delta	
Year Type	Min	Max	Min	Max	Min	Max	Min	Max
Driest Years (1924, 1929 to 1934, 1977, and 1987 to 1992)								
Critical	$255	$275	$340	$565	$315	$345	$400	$680
Dry	$205	$255	$340	$565	$255	$315	$400	$680
Non-driest Years								
Critical	$210	$230	$280	$470	$265	$285	$335	$565
Dry	$170	$210	$280	$470	$210	$265	$335	$565
Below Normal	$140	$195	$215	$335	$175	$245	$255	$400
Above Normal	$140	$195	$220	$305	$175	$245	$260	$365
Wet	$140	$195	$220	$265	$175	$245	$265	$320

*measured after pumps

4.4.4.3 NODOS PFR Delta Water Supply

For NODOS Delta outflow supply, a combination of opportunity costs of agricultural and urban water supply was used. The evaluation of EWA supply was based on a combination of the EWA Pricing Model analysis described above and opportunity cost of water for urban use. Prices were provided on a water–year-type basis.

4.4.4.4 CE/ICA for Hamilton City Eecosystem Restoration

A USACE CE/ICA analysis was recently applied for a levee setback project near Hamilton City, California (USACE, 2004). Native habitat and natural river function in the study area were altered by the existing levee and by converting the floodplain to agriculture and rural development. The levee constrained the river's ability to meander and overflow its banks, and conversion of the floodplain to agriculture and rural development reduced the extent of native habitat to remnant patches. These changes had greatly diminished the amount, richness, and complexity of riparian, wetland, and floodplain habitat in the study area and harmedthe species dependent upon that habitat.

CE/ICA using the USACE IWR Plan software was used to compare the efficiency of alternatives (DWR, 2005). Using completeness, effectiveness, efficiency, and acceptability criteria, the most cost-effective single purpose National Ecosystem Restoration (NER) plans were identified and grouped into the "final array" of NER plans. An incremental cost analysis was performed for these alternatives to determine "Best Buy" plans that provide the greatest increase in average annual habitat units (AAHUs) for the least cost. Two alternatives were identified as "Best Buy" plans; however, one of these produced AAHUs at an incremental cost of $4,900 per AAHU, compared to $7,300 per AAHU for the other. Thus, the least-cost alternative was selected as the single-purpose NER plan. This plan consisted of an intermediate setback levee about 6.8 miles in length. The selected alternative, scheduled for construction in 2012, will restore about 1,500 acres of habitat.

4.4.4.5 Benefits Analysis for Colusa Basin Wetlands

The Colusa Basin Integrated Watershed Management Study analyzed seven plans that combined various structural and nonstructural flood management measures near the town of Willows (DWR, 2005). Stand-alone environmental enhancements were also proposed. The environmental enhancements assumed in the analysis were approximately 3,000 wetland and riparian acres.

This study attempted to directly monetize the environmental benefits. Although the value of some of the habitat services could be quantified in monetary terms, quantification was beyond the study scope and resources available. Thus, it was assumed that the value of the proposed habitat is at least equal to the costs incurred by others to produce similar types of habitat in the project area. A lower bound benefit was estimated based on (1) actual expenditures to create similar types of habitat in the nearby Natomas Basin, or (2) where similar projects could not be found, upon the actual costs of the proposed restoration projects. Data used for the lower bound included the range of actual and estimated wetlands/riparian construction and operations and maintenance costs from similar wetlands projects implemented by Wildlands Incorporated in the nearby Natomas Basin. Where similar projects could not be found, the second data source was engineering cost estimates developed for the project. An upper benefit bound was estimated based upon market prices paid for habitat services through a habitat conservation bank in the region. The upper bound habitat benefit values were based on Sheridan Bank May 2004 credit prices. The specific prices were $50,000 for a wetland 1-acre credit and $58,000 to $65,000 for a riparian 1-acre credit.

4.4.4.6 Applications of Contingent Valuation in California

In the last twenty years, several CV studies have estimated the use and non-use value of Pacific Northwest salmonids (Table 3). Hanemann, Loomis, and Kanninen (1991) estimated the WTP of California, Nevada, Oregon, and Washington State households for restoring salmonid runs to the upper San Joaquin River. Olsen, Richards, and Scott (1991) estimated the WTP of households in the Pacific Northwest for increases in salmon and steelhead fisheries in the Columbia River Basin. Loomis (1996) estimated the WTP of households across the nation for an increase in salmonid populations based on the removal of dams on the Elwha River in Washington State. Layton, Brown, and Plummer (1999), estimated the WTP for several levels of salmonid restoration in Washington State. The most recent study was conducted by Bell, Huppert, and Johnson (2003). This study estimated the WTP of coastal households in Oregon and Washington for increases in salmonids in the same region.

TABLE 3
Example Survey-based Values for West Coast Salmonids
SBX7-2 Economic Methods

Author(s)	Study Region	Average WTP*	General Increase in Salmonid Population	Year
Hanemann, Loomis, and Kanninen	Upper San Joaquin	$318	15,000	1991

Example Survey-based Values for West Coast Salmonids
SBX7-2 Economic Methods

Author(s)	Study Region	Average WTP*	General Increase in Salmonid Population	Year
	River, CA			
Olsen, Richards, and Scott	Pacific Northwest	$94	2.5 million	1991
Loomis et al.	Elwha River, WA	$99	300,000	1996
Layton, Brown, and Plummer	WA	$245	2 million	1999
Bell, Huppert, and Johnson	Coastal OR and WA	$98	250,000	2003

*WTP per household per year in 2010 dollars

The WTP of households in Table 3 are not always comparable. The households surveyed, baseline salmonid populations, and the change in the population used to elicit WTP are not the same across studies. These studies demonstrate a large apparent WTP for salmon recovery; the figures in Table 3 could be multiplied by numbers of households in each region to obtain a total annual WTP that might range into the billions of dollars per year. This information generally supports the idea that effective alternative cost measures for increasing listed salmon and steelhead trout may be less than WTP measures.

In another study, the State Water Board considered water allocation for Southern California from streams flowing into Mono Lake. Reduced flows into the lake were affecting resident and migratory birds. California households received a mail survey asking whether they would pay more on their water bill to restore flows to the lake. The average WTP per household was estimated to be $156 per year. This supported the theory that the general public's interest in increased water in Mono Lake could be an important part of the water allocation decision.

The state hired a consulting firm to conduct a more in-depth survey. This survey included images showing the lake at different water levels and gave information about effects of lake levels on different bird species. Survey respondents were asked how they would vote in a hypothetical referendum. This study also suggested that the benefits of a moderately high (but not the highest) lake level were greater than the costs.

4.4.4.7 Alternative Cost Approach Using Water Transfer Prices, Land Price, or Rents

Water transfer prices from competitive water transfer markets can provide a useful measure of the value of water supply. However, water transfer markets are not very competitive in most regions of the state. By contrast, land rental and sales markets are often very competitive; there are many buyers and sellers, and water supply is often tied to the land. In this situation, the land value method can estimate the value of water by using the difference between irrigated and non-irrigated land prices or rental rates.

An example is provided in Table 4. The American Society of Farm Managers and Rural Appraisers (ASFMRA) provides current land rent and price estimates for California regions and for subregions within each of these regions by crop type (ASFMRA, 2009). Prices are estimated by consensus of appraisers operating in each region (Iliff, 2011). Estimated values are intended to include the value of land, water, irrigation distribution system improvements, and perennial plants. The value of land alone is considered by subtracting the value of non-irrigated rangeland from the irrigated land price. Where irrigation systems and perennial plants are present, the land value method requires an adjustment for these assets.

TABLE 4
Example Land Price and Rent Method for Valuing Water
ASFMRA 2009 Data for Colusa, Glenn, Butte, and Tehama (Northwestern Counties), Sacramento Valley
SBX7-2 Economic Methods

Land Price Method	Average of Min and Max Price, $/Acre	Price less Rangeland Price[a]	Annualized $/Acre, 3%	Annualized $/Acre, 4.5%	AF CU per Acre[b]	Annualized $/AF, 3%[c]	Annualized $/AF, 4.5%[c]
Rice	$6,250	$6,250	$188	$281	2.82	$58	$91
Vegetable Crops Class I	$6,500	$5,600	$168	$252	1.49	$96	$152
Irrigated Field Crops	$5,500	$4,600	$138	$207	1.13	$100	$161
Rangeland 1,000+ Acres	$900						
Land Rent Method	**Average of Min and Max Rent**	**Rent Less Rangeland Rent[a]**	**AF per Acre CU[b]**	**Estimated Value per AF[c]**			
Rice	$325	$325	2.82	$106			
Vegetable Crops Class I	$200	$183	1.49	$106			
Irrigated Field Crops	$138	$120	1.13	$84			
Rangeland	$18						

[a]Rice has no dryland opportunity cost. For others, Northwestern Counties rangeland price is used.
[b]2005 consumptive use (CU) of water, measures as evapotranspiration of applied water (ETAW) from CVPM.
[c]$25 per acre per year is allowed for irrigation system improvements.

To obtain the annual value of water from the price of land, a discount rate, or real rate of interest, is required. Table 4 uses a range of 3.0 to 4.5 percent. To obtain a value per AF, information about the amount of water used per unit land is required. Data from DWR is used in this example (DWR, 2011). The measure of water use is evaporation of applied water (ETAW). Year 2005 data were used because they are the most recent available.

In this region, the estimated benefit per AF of ETAW ranges from $58 to $161 per AF. The lower end of the range is associated with rice production ($58 to $106) and the higher end is associated with irrigated field crops ($100 to $161).

ASFMRA data are available for most regions of the state with irrigated land. However, any data on the rental rates or price of irrigated land can be used. The analysis should use sales from properties that are comparable to the area affected by the project, and sample size should be sufficient to result in a representative average.

4.5 Water Quality Improvement

Water quality improvements from water supply projects are usually related to release of stored water to provide better water quality for water users or ecosystems. Water quality improvements stemming from ecosystem improvements (for example, better water quality from restored wetlands) are discussed here, even though they are recommended for classification as ecosystem benefits. Water quality provided for ecosystem purposes is also discussed here, even though it is clearly ecosystem improvement water.

In the Delta, one long-standing water quality problem has been salinity for Delta water users, including Delta agriculture and Delta exports. Large storage projects upstream are used to repel saline water from the Delta. These operations are generally regarded as "water quality." Stored water may also be used to maintain salinity gradients to encourage primary productivity for ecosystem purposes.

Delta water export quantity has important water quality benefits for the south coast because the low-salinity Delta water serves to dilute the more saline local and Colorado River supplies. These water quality benefits can be estimated with available models, but it is not clear that the benefits should be counted as water quality because they stem from water supply.

Dissolved oxygen, turbidity, organic carbon, and bromide are often important Delta water quality constituents in some locations. Organic carbon and bromide are important disinfection byproduct precursors for municipal water users, but the benefit of small incremental changes in these constituents has proven hard to quantify and may be small.

Many other water quality constituents are important around the state; however, physical and economic methods are limited. Storage projects may be used (1) to retain and treat degraded runoff, (2) for mixing with more saline supplies, or (3) for other important local water quality purposes.

SBX7-2 refers to water quality improvements "that clean up and restore groundwater resources." In California, such improvements are likely to enable increased use of the groundwater for water supply. One benefit of improved water quality is water supply. Methods that value this water supply are discussed in "Models that provide economic information for more than one public benefits category."

4.5.1 Background

Like ecosystem benefits, water quality benefits are often hard to quantify in physical or monetary terms. In general, economic methods based on avoided or alternative costs have been preferred. Many useful examples of survey-based and revealed preference methods also exist.

4.5.2 Monetary Quantification Methods

4.5.2.1 Avoided Cost or Avoided Damage Methods

Quantification of water quality benefits uses an avoided cost approach when water quality damages or costs in the without-project condition are avoided because of the project. Two models of urban salinity costs discussed below develop benefits estimates in this way.

4.5.2.2 Alternative Cost Methods

The alternative cost method is widely applied to water quality problems, especially where a mandate exists to improve water quality. The application of alternative cost to water quality usually involves engineering costs (e.g., costs of water treatment, or costs of removal or relocation of the water quality problem).

> USACE guidance notes the importance of cost-effectiveness for water quality projects.Corps restoration and protection projects may involve cost effective solutions to improve aeration, temperature, turbidity, acidity, sedimentation and other water quality parameters. Consideration should be given to whether the water quality improvements will accomplish restoration of the system, because in many instances, other functional or structural ecosystem components may require attention as well. (USACE, 2000)

4.5.2.3 Market Prices

Market price methods have little direct application for water quality because water quality is not sold in competitive markets. However, market prices of many goods used to avoid water quality problems (i.e., bottled water, water softeners, and water filters) and prices of goods that can be damaged by water quality problems (i.e., plumbing, fixtures, and appliances) are pertinent. Also, where improved groundwater quality enables increased water supply, the price of water can convey important information about the value of water quality.

4.5.2.4 Hedonic Pricing and Land Value Methods

Hedonic pricing has been used to estimate the relationship between water quality and property values. For example, Leggett and Bockstael (1998) found that fecal coliform had a significant effect on property values on the Chesapeake Bay. Crompton (2004) reviews a study of water quality in the Willamette River, Oregon (Barranger, 1974), which attempted to determine increases in property values associated with substantially improved water quality over the 1960 to 1970 period.

Hedonic pricing is applicable where most water quality benefits are received by property owners (usually owners of waterfront properties). In these cases, the water quality improvement might have a significant influence on the property values. Similar properties that have experienced similar water quality differences can therefore serve as a sample for estimation.

