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Economic Valuation Appendix

Shasta Lake Water Resources Investigation

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United States Department of the Interior
Bureau of Reclamation
Mid-Pacific Region

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Bureau of Reclamation

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Abbreviations and Acronyms

AW	applied water
CALFED	CALFED Bay-Delta Program
CAISO	California Independent System Operator
Cal/EPA	California Environmental Protection Agency
CDF	California Department of Finance
CP	comprehensive plan
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CVPM	Central Valley Production Model
Delta	Sacramento-San Joaquin Delta
DFG	California Department of Fish and Game
DWR	California Department of Water Resources
eGRID	Emissions and Generation Resource Integrated Database
EPA	U.S. Environmental Protection Agency
EQ	Environmental Quality
ESA	Federal Endangered Species Act
ETAW	evapotranspiration of applied water
EWA	Environmental Water Account
FY	fiscal year
GAO	General Accounting Office
GHG	greenhouse gas
GWh	gigawatt-hour
HU	habitat unit
I-O	input-output
LCPSIM	Least Cost Planning Simulation Model
LPP	locally preferred plan
M&I	municipal and industrial
MWDSC	Metropolitan Water District of Southern California
MWh	megawatt-hour
NED	National Economic Development
NEPA	National Environmental Policy Act
NOD	north of the Delta
NP-15	North of Point 15
O&M	operations and maintenance

OSE	Other Social Effects
P&G	*Federal Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*
PR/FEIS	Planning Report/Final Environmental Impact Statement
PMP	positive mathematical programming
RBDD	Red Bluff Diversion Dam
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
RED	Regional Economic Development
SLWRI	Shasta Lake Water Resources Investigation
SOD	south of the Delta
SWP	State Water Project
SWRCB	State Water Resources Control Board
TCD	temperature control device
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
WAP	Water Acquisition Program

Chapter 1 Introduction

This Economic Valuation Appendix was prepared for the Shasta Lake Water Resources Investigation (SLWRI), a U.S. Department of the Interior, Bureau of Reclamation (Reclamation), study on the potential feasibility of modifying the Shasta Project by enlarging Shasta Dam and Reservoir in Northern California. Estimating the costs and potential benefits of alternative plans is critical to determining economic feasibility and identifying a corresponding recommended plan. It is also instrumental in allocating potential project costs among the various purposes and in identifying cost-sharing responsibilities among Federal and non-Federal entities.

Background

Shasta Dam is a 602-foot-tall concrete gravity dam constructed between 1938 and 1945 on the Sacramento River, approximately 9 miles northwest of Redding, California. Shasta Dam and its 4.55 million acre feet capacity reservoir is operated in conjunction with other Central Valley Project (CVP) facilities to provide for the control of floodwater, storage of surplus winter runoff for irrigation in the Sacramento and San Joaquin valleys, municipal and industrial (M&I) use, maintenance of navigation flows, protection and conservation of fish in the Sacramento River and the Sacramento-San Joaquin Delta (Delta), and generation of hydroelectric energy. The Shasta Project is the largest component in the CVP/SWP water management system, and its associated outputs contribute significantly to the California economy.

Purpose and Scope of This Document

The purpose of the Economics Valuation Appendix is to identify and apply valuation methods to estimate the economic effects resulting from plan formulation to meet the SLWRI primary planning objectives, and subsequently to calculate the benefits of each alternative. This appendix identifies valuation methods and valuation estimates for the benefit categories associated with the SLWRI primary and secondary planning objectives, which are described below.

Planning Objectives

The planning objectives listed below were developed on the basis of the identified and defined problems and needs in the study area and in relation to study authorities. These objectives were used to help guide formulation of alternatives, and are separated into primary and secondary objectives. Primary planning objectives are those for which specific alternatives would be formulated to address. Secondary planning objectives are opportunities that should be considered in the plan formulation process, but only to the extent possible through pursuit of the primary planning objectives.

- **Primary Planning Objectives –** Formulate alternatives specifically to address the following:
  - **Anadromous Fish Survival –** Increase the survival of anadromous fish populations in the Sacramento River primarily upstream from the Red Bluff Diversion Dam (RBDD)
  - **Water Supply Reliability –** Increase water supplies and water supply reliability for agricultural, M&I, and environmental purposes to help meet future water demands, with a focus on enlarging Shasta Dam and Reservoir
- **Secondary Planning Objectives –** To the extent possible, through pursuit of the primary planning objectives, include as opportunities features to help accomplish the following:
  - **Ecosystem Restoration –** Preserve and restore ecosystem resources in the Shasta Lake area and along the upper Sacramento River
  - **Flood Damage Reduction –** Reduce flood damage along the Sacramento River
  - **Hydropower –** Develop additional hydropower capabilities at Shasta Dam
  - **Recreation –** Preserve and increase recreation opportunities at Shasta Lake
  - **Water Quality –** Preserve or improve water quality conditions in the Sacramento River downstream from Shasta Dam and the Delta.

Guidelines

The economic valuation approach for Federal projects is consistent with the *Federal Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G) (WRC, 1983). The Federal objective of water and related land resources project planning is to contribute to national economic development consistent with protecting the Nation’s environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. Further, numerous Federal laws (e.g., the Endangered Species Act (ESA) (1973), Clean Water Act (1972), Central Valley Project Improvement Act (CVPIA) (1992)) establish policy and Federal interest in the protection, restoration, conservation, and management of protecting environmental quality. The Federal Objective is defined in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G, 1983): "The Federal objective of water and related resources project planning is to contribute to national economic development consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements."

The Federal Objective as updated and specified in the Water Resources Development Act of 2007 is that Federal water resources investments shall reflect national priorities, encourage economic development, and protect the environment by:

- seeking to maximize sustainable economic development;
- seeking to avoid the unwise use of floodplains and flood-prone areas and minimizing adverse impacts and vulnerabilities in any case in which a floodplain or flood-prone area must be used; and
- protecting and restoring the functions of natural systems and mitigating any unavoidable damage to natural systems.

In consideration of the many complex water management challenges and competing demands for limited Federal resources, it is intended that Federal investments in water resources should strive to maximize public benefits, particularly in comparison to costs. Public benefits encompass environmental, economic, and social goals, include monetary and non-monetary effects and allow for the inclusion of quantified and non-quantified measures. Stakeholders and decision makers expect the formulation and evaluation of a diverse range of alternative solutions. Such solutions may produce varying degrees of effects relative to the three goals specified above and as a result, tradeoffs among potential solutions will need to be assessed and properly communicated during the decision making process.

Thus, in addition to traditional, monetized economic development, projects that contribute to Federal ecosystem and species restoration goals are relevant components of water project planning and development.

Economic evaluation provides a way to understand and evaluate trade-offs that must be made between alternatives with respect to objectives, investments, and other social goals. It also provides a means to identify the plan that is acceptable, effective, efficient, and complete, and contributes the most favorably to national priorities. The Federal P&G established four main accounts for organizing, displaying, and analyzing project alternatives:

- National Economic Development (NED)
- Regional Economic Development (RED)
- Environmental Quality (EQ)
- Other Social Effects (OSE)

The above accounts encompass all significant effects of a plan, consistent with the National Environmental Policy Act (NEPA) of 1970 (42 United States Code 4321 et seq.) and other Federal guidance.

National Economic Development

The NED account identifies the alternative providing the greatest net economic benefits to the Nation. Often the plan with the greatest NED benefits is the one selected for recommendation to Congress for approval. However, a non-Federal sponsor may prefer another plan (locally preferred plan (LPP)) which may be considered and recommended by the Secretary of the Department of the Interior for approval and authorization by Congress. The NED analysis is used to define the Federal financial interest in the LPP.

Contributions to NED are increases in the total value of the national output of goods and services, expressed in monetary units. These contributions are the direct net benefits that would be expected to accrue in the primary study area and the rest of the Nation should a project or program be implemented. They include increases in the net value of those goods and services that are marketed, and also of those that may not be marketed.

The NED account describes the portion of the NEPA human environment, as defined in 40 Code of Federal Regulations 1508.14, that identifies beneficial and adverse effects on the economy which occur as a result of water resources planning and development. The NED account considers the estimated benefits and costs of alternative plans. Beneficial effects could include (1) increases in the economic value of the national output of goods and services from a plan, (2) the value of output resulting from external economies caused by a plan, and (3) the value associated with the use of otherwise unemployed or under-employed labor resources. Adverse effects in the NED account would be the opportunity costs of resources used in implementing a plan. Such opportunity costs could include decreases in output in other sectors, or employment losses. These effects usually include (1) implementation outlays, (2) associated costs, and (3) other direct costs.

Regional Economic Development

The RED account examines changes in economic activity at the local or regional level. RED analysis may reflect only a shift in economic productivity from one region to another, not the change in output at the national level required in Federal analysis. Because local and regional economic activity in California's CVP/SWP system is of great interest to decision-makers and stakeholders, RED analysis is included to assess income, employment, output, and population.

Environmental Quality

EQ benefits will be valued relative to their accomplishment levels, and corresponding policy and public laws and regulations. The anadromous fishery restoration objectives are consistent with the species recovery plan, indicating the social preference for these species and a corresponding desire for the ecosystems on which they depend, and which depend on them. The plan that maximizes fishery recovery, relative to the EQ accomplishments, will likely be the recommended plan.

Other potential key secondary and incidental ecosystem accomplishments may include watershed protection, shoreline protection, and lake protection and quality. The need and preference for these benefits are largely based on the CALFED Bay-Delta Program (CALFED) programs and objectives, which include ecosystem restoration, watershed management, and water management.

Other Social Effects

The OSE account provides for the integration of alternative plan effects not covered under the NED, RED, and EQ accounts. The effects quantified by OSE include urban and community impacts, such as effects on income or population distribution, fiscal conditions of the State and local governments, the quality of community life, and similar impacts. OSE includes impacts to life, health, and safety, including the risk of flood, drought, or disaster; the potential loss of life, property, and essential services; and environmental effects not covered under the NED and EQ accounts. OSE also includes the effects of the displacement of people, businesses, or farms; impacts to the long-term productivity of resources, such as agricultural land, for use by future generations; and effects on energy requirements and conservation.

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Chapter 2
Benefit Estimation Methods

This chapter describes methods that may be used to estimate potential agricultural, M&I, recreational, and environmental benefits from the SLWRI. Market valuation methods appropriate for water supply reliability and hydropower are addressed first. Nonmarket valuation methods, especially those associated with recreation, anadromous fish survival, and ecosystem restoration, are considered second.

NED Formulation Approach

In general, the objectives of Congress in Federally financed water resource projects are to enhance regional economic development, the quality of the environment, the well-being of people in the United States, and national economic development. NED costs and benefits are the decrease or increase in the value of the national output of goods and services expressed in dollars. NED figures measure the costs and benefits to the Nation, rather than to a particular region.

As described in the P&G, water resources project plans shall be formulated to alleviate problems and take advantage of opportunities in ways that contribute to the NED. The alternative plan with the greatest net economic benefit (the NED plan) determines the greatest potential Federal investment in the project. If the local sponsor prefers a different plan than the one that maximizes NED, the NED process is used to define the Federal financial interest in the LPP.

The NED account includes the following categories of goods and services: M&I water supply; agricultural floodwater, erosion, and sediment reduction; agricultural drainage and irrigation; urban flood damage reduction; power (hydropower); transportation (including both inland navigation and deep draft navigation); recreation; and commercial fishing. While multipurpose projects may provide additional types of benefits, these categories coincide with project purposes in which an established Federal financial interest exists. Other categories of benefits may be allowed or may be included in Congressional authorization for a specific project.

NED costs are the opportunity costs of resource use, and require consideration of the private and public uses that producers and consumers are making of available resources, now and in the future. For goods and services produced in a competitive market, price is often used to reflect opportunity cost. Consequently, market prices should be used to determine NED costs provided the market prices reflect the full economic value of a resource to society. The market price approach should reflect the interaction of supply and demand. If market prices do not reflect total resource values, surrogate values may be used that approximate opportunity costs based on an equivalent use or condition.

For M&I water supplies, the conceptual basis for evaluating benefits is society's willingness to pay for the increase in goods and services attributable to the water supply. According to the P&G, when the market price reflects the marginal cost of water, that price should be used to calculate willingness to pay for additional water supply. In the absence of a direct measure of the willingness to pay, the benefits are instead measured by the cost of the alternative most likely to be implemented in the absence of the project.

Other direct benefits in the NED evaluation are those direct effects of a project that are incidental to the purposes or objectives for which the project is being formulated. Other direct benefits may include improvement in commercial/industrial production possibilities (such as reduced water treatment process costs at industrial facilities) or increases in recreational opportunities. For the SLWRI, other direct benefits include hydropower, and recreation.

The two primary decision criteria used in a Federal economic analysis are net benefits and the benefit-cost ratio. The net benefit is the difference between the net present value of benefits and costs, and it measures the extent to which benefits to the Nation exceed project costs. The benefit-cost ratio is calculated by dividing annual project benefits by annual project costs. The net benefits and costs of alternative plans are compared to identify the plan that reasonably maximizes net benefits, or the NED plan. This is not necessarily the plan with the most benefits, but rather the plan that reasonably maximizes net benefits while protecting the environment given the cost to the Nation. Section 1.10.2 of the P&G requires that the NED plan be selected unless the Secretary of the Interior grants an exception.