4.5.2.5 Other Revealed Preference

Revealed preference methods can be applied for residential customers (in particular, purchases of bottled water and home water filters). One study estimated benefits of avoiding water quality violations by increases in bottled water sales (Zivin et al, 2011). Some revealed preference-type measures are included in the LCRBWQM, which is discussed below.

4.5.2.6 Survey-based Methods

Survey-based methods can be used to elicit WTP for water quality improvements. Numerous examples are available, such as Viscusi et al (2004, 2007) and Carson and Mitchell (1993).

4.5.2.7 Benefit Transfer

Water quality benefits are often valued by comparing them to changes and unit values estimated for other studies. An informational database called the BUVD has been compiled for the State Water Board for this purpose. The BUVD is

> an informational database of economic values for beneficial uses of water collected from a variety of sources, including scholarly journals, books, conference proceedings, government reports, and working paper series. Currently, it is available for review to the public in its alpha version.
>
> The purpose of the BUVD is to provide an educational and informational tool to the general public and interested specialists, documenting the economic values for beneficial uses of water identified by the California State Water Resources Control Board (SWRCB). It is envisioned that the BUVD be a companion to the WQSID, which currently provides information to the public on water quality standards for, and beneficial uses of, water bodies throughout California, but no information on the value of those beneficial uses. (Larson and Lew, 2011)

4.5.3 Water Quality Valuation Models

4.5.3.1 Lower Colorado River Basin Water Quality Model

This model estimates benefits of source water salinity reductions for urban water supplies. The LCRBWQM was developed by Reclamation (Lower Colorado Region) and Metropolitan in 1998. This model was updated as part of Metropolitan's and Reclamation's 1999 Salinity Management Study. The current version of the model maintained by DWR was updated with population data from DWR, and costs have been updated to 2007 levels. Most salinity costs are the reduced life of appliances and infrastructure, treatment costs, and degradation of groundwater resources. Metropolitan and Reclamation's Salinity Management Study (1999) contains a complete reference of the data and their source material.

The model inputs from CALSIM II and DSM2 are SWP East and West Branch deliveries and TDS of these deliveries in mg/L, respectively. Some water diverted at Banks Pumping Plant (PP) is conveyed directly to Southern California; other supplies are mixed in San Luis with water diverted at Jones PP. A routine to estimate salinity of urban water supplies delivered to the south coast based on timing of urban deliveries, mixing in San Luis Reservoir, and salinity estimates at Edmonston PP can be used to obtain improved salinity inputs for LCRBWQM.

LCRBWQM divides Metropolitan's service area into 15 subareas. The division of the south coast region into subareas provides detail regarding sources of water and salts in each area. This detail is necessary because each region obtains very different shares of supply from different sources; and some sources, the Colorado River and groundwater in particular, have higher salinity than others.

4.5.3.2 Bay Area Water Quality Model

The BAWQM estimates benefits of source water salinity reductions for urban water supplies in the portion of the Bay Area region from Contra Costa County south to Santa Clara

County. The model was developed and used for the economic evaluation of a proposed expansion of Los Vaqueros Reservoir (Reclamation, 2006c).

Separate calculations are provided for Contra Costa Water District (CCWD) and another region consisting of Alameda County Water District, Zone 7, and Santa Clara Valley Water District. The model inputs include water supply to the South Bay Aqueduct and Contra Costa Canal (provided by CALSIM II) and chloride concentrations in mg/L from DSM2. For CCWD, water quality estimates are based on diversion volume and water quality at Old River and Rock Slough. For the other areas, water quality is based on diversion volume and salinity at Banks PP. In the districts receiving SWP water, water quality is a function of other supplies as well as SWP imported supplies.

This model counts residential benefits only. Input data on the percent of households having appliances and the initial cost of appliances are required. Data on the salinity of supplies obtained through CCWD's intakes, through the South Bay aqueduct, and through the San Felipe system must be developed for alternatives. The model also required the average salinity of any other non-project supplies.

4.5.3.3 Disinfection Byproduct Precursor Reduction Benefits Methods

Disinfection byproduct precursors (DBPs) are naturally occurring chemicals, primarily bromide and organic carbon, that are common in Delta water. Disinfection byproducts form during the disinfection process in potable water treatment. Some of these chemicals are thought to be potential carcinogens and are regulated. Control methods include new disinfection technologies and reducing concentrations of DBPs. Bromide concentrations are highly correlated with salinity, but organic carbon is more associated with disturbance of Delta soils and rain events.

DWR and others have invested significant time in estimating economic benefits associated with reduced concentrations of DBPs. Most urban agencies that rely on Delta supplies are converting to treatment technologies that avoid creating disinfection byproducts. Because this conversion will happen regardless of small changes in Delta water quality, and because the variable costs under these new technologies associated with small increments of DBPs are small, the economic benefit associated with small changes in DBP concentrations is now believed to be small.

4.5.3.4 Agricultural Salinity Model

This model estimates benefits from a reduction in salinity of agricultural water deliveries south of the Delta. SWP and CVP deliveries to south-of-Delta agricultural users are allocated to a large geographic area that supports numerous crops and irrigation methods. Some of these areas are salt- and drainage affected and have limitations for virtually all crops. Crop production in these areas requires careful irrigation management and leaching of salts. Other irrigated areas are not drainage affected (as yet), but sensitive crops such as orchards and vegetables still require that growers maintain adequate leaching to prevent salt from accumulating in the root zone. The savings in irrigation water used for leaching is calculated for each of these areas south of Delta based on the crops grown and their salt sensitivities.

Water saved as a result of growers applying a smaller leaching requirement is assumed to be available for other irrigation use within the area. The benefit of the water saved is the unit value of water for irrigation in that area times the volume saved. Because the saved water would have been delivered to farms anyway, neither the project (SWP or CVP) nor the local district incurs any additional cost of delivery. Therefore, the marginal value of irrigation water is an appropriate measure of the benefit of an AF of water not needed for leaching and therefore available to meet other crop water uses. The saved water could be used to reduce groundwater pumping, to reduce land fallowing, or for both. The SWAP Model is typically used to estimate the value of water for irrigation.

The CALSIM II and DSM2 models are used to estimate TDS and conductivity (EC) of water pumped by the SWP and CVP facilities. Jones PP supplies water to the Delta Mendota Canal, which is the primary source of CVP water delivered into the Grasslands salinity analysis area. Banks PP supplies water to the California Aqueduct, which either delivers it directly to contractors or conveys it to San Luis Reservoir, from which it is delivered to contractors. The other salinity analysis areas receive their Delta supply from this source.

4.5.4 California Applications

4.5.4.1 Water Quality Benefits Analysis for NODOS

The NODOS PFR estimated water quality benefits for the south coast region of California using LCRBWQM. The model assessed the average annual "regional" salinity benefits or avoided costs based on demographic data, water deliveries, TDS concentration, and costs for typical household, agricultural, industrial, and commercial water uses. In the NODOS PFR, the model calculated the "incremental" economic benefits of SWP salinity changes compared to a selected without-project condition.

LCRBWQM is also being used in the Bay Delta Conservation Plan Environmental Impact Report/Environmental Impact Statement (BDCP EIR/EIS) and NODOS FS. These studies are ongoing and not publicly available. BAWQM was not used for the NODOS PFR, but it is being used for the BDCP EIR/EIS and NODOS FS.

4.6 Flood Control Benefits

Flood control benefits are provided by water storage projects in two ways. First, benefits are provided because some storage space is reserved for the capture of flood flows. Second, benefits may be incidental to the use of storage for other purposes. The empty storage space provides a benefit, especially following dry years, even though the space is made available by flood control operations. Physical models with an appropriate time step are normally required to estimate how the frequency and severity of flooding changes with new storage facilities.

4.6.1 Background

As compared to ecosystem or water quality, flood control benefit estimation is relatively straightforward. The prediction of flood control benefits has a relatively long history, so methods are well developed and understood. Benefits are mostly reduced damages, but some reduced income losses and emergency costs can also be counted. Benefits are calculated by comparing flood costs, both with- and without-project, for a number of different flood events, each with an estimated recurrence interval. An expected value of losses is estimated as the interval probability (the probability of any flood event between recurrence intervals) times the average expected flood damages in that interval and is summed over the intervals.

4.6.2 Monetary Quantification

4.6.2.1 Avoided Cost or Avoided Damage Methods

Most flood control benefits are estimated as avoided damages. Expected annual damages (EADs) are estimated from event damages and interval probabilities.

> According to ER-1105
>
> benefits from plans for reducing flood hazards accrue primarily through the reduction in actual or potential damages...
>
> (3) Types of Flood Damage. Flood damages are classified as physical damages or losses, income losses, and emergency costs.
>
> (a) Physical Damages. Physical damages include damages to or total loss of buildings or parts of buildings; loss of contents, including furnishings, equipment, [motor vehicles,] decorations, raw materials, materials in process, and completed products; loss of roads, sewers, bridges, power lines, etc.
>
> (b) Income Loss. Loss of wages or net profits to business over and above physical flood damages usually results from a disruption of normal activities. Estimates of this loss must be derived from specific independent economic data for the interests and properties affected. Prevention of income loss results in a contribution to national economic development only to the extent that such loss cannot be compensated for by postponement of an activity or transfer of the activity to other establishments.
>
> (c) Emergency Costs. Emergency costs include those expenses resulting from a flood what would not otherwise be incurred, such as the costs of evacuation and reoccupation, flood fighting, cleanup including hazardous and toxic waste cleanup, and disaster relief; increased costs of normal operations during the flood; and increased costs of police, fire, or military patrol. (USACE, 2000)

Regarding (b), income losses in California should only be counted to the extent that such loss will not be compensated by transfer of the business activity to other California establishments.

4.6.2.2 Alternative Cost Methods

The alternative cost of projects is a well-established approach for flood damage reduction. In particular, levee improvement or changes to floodplain development might provide the same level of protection as is provided by a water storage project. This alternative cost can be compared to potential damages avoided to see if it is an appropriate benefits measure.

4.6.2.3 Market Prices

Flood control is not sold in competitive markets. However, sales of flood insurance can provide useful information about WTP to be compensated for potential flood damage. Market prices also provide important information about the reduction in value of goods and services damaged by flooding.

4.6.2.4 Hedonic Pricing and Land Value Methods

Real estate prices can provide information about the value of flood protection. Properties that are prone to flood damage should have lower prices than those that are not, all else being equal.

4.6.2.5 Other Revealed Preference

Revealed preference methods have limited application for flood damage reduction benefits.

4.6.2.6 Survey-based Methods

Survey-based methods are generally not applied to flood damage reduction. People could be asked about their WTP for improved flood protection, but their benefits should be based on avoided damages, which can be calculated more directly by the available flood damage reduction models.

4.6.2.7 Benefit Transfer

Benefit transfer methods are not generally applied to flood damage reduction because damage estimates are not generally transferrable across locations. In some cases, damage information from similar situations is transferrable.

4.6.3 Flood Damage Economics Models

A number of different models are available to assist with flood damage benefits estimation; some examples are discussed below.

4.6.3.1 HEC-FDA

The most widely used model is probably the USACE's HEC-FDA (USACE, 2011). The HEC-FDA software provides the capability to perform an integrated hydrologic engineering and economic analysis. It can estimate direct flood damage losses by category (e.g., single-family residential, multi-family residential, commercial, and industrial).

According to DWR (2010), advantages of using HEC-FDA include the following:

- USACE uses the software.
- Uncertainty is directly incorporated into the analysis utilizing Monte Carlo simulation, which explicitly accounts for uncertainty in key functions.
- Levee failure assumptions (for water surface elevations below top-of-levee) can be entered into the analysis.
- Although designed for urban flood damage analyses, it can be applied to agricultural analyses.

- The model develops the stage-damage functions using structural inventories that are directly input into the software; or stage-damage functions can be developed outside of the software and then directly input into it.
- Project performance statistics (annual exceedence probability, long-term risk, and conditional non-exceedence) are outputs that can be used for determining "levels of protection."

Disadvantages of using HEC-FDA include the following:

- Training is typically required.
- HEC-FDA is data intensive, requiring hydrologic, hydraulics, geotechnical (if levees are present), and economics data.
- HEC-FDA is not GIS-based.

4.6.3.2 HAZUS-MH

The Federal Emergency Management Agency (FEMA) developed a model called HAZUS-MH (Multi Hazard), or HAZUS for short. This software

> is a nationally applicable standardized methodology that contains models for estimating potential losses from earthquakes, floods, and hurricanes. HAZUS uses Geographic Information System (GIS) technology to estimate physical, economic, and social impacts of disasters. It graphically illustrates the limits of identified high-risk locations due to earthquake, hurricane, and floods. Users can then visualize the spatial relationships between populations and other more permanently fixed geographic assets or resources for the specific hazard being modeled, a crucial function in the pre-disaster planning process.
>
> HAZUS is used for mitigation and recovery as well as preparedness and response. Government planners, GIS specialists, and emergency managers use HAZUS to determine losses and the most beneficial mitigation approaches to take to minimize them. HAZUS can be used in the assessment step in the mitigation planning process, which is the foundation for a community's long-term strategy to reduce disaster losses and break the cycle of disaster damage, reconstruction, and repeated damage. Being ready will aid in recovery after a natural disaster.

HAZUS contains a flood loss estimation model that includes flood hazard analysis and flood loss estimation modules for riverine and coastal analyses. The flood hazard analysis module uses characteristics such as frequency, discharge, and ground elevation to estimate flood depth, flood elevation, and flow velocity. The loss estimation module estimates direct and indirect economic losses using the results of the flood hazard analysis and structural inventories. HAZUS-MH analyses can be conducted at different levels of rigor. (FEMA, 2011).

According to DWR (2010), advantages of using HAZUS include the following:

- It is GIS-based.
- It can be adapted to different analysis levels depending upon user-input data; default values are available for "reconnaissance" studies.

- The availability of default values allows for analyses that otherwise could not be conducted because of the lack of local data.

Disadvantages of using HAZUS include the following:

- Users are required to have ArcGIS software and expertise.
- It does not directly incorporate uncertainty (as opposed to risk), although this can be addressed by sensitivity analyses.

4.6.3.3 FEMA Mitigation BCA Toolkit

FEMA developed the "Mitigation BCA Toolkit" for specific use by local and state agencies applying for funding in several mitigation grant programs. The software is menu-driven and is therefore relatively easy to use. Default data is provided for many variables (e.g., the contents percentage of structures), although local data can be input into the model. The software then computes net benefits and the B/C ratio. The software comes with extensive online resources, including training.

Disadvantages include the following:

- It does not directly incorporate uncertainty (as opposed to risk).
- The discount factor is fixed at 7 percent, which FEMA uses, and cannot be changed.

4.6.3.4 F-RAM

Consultants to DWR have developed a spreadsheet model F-RAM to estimate flood damage. This model develops loss-probability curves for with- and without-project conditions based upon hydrologic and hydraulics data, probability of levee failure data, structural and crop inventories, and depth-damage curves. Damage categories include crops, roads, and residential, commercial, and industrial properties; however, other categories can be added. The model is flexible in that many of the analysis assumptions and parameters can be changed (e.g., structural foundation heights, unit replacement values, and depreciation factors; depth-damage curves; discount rates; analysis period; and other indirect damage "adjustment factors").

Advantages of using F-RAM include the following:

- It can provide relatively quick estimates of EADs depending upon the availability of input data.
- It can be adapted to different analysis levels depending upon the quality of the input data.
- It incorporates probability of levee failure.
- Users can easily see data inputs and calculations (i.e., it is transparent).

Disadvantages of using F-RAM include the following:

- It does not directly incorporate uncertainty in inputs or other parameter values.
- The model has not been widely reviewed or approved by federal agencies.

4.6.4 California Applications

4.6.4.1 HEC-FIA and HEC-FDA

HEC has developed Flood Impact Analysis (HEC-FIA) to estimate direct urban and agricultural damage and loss of life that would occur if existing USACE projects had not been built. HEC-FIA estimates are provided to Congress to help document the achievements of existing USACE projects. Expected Annual Damage (EAD) estimates will not be developed by HEC-FIA, but event damage estimates from HEC-FIA can be input into HEC-FDA and other models to obtain EAD estimates.

In California, the USACE has developed HEC-FIA data for areas protected by federal levees in the Delta (USACE, 1999) for the 1995 and 1997 flood events. The USACE found that "HEC-FIA did approximate the damage values and location of damage for the Sacramento and San Joaquin River Systems."

The USACE HEC-FDA model was recently applied for a project near Hamilton City, California (USACE, 2004). An existing private levee, although not constructed to any formal engineering standards, provided flood protection to the town and surrounding area. Since Shasta Dam was constructed in 1945, floodfighting was necessary in 5 years to prevent flooding, and flood damage occurred in 1 year. Glenn County had built a backup levee about 1,000 feet in length to protect the community in the event that toe erosion caused failure at the northern end of the private levee.

A HEC-FDA application was completed in 2001 and again in 2003. The more detailed 2003 application included site-specific hydrology and hydraulics and disaggregated impact areas and analysis zones. The economic analysis included a structure inventory, structure valuation using the Marshall and Swift valuation service with assumed contents of 50 percent, generic depth-damage relationships using Economics Guidance Memorandum 01-03, an automobile depth-damage curve, crop damages, and levee failure assumptions. Uncertainty was included by use of Monte Carlo simulation. Benefits for seven levee setback alternatives were estimated, and B/C measures were provided.

The state has accepted applications for public grants for flood damage reduction and stormwater projects under the Integrated Regional Water Management and Proposition 1E Stormwater Flood Management grants programs. The state's recent guidelines for preparing grant applications (DWR, 2010) recommended that applicants use F-RAM or similar models like HEC-FDA to estimate benefits, and many of these applications have done so. This report cannot endorse any specific grant application use of these models, but some grant applications may provide useful examples and helpful information.

4.7 Emergency Response

4.7.1 Background

The main intent of emergency response in SBX7-2 is to provide public funding for water storage that can be used to repel seawater from the Delta following a Delta levee failure event. Water storage might have other emergency response benefits such as providing water for firefighting following an earthquake. Emergency response costs that are part of flood control benefits are discussed in the flood control section.

For the federal P&G, emergency response is not a benefit category; rather, it is a category of benefit under flood control. The P&G states "Emergency costs include those expenses resulting from a flood that would not otherwise be incurred, such as the costs of evacuation and reoccupation, flood fighting, and disaster relief; increased costs of normal operations during the flood; and increased costs of police, fire, or military patrol. Emergency costs should be determined by specific survey or research." (U.S. Water Resources Council, 1983)

4.7.2 Monetary Quantification Methods

4.7.2.1 Avoided Cost or Avoided Damage Methods

This approach is applicable for emergency response. Without the project, costs will be incurred for water supply and quality and for emergency response, including use of storage for salinity repulsion. With project, some of these costs might be avoided.

The Delta Risk Management Strategy (DRMS) and subsequent work on Delta levee risk economics provides information that can be used for emergency response economics. The economic costs of urban shortage are estimated using data provided in the DRMS economics technical appendix, Appendix E, Tables E-26 and E-27 (URS/JBA, 2008). These data show the economic costs of 5 percent increments of shortage for the Bay Area and the south coast for 2005 and 2030.

An economic model of seismic events and delta levee failures is being developed to consider the economics of Delta waterside transfer facilities for levee repair materials. The model has the capacity to develop expected benefits based on a large number of discrete Delta levee failure events and their probabilities. This model, with additional information from Delta water quality and supply models, could be used to develop economic benefit estimates of use of water for salinity repulsion. The current version of the model includes costs of urban water supplies and urban salinity, based on LCPSIM and LCRBWQM, costs of agricultural shortage based on the EWA water valuation study, and levee repair costs. The model could include lost land use costs based on a spreadsheet that summarizes data from the DRMS economics technical appendix (URS/JBA, 2008).

4.7.2.2 Alternative Cost Methods

Alternative cost methods have applicability for salinity repulsion because alternative projects could provide the same benefit as the project. In particular, the project salinity repulsion benefits might be provided by other storage projects, flow barriers, improved levees, Delta waterside transfer facilities, or alternative water conveyance. The costs of any of these approaches might be less than the water supply and quality damages to users who export water.

Without a new storage project, it is likely that some existing water storage facility would be used for salinity repulsion instead. Models are available that can show how a release of a large volume of stored water will increase water supply costs or water shortage costs in subsequent years. With information about the frequency of Delta levee failure events, an expected value of annual cost could be estimated. This is the cost that would be avoided by using the new storage facility instead of the existing facility.

4.7.2.3 Market Prices

Market price is not generally applicable because the relevant emergency response services, and salinity repulsion generally, are not sold in competitive markets. Some emergency costs such as ambulance services might be priced using market data.

4.7.2.4 Hedonic Pricing and Land Value Methods

Hedonic pricing and land value methods are not generally applicable because the share of land value that might be attributed to improved protection from Delta event water supply disruptions is probably not determinate.

4.7.2.5 Other Revealed Preference

Some living decisions could be based on the availability of emergency services, but revealed preference methods could not be applied to emergency response.

4.7.2.6 Survey-based Methods

Survey-based methods could be applied to emergency scenarios, but people would likely have a hard time understanding the potential costs of unprecedented events.

4.7.2.7 Benefit Transfer

Benefit transfer methods could probably not be applied to emergency response because no existing studies are known. Possibly, water valuation studies from other sources could be used to value water provided for emergency response. However, important physical parameters (including project operations to provide the water, and the probability of events) would have to be added.

4.7.3 California Applications

There are no known applications of methods for estimating emergency response benefits of stored water as defined for this document. HAZUS-MH has been suggested as a model that may have broad applicability for general emergency response benefits in California.

4.8 Recreation

Recreation benefits are use values, including consumptive use values such as fishing and non-consumptive use values such as aesthetics and viewing. For federal water resource projects, recreation benefits are those associated with water provided by the project such as flatwater recreation on storage reservoirs and any additional riverine recreation downstream. Recreation benefits are also obtained from ecosystem services. Those benefits are detailed in this section, even though they are recommended for classification under the Act as ecosystem benefits. Reclamation has published a number of documents that could help practitioners develop and use recreation studies (Platt, 2000, 2001, and 2008; Haas et al, 2007).

This section covers economic methods and models that provide a monetary value for recreational use. Methods to estimate the amount of use are covered under in Appendix A, Physical Models.

4.8.1 Background

For federal projects, recreation benefits usually have a limited economic role. Recreation benefits are usually incidental to the project, as explained in the following passage:

> Recreation is a low priority output and thus the Corps will not plan for (formulate for) single purpose recreation unless a sponsor is willing to pay one hundred percent of the associated implementation costs. Recreation development at an ecosystem restoration project shall be totally ancillary to the primary purpose, appropriate in scope and scale, and shall not diminish the ecosystem restoration outputs used to justify the project. Storage reallocations for recreation which significantly affect other authorized purposes, or involve major structural or operational changes, require Congressional approval.
>
> Benefits arising from recreation opportunities created by a project are measured in terms of willingness to pay. Benefits for projects (or project features) that increase supply are measured as the willingness to pay for each increment of supply. Benefits for projects (or project features) that alter willingness to pay (e.g., through quality changes) are measured as the difference between the without and with project willingness to pay. Willingness to pay includes entry and use fees actually paid for site use plus any unpaid value (surplus) enjoyed by consumers.
>
> Many proposed projects subject to NED benefit-cost analysis involve both recreation gains and recreation losses. Section 928 of the Water Resources Development Act of 1986 requires, for projects having recreation benefits, analysis of the effects of the proposed project on existing recreation resources. For example, stream and land-based recreation may be lost because of the project, or recreation may be transferred to the proposed site from a more distant site (USACE, 2000)

4.8.2 Monetary Quantification Methods

4.8.2.1 Avoided Cost or Avoided Damage Methods

These methods generally do not apply to recreation. However, it is important that a project may reduce visitation and crowding at other projects, so the project benefit should include these effects.

4.8.2.2 Alternative Cost Methods

Alternative cost methods might be applied to recreation if the same or similar recreation can be provided by some alternative means. For example, recreation facilities could be expanded at a similar reservoir where capacity is available. The Act suggests that such comparisons should be provided where feasible.

4.8.2.3 Market Prices

Market price methods have some applicability to recreation because some recreation services are provided privately and prices are often charged for admission. Outdoor recreation services are provided by marinas, guides, charters, or concessionaires. Prices charged by operators are useful information where competition exists. Differences in prices charged among operators, and changes in prices over time, may enable estimation of demand functions. Also, concessionaires normally pay the reservoir landowner for their use of facilities. This can be useful information for benefits analysis.

For many use values, only part of the value might be determined from the price of access. Many outdoor recreation services such as marina admission and guide services are sold in competitive markets, but some share of boating and fishing occurs without use of these services. Much outdoor recreation does not require any admission fee, so market prices cannot be used. Also, most outdoor recreation is unique in that no two locations are exactly the same.

4.8.2.4 Hedonic Pricing and Land Value Methods

Hedonic pricing has many applications for recreation because property values can be increased by nearby recreational amenities (Crompton, 2004). However, the total recreation benefit should include the additional benefits of any users who do not live nearby. Also, it may be difficult to determine what share of property values should be attributed to the recreational amenities and what share should be given to other attributes such as aesthetics and open space.

4.8.2.5 Other Revealed Preference

Travel cost models are statistical studies that estimate visitation as a function of price where distance travelled is an important part of the price paid. The resulting regression is a demand function that can be used to estimate both quantity of use and benefits. Further explanation is given below:

> The travel cost method models recreation visitation as a function of travel costs and other explanatory variables. The basic premise with the approach is that travel costs act as price for accessing the site. As travel costs increase the farther away one lives from the site, visitation decreases, all else being equal. This price and quantity information allows for construction of a site demand curve. The area under the site demand curve and above cost represents net willingness-to-pay (i.e., consumer surplus), the typical measure used to represent recreation benefits. As a result, these approaches provide estimates of both visitation and value. (Reclamation, 1999)

4.8.2.6 Survey-Based Methods

> Survey-based methods estimate recreation benefit based on stated willingness-to-pay.Contingent behavior and valuation studies use general population or recreationist surveys to estimate changes in recreationist visitation and consumer surplus at a site. The survey results can be averaged and aggregated or used to construct visitation and willingness-to-pay models. (CALFED, 2006)

4.8.2.7 Benefit Transfer

Benefit transfer is a common method for recreation. Typically, economic values from a similar site are adopted with adjustments for size, amenities, and distance from population centers. The BUVD, maintained at the University of California Davis, provides many studies that might be used for benefit transfer. More discussion is provided under the benefit transfer section of water quality (Section 4.5.2.7). The Benefit Transfer and Use Estimating Model Toolkit, discussed in the benefit transfer section of ecosystem improvement (Section 4.4.2.7), is another resource for recreation.