Economic Valuation Methods

Economic valuation methods generally fall into one of two categories: market valuation or nonmarket valuation. Market values refer to conditions for which a price can be observed. Nonmarket valuation methods usually apply to resources for which there are no established markets, such as ecosystem restoration or wildlife conservation. In general, the P&G recommend that the value of goods and services be measured according to willingness to pay as a measure of demand. However, demand functions cannot be practically estimated for many goods and services due to a lack of market data. Where demand functions cannot be reliably estimated, the P&G offer several alternative approaches beginning with the use of actual or simulated market prices.

As recommended in the P&G, economic benefits may be determined by one of five valuation approaches (listed in order of preference):

- Willingness to pay
- Actual or simulated market prices
- Change in net income
- Cost of the most likely alternative
- Administratively established values

Each of the valuation approaches are briefly described below.

Willingness to Pay

The user value, or willingness to pay, refers to the value of the resource to the consumer. Willingness to pay refers to the value that a "seller" would obtain if able to charge each individual user a price that captures the full value to the user. Implementation of this approach requires estimation of a demand curve. Three methods are commonly used to estimate a demand curve. The methods include revealed preferences, which rely on market-based data; contingent valuation, which uses surveys to directly elicit consumer benefits; and benefits transfer, which uses estimates from previously completed studies. A well-designed contingent valuation survey represents one possible method to measure willingness to pay in a developing market. However, many economists question the hypothetical nature of the contingent valuation method and prefer measuring revealed preferences when the data are available. Further, conducting a primary revealed preference or contingent valuation study is often prohibitively time-consuming and expensive. Therefore, values from previous economic studies may be used to estimate willingness to pay provided they are relevant to the study area and output being valued.

Actual or Simulated Market Prices

In cases where a demand curve cannot be directly estimated, market prices represent the next best approach to estimate willingness to pay for a good or service resulting from the project. The P&G provide some limited guidance on the use of market prices where the output of the plan is expected to have a significant effect on market price. Prices should be expressed in real terms (inflation adjusted). Real prices should be adjusted, where possible, throughout the planning period to account for expected changes in demand and supply conditions.

Change in Net Income

When willingness to pay and market price methods cannot be implemented, the P&G allow estimation of the change in net income to producers associated with a project to obtain an estimate of total value. This method is most frequently applied to circumstances when water supply from the project will be used as an input in a production process. One example is the agricultural Central Valley

Production Model (CVPM), which measures the change in net income to agricultural producers associated with changes in water supply conditions.

Cost of the Most Likely Alternative

In situations where water supply alternatives to the proposed project exist, the cost of the most likely alternative to obtain the same level of output can be used as a measure of NED benefits. When applying this method, it is important to consider alternatives that would realistically be implemented in the absence of the proposed project. The method is generally considered for benefit categories that cannot be estimated through the methods described above. The cost of the most likely alternative method identifies the cost of obtaining or developing the next unit of a resource to meet a particular objective. The net benefit is estimated by subtracting the cost of developing the project under consideration from the cost of the alternative unit. For water supply reliability benefits, for example, the cost of the most likely alternative represents the next unit of water supply the water user would purchase or develop if the project under consideration were not in place. The cost of the most likely alternative method assumes that if the preferred alternative is not implemented, the alternative action most likely to take place provides a relevant comparison. If the preferred alternative provides the same output as the most likely alternative at a lower cost, the net benefit of the preferred alternative is equal to the difference in the project costs.

Administratively Established Values

Administratively established values are representative values for specific goods and services that are cooperatively established by the water resources agencies. This method is the least preferred approach to estimating economic benefits identified in the P&G and is only implemented when other options cannot be completed.

Recommended Valuation Approaches

This section briefly describes the recommended methods to value economic contributions to the objectives of the SLWRI: anadromous fish survival; water supply reliability; ecosystem restoration; flood damage reduction; hydropower; and recreation. Additional information describing each benefit category and the valuation approaches is described in the sections that follow.

Water Supply Reliability

Agriculture

The SLWRI alternatives will improve water supply reliability to agricultural water users particularly during dry years. Agricultural water supply reliability benefits are commonly estimated through the “change in net income” approach described in the P&G. Implementation of the approach can range from simple crop production budget analysis to more complex mathematical programming models such as the CVPM. This study provides an estimate of water supply reliability benefits to agriculture through application of the CVPM to projected changes in water supply resulting from the project alternatives. This analysis included adjustments to model assumptions concerning groundwater availability and depth during dry years within Westlands Water District (Region 14 of the CVPM model) based upon available information.

Urban

Water supplies from the SLWRI alternatives will also improve water supply reliability to M&I water users primarily located south of the Delta. M&I water users have been increasingly participating in the water transfer market to augment supplies. This analysis assumes that the next increment of water supply to M&I users would likely be obtained through water transfers. This analysis relies on values estimated through application of a water transfer pricing model and through consideration of the costs associated with conveying the water to the M&I service areas. This method is consistent with the “actual or simulated market price” and the “cost of the most likely alternative” methods recommended by the P&G.

The Least Cost Planning Simulation Model (LCPSIM)[1] is another tool available to estimate the economic benefits associated with changes in water supply reliability in California. LCPSIM was developed to provide an estimate of the value of water to urban users in the San Francisco Bay Area and South Coast Region through a “least-cost” alternative approach. The regional model uses linear programming to simulate regional water management operations on a yearly time step. This analysis does not directly apply LCPSIM to estimate urban water supply reliability benefits due to water supply benefits that accrue to urban water users located outside of the model’s geographic coverage, but does use LCPSIM results for comparison to actual or simulated market prices.

Hydropower

The proposed modifications of Shasta Dam will alter water flows and elevations and have varying incidental effects on power generation capacity at Shasta Dam and other hydropower facilities throughout the CVP. Estimates of net changes in power generation capacity in the electrical power system were derived through CalSim-II estimations and power generation models of the affected facilities. Changes in the economic value of power generation are assessed in this study through application of average wholesale power market prices in California. The potential economic benefits from reductions in carbon emissions associated with electricity provided from fossil-fuels is also presented.

Recreation

Raising Shasta dam would affect recreational participation by increasing reservoir surface area and elevation throughout the year over without-project conditions. Previous studies have found that aquatic recreational activity is sensitive to fluctuations in these parameters, increasing and decreasing in

[1] LCPSIM is currently undergoing revisions and was therefore not available for review or use in this analysis.

accord with rises and falls in lake water levels. Recreation benefits are quantified through application of unit values determined by a previous U.S. Forest Service (USFS) economic study. Changes in recreation visitation are assumed to vary in proportion to changes in pool surface area.

Flood Damage Reduction

Potential flood damage reduction benefits are not quantified in this appendix. Shasta Dam currently provides significant flood reduction benefits and it is anticipated that the incremental benefits from the project alternatives will be relatively small. This assessment could change for future studies as the management of the dam and potential for reducing flood events is still being studied.

Ecosystem Restoration

The recommended method for assessing the economic value of contributions of SLWRI to anadromous fish survival and ecosystem restoration is through implementation of a “cost of the most likely alternative” approach. The underlying premise for the valuation approach is that increasing salmon populations is a socially desirable goal, as indicated by the listing of several species as threatened or endangered and the demonstrated expenditures on salmon restoration projects. Because the increased potential to reduce water temperatures during critical periods provided by additional surface storage is essential to increasing salmon production, the cost of the most likely alternative is based on the cost of various dam raises operated solely for the purpose of increasing the number of salmon smolt in the Sacramento River.

Risk and Uncertainty

With each aspect of this report, certain assumptions were made based on engineering and scientific judgment. Careful consideration was given to the methodologies and evaluations for hydrology and system operations, cost estimates, and biological analyses. Analyses were developed with advanced modeling and estimating tools using historical data and trends. While this is an effective way to help predict outcomes for future operations, biological conditions, and costs, many uncertainties could affect the findings of this appendix. Various uncertainties and risks associated with the SLWRI are discussed in Chapter 5 of the Draft Feasibility Report.

Next Steps

As the SLWRI progresses, Reclamation will continue to address and resolve unresolved issues and concerns. Additional refinement to the comprehensive plans is expected following public input on the Draft Feasibility Report and Preliminary Draft EIS and updated water operations and related analyses in response to changes in water management directives related to statewide water operations.

Future Economic and Financial Evaluations

Future economic and financial evaluations will focus on reassessing alternative plan benefits based on updated estimates of alternative accomplishments, identification of the preferred plan/proposed action, and allocation of costs to project purposes (e.g., cost allocation). As stated above, Reclamation anticipates developing more detailed plans and cost estimates for the specific mitigation activities and enhancement features before finalizing project costs. Accordingly, all economic analyses will be updated. In addition, Reclamation plans to refine analyses of financial capability of project beneficiaries.

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Chapter 3 Water Supply Reliability Benefits

This chapter describes water supply reliability benefit estimates for five action alternatives, or comprehensive plans (CP). These alternatives are described in the Plan Formulation Appendix. They include three raises of Shasta Dam primarily for water supply reliability: 6.5 feet (CP1), 12.5 feet (CP2), or 18.5 feet (CP3). The fourth plan, CP4, includes raising Shasta Dam 18.5 feet with an emphasis on anadromous fish survival. The CP4 alternative would increase Shasta Reservoir storage by a quantity identical to the CP3 dam raise but would release water to contract holders by a quantity identical to those released under a 6.5-foot raise. CP5 is a combination plan with water supply deliveries similar to CP3.

Agriculture Water Supply Reliability

Value of Agriculture in California

California agricultural production is a multibillion dollar industry that relies on water as a primary input for production. The farm gate value of the State's agricultural output in 2005 was more than $32 billion (in 2006 dollars). Five commodities make up 50 percent of this value: dairy, greenhouse and nursery, grapes, almonds, and cattle/calves. Furthermore, key crops, also produced in California, such as alfalfa and hay, constitute key inputs to the success of these industries.

Table 3-1 presents the top five commodities, their contribution to California agricultural values in 2005, and their percentage share of the crop's production on a national scale. From an NED perspective, it is notable that California-produced almonds represent 100 percent of the Nation's production. California's dairy industry produces 20 percent of the Nation's dairy value, and its grape production is 92 percent of the Nation's value. These five crops represent 13 percent of the Nation's agricultural production value.

Table 3-1. Top Five Agricultural Commodities

	% CA Total Farm Receipts	% US Farm Receipts for Crop
Dairy	17	20
Greenhouse/Nursery	11	21
Grapes	10	92
Almonds	7	100
Cattle/Calves	6	4

Source: U.S. Department of Agriculture National Agricultural Statistics Service

Key:
% = percent
CA = California
US = United States

There are at least two key implications of these statistics: (1) California agriculture plays an important role in national food products, and (2) interruptions to this production would be notably costly in terms of direct economic losses to the Nation, resulting from potential replacement through higher cost imports or reductions in output that result in higher commodity prices.

Benefit Valuation Methods

NED benefits from improvements in water supply to agricultural users include the value of increases in agricultural output to the Nation and the cost savings associated with maintaining a given level of output. When water is scarce, farmers may respond by changing cropping patterns, fallowing fields, pumping more groundwater, and/or participating in increased water transfers and exchanges. When water is relatively plentiful, farmers may react by bringing idle fields into production and using increased surface water deliveries instead of pumping groundwater, or engaging in additional groundwater storage and banking. The economic benefits associated with increased water supply reliability to agriculture can be estimated using a variety approaches described in the P&G. Commonly, willingness to pay is measured by the change in net income that would accrue to agricultural producers as a result of changes in water supply conditions. In addition, the P&G recommends consideration of changes in agricultural land values as a possible valuation approach. Given the history of water market purchases in California, it may also be appropriate to consider water transfer market prices to estimate willingness to pay. This analysis provides preliminary benefit estimates produced through the application of the “change in net income” method as estimated by the CVPM.

The above methods identified below have advantages and disadvantages for estimating the value of new agricultural water supplies. Reclamation, however, has traditionally considered the farm budget analysis method its procedure of choice for valuing the economic benefits of changes in irrigation water supply. The CVPM represents an example of a complex farm budget approach.

Accordingly, this method is used to assess agricultural water supply benefits for the SLWRI.

To develop an estimate of value, this analysis applies the CVPM, a mathematical production model that indicates likely cropping and production patterns for given water supply and price scenarios. The output of the model is used to quantify direct on-farm benefits (such as changes in net farm income) that may be included in a quantification of national economic effects. CVPM output may also be used as an input to a regional input-output (I-O) planning model such as IMPLAN® for quantifying regional effects.

It important to note that potential new supplies developed for the SLWRI have been formulated for drought period supplies when new increments of reliable water supply would be most needed. Due to data limitations, the CVPM model is currently calibrated to a dry year as represented by 2001. The calibration year reflects only moderate drought conditions. As a result, the effects of dry years on cropping decisions and production costs may not be fully represented by the model. The CVPM model is run for the long-term average water supply condition to establish the equilibrium crop and technology mix. The model is then run for dry years by considering fixed capital investments established in the long-term run and allowing groundwater pumping and annual crop idling to occur as a result of reduced water supplies. This analysis uses results from both the long-term average and dry year runs to estimate the annual benefit associated with the SLWRI alternatives.