The Sportfishing Values Database provides information about numerous recent nonmarket valuation studies, including information from more than 100 travel cost and CV studies. The database describes the resource and the change that provide the basis for the reported value, including species and resource quality characteristics. In addition, the database describes study characteristics (including respondent sample information), the valuation methodology, and other study-specific conditions (Industrial Economics, 2011).

4.8.3 Recreation Economics Models

4.8.3.1 Unit Day Values

The unit day value (UDV) method uses information about a site's characteristics with a point ranking system to value recreation visits. The amount of visitation must be estimated separately. Discussion of visitation methods is provided in Appendix A.

> ER 1105 explains the unit day value method.The unit day value method relies on expert or informed opinion and judgment to estimate the average willingness to pay of recreational users. By applying a carefully thought-out and adjusted unit day value to estimated use, an approximation is obtained that may be used as an estimate of project recreation benefits.
>
> The UDV approach in recreation benefit analysis consists of two parts: estimating visitation and determining value per visit. Both must be documented in planning reports. (USACE, 2000)

The preferred site-specific method of estimating amount of use is a use-estimating model (UEM) that relates use per 1,000 of origin population to distance traveled, socioeconomic factors, and characteristics of the site and alternative recreation opportunities. The USACE (2010) provides information regarding how to apply unit values for current conditions.

If the UDV approach is used, the minimum and maximum range of UDV for FY 2011 studies is, for general recreation, $3.58 and $10.75, and for specialized recreation, $14.56 and $42.57, respectively. The unit values per day to assign based on points are shown in Table 5.

The UDV memorandum (USACE, 2010) provides guidance for planners in the selection of UDV for particular recreation activities. Tables provided in the memorandum illustrate a method of assigning a point rating to a particular activity. Point values are assigned based on measurement standards described for the five criteria of activities, facilities, relative scarcity, ease of access, and aesthetic factors. Table 1 of the memorandum provides the scoring to be used for general recreation. Recreation experience can obtain up to 30 points based on the number and quality of activities. Availability of opportunity can obtain up to 18 points, carrying capacity up to 14 points, accessibility up to 18 points, and environmental up to 20 points. Descriptions regarding scoring are provided.

The specialized recreation category, covered in Table 2 of the memorandum, includes such unique experiences as big game hunting, wilderness pack trips, white water canoeing, and other activities generally categorized by more extensive, low-density use. Table 2 scores special recreation using the same point scale, but the descriptions on scoring are different.

TABLE 5
Conversion of Points to Dollar Values, USACE Unit Day Value Methods
SBX7-2 Economic Methods

Point Values	General Recreation Values	General Fishing and Hunting Values	Specialized Fishing and Hunting Values	Specialized Recreation Values other than Fishing and Hunting
0	$3.58	$5.15	$25.09	$14.56
10	$4.26	$5.83	$25.76	$15.46
20	$4.70	$6.27	$26.21	$16.58
30	$5.38	$6.95	$26.88	$17.92
40	$6.72	$7.62	$27.56	$19.04
50	$7.62	$8.29	$30.25	$21.51
60	$8.29	$9.19	$32.93	$23.75
70	$8.74	$9.63	$34.95	$28.68
80	$9.63	$10.31	$37.64	$33.38
90	$10.31	$10.53	$40.33	$38.09
100	$10.75	$10.75	$42.57	$42.57

4.8.4 California Applications

Fall run salmon caught in the recreational fishery were valued for the NODOS PFR. Pacific Fisheries Management Council keeps records on escapement, ocean sport catch, and level of effort (PFMC, 2006b). Additional information on the amount of effort per fish caught in the inland fishery was obtained from Reclamation (1991). Value per day of ocean recreational fishing can be obtained from Reclamation (1991); information on the value of a day in the inland fishery can be from Roach and Loomis (1996); and data on effort per fish in the Upper River can be provided by DFG (2000). It can be assumed that for every three fish that escape, one is caught in-river (Grover, 2006). This information enabled a combined commercial and recreational catch value of $105 associated with each escaping adult.

Recreation benefits for Sites Reservoir were estimated for the NODOS PFR. Sites Reservoir would provide a maximum of 14,000 acres of surface water recreation for boating and fishing, and facilities would be provided to support camping, hiking, swimming, picnicking, and sightseeing. Potential recreation development for the facility includesaccess and recreation facilities at five recreation areas; recreation facilities would include boat launch sites, picnic area and tables, fully developed campsites, restrooms, trails, designated swimming areas, and parking. Approximately 300 overnight campsites would be developed. All action alternatives assumed that these recreation facilities would be provided.

The analysis of visitation at Sites Reservoir considered the characteristics of the facility for recreation, the amount of use and value at similar facilities, and the amount of surface area provided by the different alternatives. Planning estimates indicated that the reservoir would have the potential to support an average of around 410,000 recreation user days annually (Reclamation, 2006a). However, use might be limited by the availability of facilities. The amount of facility development was expected to be limited by suitable land.

Maximum use could be reduced by operations that reduce surface area during the peak recreation months. CALSIM II provided ending storage by month for each alternative. For some alternatives, surface acreage was well below 14,000 acres in the summer months of many years. In these conditions, use of facilities would be impaired, crowding would influence values, and recreation use and value would be less than the maximum. It was assumed that full economic value would be obtained in any month when end-of-month surface area is more than 10,000 acres. Assumptions of the share of maximum economic value that could be obtained under other conditions were required.

The value of a visitor-day was estimated using data on typical recreation activity patterns for the region. Reclamation (2006b) analyzed recreation activity patterns at Black Butte and East Park reservoirs. The expected distribution of visitor-days given the activity patterns at these two facilities was estimated. The value per day of the different activities was estimated by using activity-specific values from Kaval and Loomis (2003). The weighted average value per day using activity patterns from the two existing facilities was almost identical at about $47 per day.

Ward et. al (1996) collected data on visitors to USACE reservoirs by origin and destination before and during the early part of the 1985–1991 California drought. Because lake levels varied widely during the sample period, water's effect on visits was isolated from price and other effects. An estimated regional travel cost model containing water level as a visit predictor provided information to compute marginal values of water in recreation. For the range of the lake levels seen, annual recreational values per acre-foot of water varied from $6 at Pine Flat Reservoir to more than $600 at Success Lake.

Creel and Loomis (1992) estimated recreation benefits associated with water supply for California wildlife refuges. Telephone and mail survey data were obtained to determine how travel cost and other factors affected use of 14 recreation sites in the San Joaquin Valley. Total benefits for viewing, hunting, and fishing are estimated. An additional allocation of 63,000 AF to seven wildlife refuge and wildlife management areas would increase benefits by $303 per AF. An increase in water supply for just the refuges with the least reliable supplies was worth $348 per AF.

4.9 Models that May Apply to More than One Public Benefits Category

The following models provide estimates of the value of urban or agricultural water that could be used in an avoided cost or alternative cost approach for one of the public benefits categories. They might be used to value water supply enabled by ecosystem or water quality improvements, or water supply no longer required for these purposes; or the models might be used to estimate the value of water supply released from storage to repel saline water following a Delta levee break.

4.9.1 LCPSIM

LCPSIM estimates economic benefits of changes in urban water supply in California using a simulation/optimization framework. The model takes annual water supplies over a hydrologic sequence as input and estimates how local storage operations, conservation, recycling, transfers, contingency shortage, and other local management will work together to minimize total economic costs of water and shortage. The value of the availability of supply from a proposed project can be determined from the change it produces in this least-cost mix of demand and supply measures and shortages. The reduction in all costs associated with a water supply increment is the benefit of the increment.

Two applications of the model currently in use correspond to the two largest urban water use areas in the state: the south coast and the South Bay region. For each region, carefully defined development conditions describe the level of demands and facilities in place to manage supplies. Development conditions are normally named according to a recent or future year. The assumptions for each development condition are selected according to local plans for demands, facilities and operations. The assumptions include what is allowed or required for the type of study at hand (e.g., NEPA/CEQA or federal P&Gs).

4.9.2 CALVIN

CALVIN is a "generalized network flow-base economic-engineering optimization model of California's intertied water supply system" (Tanaka et al., 2011). It includes many local and regional water operations facilities along with the major SWP and CVP water operations facilities. Agricultural and urban water users are included for the Sacramento Valley, Bay Delta, San Joaquin Valley, South Bay, Tulare Basin, and Southern California. CALVIN minimizes the operating costs of the system and the economic losses from water shortages for agricultural and urban water users.

The value of the availability of supply from a proposed project can be determined from the change in the minimized operational and shortage costs. The reduction in these costs associated with a water supply increment is the benefit of the increment.

4.9.3 OMWEM

A number of relatively small M&I water providers receive SWP or CVP water but are not covered by LCPSIM. A set of spreadsheet calculations, collectively called OMWEM, can be used to estimate economic benefits of changes in SWP or CVP supplies for these potentially affected M&I water providers. The model includes CVP M&I supplies north of Delta, SWP and CVP supplies to the Central Valley and the central coast, and SWP supplies or supply exchanges to the desert regions east of LCPSIM's south coast region. The model estimates the economic value of M&I supply changes in these areas as the change in cost of shortages and alternative supplies such as groundwater pumping or transfers.

4.9.4 IRPSIM and other Agency-specific Models

Many water supply agencies maintain agency-specific models of water demands, operational costs, rules, and constraints on local delivery systems, local supplies, and regional supplies. For example, IRPSIM is a model of urban water economics maintained by Metropolitan. The model integrates projected demand and imported water supply, accounting for local supply conditions. Evaluating regional reliability and storage operations, IRPSIM indentifies resource opportunities to meet demand under various supply conditions.

4.9.5 CVPM and SWAP Models

CVPM is a regional model of agricultural water use and economics for the Central Valley of California. By estimating the value of water supply changes to agricultural users, it has been used to estimate opportunity costs of agricultural water supplies for environmental or other uses. It could also provide estimates of the value of emergency response related to water supply interruptions from the Delta.

The SWAP model shares some basic model structure and much of the data and regional configuration with the CVPM, and SWAP has the same potential uses. Both are regional models of irrigated agricultural production and economics that simulate the decisions of agricultural producers (farmers) in California. The models assume that farmers maximize profit subject to resource, technical, and market constraints. Farmers sell and buy in competitive markets. The models select those crops, water supplies, and other inputs that maximize profit subject to constraints on water and land, and subject to economic conditions regarding prices, yields, and costs. The SWAP model allows for greater flexibility in production technology and input substitution than CVPM, and it has been extended to allow for a range of analyses, including interregional water transfers and climate change effects. Its data coverage is most detailed in the Central Valley, but it also includes production regions in the central coast, south coast, and desert areas.

CVPM and SWAP incorporate project water supplies (SWP and CVP), other local water supplies, and groundwater. The models both cover 27 agricultural subregions in the Central Valley.

SECTION 5

Screening and Evaluation of Economic Quantification Methods and Models

The number of potential methods, models, data sources, and project characteristics is extremely large. It would be difficult and unwise to prescribe one method or model for SBX7-2 applicants to use in all possible situations. The approach described below sets some minimum criteria and characteristics of acceptable methods for quantifying public benefits. Some methods and models are screened out. The remaining methods are categorized as follows:

- Preferred in most cases
- Conditional as preferred method
- A second best method
- Might estimate only a part of benefit
- Not likely to be possible to apply

5.1 Physical Quantification

This report does not evaluate or screen physical models in any detail; a minimum amount of information has been provided. This should not imply that physical quantification is in any way less important that economic quantification. Physical quantification is necessary for economic quantification. An inability to estimate physical benefits, or poor documentation of those estimates, should raise questions about whether a proposed project is ready for public funding.

For many benefits, the amount of physical, end-product benefit cannot be estimated, but the amount of intermediate benefit or the amount of water supply required to achieve the benefit can be estimated.

Examples of physical end-product benefits are the following:

- Enhanced end-user water quality
- Enhanced fish and wildlife populations
- Ecosystem services from wetlands such as water treatment, primary production, and carbon sequestration
- Recreation user days
- Reduced flood damage

The amount of intermediate physical benefit should also be reported if possible. Examples of intermediate benefits are the following:

- Enhanced Delta water quality or productivity factors such as X2 position

- Instream flow and temperature for salmonids
- Riparian or wetland habitat acreage
- Reservoir recreation amenities such as surface area

The amount of water supply or reservoir space used to provide the benefit should be provided if possible. For example, a known quantity of project water supply may be planned for a water quality, ecosystem, or recreation benefit. In this case, the alternative cost approach can be applied by estimating the cost of providing the water supply from another source.

Section 4.9 described models that provide economic information for more than one public benefits category. These, or similar, models estimate the value of urban or agricultural water use and can be used to provide avoided cost or alternative cost estimates for public benefits. The following minimum standards should be met by any such models:

- Hydrologic models used for estimating physical benefits should account for the source and disposition of all water involved in the benefit (i.e., they should maintain a water balance).
- Models should consider the range of hydrologic, water supply, or other relevant conditions, either based on the probability distribution of hydrology as best measured by a representative hydrologic period, or based on outcomes and probabilities of defined year types (e.g., average, dry, critical, wet).
- Models should provide information for a specified development condition, usually defined as a current or future year, by adjusting historical hydrologic and delivery data for demands, supplies, and runoff conditions at the defined year.
- Models should utilize an annual or more frequent time step.
- Models should value water according to its marginal cost and benefits as opposed to averages or local prices.

Most water storage projects are multipurpose and provide several types of public benefits. Usually, no multipurpose alternative will provide the same package of physical benefits as another alternative will. If a similar alternative exists, this alternative should be described and its cost should be provided. If not, there may be single-purpose projects or actions that, taken together, provide the same package of physical benefits, and the sum of the single-purpose alternative costs is the appropriate alternative cost measure. This sum may include single-purpose costs that exceed their WTP benefit, so the analysis should claim only the lesser of the WTP (if it can be estimated) or the alternative cost.[2]

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[2] Suppose that the costs for two single-purpose alternatives providing 15 TDS and 40 visitor-days are $3,000 and $5,000, respectively, and the WTP benefits are $2,000 and $8,000, respectively. The alternatives could be implemented for $8,000, which is less than the WTP benefits of $10,000. Therefore, total benefits to compare to subject project costs should be $8,000 even though the water quality WTP is less than the alternative cost. The sum of single-purpose alternative costs is less than the sum of all WTP benefits, so this alternative cost becomes the benefit.

5.2 Screening Criteria

In general, economic methods for quantifying benefits should possess a minimum level of rigor and documentation so that proposed projects can be compared on a reasonably fair and consistent basis. Each economic method must demonstrate the following:

1. Estimate economic benefits as defined in the glossary, as opposed to estimating other economic measures such as regional output, income, or employment.
2. Be consistent with principles of economic benefits estimation, as described in Section 2, Principles of Economic Benefits.
3. Use verifiable information about the project's physical effects.
4. Be able to employ a geographic scale, time horizon, and time step consistent with the accurate estimation of a project's physical benefits. For example, a monthly time step may be sufficient for water supply studies but inappropriate for flood damage studies.
5. Be capable of estimating benefits from a statewide perspective, and not just from a local or national perspective.
6. Be applicable or adaptable to existing and forecasted conditions within the state and the proposed project area.
7. Be at a level of rigor and detail commensurate with the size of the benefit being claimed.
8. Not be clearly inferior to another method in terms of reliability, accuracy, and cost of use.
9. Use information whose source can be clearly described and documented. For example, personal communications must be documentable by name and in written form. Assumptions must be clearly stated and justified.

5.3 Initial Screening

Table 6 summarizes the results of the initial screening of methods and models, thereby identifying those that do not meet minimum standards and should not be used. Potentially, a method or model could fail to meet a minimum standard of acceptance based on any of the nine screening criteria. However, only the first two criteria provide clear, yes-or-no judgments that can be applied prior to submitting a specific proposal.

Only three methods are found to be generally inappropriate: (1) regional impact models based on I-O relationships among sectors, (2) economic growth models that forecast employment, income, and sales, and (3) financial models that rely on a particular agency's rate and cost structure. Even though the methods are screened out, they often contain information that could be used carefully and appropriately in another method such as alternative costs. For example, I-O models can provide information about income, but any inference about economic benefit requires information about employment mobility and other factors. Results from financial models for a water supply agency must be adjusted to convert local benefits (to the agency and its constituents) to statewide benefits.

Within the methods category of hedonic pricing and land value method, hedonic pricing is generally preferred because of its statistical properties and because it can isolate the land price effect of multiple attributes.

TABLE 6
Initial Screening Results
SBX7-2 Economic Methods

Methods and Models That Do Not Meet Initial Screening Criteria	
Regional I-O Models (e.g., IMPLAN and REMI)	These models estimate flows of money within and between sectors and regions. They do not estimate economic benefits as defined in this report, although there may be information within the models that can be used for a benefits analysis.
Growth Models	These models forecast future employment and income, which are not generally considered economic benefits.
Financial Models	These models estimate the change in specific revenues and/or costs to an accounting entity such as a water district or county. Revenue calculations use existing rules for rates and assessments, which typically do not represent the marginal opportunity cost of services provided. These models, however, may include information that can help estimate economic benefits, such as avoided costs.

5.4 Use of Criteria for Detailed Screening and Evaluation

The criteria require that any application of a method or model must be appropriate for the situation. Given this generality, it is difficult to categorically exclude most of the methods for all possible situations.

Table 7 provides results of the detailed screening of methods and models that may be appropriate for one or more benefit category. "PM" for "preferred method" denotes a method that is generally preferred for that benefit category. It is unlikely that some methods could be applied to estimate benefits in a category. These combinations are assigned "NL" for "not likely." For others, the method is rated second best to one of the other methods; these are assigned "SB" for "second best." For other combinations, the method can only estimate some subtypes or share of benefits under each category; these are assigned "PB" for "partial benefit." Other methods are appropriate only given specific conditions; these are assigned "CO" for "conditional," and the conditions under which they might be used are described.

Table 8 provides similar results applied to the economic models. Models that may be appropriate for each benefit category are provided the same PM, NL, SB, PB, and CO ratings.

Methods may pass the detailed screening as acceptable but may be applied to a project, region, or situation inappropriately. Therefore, the detailed screening results cannot be viewed to imply an automatic acceptance of benefit estimates prepared using one of the methods. The project applicant must still demonstrate that the particular application, data, and assumptions are justified. An applicant may even develop a method or conduct a study specific to its proposed project or region. The screening criteria listed above provide the standards that must be met by any method used to evaluate a proposed project.

TABLE 7
Detailed Screening and Evaluation of Economic Quantification Methods*
SBX7-2 Economic Methods

General Methods	Ecosystem Benefits (not including recreation or water quality)	Water Quality Benefits	Flood Control Benefits	Emergency Response Benefits	Recreation Benefits	Notes and Limitations
Market Pricing	PB, for the share of products sold in markets such as commercial fish	NL, Delta and in-stream water quality not sold in markets. Market prices are used as part of other methods.	NL, but flood insurance premiums and replacement costs can provide partial information.	NL, water costs of Delta events are not insured. Private costs of emergency response services may be relevant	PB, admission, guide and charter prices don't usually capture most participants	Usually only some of the benefits in each category, or some aspects of those benefits, can be valued using market prices. Other methods usually make some use of market prices.
Hedonic Price or Land Price	PB, land values reflect share of benefit enjoyed by landowners	PB, land values reflect share of benefit enjoyed by landowner.	SB, value of flood-prone lands should reflect expected flood costs.	NL, land values may reflect availability of emergency services, but hard to parse out	PB, land values reflect only the share of benefit enjoyed by landowner	Applies only to share of benefits that is reflected in property values. A similar sample with similar differences is required. Won't work unless benefits significantly affect land prices.
Revealed Preference	NL, PB, for most people, non-use benefits are not acted on	PB, avoided cost of bottled water, filters, water softeners, etc.; however, not all benefit revealed.	NL, but decisions about living in flood-prone areas are relevant.	NL, but decisions about living where emergency services are better are relevant	PM, Travel cost method with use-estimating model a preferred approach	
Survey-based Methods	SB, this method, or benefit transfer based on this method, can provide non-use values, but these may not be accepted by federal partners	SB, hypothetical range should be similar to project improvement .	NL, WTP could be elicited, but damage reduction models are more direct.	SB, people may have difficulty understanding impacts	Surveys for unit value are SB, surveys to obtain use information may be PM for travel cost method or use model	Where used, surveys should be tailored to the actual physical benefits expected.

Detailed Screening and Evaluation of Economic Quantification Methods*
SBX7-2 Economic Methods

General Methods	Ecosystem Benefits (not including recreation or water quality)	Water Quality Benefits	Flood Control Benefits	Emergency Response Benefits	Recreation Benefits	Notes and Limitations
Avoided Cost/ Avoided Damage	CO, when costs or damages would occur in the without-project condition and the project would allow those to be avoided		PM, generally using models in Table 8.	PM, count avoided damages and costs	NL, projects don't usually avoid other recreation costs.	Apply when the costs or damages in the without-project condition are likely, but with-project are not.
Alternative Cost	PM, for valuing wetland or riparian acreage CO, for ecosystem or water quality benefit provided by water supply, as long as alternative cost is likely to be less than WTP		CO, when there is at least one viable alternative to provide the project's public benefits and the cost of this alternative is likely to be less than the WTP benefit.			Can apply when the alternative is not part of without-project condition, but it is a viable way to provide same benefit. Must use the lowest-cost alternative.
Benefit Transfer	SB, but only for same ecosystem benefits types in similar conditions	SB, but only for same constituents in similar conditions.	NL, chance of finding a very similar project in a very similar basin is slim.	NL, few studies value extended water shortage or emergency response.	PM, commonly used for similar facilities.	Must be carefully applied or adjusted to account for differences in site and economic conditions, and project specifics.
Statistical, Simulation and Optimization Models	CO, models typically include a mix of physical models and economic methods, so all qualifications above are relevant. Suitability based entirely on project-specific circumstances.					

***Applicability of Methods by Benefit Categories:** Within category applications, PB = might estimate only a part of benefit, PM = preferred in most cases, SB = a second best method, NL = not likely that the method could be applied, or CO = conditional as preferred method, for reasons summarized. Ecosystem and water quality do not have a generally preferred method because conditions are too variable, and different methods are best for different benefit subtypes.

TABLE 8
Results of Screening and Evaluation of Economic and Related Quantification Models, Model Screening by Benefit Category
SBX7-2 Economic Methods

Existing Models	Ecosystem Improvement	Water Quality Benefits	Flood Control Benefits	Emergency Response Benefits	Recreation Benefits	Comments
USACE Cost-Effectiveness Analysis	SB					Not a method for estimating WTP; useful for alternative cost analysis.
SWAP, LCPSIM, IRPSIM, CALVIN	CO	CO		CO		Use urban and agricultural water supply models when avoided or alternative cost principles apply and the amount of water required for ecosystem or WQ is known.
LCRBWQM		PB				Limited; only south coast salinity damages are included.
Bay Area Water Quality Model		PB				Limited; only South Bay area salinity damages are included.
HEC-FDA			CO	CO, PB for some events		Preferred for large projects.
HAZUS-MH			CO	CO, PB for some events		Not Level 1. Level 2 preferred for large projects.
FEMA BCA			Screened out			7 percent discount rate is hardwired, not appropriate for CA water project studies.
DWR F-RAM			CO			Preferred for small projects.
Unit-Day Value Models					SB	Without an integrated use-value model, a second-best method.

Notes:

CO = conditional as preferred method, for reasons summarized
NL = not likely method could be applied
PB = might estimate only a part of benefit
PM = preferred in most cases
SB = a second best method

5.4.1 Avoided Cost

The avoided cost method cannot be screened out for any benefit category because avoided cost-type benefits are not a method per se. Rather, they are a result of the with- or without-project planning principle. The without-project condition must be the most likely future in the absence of the project. Proposals should avoid specifying a without-project condition in order to obtain greater avoided-cost benefits.

5.4.2 Alternative Cost

The alternative cost method cannot be screened out for any benefit category because SBX7-2 appears to require that a project be cost-effective. Alternative cost should be used as a measure of benefit if (1) a viable alternative to the project can provide about the same level of physical benefits, and (2) the alternative cost is less than the WTP for the physical benefits.

Any attempt to address conditions (1) and (2) should include a comparison of physical benefits with- and without-project wherever possible.

Regarding condition (1), any exercise to fulfill the cost-effectiveness mandate of SBX7-2 and the subsequent use of this information for alternative cost analysis should require a consideration of the alternative's feasibility. The alternative's feasibility should be considered under the same criteria as the project (i.e., the same baseline assumptions and general cost estimation procedures). However, the level of effort required for the alternative feasibility investigation can be less than that required for the project itself.

If, at the project planning level, an alternative appears to be economically and otherwise superior to the proposed project, then the alternative should be evaluated at the same level of rigor, effort, and detail as the original proposed project. If the alternative then appears to be less feasible or economical than the original project, then the original proposed project again receives sole consideration.

Regarding condition (2), in most situations it may be difficult to prove that the alternative cost is less than the WTP. Information from revealed preference, survey methods, or benefit transfer may be required. Where quantitative WTP estimates are not possible, the significance of outputs should be documented in terms of their institutional, public, and/or technical importance. This documentation should include a comparison of physical benefits with- and without-project wherever possible. At a minimum, the following types of information should be provided to support qualitative WTP:

- The number of persons affected and the way they are affected.
- Evidence that the project benefit will result in at least a noticeable change in these effects.
- Evidence that the affected people or their representatives have an interest in the effects (i.e., time, money, or other resources have been expended because of the effects).

The methods to estimate WTP for each benefit category are discussed below.

5.4.3 Ecosystem Improvement

Where water quality and recreation improvement as a result of ecosystem improvement can be quantified, screening of those benefit categories applies.

When other ecosystem products can be quantified, market price techniques can be used for ecosystem products sold in competitive markets. This should include non-listed, commercially valuable species such as fall run Chinook salmon. Many ecosystem products provide most of their benefits to adjacent land. In this case, hedonic pricing methods are preferred; the land value method might be used, but it is less reliable.

Non-use values are difficult to measure. Revealed preference methods may be useful because people contribute to organizations for ecosystem purposes. However, it may be impossible to determine how much contribution to assign to different ecosystem products. Also, many people do not contribute even though surveys show non-use values.

Survey methods are the only approach that can elicit all non-use value, but results and non-use values may not be accepted by some participants and other economists. For non-use values, USACE guidance does not allow use of CV methods, as shown in the following excerpt:

> Contingent value techniques shall not be used to estimate existence, "option," bequest or other such non-use values, due to several factors including the conjectural nature of estimated values and the high difficulty in controlling bias. (USACE, 2000)

As a result, non-use benefits estimated with CV might not qualify for federal cost sharing.

Original CV studies should include verification checks, including an independent evaluation, that demonstrate that (1) respondents understood and responded to the survey questions in terms of the amount, quality, and timing of public goods proposed, and (2) the study used an unbiased presentation of the survey technique.

The Technical Workgroup (2010) notes that the Office of Management and Budget's approval of federally sponsored surveys may be required. This could result in important delays for benefits estimation where there is a federal partner.