Model assumptions regarding the availability of groundwater and non-project surface water supplies may be overstated in the model. However, currently, limited hydrologic information is available to adjust model assumptions concerning groundwater availability. For SLWRI, groundwater availability and depth during dry years was adjusted in CVPM model Region 14 (Westlands Water District). Specifically, total groundwater pumping was limited to approximately 600,000 acre-feet during dry years. In addition, groundwater pumping lift during dry years was increased by 20 percent above the pump lift during average water years. These adjustments were based upon information reported by Westlands Water District.

Benefit Estimation

Preliminary CVPM Assessment

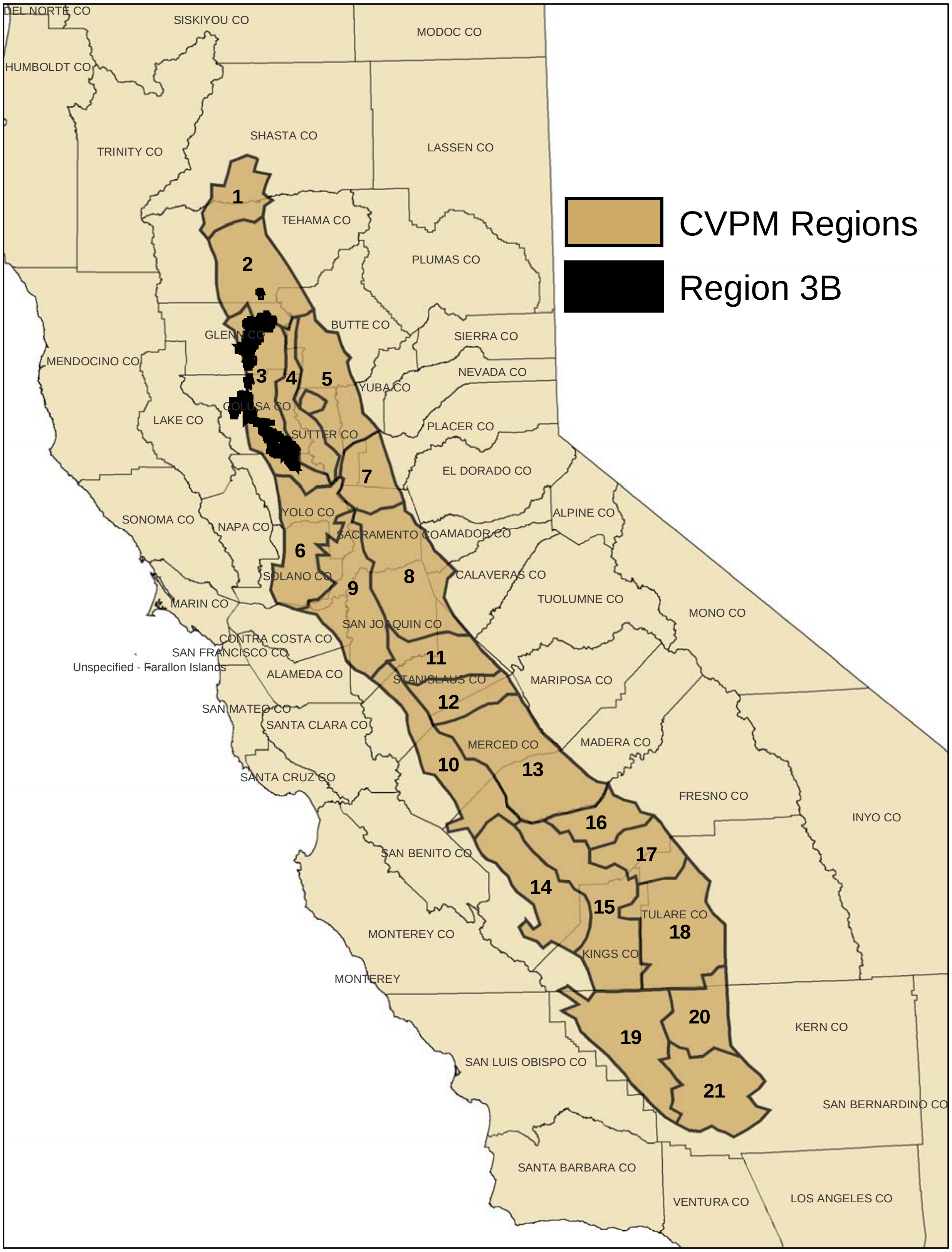
The CVPM is a regional economic model that simulates the decisions of agricultural producers (farmers) in 22 crop production regions in California's Central Valley (Figure 3-1). Major users include CVP contractors and others (Table 3-2). The CVPM predicts cropping patterns, land use, net farm income, and water use for 20 categories of crops (Table 3-3) by considering land availability, water availability and cost, irrigation technology, market conditions, and production costs. Crops examined by the CVPM include both field crops, including cotton, silage corn, rice, and alfalfa, and nonfield crops, including oranges, grapes, almonds, pistachios, and walnuts.

Although the value of California's agricultural production is greater than that of any other state, California is a relatively insignificant producer of field crops (Figure 3-2). In contrast, California is a leading producer of specialty crops. In terms of harvested acres and value, California raises approximately half the cantaloupes, virtually all the processing tomatoes, broccoli, and wine grapes, and all of the almonds and walnuts grown commercially in the United States. Interruptions to critical water supplies used to grow crops that are primarily produced in California would potentially significantly disrupt U.S. food markets, and other industries dependant on agricultural inputs.

Field crops composed 54.2 percent of the harvested acres among the CVPM modeled crops but only 21.9 percent of the total value of these crops. Although nonfield crops accounted for less than half the acreage among all CVPM crops, the value (2003 through 2005 average) for CVPM nonfield crops was nearly 80 percent of the value of all crops included in the CVPM model.

Since 1980, the harvested area and value of field crops in California has declined. The harvested area for nonfield crops in California has increased by approximately 40 percent while the value has increased by approximately 70 percent. The increase in the value of almonds and wine grapes has been especially notable among the crops included in the CVPM.

The CVPM is an application of positive mathematical programming (PMP), a technique that has been applied relatively recently by agricultural economists to examine the potential effects of changes in policy or resource availability. The PMP technique is an optimization approach that can incorporate average as well as marginal conditions to estimate the responses of agricultural producers to changes in resource availability. The CVPM assumes that the diversity of crop production is caused by factors that can be represented as increasing marginal production costs for each crop at a regional level. (For example, costs per acre for cotton production increase as farmers expand cotton production onto more acreage.)



Source: Reclamation, 1999

Figure 3-1. Agricultural Areas Modeled by Central Valley Production Model

Table 3-2. Central Valley Production Model Regions and Descriptions of Major Users

Region	Description of Major Users
1	CVP Users: Anderson-Cottonwood, Clear Creek, Bella Vista, Sacramento River
2	CVP Users: Corning Canal, Kirkwood, Tehama, Sacramento River miscellaneous
3	CVP Users: Glenn-Colusa Irrigation District, Provident, Princeton Codora, Maxwell, Colusa Basin Drain Mutual Water Company
3b	CVP Users: Orland Artois Water District, most of County of Colusa, Davis, Dunnigan, Glide, Kanawha, La Grande, Westside Water District Others: Tehama-Colusa Canal Service Area
4	CVP Users: Princeton Codora Glenn, Colusa Irrigation Co., Meridian Farm Water Company, Pelger Mutual Water Company, Reclamation District 1004, Reclamation District 108, Roberts Ditch, Sartain M.D., Sutter Mutual Water Company, Swinford Tract Irrigation Co., Tisdale Irrigation, Sacramento River miscellaneous users
5	Most Feather River region riparian and appropriative users
6	CVP Users: Conaway Ranch, Sacramento River miscellaneous users Others: Yolo, Solano counties
7	CVP Users: Natomas Central Mutual Water Company, Sacramento River miscellaneous users, Pleasant Grove Verona, San Juan Suburban Others: Sacramento County north of American River
8	Sacramento County south of American River, San Joaquin County
9	CVP Users: Banta-Carbona, West Side, Plainview Others: Delta regions
10	CVP Users: Panoche, Pacheco, Del Puerto, Hospital, Sunflower, West Stanislaus, Mustang, Orestimba, Patterson, Foothill, San Luis Water District, Broadview, Eagle Field, Mercy Springs, Pool Exchange Contractors, Schedule II water rights, more Others: Delta-Mendota Canal
11	Stanislaus River water rights: Modesto Irrigation District, Oakdale Irrigation District, South San Joaquin Irrigation District
12	Turlock Irrigation District
13	Others: Merced Irrigation District
14	CVP User: Westlands Water District
15	CVP Users: Fresno Slough, James, Tranquility, Traction Ranch, Laguna, Real. District 1606. Others: Tulare Lake Bed
16	CVP Users: Friant-Kern Canal. Fresno Irrigation District, Garfield, International Others: Eastern Fresno County
17	CVP Users: Friant-Kern Canal, Hills Valley, Tri Valley Orange Cove
18	CVP Users: Friant-Kern Canal, County of Fresno, Lower Tule River Irrigation District, Pixley Irrigation District, portion of Rag Gulch, Ducor, County of Tulare, most of Delano-Earlimart, Exeter, Ivanhoe, Lewis Creek, Lindmore, Lindsay-Strathmore, Porterville, Sausalito, Stone Corral, Tea Pot Dome, Terra Bella, Tulare
19	Kern County SWP Service Area
20	CVP Users: Friant-Kern Canal, Shafter-Wasco, South San Joaquin
21	CVP Users: Cross Valley Canal, Friant-Kern Canal, Arvin-Edison

Source: Reclamation, 1999
Key:
CVP = Central Valley Project
SWP = State Water Project

Table 3-3. Central Valley Production Model Crop Groupings

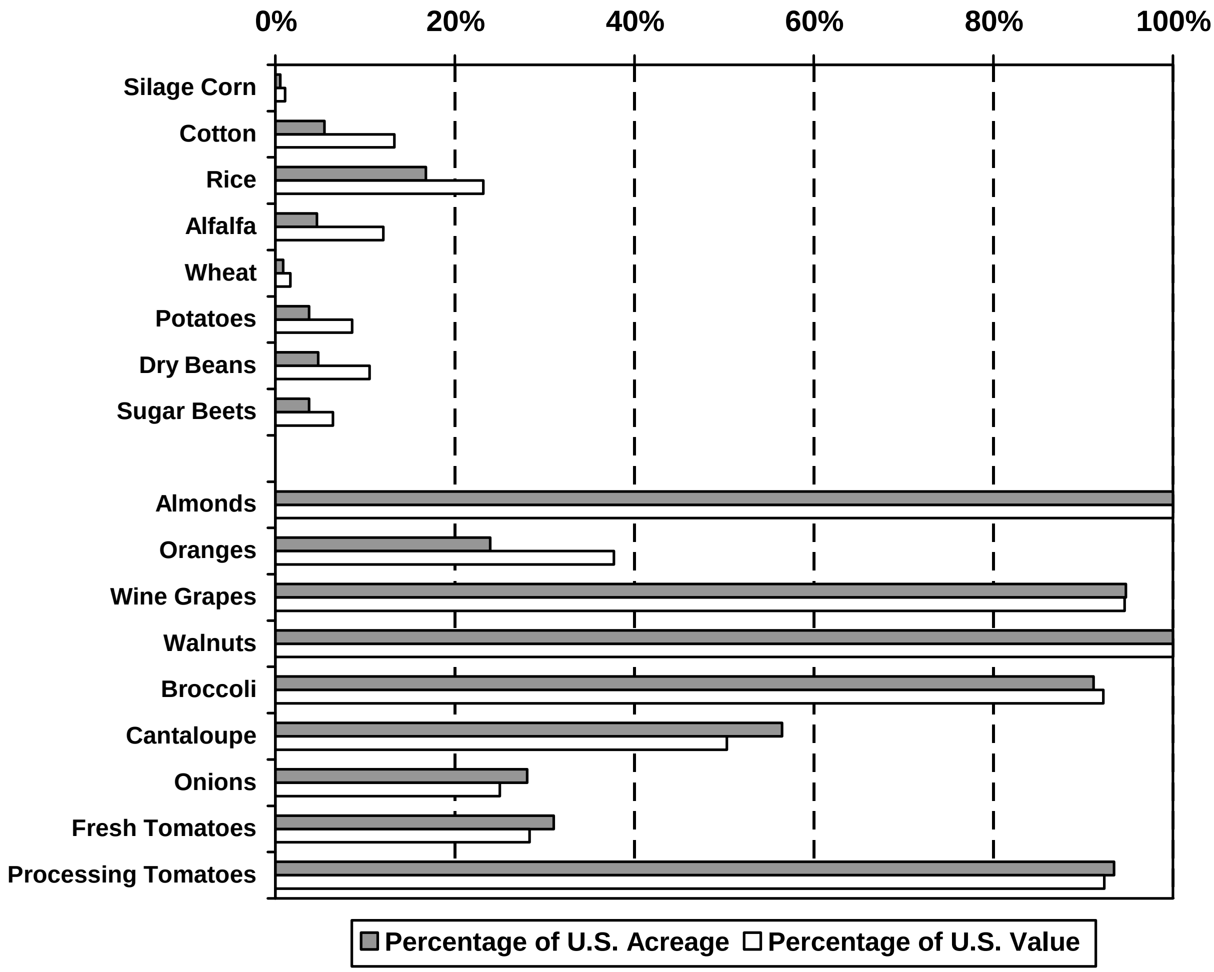
Category	Proxy Crop[1]	Unit of Measure
Grain	Wheat	Tons
Rice	Rice	Tons
Cotton	Cotton	Bales
Sugar Beets	Sugar Beets	Tons
Corn	Corn Silage	Tons
Dry Beans	Dry Beans	Tons
Safflower	Safflower	Tons
Other Field	Sudan Grass	Tons
Alfalfa	Alfalfa Hay	Tons
Pasture	Irrigated Pasture	Acres
Processing Tomatoes	Processing Tomatoes	Tons
Fresh Tomatoes	Fresh Tomatoes	Tons
Cucurbits	Cantaloupe	Tons
Onions and Garlic	Dry Onions	Tons
Potatoes	White Potatoes	Tons
Other Truck	Broccoli	Tons
Almonds and Pistachios	Almonds	Tons
Other Deciduous	Walnuts	Tons
Sub Tropical	Oranges	Tons
Vine	Wine Grapes	Tons

Source: Reclamation, 1999

Notes:

[1] Production costs, yields, and prices for this crop used in the CVPM.

Acreage data for all crops in specific category summed with the proxy crop.



Source: U.S. Department of Agriculture National Agricultural Statistics Service

Figure 3-2. Percentage of Total United States Harvested Acres and Value of Central Valley Production Model Crops Produced in California (2003 – 2005 Average)

The CVPM applies mathematical programming techniques to empirical information on acreage responses and implicit resource prices (shadow prices) based on a calibration period data set (1998, 2000, and 2001). Acreage response coefficients and shadow prices are used to calculate parameters of a quadratic cost function that is consistent with economic theory. The calibrated model is used to predict exactly the original calibration data set, and can then be used to predict impacts of specified policy changes, such as alterations in water supplies.

The CVPM includes tradeoff functions between water use and irrigation costs. Water use is defined as relative applied water (AW), the ratio of AW divided by evapotranspiration of applied water (ETAW). This ratio is the inverse of the most commonly used measure of field irrigation efficiency. Using relative AW, which varies regionally, allows the parameters of the tradeoff functions to be more site-independent.

Economic analysis of benefits from irrigation was based on estimated water deliveries from CalSim-II, a generalized water resources simulation model for evaluating CVP and State Water Project (SWP) operations (see the Modeling Appendix for more information on operations modeling). The modeling studies specify deliveries in 82 years of historical hydrology under the without-project and three with-project scenarios.

The CalSim-II water deliveries were applied to the CVPM model with demands based on a 2030 level of development for the base case (without-project) and each with-project alternative. The following assumptions and decision criteria were made for the agricultural analysis:

- The potential sources for agricultural water include CVP contract supply, CVP water rights and exchange supply, SWP contract supply, SWP interruptible supply, local surface water, and local groundwater. Local surface water and groundwater supplies are assumed to make up any shortages in project water supply availability during the model calibration process due to limited hydrologic data. This assumption is maintained in the estimation stage of the model.

- Water supply is applied independently to each production region. Within each production region, water supplies can move freely (without additional cost) to satisfy crop water needs and minimize production costs.

- Depth to groundwater within each region is held static in the model across with and without project conditions. Changes in surface water deliveries may result in reductions in depth to groundwater in some regions. Currently, no groundwater model is available to estimate the long-term changes. Consequently, the benefits of additional surface water supply may be understated.

Estimates for dry year and average deliveries to irrigation water user located north and south of Delta for CP1 through CP5 are shown in Table 3-4. Weighted average changes in deliveries are based on the probability of each year type. Weighted average and dry year changes in deliveries for each CVPM region are shown in Table 3-5.

Table 3-4. Changes in CVP/SWP Irrigation Deliveries Relative to Without Project Conditions

CVPM Year Type	CP1 (acre feet)	CP2 (acre-feet)	CP3 (acre-feet)	CP4 (acre-feet)	CP5 (acre-feet)
Dry/Critical NOD[1]	7,800	17,100	25,300	7,800	25,300
Dry/Critical SOD[1]	42,600	66,900	86,300	42,600	86,300
Average – All Years NOD	5,200	11,500	16,100	5,200	16,100
Average – All Years SOD	22,700	36,200	43,700	22,700	43,700

Note:
[1] Year-types as defined in the Sacramento Valley Water Year Hydrologic Classification Index.
Key:
CP = comprehensive plan
CVP = Central Valley Project
CVPM = Central Valley Production Model
NOD = North of Delta
SOD = South of Delta
SWP = State Water Project

Table 3-5. Estimated Changes in Water Deliveries by Central Valley Production Model Region

CVPM Region	CP1		CP2		CP3		CP4		CP5	
	Average (TAF)	Dry (TAF)	Average (TAF)	Dry (TAF)	Average (TAF)	Dry (TAF)	Average (TAF)	Dry (TAF)	Average (TAF)	Dry (TAF)
R1	1.0	1.0	2.0	2.0	2.0	3.0	1.0	1.0	2.0	3.0
R2	1.0	1.0	1.0	2.0	2.0	2.0	1.0	1.0	2.0	2.0
R3	-1.0	-1.0	-1.0	-1.0	0.0	1.0	-1.0	-1.0	0.0	1.0
R3B	5.0	8.0	10.0	16.0	14.0	22.0	5.0	8.0	14.0	22.0
R4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R9	0.0	0.0	1.0	1.0	1.0	1.0	0.0	0.0	1.0	1.0
R10	5.0	8.0	8.0	15.0	9.0	19.0	5.0	8.0	9.0	19.0
R11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R14	10.0	21.0	19.0	38.0	24.0	51.0	10.0	21.0	24.0	51.0
R15	1.0	2.0	1.0	2.0	1.0	2.0	1.0	2.0	1.0	2.0
R16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R19	4.0	5.0	3.0	4.0	3.0	4.0	4.0	5.0	3.0	4.0
R20	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0
R21	1.0	2.0	1.0	2.0	1.0	2.0	1.0	2.0	1.0	2.0
Total	27.0	48.0	45.0	82.0	57.0	108.0	27.0	48.0	57.0	108.0

Note:
Totals may not add due to rounding.
Key:
CP = comprehensive plan
CVPM = Central Valley Production Model
TAF = thousand acre-feet

Agricultural water supply reliability benefits are measured by the expected changes in net farm income relative to the without-project conditions for each of the proposed alternatives for long-term average and dry year conditions (Table 3-6). (The values for CP1 and CP4 are identical because both release the same quantities of agricultural water supplies.) Increases in the average annual net farm income range from $8.3 million for CP1 and CP4 to $12.9 million for CP3. Table 3-7 presents the estimated annual agricultural water supply reliability benefits by SLWRI alternative.

Table 3-6. Expected Change in Net Farm Income, Relative to Without-Project Conditions, for All Central Valley Production Model Regions, by Year Type

Item	Average Year Type ($1,000)	Dry Year Type ($1,000)	Weighted Average ($1,000)
CP1 6.5-foot raise	2,956	17,753	8,283
CP2 12.5-foot raise	4,857	21,796	10,955
CP3 18.5-foot raise	6,072	25,054	12,905
CP4 18.5-foot raise	2,956	17,753	8,283
CP5 18.5-foot raise	6,072	25,054	12,905
Year Type Probabilities (%)	0.64	0.36	----

Key:
CP = comprehensive plan

Table 3-7. Estimated Agricultural Water Supply Reliability Annual Benefits by Alternative

Year Type	CP1 ($ millions)	CP2 ($ millions)	CP3 ($ millions)	CP4 ($ millions)	CP5 ($ millions)
Average (all years)	8.3	11.0	12.9	8.3	12.9

Notes:
Dollar values are expressed in April 2010 price levels.
Key:
CP = comprehensive plan

Municipal and Industrial Water Supply Reliability

The SLWRI alternatives increase water supplies to M&I water users, especially during dry years. The M&I water supply benefits largely accrue to SWP contract holders located south of the Delta. Estimates for dry year and average deliveries to M&I water users located north and south of the Delta for CP1 through CP5 are shown in Table 3-8.

Table 3-8. Changes in CVP/SWP M&I Deliveries

CVPM Year Type	CP1 (acre-feet)	CP2 (acre-feet)	CP3 (acre-feet)	CP4 (acre-feet)	CP5 (acre-feet)
Dry/Critical NOD[1]	1,800	2,700	4,300	1,800	4,300
Dry/Critical SOD[1]	24,200	18,400	17,500	24,200	17,500
Average – All Years NOD	1,000	1,600	2,300	1,000	2,300
Average – All Years SOD	17,500	13,500	13,700	17,500	13,700

Note:
[1] Year-types as defined in the Sacramento Valley Water Year Hydrologic Classification Index.

Key:
CP = comprehensive plan
CVP = Central Valley Project
CVPM = Central Valley Production Model
M&I = municipal and industrial
NOD = North of Delta
SOD = South of Delta
SWP = State Water Project

In this analysis, the benefits to M&I water users are measured according to the cost of the most likely alternative water supply that would be pursued in the absence of development of the alternative plans. For water supply reliability benefits, the cost of the most likely alternative represents the next unit of water supply the water user would purchase or develop if the project under consideration were not in place. The cost of the most likely alternative plan assumes that if the preferred alternative plan is not implemented, the alternative action most likely to take place provides a relevant comparison. If the preferred alternative plan provides the same output as the most likely alternative plan at a lower cost, the net benefit of the preferred alternative plan is equal to the difference in the project costs.

M&I water users have increasingly relied on the water transfer market to augment existing supplies and avoid shortages. This analysis relies in part on market prices paid to purchase water on an annual basis from willing sellers. The market prices are reported according to the payments made directly to the sellers. The buyers incur additional costs to convey the water to their M&I service areas. These costs include both conveyance losses, which diminish the volume of water delivered to end users, as well as wheeling and power charges. The conveyance costs are estimated for M&I water users benefiting from the alternative plans, and added to the estimated market prices to acquire the water to develop an estimate of the full cost associated with additional water supply obtained in the transfer market.

Figure 3-3 illustrates the information used to estimate the value of M&I water supplies.

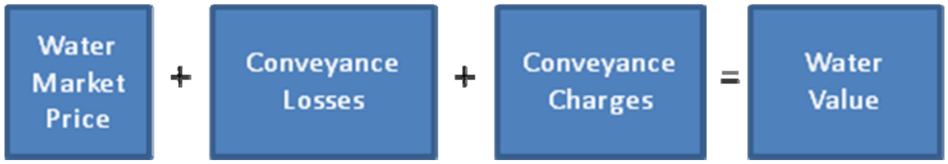


Figure 3-3. General M&I Water Value Estimation Procedures

Data and estimation methods are described below.

Water Market Prices

A database of California water market sales was developed for use in this analysis. Information for each transaction was researched and recorded to allow statistical analysis of a variety of factors influencing water trading activity and prices. During the research, transactions occurring from 1990 through July 2008 were documented. The transactions were filtered for this analysis according to the following criteria:

- Water sales originating outside the operating region of the SWP facilities were excluded. These regions include the North Coast, North Lahontan, and South Lahontan regions.
- Permanent water sales were excluded.
- "Within-project" transfers were removed from the analysis because they do not reflect "arms-length" transactions.
- Transactions associated with SWP Turnback Pool supplies were excluded because they are associated with rules that limit market participation.
- Purchases of "flood" supplies were excluded.
- Reclaimed and desalination water sales were removed from the analysis.
- Water sales with incomplete or inadequate information were excluded.

Following application of the above criteria, 472 long- and short-term transfers remained to support the statistical analysis. All prices are adjusted to 2008 dollars using the U.S. Consumer Price Index. As previously described, prices and volumes are presented from the seller's perspective and do not include conveyance charges or losses.

Although Federal and State government agencies have recently been more active in recording some information related to water sales or leases, California has few sources that track water transfers between private individuals. Most of the recorded transfers involve a Federal or State government party either because an agency had to approve the transfer, as is the case when a transfer involves CVP or SWP water, or because the government agency was directly involved in the transfer as a purchaser or a seller. Transfers involving private parties are more difficult to track because the State does not have any reporting requirements. California law states that single-year water transfers issued before 1914 are allowed without review as long as they do not adversely impact the water rights of a third party (CALFED, 2000). For water rights issued after 1914, the buyer and seller can petition the State Water Resources Control Board (SWRCB) for a 1-year temporary transfer. Nonetheless, prices for these transfers are not well documented. As a result, the data for this study were obtained from a mixture of public and private sources. Public sources include the following:

- Water Acquisition Program (WAP), Reclamation
- Resources Management Division, Environmental Water Account (EWA)
- State Water Bank, California Department of Water Resources (DWR)
- OnTap database, California DWR
- SWRCB, California Environmental Protection Agency (Cal/EPA)

These sources provided information on the WAP, EWA, State Water Bank, and other public water transfers. State Water Bank observations included transfers to the State Water Bank to capture the price the seller receives.