Benefit transfer studies might be used to interpolate reasonable non-use benefits. In general, original CV studies that evaluate benefits specifically for the proposed project or its affected resource and location should receive much more weight than benefit transfer studies.

For survey methods or benefit transfer methods, only the non-use values of Californians should be counted if possible, and the values should be reported separately from other ecosystem improvement benefits.

The cost of ecosystem improvement water supply can be used as a measure of benefit as long as the conditions for use of alternative cost—that it is a viable alternative and is likely to cost less than the WTP benefit—are met. Habitat valuation based on the alternative cost of resources used to create the habitat appears to provide an appropriate estimate of benefits in many situations. For example, alternative cost can apply where water is being used for habitat, or where wetland or riparian habitat is being created. An important use of ecosystem water would be for instream flows or Delta outflow. Usually, existing alternative sources of water supply could be used for those purposes. In particular, water transfers have been and could be used instead of the project, and there may be information available and specific to local regions. Where water transfer price information is unavailable or sparse, usable information can include the price or rental rate for irrigated land and dryland. Statistical methods (hedonic pricing) are preferred as a way to isolate the influence of water supply on land rent or price.

Where projects will create wetlands or riparian habitat, the cost of restoring, creating, or protecting these habitats by alternative means can be a reliable estimate of benefit. Cost of restoration can be used when the land to be restored has little ecosystem value in its without-project condition. Data from wetlands mitigation banks, or sales prices of riparian lands or wetlands, can provide a reliable estimate of alternative costs. The argument for use of sales price is improved if the alternative wetland or riparian land will be lost in the without-project condition. Where recent sales data are not available or existing lands are not slated for development, the costs of creating wetlands or riparian lands can be used. Costs may include land acquisition, land shaping, costs of soils and water, and ongoing management costs.

The USACE CE/ICA analysis does not estimate economic benefits. Therefore, without additional information, it cannot be used to estimate ecosystem benefits. However, it may be used to help estimate alternative costs to demonstrate cost-effectiveness of the proposed project, as required by SBX7-2. Even though CE/ICA can be used to identify the cost-effective alternative, that alternative's costs may still exceed benefits estimated using one of the other methods. Therefore, a lowest alternative cost derived by CE/ICA cannot be used as the benefit without some additional analysis to demonstrate that the WTP benefit is likely to be at least as large.

5.4.4 Water Quality

Where physical benefits in terms of water quality improvement can be estimated, revealed preference, hedonic pricing, survey-based methods, or benefit transfer methods may be appropriate. For residential water quality, the costs of behaviors to avoid poor water quality may be useful (e.g., purchases of bottled water, water filters, and water softeners). However, for the south coast and South Bay areas, available models are preferred. Hedonic pricing is appropriate where most of the benefit is reflected in adjacent property values.

We recommend that any use of CV studies include independent evaluation to confirm that the survey was unbiased and that respondents understood the stated questions or options. Benefit transfer is a second-best, but often cost-effective, method.

Alternative cost for water quality purposes may include costs of water treatment, modified practices, or alternative supplies. Alternatives should provide about the same amount of physical benefit as the proposed project for all economically important water quality constituents. For projects where the water quality benefit is created by water supply, the alternative cost of providing that water supply is an acceptable measure of benefit as long as this cost is likely to be less than the WTP benefit.

5.4.5 Flood Control

The FEMA Mitigation BCA Toolkit uses a required discount rate of 7 percent. This apparently cannot be changed and is inconsistent with both the state's rate of 6 percent and Reclamation's required rate. Therefore, the FEMA BCA Toolkit is screened out.

A recent study compared HAZUS-MH to HEC-FDA (Ding et al, 2008). The analysis found that a Level 1 HAZUS-MH analysis was questionable. Therefore, the HAZUS Level 1 model is screened out because it is believed to be potentially inaccurate. This leaves HAZUS-MH Level 2, HEC-FDA, and F-RAM as potential flood damage reduction economic models.

The choice of a flood damage reduction model is not a trivial matter. The amount of effort required could differ significantly among methods, and results could be questioned.

Ding et al (2008) found that the HAZUS Level 2 analysis results were comparable to results from HEC-FDA, and cost was appreciably less. HAZUS-MH has a substantial default database available for use. However, the cost of GIS software might be prohibitive for some project sponsors, and the memory requirements when running the model with GIS software can be too large for many computers.

In general, for large projects, either HAZUS-MH Level 2 or HEC-FDA can be used. For smaller projects, F-RAM or other methods that calculate an expected value are acceptable.

HAZUS-MH Level 2 is recommended under the following conditions:

- When available computers have GIS capability and adequate memory
- Where coastal (including Delta) flooding is included

HEC-FDA is recommended under the following conditions:

- When USACE cooperation is desired or required
- When available computers do not have GIS capability
- When there is uncertainty about key probability parameters

For uncomplicated and small-scale problems, DWR's F-RAM or similar spreadsheet methods can suffice. Any flood damage reduction calculation should at least have the following capabilities:

1. Utilize an exceedance probability function for flood area and depth based on historic hydrology. The most frequent event in the function should be one where no damages occur either with- or without-project. The least frequent event should be one where the project makes no difference to expected damages.

2. Derive interval probabilities (i.e., the probabilities of events within ranges of the exceedance probability function).

3. Include a damage function as a function of depth and area flooded with damages based on replacement costs of structures and contents. The depths and damages should be sized to be the average value for each probability interval.[3]
4. Include costs of damages to roads, vehicles, equipment and infrastructure, and emergency response. Potential loss of life should be reported. Damages to vehicles and equipment and loss of life should consider potential notification time.
5. Base damages for agricultural flood damage reduction on historic cropping patterns and lost net revenue as of the expected time of floods, clean-up and re-grading costs, and damages to perennials, structures, and improvements.
6. Do not count lost revenues, income, output, and employment as benefits at the state level. Lost net revenues outside of agriculture can be counted if it can be demonstrated that these net revenues will not be captured by other California businesses.

5.4.6 Emergency Response

The major purpose of this benefit category is the provision of water supply for repulsion of seawater from the Delta, thereby restoring export water service. Benefits estimation requires use of hydrologic models like WAM and CALSIM II as well as information about the benefits of avoiding export water supply reductions. This benefit information can be obtained from the DRMS economic appendix, LCPSIM, OMWEM and CVPM, or SWAP. Economic information regarding expected costs under a probability distribution of levee-breaching events is being developed by DWR and should be available soon. Until then, information from hydrologic and economic models regarding the alternative value of urban and agricultural water supply required for salinity repulsion is preferred.

5.4.7 Recreation

USACE's ER 1105-2-100 (USACE, 2000) allows three methods for estimating benefits of recreation: the travel cost method, CVM, and UDV method.

For surface water recreation, development of empirical methods for recreation site choice and value in California are desirable. The travel cost method has the advantage of being based on actual behavior. There is potential to develop information about how new recreation sites affect use and value (related to crowding) at existing sites; this information is not provided by the UDV method.

Absent such information, benefit transfer studies may provide the next-best information. Hedonic pricing is appropriate where most of the benefit is captured by waterfront properties. The UDV method with value information from USACE can be used to estimate recreation value. Care should be taken to adjust for recreation days that are transfers from other locations.

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[3] Sometimes, information about the depth-damage function is provided and the analysis must work backwards. For example, suppose depth and subsequent damage is provided for the 1 in 100 year event. This is the average damage experienced for events in the probability interval of 1 in 90 to 1 in 110 years with a probability of about 0.2 percent (0.01111 - 0.00909), or less accurately, for events in the interval of 1 in 80 to 1 in 120 years with a probability of about 0.42 percent (0.0125 - 0.00833).

For projects where the recreation benefit is created by water supply, the alternative cost of providing that water supply is a preferred measure of benefit as long as this cost is likely to be less than the WTP benefit.

SECTION 6

Additional Information Regarding Shares of Public Benefits

This section describes information that may help the Commission in judging what share of public benefits should be considered for state funding.

6.1 Private Benefits

ER-1105 (USACE, 2000) provides guidance where ecosystem benefits accrue to private owners

> for projects where the land on which the majority of the physical ecosystem restoration will occur is in the ownership of a single firm, individual, club, or association with restrictive membership requirements, it must be demonstrated clearly that the restoration benefits are in the overall public interests and that the benefits do not accrue primarily to the property owner. (USACE, 2000)

Federal standards do not allow for cost sharing where water quality problems are a private responsibility:

> Water quality is an important component of ecosystem structure and water quality improvement can be considered as an output of an ecosystem restoration project. However, projects or features that would result in treating or otherwise abating pollution problems caused by other parties where those parties have, or are likely to have a legal responsibility for remediation or other compliance responsibility shall not be recommended for implementation. (USACE, 2000)

Recreation benefits are somewhat loosely defined in SBX7-2, Chapter 8, as "including, but not limited to, those recreational pursuits generally associated with the outdoors." We recommend that first priority be given to outdoor recreation activities associated with natural water bodies such as rivers, streams, lakes, wetlands, and the ocean. Benefits from outdoor recreation at man-made water bodies could be considered if the water bodies are open to the public and serve some other public purpose such as municipal water supply or habitat restoration. Recreation benefits from golf courses, swimming pools, or private, water-based theme parks might not qualify for public funding because these are not commonly regarded as outdoor recreation.

6.2 Public Benefits that Accrue Outside of California

The Commission might choose not to fund costs associated with benefits to non-Californians. It is recommended that "Californians" should include residents of the state, state and local governments, owners of California property (whether resident or not) and net business incomes arising from operations of places of businesses located within the state, whether paid to residents or not. The latter two categories are included not only because of a state interest in nonresident owners, but also because it is not possible to split business and property incomes according to residence locations of owners.

The types of public benefits accruing to non-Californians that may be important in a benefits analysis are the following:

1. Non-use values of non-residents for California ecosystem improvement. Some surveys suggest that people value rare species and, by association, their habitats, even if the people do not live near them. These non-resident benefits and benefit shares might be identified from CV studies (Hanemann et al, 1991; Loomis, 1996).
2. Recreational use values to non-residents. The share of visitors that are non-resident would need to be estimated, along with their expenditure patterns. In general, the non-resident share of visitation on California reservoirs is believed to be small.

6.3 Public Benefits that Might be Financed by the Federal Government

Table 9 provides information regarding USACE cost sharing provisions by benefit type. These criteria generally apply for Reclamation as well. Section 3406 of the Central Valley Project Improvement Act added mitigation, protection, and restoration of fish and wildlife to the purposes of the CVP.

Water supply for salinity repulsion could be considered emergency response for federal purposes, and costs allocated to storage might qualify for federal cost sharing. PL 93-251 (WRDA, 1974) provided that an emergency supply of clean drinking water where the source is contaminated can qualify for federal cost sharing.

Reclamation could participate in financing public benefits by sponsoring a project, either solely or in partnership with the state of California or other agencies. Reclamation also has a number of programs and funding sources that can provide direct grants, loans, or cost-shares for local projects that meet Reclamation's criteria. These programs, criteria, and funding levels vary over time based on congressional authorization and appropriation.

TABLE 9
USACE Civil Works Projects Cost Sharing Formulas, by Purpose
SBX7-2 Economic Methods

Project Purpose	Construction	O&M
Flood Control		
Structural		
LERRD	100% nonfederal for all structural projects.	100% nonfederal for all structural projects.
Construction	Minimum of 35% nonfederal and a maximum of 50% (to include the value of LERRD). A minimum of 5% of the nonfederal share must be cash.	100% nonfederal for all structural projects.
Nonstructural		
LERRD	100% nonfederal except that it shall not exceed 35% of project costs.	100% nonfederal.

USACE Civil Works Projects Cost Sharing Formulas, by Purpose
SBX7-2 Economic Methods

Project Purpose	Construction	O&M
Construction	35% nonfederal. The value of LERRD counts against this percentage.	100% nonfederal.
Hurricane and Storm Damage Reduction		
LERRDs	100% nonfederal.	100% nonfederal.
Construction	35% nonfederal.	100% nonfederal.
Ecosystem Restoration and Protection		
Project modifications	25% nonfederal; additional LERRD required count toward this percentage.	100% nonfederal.
Aquatic ecosystem restoration	35% nonfederal; LERRD count toward this percentage.	100% nonfederal.
Recreation		
Harbor and channel projects, recreational navigation	50% of costs nonfederal. LERRD – 100% non-federal.	100% nonfederal.
Reservoir Projects and other	50% of separable costs nonfederal. LERRD – 100% non-federal.	100% nonfederal.
Emergency	Construction costs – 20% non-federal. LERRD – 100% non-federal.	100% nonfederal.
Municipal and Industrial Water Supply	100% nonfederal.	100% nonfederal.
Agricultural Water Supply	35% nonfederal. The value of LERRD counts against that percentage.	100% nonfederal.

Note:

LERRD = Lands, easements, rights-of-way, relocations, and disposal areas

Source: USACE, 2000; CAUSACEWRPPP, 1999

6.4 Cost Allocation

Chapter 8 of the Act includes several provisions dealing with the distribution of benefits among public benefit categories and the distribution of costs among beneficiaries (both public and nonpublic). It also states that the benefits available to a party shall be consistent with that party's share of total project costs. A mechanism is needed that relates each beneficiary's quantified benefits to its assigned costs.

Water storage projects typically have multiple purposes such as water supply, hydropower, ecosystem, water quality, and flood control. Cost allocation is the process of partitioning project costs among project purposes, and then among beneficiaries. Each purpose is typically expected to pay, at a minimum, the cost it imposes on the project; however, most cost is not usually attributable to a single purpose. Separable cost is the share of total cost that is clearly attributable to many purposes. The remaining cost is called joint cost. A transparent, efficient, and equitable process to allocate joint costs is required.