Information on water transfers was also obtained from the January 1990 through December 2010 issues of Water Strategist Monthly. The publication, previously called Water Intelligence, assembles information on public and private water transfers. Although not all transfers are recorded in the Water Strategist, the publication represents a primary source for water market research. Many of the transfers reported in the Water Strategist were independently researched to obtain more specific information and confirm transaction terms. In addition, transactions not covered by the Water Strategist were researched and verified through communication with the transfer participants.

Estimation Procedures

This study builds on a previous analysis completed by Mann and Hatchett (2006) by applying an expanded data set and considering additional factors that may describe water market trading activity and prices. Similar to the Mann and

Hatchett (2006) analysis, the water transfer pricing regression applied in this study is estimated using a recursive specification. The first regression estimates the unit price for water trades and the second estimates the level of water trading activity. The coefficients from the models are used to forecast water prices north of the Delta (NOD) and south of the Delta (SOD) over the 100-year planning period.

This study applies a water transfer pricing regression model. The model theorizes that prices and volume of water traded can be estimated through consideration of the following market factors: water supply, geographic location, real water price escalation, buyer type, water type/source, contract terms, and state water banking programs.[2] These factors are described below.

Water Supply

As previously described, hydrologic conditions are a primary driver of water transfer market activity and prices. Therefore, it is important to include a variable that appropriately captures water supply conditions to describe water trading activity. In this analysis, water supply conditions are measured using the Sacramento Valley Water Year Hydrologic Classification Indices (DWR, 2007).

Geographic Location

Water prices and trading activity vary by location according to water year type. Consequently, the origin of the water source for each transaction is used to determine geographic differences in water prices. In addition, prices in long-distance trades are often higher than prices observed in trades among entities located within the same region. These differences reflect regional water conveyance constraints, the costs of accessing alternative water supplies, and local political restrictions that limit the supply of water that can be marketed. Water sales applied in the regression analysis were allocated among the Water Transfer Analysis Regions identified by the Common Assumptions Economic Workgroup (CH2M Hill, 2006). Binary variables are used to denote the different geographic regions.

Real Water Price Escalation

Due to the growing urban water demand in the State, population is considered to have an important influence on past and future water transfer prices. The water trading activity equation uses population within the SOD regions to isolate the impact of population growth on water transfer demand and water right prices. Population forecasts prepared by California Department of Finance (CDF) are then used to estimate future changes in water transfer demand and prices. In addition, the price equation includes an independent variable representing the year in which each transaction occurred.

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[2] Additional demand and supply factors were tested in the model but did not result in an improvement in overall explanatory power.

Buyer Type

Previous economic analyses of water prices have concluded that the type of buyer (e.g., M&I, agricultural, and environmental) can influence water prices. The regression water pricing model tests the influence of buyer type on water price. In this analysis, binary variables are used to estimate price differences between environmental, urban, and agricultural buyers.

Contract Terms

The terms of the contract between buyer and seller often influence water prices. This is particularly true in California, where environmental documentation is required for some types of long-term and permanent transfers. Consequently, this analysis distinguishes between transactions with short- and long-term (more than 1 year) contracts. Short-term contracts were used to measure spot-market prices. These contracts best represent current prices because they are negotiated annually. Both long- and short-term contracts were used to estimate the annual volume of water traded. Long-term contracts were included only if the water had actually been traded during the year. The volume of water traded through both short- and long-term trades represents the amount of water being moved throughout the market region to meet annual water demands. This volume is expected to affect spot-market prices because it represents annual water demand.

Drought Water Bank

The State has participated in the water market during drought years to facilitate trades. Under this program, DWR sets up a state water bank to buy water primarily NOD and sell the water to agricultural and urban water users facing shortages. To account for the market conditions that existed during operation of the state water bank, a binary variable is included in the model to isolate the transactions from other observations included in the regression analysis.

Model Results

Two equations are constructed to estimate the economic benefits of increased M&I water supplies. The first equation forecasts water transfer prices based on hydrologic conditions, price appreciation over time, water supplier region, buyer type, and premiums associated with DWR Drought Water Bank transactions. Information on 472 short-term water right transactions is included in the data, allowing the model to forecast spot-market prices.

The second equation predicts the total annual volume of water traded. Total annual trading volume is calculated using 750 short-term and long-term contracts, and is reported in thousands of acre-feet. The trading volume equation projects total annual volume traded based on hydrologic conditions, SOD population, and water transfer prices predicted by the first equation. The use of predicted prices in the trading volume equation rather than observed prices recognizes that price and volume are jointly determined. The estimation results of the model are provided below.

Equation 1

$$lnadjprice=dwb+sc+nod+local+lnfswp+lnyear+env+ag+e$$

lnadjprice=Natural Logarithm of Price per Acre-Foot, Adjusted to 2010 Dollars

dwb=State Water Bank/ Dry Year Water Acquisitions (binary)

sc=South Coast Region Water Supplier (binary)

nod=North of Delta Water Supplier (binary)

local=Water Transfer among Parties Located within the same Hydrologic Region (binary)

lnfswp=Natural Logarithm of Annual Final State Water Project Allocation to M&I Contractors

lnyear=Natural Logarithm of the Year in which the Transfer Occurred

env=Environmental Water End Use (binary)

ag=Agricultural Water End Use (binary)

e=Error Term

Equation 2

$$lntaft=lnfswp+lnsodpop+lnadjpricehat+e$$

lntaft=Natural Logarithm of Total Acre-Feet Traded Annually (thousands)
lnfswp=Natural Logarithm of Annual Final State Water Project Allocation to M&I Contractors
lnsodpop=Natural Logarithm of Population SOD (thousands)
lnadjpricehat=Values of the Variable lnadjprice Predicted by Equation 1
e = Error Term

Table 3-9. Two-Stage Least-Squares Regression Results

Equation	Obs	Parms	RMSE	"R-sq"	F-Stat	P
lntaft	472	3	0.2721692	0.3115	76.44	0.0000
lnadjprice	472	8	0.618206	0.4452	46.44	0.0000

Stage 1: Dependent Variable *lnadjprice*						
	Coef.	**Std. Err.**	**t**	**P>|t|**	**95% Conf. Interval**	**95% Conf. Interval**
dwb	0.29224	0.0891954	3.28	0.001	0.1171926	0.4672874
sc	0.5909642	0.1074342	5.50	0.000	0.3801229	0.8018055
nod	-0.1839191	0.0649516	-2.83	0.005	-0.3113875	-0.0564506
local	-0.1298763	0.0669075	-1.94	0.053	-0.2611834	0.0014307
lnfswp	-0.4751585	0.0690034	-6.89	0.000	-0.6105788	-0.3397382
lnyear	97.86914	8.185232	11.96	0.000	81.80549	113.9328
env	-0.2405238	0.0853025	-2.82	0.005	-0.4079313	-0.0731163
ag	-0.3912467	0.0703602	-5.56	0.000	-0.5293296	-0.2531638
constant	-739.1594	62.22522	-11.88	0.000	-861.2773	-617.0414
Stage 2: Dependent Variable *lntaft*						
	Coef.	**Std. Err.**	**t**	**P>|t|**	**95% Conf. Interval**	**95% Conf. Interval**
lnfswp	-0.3536926	0.036255	-9.76	0.000	-0.4248436	-0.2825416
lnsodpop	1.847673	0.1958277	9.44	0.000	1.463358	2.231988
lnadjpricehat	-0.1135604	0.0402871	-2.82	0.005	-0.1926244	-0.0344964
constant	-12.21379	1.902784	-6.42	0.000	-15.94803	-8.479543

Key:
Coef. = coefficient
Conf. = confidence
F-stat = Value calculated by the ratio of two sample variances
P = the probability of obtaining a test statistic at least as extreme as the one that was actually observed, assuming that the null hypothesis is true
Parms = parameters
RMSE = root mean square error
R-sq = R-squared value
Std. Err. = standard error
t = a ratio of the departure of an estimated parameter from its notional value and its standard error

All estimated relationships between dependent and independent variables are statistically significant at the 99 percent confidence level, with the exception of *local* which is statistically significant at the 90 percent level. A log-log specification was selected for both equations. Box-Cox transformations show that this specification is preferable to linear or semi-logarithmic equations. In addition, the alternate specifications tested decreased the model's fit. The logarithmic relationships between dependent and independent variables can be interpreted as elasticities. For example, the coefficient of approximately -0.48 on the variable *lnfswp* in the price equation indicates that a 1 percent increase in the final SWP allocation is associated with a 0.48 percent decrease in water transfer prices, all else equal.

Equation 1 Discussion

The variable *lnfswp* is a measure of annual water availability. The SWP allocation decreases during drought conditions. Regulatory actions such as the recent Wanger decision can further impact SWP deliveries. The inverse relationship between *lnadjprice* and *lnfswp* is attributable to increased demand for additional water supplies under the hydrologic and regulatory scarcity conditions that drive reduced SWP allocations.

The coefficient value on the variable *lnyear* indicates that water transfer prices rose at a real rate of approximately 4.9 percent between 1990 and 2010. The binary variables in the price equation describe conditions that influence prices but are qualitative in nature. The coefficients for *env* and *ag* represent the influence that end-water use has on price. When these variables are zero, the model estimates prices to urban water users. Agricultural and environmental water users generally paid more for water than urban users, as indicated by the positive coefficients on the two variables. The results show environmental water buyers pay 24 percent less per acre-foot than urban buyers in the market, all else equal. Similarly, water leases for agricultural use were priced 39 percent per acre-foot less than urban water leases, all else equal.

dwb is an indicator of State water leases through the Drought Water Bank of 1991, 1992, 1994, and 2009. The binary variable is used to account for the price discovery that occurred during operation of the bank. The coefficient value indicates that water leased under the Drought Water Bank was priced 29 percent higher than other transactions, all else equal.

sc and *nod* are binary variables measuring the difference between NOD and SOD water prices. SOD was separated into two regions because of differences in market conditions and conveyance infrastructure. Water transactions involving sellers in the South Coast region were priced 60 percent higher than other SOD transactions. Sales from NOD suppliers attract 18 percent lower prices than sales from SOD suppliers outside of the South Coast region, all else equal.

The variable *local* assumes a value of “1” for transfers among entities located within the same hydrologic region, and “0” for water trades across regions. The coefficient value indicates that prices for sales within the same hydrologic region are 13 percent lower than prices for longer-distance trades, all else equal. The estimated coefficient value can be attributed to physical and regulatory constraints that limit the mobility of specific water sources and entitlements.

Equation 2 Discussion

The second equation estimates total annual water market activity in short-term and long-term transfers according to hydrologic conditions, demand, and the current range of water transfer prices. The coefficients are used to project the volume of water traded over the analysis period.

The dependent variable in the second equation, *lntaft*, is measured as the total annual volume of water (in thousands of acre-feet) traded in regions within the SWP service area through the recorded short-term and long-term lease agreements since 1990. As shown, the level of market activity holds an inverse relationship with water transfer prices (*lnadjpricehat*), indicating a down-sloping demand curve. Under the same hydrologic and demand conditions, more water trading occurs as prices drop.

lnsodpop assumes the value of total population located SOD in thousands of people (CDF, 2007).[3] This variable serves as a proxy for rising water demand over time. The positive association between trading volume and *lnsodpop* is consistent with expectations that water market activity occurs partially in response to population growth.

Several different proxies for physical water scarcity conditions were tested, including annual CVP allocations, the Sacramento River Water Year Index, and a binary variable separating dry and critically dry years from wetter years. The selected variable *lnfswp* held the strongest statistical relationship with *lntaft*, and has the capacity to shows changes in water availability due to legal changes as well as hydrologic changes.

Future Water Market Prices

In this section, the model is used to project water prices to 2030 by geographic region and hydrologic condition.

Table 3-10 provides estimated water market prices for municipal water acquisitions for selected years. *NOD* and *SODO* were selected as supplier regions used to estimate the value of the project alternatives. During wet and above normal water years, the analysis applies *SODO* prices to value increased M&I supplies due to conveyance limitations for NOD supplies. During below normal, dry, and critical-dry years, the analysis applies NOD prices due to increased capacity to move the relatively less expensive NOD water through the Delta. As shown, the estimated water market price difference between wet and dry years is relatively low. This is likely the result of few dry years during recent periods of the model data. As a result, it is expected that the estimated dry year prices are less than those that will be observed during future dry conditions.

[3] The California Department of Finance only calculates projections by county. The projections displayed are based on counties with a majority of their population residing south-of-Delta using the California Department of Water Resources California Interagency Watershed Map of 1999.