Although B/C analysis and cost allocation are separate processes, interdependencies are important. A necessary condition for a feasible cost allocation is that a project must have benefits that exceed its costs. If a beneficiary imposes a cost on the project that is greater than that beneficiary's cost share, the other beneficiaries would prefer to exclude them. If any beneficiary is asked to pay a cost more than the benefit received, then they may choose not to participate. These situations would require reconsideration of project operations and ultimately, economic feasibility.

The *separable cost-remaining benefits* (SCRB) method is a common approach used for allocating costs (Griffin, 2006). SCRB is used to allocate costs in an equitable way that determines which project purpose should be included and assures that each project beneficiary is not responsible for costs in excess of benefits. The SCRB methods contains the following steps:

1) Separable Costs—The cost of the project in the absence of a particular purpose (e.g., hydropower) is calculated by reengineering the project plan to provide no hydropower benefit but with the same amount of benefit for all other purposes. The difference between the project cost with and without the hydropower purpose is the separable cost—the portion of project cost that can be clearly and solely attributed to hydropower. For example, a hydropower turbine would be a separable cost for hydropower.

   This is an important step because if the separable cost is greater than the benefit of the single purpose, it is economically efficient to omit that purpose; and the other beneficiaries are better off if that purpose is omitted from the project. This step also ensures that no single purpose will be asked to pay costs in excess of benefits.

2) Joint Cost—Once separable costs of each purpose are established, the joint cost can be calculated as the total cost minus the sum of the separable costs.

3) Remaining Benefits—Each separable cost is subtracted from that purpose's benefit. This is the remaining benefit of the purpose. The remaining benefits are summed and the share of the total remaining benefit for each purpose is calculated. The joint cost is allocated according to the share of remaining benefit of each purpose.

4) Cost Shares—Then, the cost allocated to each purpose is its separable cost plus its share of joint cost. Each beneficiary's costs are bounded by their benefits, ensuring that each beneficiary is left with a positive net benefit and that no purpose is assigned any cost that is clearly caused by any other purpose.

SECTION 7

Recommendations for Regulations and Guidelines

The Commission is directed in Chapter 8 of the Act to "develop and adopt, by regulation, methods for quantification and management of public benefits" if the bond is approved by voters in 2012. The following recommendations are drawn from the assessment of methods for quantification developed in this report and are presented for the Commission to consider as it develops regulations and guidelines. The decision about how to incorporate methods for quantification into regulations or guidelines is beyond the scope of this report—it is a question of policy and regulatory law.

The following list is a compilation of the recommendations presented in this report. The recommendations include general standards, recommendations for physical quantification, and recommendations for economic quantification.

The recommendations for quantification methods are provided as a set of steps or protocols that suggest all of the necessary calculations, comparisons, and checks to obtain valid public benefits quantified in dollars. These recommendations do not include suggestions for dealing with benefits that cannot be quantified, or for dealing with project effects that are not economic public benefits. Examples of such effects may include water supply and hydropower benefits, income distribution, employment, or certain social and environmental effects.

These recommendations also do not address the Act's requirement for the Commission to develop a process that considers the DFG and State Water Board's priorities and relative environmental values as well as economic benefits.

7.1 General Standards

An application for public funds for public benefits should ideally include clear documentation of assumptions, methods, without-project conditions, benefits described and quantified in physical terms (e.g., population improvements in listed species, acres of habitat, and changes in water quality constituents), and benefits quantified in monetary values. Specific questions that the Commission could consider as it reviews these recommendations include the following:

- Does the recommendation provide clear guidance both to the Commission and to applicants?
- Does the recommendation set an achievable level of analysis for potential applicants, or is it onerous?
- Should the recommendation become the basis for a requirement or minimum standard for applications, or should it be a preferred but not required component of applications?

- Do the recommendations taken as a whole provide a reasonable set of requirements and guidance for applicants?
- Do the recommendations taken as a whole meet the quantification needs embodied in the provisions of Chapter 8?

7.2 Recommendations for Physical Quantification

Methods for physical quantification of public benefits should meet the following criteria:

1) Provide a list of project objectives including the public benefit categories that the project intends to claim and showing a breakdown of benefit subtypes within each category.
2) Document any physical benefit's measures, as well as the methods and models used to obtain the measures.
3) Where physical benefits are not estimated for any public benefit, describe and, if possible, quantify other physical changes resulting from the project that directly lead to the benefit. For example, if fish population cannot be estimated, estimate changes in habitat conditions or the volume of flow provided for fish habitat.
4) Explain any lack of physical benefit measures for a given benefit subtype.
5) Provide a summary of with- and without-project conditions over the planning horizon, including related facilities and programs expected to be in place, other water supplies, and other conditions related to the public benefits categories from item 1.
6) Provide a water balance and storage yield analysis if the public benefit will be provided by water supply, including the following:
7) A description of methods, including the hydrologic period, development condition, hydrologic time step, and planning horizon
8) A water balance analysis comparing without-project to with-project conditions, showing all flows and water supplies relevant to the public benefits analysis, including flows, water supplies, and the quantities for each named measure for each public benefit subtype

7.3 Recommendations for Economic Quantification

Methods for economic quantification of public benefits should meet the following criteria:

1. Provide the following for all public benefits:
    a. Provide a calculation of any cost savings (without-project minus with-project costs) that are caused by the provision of public benefits.
    b. Provide a discussion of the feasibility and cost of all reasonable and substantially different alternative means (i.e., projects, programs, and/or actions) for providing the same package of all eligible public benefits.
2. Provide the following for each public benefit type:

   a. Estimate the least cost alternative means of providing the amount of water in item 6) above.
   b. Show the stand-alone least cost of providing this physical amount by alternative means if any public benefit subtype is quantified under item 3) above.

3. Show, if possible, the following WTP values for each public benefit type for physical benefits quantified in item 2) above (If not possible, explain why.):
   a. **Ecosystem Improvement.** For water quality and recreation benefits caused by the ecosystem improvement, see 3.b. and 3.c. below. For ecosystem products sold in competitive markets, use market price as the basis for WTP, and subtract additional private and public costs required to produce and market the product. For other products that enhance property values, estimate the increase in property values associated with the product using land price or hedonic pricing. For non-use values, survey-based methods should be designed around the project's physical benefits, or benefit transfer should be used if necessary. Report non-use values separately.
   b. **Water Quality.** For urban water salinity in the south coast and South Bay areas, existing models based on avoided cost are preferred. For agricultural salinity, models that estimate the value of crop yield reduction and reduced water application for leaching are preferred. For other subtypes, use hedonic pricing (or land value as the second-best method) to obtain the share of benefit obtained by adjacent properties, revealed preference or survey methods for improved household water quality, or benefit transfer if necessary.
   c. **Recreation.** A UEM is required. Either the revealed preference method or benefit transfer based on similar use at similar regional facilities is preferred. Market prices or hedonic pricing may provide partial benefits. Survey methods and the USACE unit-day value method are the second-best approaches for valuing use.
   d. **Flood Damage Reduction.** The preferred method is to use established models to estimate avoided damage and avoided costs. For large projects (i.e., more than $10 million capital cost), use HEC-FDA or HAZUS-MH level 2. For smaller projects, use DWR's F-RAM or follow similar EADs algorithm.
   e. **Emergency Response.** The WTP value for reduced cost of a Delta seismic event should be based on the avoided costs of export reductions and increased salt exports. For other events, use the avoided cost of emergency services and casualties as appropriate.

4. Provide the following for each public benefit type:
   a. If the alternative cost was quantified under item 2.a. or item 2.b. above, compare these values to the WTP from item 3. The public benefit is the smallest of these values.
   b. If no physical benefits measures were provided, then the public benefit is no more than the alternative cost from item 2.a. above.

5. If the sum of resulting public benefits for all public benefit categories is more than the alternative cost from item 1.b above, then the total public benefit is limited to the alternative cost from item 1.b.

6. Provide a planning horizon analysis that discounts annual public benefits over the useful life of the project using a real discount rate of 6 percent.

SECTION 8

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APPENDIX A

Physical Models

Monetary valuation normally requires physical benefits quantification. This section describes some models that quantify California water supply, water quality, ecosystem, and recreation benefits.

CALSIM

CALSIM II is a general-purpose planning simulation model developed by DWR and Reclamation for simulating the operation of California's water resources system, specifically the federal Central Valley Project (CVP) and the California State Water Project (SWP). On a monthly time-step, CALSIM II utilizes optimization techniques to route water through a network. A linear programming/mixed integer linear programming solver determines an optimal set of decisions for each time period given a set of weights and system constraints. A key component for specification of the physical and operational constraints is the WRESL language. The model user describes the physical system (e.g., dams, reservoirs, channels, and pumping plants), operational rules (e.g., flood-control diagrams, minimum flows, delivery requirements), and priorities for allocating water to different uses in WRESL statements.

It is intended that CALSIM II be used in a comparative mode. The results from a with project alternative simulation are compared to the results of a "base" simulation in order to determine the incremental effects of a project. The results from a single simulation may not necessarily represent the exact operations for a specific month or year, but the results should reflect long-term trends. The model should be used with caution to prescribe seasonal or to guide real-time operations or to predict flows or water deliveries for any real-time operations.

CALSIM II covers the valley floor drainage area of the Sacramento and San Joaquin Rivers, the upper Trinity River, and the San Joaquin Valley, Tulare Basin, and Southern California areas served by the CVP and the SWP. The focus of CALSIM II is on the major CVP and SWP facilities, but operations of many other facilities are included to varying degrees.

DSM2

The Delta Simulation Model II (DSM2) is a one-dimensional mathematical model for dynamic simulation of one-dimensional hydrodynamics, water quality, and particle tracking in a network of riverine or estuarine channels. DSM2 can calculate stages, flows, velocities, and mass transport processes for conservative and non-conservative constituents including salts, water temperature, dissolved oxygen, and trihalomethane formation potential, as well as transport of individual particles.

Delta planning studies evaluate how hypothetical changes to factors such as hydrologic regimes, water quality standards, system operations, and Delta configurations may impact

Delta conditions. To explore the impacts of a given scenario under various hydrologic conditions, DSM2 planning studies are run under a 16- or 82-year sequence of Delta inflows and exports derived from statewide water operations simulations using CALSIM II. Planning simulations use astronomical tidal data, which incorporate influences of the spring-neap tidal cycle; or simulations can use an average repeating tide (typically the 19-year mean tide). Planning simulations usually assess impacts of proposed changes to Delta operations or configuration such as modified reservoir releases or dredging of channels. Planning studies may also investigate impacts of hypothesized changes in the natural environment such as sea level rise.

Upper Sacramento River Water Quality Model

Physical quantification may include intermediate measures. For example, The Upper Sacramento River Water Quality Model was developed using the HEC-5Q model to simulate mean daily (using 6-hour meteorology) reservoir and river temperatures at Shasta, Trinity, Lewiston, Whiskeytown, Keswick, and Black Butte Reservoirs as well as the Trinity River, Clear Creek, Stony Creek, and the upper Sacramento River from Shasta to Knights Landing. The objective is to find temperature variability in these the reservoirs and streams, given CVP/SWP operations, and compare the variability between existing and assumed future scenarios.

SALMOD

The quantification of the effects of water management on ecosystem products such as fish and waterfowl has proven difficult. Recently, SALMOD has been used to estimate percent changes in survival of juvenile salmonids in the Sacramento River. SALMOD simulates the dynamics of both anadromous and resident freshwater salmonid populations. The conceptual model was developed in workshop settings by fish experts concerned with Trinity River Chinook restoration, and building on the foundation laid by similar models. SALMOD is a component of the Instream Flow Incremental Methodology (IFIM).

Ecological Flows Tool

The Ecological Flows Tool (EFT) is a decision support model that evaluates changes in habitat variables such as flow, salinity, temperature, and turbidity and the variables' relationships to specific species (e.g., chinook salmon, steelhead, and green sturgeon) and habitats (e.g., channel erosion/migration, Fremont cottonwoods, and large woody debris recruitment).

The EFT is compatible with CALSIM II and DSM2. The water operation and quality output from these models is used to estimate changes in habitat. The EFT is available for the Sacramento River (SacEFT) and is under development for the Delta (DeltaEFT). Model documentation and other pertinent information can be found at http://essa.com/tools/eft/.

NMFS Salmon Population Model

(placeholder)

Water Allocation Model

The Water Allocation Model (WAM) is used with CALSIM II to develop water allocation scenarios following Delta levee failure events.

Water Quality Standards Inventory Database

> The state has developed a database to help identify local water quality objectives.The Water Quality Standards Inventory Database (WQSID) was created to provide water quality standards information for California surface water bodies to the public. This inventory includes data from Regional Water Quality Control Plans and the State Water Resources Control Board's Ocean Plan and organizes it in a Geographic Information System (GIS)-oriented database. It contains both numeric and narrative information about water quality objectives and beneficial uses associated with specific bodies of water within the State of California. The web-based database is currently being maintained by the Information Center for the Environment (ICE) at the University of California, Davis, and can be found at http://endeavor.des.ucdavis.edu/wqsid. (Lew et al, 2001)

HEP

Habitat evaluation models use criteria to rate the habitat value of a project based on the benefit the habitat provides to one or more species. The Habitat Evaluation Procedure (HEP) was developed by the U.S. Fish and Wildlife Service (1980) and is the most well-known model. It is used by several federal agencies, including USACE, to assess the quality and quantity of available habitat for wildlife species.