Table 3-10. Estimated M&I Water Prices ($/acre-foot)*

	2010		2030	
	NOD	**SOD**	**NOD**	**SOD**
Wet	$154	$185	$407	$489
Above-Normal	$172	$206	$452	$543
Below-Normal	$197	$236	$518	$623
Dry	$225	$271	$594	$714
Critical	$254	$305	$669	$805

Note:
*Estimated prices are for water transferred among parties located in different hydrologic regions.
Key:
Above Normal = Final SWP allocation assumed to be 80%
Below Normal = Final SWP allocation assumed to be 60%
Critical = Final SWP allocation assumed to be 35%
Dry = Final SWP allocation assumed to be 45%
M&I = Municipal and industrial
NOD = Supplier located North of the Delta
SOD = Supplier located South of the Delta, excluding South Coast region suppliers
Wet = Final SWP allocation assumed to be 100%

Water Conveyance Costs

The cost to convey water to M&I users is estimated according to the cost to move water through SWP facilities. Conveyance cost varies by location and user type. For example, SWP contractors pay a unit variable cost to move water based on a melded power rate. In comparison, non-SWP contractors pay a wheeling charge for access to SWP facilities in addition to a market rate for the power required to pump the water. As a result, non-SWP contractors incur significantly higher conveyance costs. This section reviews water conveyance costs by buyer type and describes how the information is applied to value the M&I water supply reliability benefits of the alternative plans.

SWP Contractors

DWR charges SWP contractors a Delta water charge and a transportation charge capital cost.

- **Delta water charge –** The Delta water charge is a unit charge applied to each acre-foot of SWP water the contractors are entitled to receive according to their contracts. The charges cover the repayment of all outstanding costs of the project conservation facilities.

- **Transportation charge capital cost component –** The transportation charge capital cost component covers the cost of using the facilities to transport water. The transportation component includes a capital cost for the transportation facilities, a minimum fee for operation of these facilities, and a variable unit cost for water delivery.

The variable unit of the transportation charge capital cost component best represents the conveyance cost that a SWP contractor would incur if it were to purchase water and convey water using SWP facilities. The variable cost reimburses the State for operating costs that depend on the quantities of water delivered to the contractors. The cost is based on the following factors (DWR, 2006b):

- Power purchase costs
  - Capacity
  - Energy
  - Pine Flat bond service, operations and maintenance (O&M), and transmission costs allocated to aqueduct pumping plants
- Alamo, Devil Canyon, Warne, and Castaic power generation credited at the powerplant reach and charged to aqueduct pumping plants
- Hyatt-Thermalito Diversion Dam powerplant generation charged to aqueduct pumping plants (credits for this generation are reflected in the Delta Water Rate)
- Replacement deposits for equipment at pumping plants and powerplants
- Credits from sale of excess SWP system power
- Program costs (portion) to offset annual fish losses resulting from pumping at Banks Pumping Plant (DWR-DFG)

The variable unit cost is paid monthly following actual water delivery. The charges are projected based on a unit charge per acre-foot established on or before July 1 of the preceding year. Those unit charges may be revised during the year to reflect current power costs and revenues. Bulletin 132-05 (DWR, 2006a) provides historic and projected variable unit cost by location (reach) from 1961 to 2035. Table 3-11 provides the 2016 projected conveyance cost.

Table 3-11. SWP Estimated M&I Conveyance Cost by Region for 2016

Buyer Region	Point of Reference (reach in region)	2016 Projected Conveyance Cost
North Bay Aqueduct	Reach 3a Cordelia Pumping Plant	$25.99
South Bay Aqueduct	Reach 1 South Bay and Del Valle Pumping Plants	$49.20
North San Joaquin Division	Delta Bay through Bethany Reservoir	$7.84
San Luis Division	Reach 4 California Aqueduct	$19.33
South San Joaquin Division	Reach 15A Teerink Pumping Plant	$39.95
Mojave Division	Reach 22b Pearblossom Pumping Plant	$183.03
Santa Ana Division	Reach 26a South Portal	$151.81
West Branch	Reach 29j Pyramid Lake	$130.46
Coastal Branch	Reach 33a Devil’s Den Pumping Plant	$131.83

Source: California Department of Water Resource, 2006a. Management of the California State Water Project: Bulletin 132-05. Table B-17 Unit Variable OMP&R Component of Transportation Charge. December.

Non-SWP Contractors

Non-SWP contractors pay a different rate to wheel water through the SWP facilities. The primary difference is the cost of power. SWP contractors pay a melded rate for power that is below the market rate while non-SWP contractors pay the market rate for power. In addition, non-SWP contractors pay a different wheeling rate for access to SWP facilities. This analysis applies the non-SWP conveyance costs to estimate willingness to pay because they are considered to be more reflective of the opportunity cost for use of the resource.

The following variables are used to estimate conveyance costs:

- **SWP Wheeling Rate –**The non-SWP contractor wheeling rate includes the O&M and capital costs for transportation and conservation facilities, and a cost for direct fish losses (Jones 2006). Wheeling rates were derived for each region by taking the volume-weighted average of annual quantities delivered from each canal (DWR, 2006b). The SWP wheeling rate is listed by region in Table 3-12. The rate ranges from $15 per acre-foot for San Luis Division buyers to $689 per acre-foot for buyers in the Coastal Branch of the California Aqueduct. The wheeling rate is provided separately for the Metropolitan Water District of Southern California (MWDSC) because the district receives its water from two different regions where rates vary significantly.

- **Power Costs –** In addition to the SWP wheeling rate, non-SWP contractors pay for power used at the pumping facilities. Power costs are available from the Dow Jones SP15 Index (DJ 2002–2006). Path 15 is an 84-mile-long power transmission corridor running north and south through California’s Central Valley. SP15 connects Southern California with the northern part of the state. The index provides the volume-weighted averages of wholesale day-ahead firm physical electricity transactions for SP15. This study uses the index's weighted average off-peak and peak annual price from 2002 to 2006 to estimate power costs. The power rate is listed in Table 3-12.

- **Cumulative Power Demand –** The amount of power required is based on DWR's estimations of power use per acre-foot for SWP power facilities (DWR, 2006b). A pumping plant facility is selected as a reference delivery point for each region. For example, the Cordelia Pumping Plant is chosen as the plant used for buyers wheeling water to the North Bay Aqueduct. Table 3-12 lists the point of reference for each buyer region and the associated cumulative power demand.

Estimated Conveyance Losses

Water delivery results from the CalSim model incorporate conveyance losses. Consequently, it is necessary to estimate conveyance losses to adjust estimated water market prices according to the geographic source of the supply. For example, an estimated delivery from CalSim of 1,000 acre-feet to an M&I user may require the purchase of 1,100 acre-feet at the source if 10 percent conveyance losses apply. Due to limited information regarding convey losses and specific sources of the transfer water, this analysis applies a 20 percent conveyance loss to water originating NOD. Conveyance losses for water supplies originating SOD were not considered.

Table 3-12. Estimated M&I Conveyance Costs by Region

Contractor Region	Reach	Pumping Plant	Cumulative Power Demand from the Delta (kWh/acre-foot)	Power Rate ($/kWh)	SWP Wheeling Rate ($/acre-foot)	Total Conveyance Cost ($/acre-foot)
North Bay Aqueduct	1,3a,3b	Cordelia-Napa	786	0.049	152	191
South Bay Aqueduct	1, 2, 4-9	South Bay and Del Valle	1,165	0.049	61	119
North San Joaquin Division	1	Banks	296	0.049	15	30
San Luis Division	4	Dos Amigos	434	0.049	28	49
South San Joaquin Division	10s,12e,12a,11 b,13b, 16a	Teerink	971	0.049	37	85
Mojave Division	19, 20a, 20b, 21, 22a, 22b, 24	Pearblossom to West Fork Mojave River	4,549	0.049	175	389
Santa Ana Division	22b, 22a	Crafton Hills	6,507	0.049	164	485
West Branch	30	Oso	4,126	0.049	175	378
Coastal Branch	35	Devil's Den through Tank I	1,416	0.049	689	759
Metropolitan Water District	36a, 28h, 28j, 30	Oso; Cherry Valley	4,126; 6,731	0.049	117	446

Sources: California Department of Water Resources, Management of the California State Water Project: Bulletin 132-05. Table B-17 Unit Variable OMP&R Component of Transportation Charge, December 2006.

California Department of Water Resources, Management of the California State Water Project: Bulletin 132-05. Table 7. Kilowatt-Hour Per Acre-Foot Factors for Allocating Off-Aqueduct Power Facility Costs, December 2006.

Dow Jones (DJ). 2002–2006. Dow Jones U.S. Daily Electricity Price Indexes: DJ South Path 15.

Jones, Jon. 2008 Charges for Wheeling Non-State Water Project Water Through State Water Project Facilities, State Water Project Analysis Office Division of Operations and Maintenance, Sep. 19, 2006.

Key:
kWh= kilowatt hour
M&I= municipal and industrial
SWP= State Water Project

Combined water market prices and conveyance costs are illustrated in Figure 3-4. The values reflect the cost of water to M&I users by location within the SWP system in 2010 assuming a critical year.

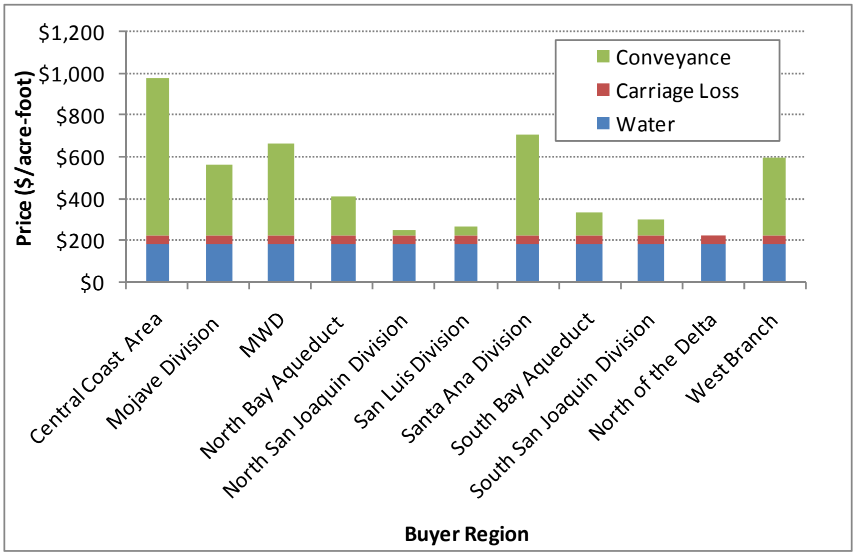

Figure 3-4. Estimated 2008 Water Cost for M&I Water Use During a Critical Water Year

Table 3-13 presents the estimated annual M&I water supply reliability benefits by SLWRI alternative.

Table 3-13. Estimated Annual M&I Water Supply Reliability Benefits by Alternative

Year Type	CP1 ($ millions)	CP2 ($ millions)	CP3 ($ millions)	CP4 ($ millions)	CP5 ($ millions)
Average (all years)	18.7	14.0	13.8	18.7	13.8

Notes:
Dollar values are expressed in April 2010 price levels.
Key:
CP= Comprehensive Plan

Total Water Supply Reliability Benefits

Total water supply benefits (Table 3-14) are the sum of the agricultural water supply reliability benefits and M&I water supply reliability benefits. Total water supply reliability benefits range from $25.0 million for CP2 to $27.0 million for CP1 and CP4.

Table 3-14. Total Average Annual Water Supply Reliability Benefit Estimates

Type	CP1 ($ millions)	CP2 ($ millions)	CP3 ($ millions)	CP4 ($ millions)	CP5 $ millions)
Agricultural Water Supply	8.3	11.0	12.9	8.3	12.9
M&I Water Supply	18.7	14.0	13.8	18.7	13.8
Total	27.0	25.0	26.7	27.0	26.7

Notes:
Dollar values are expressed in April 2010 price levels.
Key:
CP = comprehensive plan
M&I – municipal and industrial

Sensitivity Analysis

It is assumed in the above analysis that water supply reliability benefits will remain relatively constant over the 100-year period of analysis. This section includes a preliminary assessment of possible changes in water supply reliability benefits if the value of available and reliable supplies were to increase in real terms over the project planning period. For many reasons, it is expected that net water demands for all purposes will increase in the future. This assessment is to attempts to account for the expected net increase in demand under a without-project future condition of no new projects constructed. Values computed in this sensitivity analysis are displayed but not applied as NED benefits.

Several economic and demographic trends suggest the possibility of an increase in the value of reliable water supplies in the decades ahead. Population growth is one of the driving factors in this trend toward an increase in the value of water in the future. Because of increasing demands on a relatively fixed water supply existing water storage capacity is likely to grow increasingly valuable as water shortages become more frequent and severe. In addition, shifts in cropping patterns from field crops to fruits, nuts, and vegetables may contribute to future increases in the value of water supply reliability as more irrigation water is applied to high-valued commodities. Among the specialized commodities are permanent crops, such as almonds, walnuts, and grapes, which require reliable water supplies and will result in a “hardening” of water demand in the agricultural sector. As this trend continues, it is likely that agriculture will have less flexibility during dry years to transfer water supplies to other users. This demand hardening, in combination with increases in urban water demand will result in increases in the value of reliable water supplies.

Compounding these trends is the uncertainty associated with an apparent warming climate. As California, the United States, and others prepare for the contingencies of global warming, the demand for and value of water supply reliability will rise.

Table 3-15 shows the resulting increase in water supply benefits for agricultural and M&I uses for CP1 through CP4, assuming a 1- and 2-percent increase in the real rate of benefit values. As water becomes more limited in the future, it is believed highly certain that the relative benefit of new storage will substantially increase. The actual rate of this benefit increase above other factors (construction costs for instance) is not known. However, a 1- or 2-percent increase likely represents a conservative estimate. As illustrated by the table, relatively minor annual increases in values over the project planning period have a significant on the total estimated benefits.

Table 3-15. Relative Sensitivity of Change in Water Supply Reliability Benefits Relative to Without-Project Conditions

Assumed Change in Water Supply Reliability Benefits	CP1 ($ millions)[1 2]	CP2 ($ millions)	CP3 ($ millions)	CP4 ($ millions)	CP5 ($ millions)
One Percent Above Inflation					
Agricultural Water Supply	10.6	14.0	16.5	10.6	16.5
M&I Water Supply	23.9	18.0	17.7	23.9	17.7
Total[3]	34.5	32.0	34.2	34.5	34.2
Two Percent Above Inflation					
Agricultural Water Supply	14.3	18.9	22.3	14.3	22.3
M&I Water Supply[4]	32.2	24.2	23.8	32.2	23.8
Total[3]	46.5	43.1	46.1	46.5	46.1

Notes:
[1] Based on weighted average annual water yields shown in Tables 3-4 and 3-8.
[2] Unit values capped at $1,000 per acre-foot for all scenarios considered. Other sources such as desalinization could conceivably be considered at that cost (ignoring the cost of construction and energy).
[3] Totals may not add because of rounding.
[4] Dollar values are expressed in April 2010 price levels.
Key:
CP = comprehensive plan
M&I = municipal and industrial

Chapter 4
Hydropower Benefits

The proposed modifications of Shasta Dam, by altering water flows and elevations, would have varying incidental effects on power generation capacity at Shasta Dam and other hydropower facilities throughout the CVP. Estimates of net changes in power generation capacity in the electrical power system were derived through CalSim-II estimations and power generation models of the affected facilities.

Hydropower Valuation Methods

User-Value Method

The user-value method would estimate the magnitude of the economic benefit from increased net generation. The user-value method would use current rates charged for power, such as those obtained from the California Independent System Operator (CAISO), to determine the value of new hydropower output.

Least-Cost Alternative Method

The least-cost alternative method would be based on the cost of developing an equal quantity of net power generation capacity at an alternative facility.

Selected Valuation Method

At this stage in the SLWRI, hydropower benefits will be estimated by the user-value method, largely because the necessary parameters (electricity prices and CalSim-II model net hydropower generation estimates) are readily available.

Results of Hydropower Generation Benefits Estimation

Changes in the value of power generation alterations were calculated by multiplying the expected monthly power generation change by a 5-year average monthly price for power in the North of Point 15 (NP-15) region. The expected annual increase in the value of power generation benefits are $2.4 million for a 6.5-foot raise, $3.9 million for a 12.5-foot raise, $5.4 million for an 18.5-foot raise, and $7.7 million for an 18.5-foot raise with anadromous fish focus (Table 4-1).

Table 4-1. Change in Power Generation Capacity and Value Relative to Without-Project Conditions

Month	6.5-Foot Raise (CP1)		12.5-Foot Raise (CP2)		18.5-Foot Raise (CP3)		18.5-Foot Raise (CP4)		18.5-Foot Raise (CP5)	
	Power Generation Capacity (GWh)	Value ($1,000)	Power Generation Capacity (GWh)	Value ($1,000)	Power Generation Capacity (GWh)	Value ($1,000)	Power Generation Capacity (GWh)	Value ($1,000)	Power Generation Capacity (GWh)	Value ($1,000)
Jan	0.0	0	1.0	52	2.0	103	9.0	465	2.0	103
Feb	8.0	402	8.0	402	10.0	502	17.0	853	10.0	502
Mar	0.0	0	3.0	147	4.0	197	7.0	344	4.0	197
Apr	(1.0)	(55)	2.0	111	5.0	277	10.0	553	5.0	277
May	2.0	103	3.0	154	7.0	360	11.0	566	7.0	360
Jun	6.0	350	7.0	408	10.0	583	16.0	933	10.0	583
Jul	13.0	777	20.0	1,196	29.0	1,734	26.0	1,554	29.0	1,734
Aug	(1.0)	(57)	6.0	341	10.0	569	16.0	910	10.0	569
Sep	(2.0)	(108)	3.0	162	5.0	270	7.0	378	5.0	270
Oct	5.0	291	5.0	291	5.0	291	7.0	407	5.0	291
Nov	4.0	229	3.0	172	2.0	115	5.0	287	2.0	115
Dec	8.0	484	7.0	423	7.0	423	7.0	423	7.0	423
Total	42.0	2,416	68.0	3,859	96.0	5,423	138.0	7,674	96.0	5,423

Notes:

Dollar values are expressed in thousands of dollars, 2007 price levels.

Power generation capacity estimates represent the increased generation at Central Valley Project and State Water Project facilities. Energy requirements for pumping and conveyance of increased water deliveries are accounted for in operations and maintenance costs for each alternative.

Totals may not add because of rounding.

Key:
CP = comprehensive plan
GWh = gigawatt-hour

Potential Carbon Trading Benefits

A secondary benefit of hydropower generation is its lack of emissions that are associated with other forms of energy generation. Each megawatt-hour (MWh) of energy produced through traditional fossil fuel sources, such as coal or gas, produces emissions, including carbon dioxide. Clean power forms, such as hydropower, do not produce carbon dioxide emissions. The offset of fossil fuel emissions through the production of clean energy is valued through carbon emissions trading systems.

Carbon emissions trading systems have developed in response to concern over the potential contribution of greenhouse gasses (GHG) to global climate change. These trading systems allow parties that wish to increase or maintain emissions by some specific quantity to purchase the right to emit from other parties that agree to decrease their output by the agreed amount. Carbon emissions trading markets, operating much like stock or commodity markets, have been established in London, Chicago, and New York.

The U.S. Environmental Protection Agency (EPA) tracks information on the emissions from virtually every powerplant and company that generates electricity in the United States. Emissions data are currently published through 2000 in the Emissions and Generation Resource Integrated Database (eGRID). According to eGRID, the average emissions rate across the United States was 1,949.92 pounds of carbon dioxide per MWh of energy produced from fossil fuel sources in 2000. CP2, as an example, would produce 68 gigawatt-hours (GWh) over the No-Project Alternative – the equivalent of 60,144 metric tons (nearly 120 million pounds) of carbon dioxide. The need for this 68 GWh of energy exists; assuming the need would be met by a fossil fuel source (the most common energy source in the United States) under the No-Project Alternative, CP3 would effectively displace 84,910 metric tons of carbon dioxide emissions each year. Similar results are summarized for each alternative in Table 4-2. Using the Chicago Climate Exchange market price of $3.30 per metric ton of carbon dioxide equivalent, the exchange value of carbon reductions alone would be $123,000 per year under CP1; $198,000 per year under CP2; $280,000 per year under CP3 and CP5; and $403,000 per year under CP4 (Table 4-3).

It is believed that the values in Table 4-2 underestimate the true value of emissions displaced by hydropower. The Chicago Climate Exchange trades emissions of the carbon dioxide equivalent of six GHGs, including carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. Emissions of all noncarbon dioxide GHGs are converted to metric tons of carbon dioxide equivalent, using the 100-year Global Warming Potential values established by the Intergovernmental Panel on Climate Change. Because reliable nationwide values of the emissions of the noncarbon dioxide GHGs from fossil fuels are difficult to obtain, the benefit of GHG displacement through hydropower developed at Shasta Dam is limited in this discussion to carbon dioxide.

Table 4-2. Value of Carbon Dioxide Displaced Relative to No-Project Alternative

Description	New GWh	Metric Tons Carbon Dioxide Displaced	Benefit at $3.30 per Metric Ton Carbon Dioxide ($1,000)
Without Project	--	--	--
6.5 Foot Raise (CP1)	42	37,148	123
12.5-Foot Raise (CP2)	68	60,144	198
18.5-Foot Raise (CP3)	96	84,909	280
18.5-Foot Raise (CP4)	138	122,057	403
18.5-Foot Raise (CP5)	96	84,909	280

Key:
CP = comprehensive plan
GWh = gigawatt-hour

Table 4-3. Total Hydropower Generation Benefits

Item	CP1 ($1,000)	CP2 ($1,000)	CP3 ($1,000)	CP4 ($1,000)	CP5 ($1,000)
Generation	2,416	3,859	5,423	7,674	5,423
Carbon Trading	123	198	280	403	280
Total	2,539	4,057	5,703	8,077	5,703

Note:
Values are expressed in thousands of dollars, 2007 price levels.
Key:
CP = comprehensive plan

Total Hydropower Benefits

Total hydropower generation benefits summarized in Table 4-3 are the sum of the carbon trading benefits (Table 4-2) and the change in net power value (Table 4-1). Total hydropower generation benefits range from $2.5 million for CP1 to $8.1 million for CP4 (Table 4-3).

Relative Sensitivity

The above analysis assumes that energy prices remain constant across the 100-year period of analysis. This section considers changes in hydropower generation benefits if energy prices were to increase over time, a possibility suggested by a variety of demographic and economic factors. These computations are intended solely for the purpose of sensitivity analysis. The hydropower generation benefits estimated in this sensitivity analysis are not included in the calculation of the total benefits, net benefits, or benefit-cost ratios.

A variety of factors suggests that energy prices may grow in value at some rate distinct from inflation over time. Population growth within California will increase the demand for electricity. In keeping with the State's recent policies aimed at reducing GHG emissions, electricity-generating technologies, such as hydropower, that do not produce carbon dioxide will be at a premium. Further, global population increases and increasing incomes in developed and developing nations will likely to lead to increases in the demand for and price of energy.

If the price of electricity were to increase at 1 percent increase per year above inflation, assuming a discount rate of 4.125 percent and a project life of 100 years, the annualized value of net energy changes relative to without-project conditions would be $3.1 million for CP1; $4.9 million for CP2; $6.9 million for CP3; $9.8 million for CP4, and $6.9 for CP5 (Table 4-4). For a 2-percent increase in the price of energy above inflation, the annualized value of net energy changes relative to without-project conditions would be $4.2 million for CP1; $6.7 million for CP2; $9.4 million for CP3; $13.2 million for CP4; and $9.4 for CP5 (Table 4-4).

Table 4-4. Sensitivity Analysis for Change in Generation Benefit Relative to Without-Project Conditions

Change in Price of Electricity	CP1 ($1,000)	CP2 ($1,000)	CP3 ($1,000)	CP4 ($1,000)	CP5 ($1,000)
One Percent Above Inflation					
Generation	3,091	4,939	6,940	9,821	6,940
Two Percent Above Inflation					
Generation	4,166	6,655	9,352	13,234	9,352

Notes:
Values are expressed in thousands of dollars, 2007 price levels.
Values do not include benefits for carbon trading.
Key:
CP = comprehensive plan

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Chapter 5
Recreation Benefits

Shasta Lake is the centerpiece of the Shasta Unit of the Shasta-Trinity National Forest. The combination of water surface and lands provides the opportunity for many types of outdoor recreation, with water oriented recreation as the main attraction. A recent study of recreational sites in Northern California performed by the DWR as part of the Oroville Dam relicensing project places the estimated number of annual visitors at 2.5 million per year.

Raising the dam would affect recreational participation by increasing reservoir surface area and elevation throughout the year over without-project conditions. Previous studies have found that aquatic recreational activity is sensitive to fluctuations in these parameters, increasing and decreasing in accord with rises and falls in lake water levels (English et al., 1995; Hanson et al., 2002; Kaval and Loomis, 2003; Platt and Munger, 1999). In an economic study of Shasta Lake recreation by Bowker et al. (1994), a logarithmic regression using 21 years of data (1971 to 1991) found that reservoir recreational visitation was positively related to the elevation of Shasta Lake in May, the beginning of the peak visitation season, and negatively related to the change in reservoir water elevation between May and September, the end of the peak visitation season.

Following is an estimate of potential monetary benefits to water-oriented recreation at Shasta Lake based on an increase in water surface area. A major assumption in these estimates is that features to mitigate adverse impacts to existing recreation facilities are implemented as part of the plan features. Further, it is assumed that these added mitigation features do not limit or restrict access to lake area facilities or overall lake capacity.

Valuation Methods

Benefits from recreation opportunities created by a project are measured in terms of willingness-to-pay for enjoyment or participation. Benefits for projects that increase the quantity of recreational opportunities are measured as the willingness to pay for an additional increment of recreation activity. Benefits for projects that alter willingness-to-pay for recreational facilities are measured by comparing the with-project and without-project willingness-to-pay. Projections for increases in recreational activity may be combined with unit willingness-to-pay measures to estimate total change in economic value.

Shasta Lake is an example of a natural resource that is used for recreational purposes that may not be accurately valued using user fees, access charges, or similar fees. Some natural resources may be "open access" resources with no charge assessed for access. For other natural resources, access fees may be determined administratively by an agency that does not charge an amount based on individuals' willingness-to-pay. In such cases, a variety of methods exist to estimate recreational user values, including the travel cost method, contingent valuation method, and administratively estimated values.