Other Physical Models

> Other physical models may be developed in the future, or are available now.Many methods and models are available to measure existing ecosystem resource conditions and to estimate future conditions of those resources. Habitat models developed for individual species may have limitations when used to assess ecosystem restoration problems and objectives. …The assessment methodology may include habitat models, or information derived from community or ecosystem assessments using other scientifically based methods that are generally accepted by state or Federal resource agencies. (USACE, 2000)

For wetlands or refuge lands, intermediate measures might include wetted area, duration of inundation, or water depth. These measures might be used to value or rank alternatives that increase wetland acreage or water supply.

Recreation Use Estimating Models

Use estimating models are characterized by whether the model predicts visitation at just one site or at multiple sites, and by the extent to which the capacity of facilities limits use.

Single Site

This approach also uses statistical methods to estimate use as a function of explanatory variables; however, the focus is on the relationship between quantity of the recreation resource and use. According to CALFED (2006), the method uses

> historical (i.e., time series) information on visitation, water level/surface area, population within a given distance, weather, etc. data for the expanded site. Using this data, estimate a Use estimating model with visitation as a function of the remaining variables. Plug in the characteristics of the expanded site, for each of the explanatory variables, into the UEM to estimate visitation. The water level/surface area variable would be critical in estimating the change in visitation.

Gravity Models

Gravity models are also statistical applications where the focus is on allocation of use among competing recreation sites. According to Reclamation (1999):

> Gravity models allocate a given level of activity across locations. Total visitation for an entire region is first estimated, followed by use of the gravity concept where the total visitation is then allocated across sites based on relative attractiveness (trip distribution submodel).

Carrying Capacity Approaches

These approaches estimate use based on potential capacity. According to CALFED (2006):

> Percent of Carrying Capacity Approach (new or expanded sites): Estimate carrying capacity of new or expanded recreation site. Carrying capacity can be based on proposed recreation facilities, size of the resource (e.g., reservoir surface acres), etc. Obtain existing carrying capacity and current visitation information from other similar sites in the region. Calculate percent of capacity at the other regional sites. Apply average or similar site percent of capacity estimates from other regional sites to new or expanded site.

Facility Availability Approach

Forecasted monthly water levels or average monthly instream flows are compared to high- and low-end usability thresholds of current, anticipated, or relocated water-based recreational facilities. Taking into account possible facility substitution as facilities become unusable, the monthly availability of facilities can be compared to estimates of monthly visitation by activity to predict differences in use across alternatives. The approach can be used for both new and expanded sites, but it would work best with expanded sites where monthly visitation by facility information would be available. For new sites, such data would need to be derived from similar existing sites.

Similar Site Visits per Capita Approach

Visitation rates by concentric distance zone (e.g., 25-mile geographic rings) are calculated for an existing site. A similar site would be one that draws from a similarly sized population, has similar recreation facilities and therefore provides essentially the same recreational opportunities, or has similar site quality characteristics (e.g., physical setting, reservoir size/river length, and water level or instream flow fluctuation). This calculation requires data on the zip code, city, or county of residence of a sample of visitors at the existing site. Such data is typically obtained from surveys. Population is estimated by distance zone for the study site. Visits per capita rates are applied from the similar existing site to the new or expanded site.

APPENDIX B

Glossary

This glossary incorporates several other works by reference. DWR's Economic Analysis Guidebook (2008) provides a more detailed glossary of terms in its Appendix D. The glossary below focuses on those terms relevant to the quantification of benefits that fall into the five categories defined in SBX7-2.

Accounting or analysis perspective. The group of people whose economic costs and benefits are being counted in an analysis. Common accounting perspectives are the U.S. as a nation, the State of California, or a region within the state (e.g., a city, county, local agency, or group of agencies). One particular case, the *California accounting perspective*, considers the following: California residents and governments, businesses located in the state, and owners of California property. Note that nonresident business owners and nonresident property owners fall within this category to the extent their economic activities are affected by a proposed project.

Alternative cost. The cost of a different project or action that provides at least the same level of physical benefit as the proposed project. The alternative project or action need not provide the full range of benefits as the proposed project; single-purpose alternatives can be used to estimate the value of one of the benefits provided. The appropriate alternative for this approach is the one most likely to be implemented in the absence of the proposed project. "Most likely" means that the alternative has the lowest cost among potential, feasible alternatives.

Amortizing. Finding a constant payment per period that pays off a present value or principal amount, plus interest, given an interest rate and a number of periods.

Application. The use of an *Economic Method* to quantify the economic benefits for a specific project or policy evaluation. An *Application* will use data and assumptions specific to the situation analyzed, and these may not be transferable to other situations.

Avoided cost. An economic cost that would be incurred without the proposed project but that would not be incurred with the proposed project. Avoided cost is one way of estimating a benefit of a proposed project, if it can be shown that the avoided cost would actually have been incurred in the absence of the proposed project.

Beneficiary. An identifiable group of people and/or businesses that obtains benefit from a project. The group could be defined based on a common geographic location (e.g., the South Coast Hydrologic Region), a common economic activity or interest (e.g., recreational boating), or both.

Benefit, Economic. The net change in total willingness to pay for a good or service provided by a project. Benefits include anything that society values, even though they may not be expressed in monetary terms. For quantitative economic evaluation, a benefit is estimated and expressed in monetary terms to compare it to costs or to other benefits.

Benefit categories. The different kinds of goods or services that could be provided by projects. In some literature on B/C analysis or project evaluation, benefit categories that are intended to be provided may be referred to as "project purposes." Important categories include water supply/water supply reliability (this may be further broken into use categories such as irrigation and M&I), ecosystem improvement, navigation, flood control (or damage reduction), water quality improvement, emergency response, power production, and recreation.

Benefit-cost analysis. A quantitative calculation procedure that compares the benefits and costs of a project. Benefits and costs are defined by comparison of the without-project versus with-project conditions, extended over a planning horizon. Discounting is used to account for differences in timing of benefits and costs during the planning horizon. Results are generally shown as a net benefit, also called *Present Net Worth* (the discounted value of benefits minus the discounted value of costs), or the benefit cost ratio (the discounted value of benefits divided by the discounted value of costs).

Benefit Transfer. A method of valuing a benefit based on a benefits measure from a different location.

Carbon Sequestration. Storing carbon or avoiding release of carbon into the atmosphere, usually as a method of offsetting carbon emissions.

Cost. Costs are the value of resources required for a specified economic activity. Costs are usually expressed in monetary terms. Typical costs include construction, operations, maintenance, repairs, replacement, and mitigation. Some costs are more difficult to express as monetary values, such as losses in habitat caused by project construction. Note that there is symmetry between costs and benefits that often leads to confusion: a reduction in cost is equivalent to a benefit; therefore, an avoided cost is an important and common way to estimate a benefit.

Cost Allocation. The process of distributing costs of a project among beneficiaries. In many formal planning processes such as for federal water project planning, costs are normally first allocated among project purposes (i.e., benefit categories).

Cost effective. A project is cost effective if no other project or combination of actions can provide at least the same levels of physical benefits at lower economic cost.

Development condition. The facilities in place, border levels of water and land use, and other factors that are held constant in a water balance model to determine how hydrologic variability affects water levels, flows, and supplies. Normally expressed as a year, for example, 2020.

Discount Rate. In a BCA, the annual rate at which projected future real benefits and costs are reduced relative to the present.

Discounting. The process by which benefits and costs that occur at different times during a planning horizon are adjusted to account for individuals' or society's preference for enjoying benefits sooner rather than later.

Economic Effects. A general term for any of a variety of economic measures that include benefits and costs, but also can include changes in income, employment, sales, expenditure, prices, and value of production. Some economic effects are appropriate for use in BCA, while others are appropriate for regional economic impact analysis.

Economic Method. For this report, an economic method is a quantification technique that can be used to estimate the benefits of a project. It is a way to convert levels of or changes in physical quantities of water-related services (ecosystem improvements, recreation, etc.) into economic values that represent the underlying WTP for the service by consumers or producers. Various methods are discussed in this report, including ones for services that are traded in observable economic markets and ones for services that are not. Methods include market pricing, alternative costs, survey-based methods, and avoided costs.

Economic Model. Formalized sets of calculations that employ one or more of the economic methods. Economic models generally include a database of economic and physical information, a set of calculations, and a standardized output.

Ecosystem improvements. Defined by 79743(a) as "including changing the timing of water diversions, improvement in flow conditions, temperature, or other benefits that contribute to restoration of aquatic ecosystems and native fish and wildlife, including those ecosystems and fish and wildlife in the Delta."

> Note: This definition clearly includes hydrologic changes that benefit fish and wildlife in aquatic systems; hydrologic changes that benefit riparian systems and other related ecosystems are included. It's not clear that enhancements to upland areas—for example, on land owned adjacent to a reservoir—should be included.

Emergency Response. Defined by 79743(a) as "including, but not limited to, securing emergency water supplies and flows for dilution and salinity repulsion following a natural disaster or act of terrorism."

> Note: This definition clearly includes emergency water supplies in response to a Delta event that requires repulsion of saline or contaminated water. Benefits that are reduced emergency response costs caused by flood events could be included here as well as under Flood Control Benefits.

Flood Control Benefits. Defined by 79743(a) as "including, but not limited to, increases in flood reservation space in existing reservoirs by exchange for existing or increased water storage capacity in response to the effects of changing hydrology and decreasing snow pack on California's water and flood management system."

> Note: This definition clearly intends to cover increased flood reservation space needed to offset climate change. However, it also could include any reduced flood damage enabled by more storage space. Economic categories of flood damage include structures and contents, clean-up costs and debris removal, public costs such as emergency response and assistance, and costs of lost use of roads and other infrastructure.

Hedonic Pricing. A method of valuing attributes of a good or resource, typically real property, using an analysis of observed market prices. The method attempts to quantify the value of attributes that owners and buyers enjoy, including public benefits of interest in this report such as environmental amenities or access to recreation, through a statistical analysis that relates the price of property to all of its important attributes.

Hydrologic Period. The period of recorded precipitation and inflows used as data for a water balance model.

Hydrologic Time Step. The time over which measures in a water balance model are calculated; usually daily, monthly, or annually.

Mitigation. A project component and cost that intends to compensate for an adverse environmental impact of a project. From SBX7-2, "funds shall not be expended pursuant to this chapter for the costs of environmental mitigation measures or compliance obligations except for those associated with providing the public benefits as described in Section 79743."

Monetize. To assign a dollar value to a physical change.

Opportunity cost. The value of other goods and services that are given up by using a resource for a particular purpose. For example, if water is released for Delta outflow, that water (or a portion of it) is not available for municipal and irrigation purposes; the economic value of that foregone, next best use is the opportunity cost.

Physical benefits. The quantity of a desirable good or service provided by a project, expressed in nonmonetary values, such as acres of habitat, parts per million of a water quality constituent improvement, acre-feet of water supply, or visitor-days of recreation use.

Planning Horizon. The future period over which benefits and costs of a project are compared. Generally, the planning horizon begins at the first year of construction and extends until the end of the forecasted useful life of the project.

Present Net Worth. The present value of all benefits minus all the present value of all costs. It is calculated by discounting all benefits and costs to the same point in time, usually either prior to any project construction or just before project operations would begin.

Project. For purposes of SBX7-2, a water storage project that improves the operation of the state water system, is cost effective, and provides a net improvement in ecosystem and water quality conditions. The project must provide at least one *Public Benefit*, and it must provide "measurable improvements to the Delta ecosystem or to the tributaries to the Delta."

Project Purposes. Benefit categories that are the stated reasons for a project. For federal water development projects, allowable project purposes are navigation, flood damage reduction, ecosystem restoration, hurricane and storm damage reduction, water supply, hydroelectric power generation, and recreation. (USACE, 2000)

Public Trust Resources. In California, the public trust doctrine holds that water resources are publicly owned and that the state is a trustee that manages them for the benefit of the people. Article 10, Section 2 of the California Constitution states that the water resources of the state be put to "reasonable and beneficial use … in the interest of the people and for the public welfare." The public trust doctrine also extends to aquatic resources, birds, and other wildlife.

Qualifying Benefit. One of the five benefit categories defined in Chapter 8 of SBX7-2 that may qualify for public funding. The benefit categories are Ecosystem Improvement, Emergency Response, Flood Control, Recreation, and Water Quality Improvement.

Real. Free of or adjusted for inflation. Dollar values are often adjusted for inflation to reflect a common base year.

Recreation. Defined by 79743(a) as "including, but not limited to, those recreational pursuits generally associated with the outdoors."

Resources. Land, labor, water, capital, technology, and other goods and services used for production.

Risk. Variability or chance that can be represented by a probability distribution, usually because there is a historic record.

Sensitivity analysis. Conducting an analysis multiple times where one or more parameters are changed to see how results are affected. Usually, the parameters that are changed are uncertain.

Travel Cost Method. A statistical method to estimate the value of recreation use for a recreation site based on visitation and the travel costs incurred to visit the site.

Uncertainty. Variability or chance that cannot be represented by a probability distribution; usually, there is not enough historic information to estimate the distribution, or qualified experts disagree.

Water quality improvements. Defined by 79743(a) as "water quality improvements in the Delta, or in other river systems, that provide significant public trust resources, or that clean up and restore groundwater resources."

Without vs. With Conditions. The without-project condition is the most likely condition expected to exist in the future in the absence of a proposed water resources project. Economic analysis (as well as all aspects of project evaluation) must focus on the difference in conditions expected to occur "with" the project versus "without" the project. The "without" project condition is the baseline from which all project effects (positive and negative) are derived.