- **Travel Cost Method –** Travel cost methods value resources based on observable expenditures incurred in accessing and using the resources. A travel cost method for Shasta Lake might estimate the value for enlarging the reservoir based on visitors' expenditures in reaching and recreating on the lake.

- **Contingent Valuation Method –** The contingent valuation method uses surveys or other methods of direct contact with respondents that solicit changes in behavior or willingness-to-pay to conserve, maintain, or improve some amenity. An example of a contingent valuation application for Shasta Lake enlargement might be to ask current and potential recreationists about their willingness-to-pay to increase the size of the reservoir.

- **Administratively Estimated Method –** Administratively estimated values are estimates of recreationists' willingness-to-pay for recreational opportunities based on expert opinion and assessments according to government agency criteria. Examples include unit day values for a variety of outdoor recreational activities such as those that have been calculated by the U.S. Bureau of Land Management, the USFS, and the U.S. Water Resources Council. Unit day values may be used in the estimation of NED accounts according to the P&G, Chapter 1, Section VII (WRC, 1983).

Existing data are not sufficient to support an adequate estimate of the travel cost or contingent valuation method estimations. Accordingly, for this evaluation, use of the administratively estimated method, or unit day method, was considered. It relies on the unit day values established by USFS since Shasta Lake is situated in the area of Shasta-Trinity National Forest, a USFS facility. USFS used five criteria (recreation experience, availability of substitutes, carrying capacity, accessibility, and environmental quality) in establishing unit day values for six activity categories in each of the 10 USFS Regions (U.S. Department of the Interior, National Park Service 1995). Shasta Lake is located within U.S. Forest Region 5, the Pacific Southwest Region.

Results of Recreation Benefits Estimation

This report extends the Bowker et al. (1994) study by incorporating CalSim-II estimates of May reservoir elevations and May-September elevation drops into the 1994 Shasta Lake recreational visitation model. Estimates for the expected number of recreational visitors vary from 83,000 for a 6.5-foot raise to 224,000 for an 18.5-foot raise. In this analysis, the reservoir elevations and elevation drops are similar for both 18.5-foot dam raise alternatives (CP3 and CP4). For each of the scenarios, the percentage of predicted increase in visitor days is similar to the expected increase in pool surface area.

Local facilities, such as parking lots, docks, and boat ramps, may not be adequate to sustain such large increases in recreational uses. USFS, in the Shasta-Trinity Land and Resource Management Plan (USFS, 1994), noted that developed recreational use had approached the maximum capacity for developed facilities in the area. Anecdotal evidence suggests that a similar situation may still exist and that current facilities may not accommodate increases of tens of thousands of visitors. Economic theory would suggest, however, that, in the absence of regulatory restrictions on facility development, the supply of recreational resources would expand in the long term to meet the expected increase in demand.

Since motorboating and angling are popular recreational activities in Shasta Lake (Kocis, et al. 2003), recreational benefits are calculated using a unit day value of $37.00, the midpoint between the USFS Region 5 benefit estimate for a unit day engaged in water travel ($10.00 in 2010 dollars) and a unit day engaged in fishing ($63.99). Recreational benefits, the product of the change in visitor days multiplied by unit day values, range from $3.08 million for a 6.5-foot raise to $8.29 million for both the CP3 and CP4 18.5-foot raises (Table 5-1).

All of the comprehensive plans include relocation/replacement of recreation facilities affected by the various day raises. These recreation relocations would provide for modernization of marinas, resorts, boat launches, camp grounds, day use areas and related recreation facilities to accommodate the needs and requirements of today’s recreational users. This modernization of facilities would likely result in increased occupancy and increased visitor user days annually.

It is important to note that various factors affect visitation at Shasta Lake other than water surface area. As mentioned, ongoing evaluations are considering not only features to mitigate potential impacts to existing faculties, but to identify features and actions that could further benefit the recreational experience at Shasta Lake.

Table 5-1. Estimated Average Annual Recreational Benefit

Item	Without-Project	With-Project				
		CP1	CP2	CP3	CP4	CP5
Visitor Days (1,000)	2,584	2,667	2,725	2,808	2,808	2,808
Change in Visitor Days Relative to Without-Project (1,000)	---	83	141	224	224	224
Total Recreational Value ($ millions)[1]	95.58	98.66	100.79	103.87	103.87	103.87
Change in Value Relative to Without-project ($ millions)[1]	---	3.08	5.21	8.29	8.29	8.35[2]

Note:
[1] Dollar values are expressed in millions, April 2010 price levels, and average user day value of $37.00.
[2] The difference in benefit from CP3 and CP4 is due to the construction of trails and trailheads to enhance recreation opportunities at Shasta Lake.
Key:
CP = comprehensive plan

Chapter 6 Flood Damage Reduction Benefits

Flood Damage Reduction

Flooding along the Sacramento River poses risks to human life, health, and safety. Urban development in flood-prone areas has exposed the public to the risk of flooding. While the existing flood management system has significantly reduced the frequency of flooding, large storms can result in river flows that exceed the capacity of the system or cause failures in the system. Threats to the public from flooding are caused by many factors, including overtopping or sudden failures of levees, which can cause deep and rapid flooding with little warning, threatening lives and public safety.

Physical impacts from flooding occur to residential, agricultural, commercial, industrial, institutional, and public property. Damages occur to buildings, contents, automobiles, and outside property, including agricultural crops, equipment, and landscaping. Physical damages include cleanup costs and costs to repair roads, bridges, sewers, power lines, and other infrastructure components. Nonphysical flood losses include income losses and the cost of emergency services such as flood fighting and disaster relief.

Even though a project to enlarge Shasta Reservoir has the potential to significantly reduce flood flows in the upper Sacramento River, influencing factors exist that can conflict with flood operation. Flood management operations at Shasta Dam, even with explicit rules provided in the flood control manual, are difficult to manage during a flood event. This is primarily due to the extreme inflow volumes to Shasta Reservoir that can occur over long periods, numerous points of inflow along the river downstream from Shasta Dam, and multiple points of operational interest downstream. The primary downstream control point along the Sacramento River that determines reservoir releases under real-time operation is Bend Bridge. Other unofficial factors enter into flood management decisions, such as the need to reduce peak flows at Hamilton City or other rural communities that are at risk of flooding.

On the basis of studies to date for the SLWRI, potential monetary benefits to flood damage reduction could be significant. However, by observation, it is believed that these benefits would be significantly less than the costs to provide them. This is primarily because Shasta already provides a significant reduction in flood threat downstream, particularly to the City of Redding. Tributary inflow to the Sacramento River further downstream lessens the effectiveness of Shasta Dam in reducing flood damage. Because of (1) a generally higher level of protection already provided by Shasta Dam, and (2) likely difficulty in changing existing river flow operation objectives along the upper Sacramento River, it is anticipated that benefits specifically for flood damage reduction would not be economically feasible. However, any increase in storage at Shasta Reservoir would likely result in a small and incidental decrease in flood damages. Accordingly, potential benefits to flood damage reduction resulting from reducing peak flood flows are not expressed in quantified terms in this appendix.

Chapter 7
Regional Economic Development

This section addresses the interim findings of a regional economic analysis of the direct project construction effects, and to satisfy the requirements of the Regional Economic Development (RED) account of the P&G. The preliminary findings incorporate changes in the local economy due to project construction activities for the five action alternatives or comprehensive plans. The changes in hydroelectric power generation would affect statewide residents as a whole in terms of electricity rates; however, preliminary results indicate the changes would be virtually imperceptible at the statewide level, and were not included in the analysis. A regional analysis has not been conducted incorporating other potential direct effects, including changes in agricultural production, recreation, M&I water quality, flood control, or other areas potentially affected by the alternatives.

An input-output (I-O) regional economics model was developed for regional economic analyses specific to the SLWRI. It incorporated project construction-related economic activity in the four-county region surrounding Shasta Lake. The four counties include Shasta, Tehama, Trinity, and Siskiyou.

Regional Economic Impacts Model Description

The regional economics model is based on IMPLAN software. The model is used to measure the indirect effect that construction-related expenditures (or other direct effects) may have on the regional economy, in terms of changes in industry output, employment, and income. The model is based on 2007 data. More current data will be obtained for the feasibility level report.

In general terms, an I-O model is used to estimate the effects of changes in output on the rest of the local economy. The direct effect is the change (or increase) in construction-related output determined from the engineering design estimates described previously. Because the businesses within a local economy are linked together through the purchase and sales patterns of goods and services produced in the region, an action which has a direct effect on one industry is likely to have an indirect effect for firms providing production inputs and support services, as the demand for their products also increases. As household income is affected by the increases in regional economic activity, additional induced benefits are generated by increased household spending.

Three different economic measures are typically presented when discussing regional impacts. “Output” (also known as total industry output) represents the value of production of goods and services by businesses in the regional economy. This can serve as an overall measure of the local economy, and is useful for comparing regions and considering impacts. The second measure is "personal income," which is the sum of employee compensation and proprietor income. Employee compensation represents total payroll costs, including wages and salaries paid to workers plus benefits such as health insurance, as well as retirement payments and non-cash compensation. Proprietor income includes payments received by self-employed individuals as income, such as income received by private business owners, doctors, or lawyers. This measure is useful to show how the employees and proprietors of businesses producing the output share in the fortunes of those businesses. The third measure is "employment." This represents the annual average number of employees, whether full- or part-time, of the businesses producing the output.

The construction activity associated with each of the alternatives will take place over three to five years, depending upon the alternative. Because economic impacts are typically measured and reported in annual terms, the costs were converted to average annual expenditures. Therefore, the results should be interpreted as "dollars per year" or "jobs per year" for the duration of the construction period, and proper care must be taken to when making direct comparisons among alternatives.

The link from regional analysis to the RED account specified in the P&G is straightforward. The RED account considers changes in the distribution of regional economic activity through two measures:

- Regional income, and
- Regional employment.

From the regional impact analysis, regional income is derived directly from the measure of "personal income." Regional employment is associated with the measure of "employment" from the regional impact analysis.

Applying the Four-County Regional Model

The primary set of effects analyzed using the regional model is how project construction would affect output, personal income, and employment within the four-county area containing the dam and reservoir. The project costs were developed for each alternative by the engineering team, which also estimated the duration over which construction activity would take place. The costs were organized into categories in order to assess the required investment that would take place in certain primary sectors of the local economy, namely concrete- and steel-related manufacturing, rock and aggregate, and dam and non-residential construction. Table 7-1 provides a summary of project costs by category for the alternatives.

Table 7-1. Project Construction Cost by Category

Category	Detail	CP1 ($ millions)	CP2 ($ millions)	CP3 ($ millions)	CP4 ($ millions)	CP5 ($ millions)
Concrete	Manufacturing, testing, treatments, precast, structure erection, and pile driving	157	147	202	203	203
Metalwork	Manufacturing, testing, construction, preconstruction, mechanical, electrical, pipe, and temporary structures	314	284	309	310	311
Glass	Manufacturing, construction	0.50	0.40	0.50	0.50	0.50
Interior	Carpet, tile, paint, appliance	0.80	0.70	0.70	0.70	0.70
Fill and Aggregate	Imported, On-site, Reuse, manufacturing geofill/textiles, compaction, and construction	38	59	83	86	86
Asphalt and Roadway	Production, paving, roadway painting and signage	7	15	16	16	16
Timber	Construction and Timber Clearing	5	59	72	72	72
Plastics	PVC pipe, HDPE, rubber, and composites	2	2	2	2	2
Excavation and Demolition	Excavation, clearing and grubbing, structure demolition, salvaging, and relocating of equipment	80	92	71	72	72
Landscaping	Gardening, seeding, and planting	0.30	0.30	0.30	0.30	0.30
Planning, Engineering, Design, and Construction Mgmt.		121	132	151	153	153
Land Acquisition		26	41	60	61	61
Environmental Mitigation		61	66	76	76	76
Cultural Resources Mitigation		12	13	15	15	15
Water Use Efficiency Actions		2	3	4	2	4
Total Construction Cost		827	913	1,064	1,070	1,073
Duration (years)		3	4	5	5	5

Note:
Dollar values are expressed in millions, April 2010 price levels.
Key:
CP = comprehensive plan
HDPE = high-density polyethylene
PVC = polyvinyl chloride

The cost summary provides information as to the anticipated generalized expenditure pattern (production function) within IMPLAN associated with the dam construction activity. The IMPLAN production function is based upon an aggregation of national data distributed proportionally to states and counties, and may precisely match local conditions. However, adjustments for local conditions may be made within IMPLAN when additional data are available. The project cost summary was compared to the IMPLAN sector data detail for the region in order to confirm the local presence of businesses able to serve the project's need for materials and services. It was confirmed that local sources could be used for the primary construction service needs. The organized cost data were entered as inputs to appropriate sectors within the regional impacts model.

The engineering team considered the necessary and appropriate size of the construction crew on an average annual basis, considering the size and duration of the construction activity. It is estimated that a crew of approximately 350 would be sufficient for each of the alternatives. The IMPLAN production function vector for construction was adjusted to ensure a direct employment ratio of 350 jobs per year, using CP4 as the proxy. The average annual investment cost for the alternatives are shown in Table 7-2.

Table 7-2. Project Construction Cost, Average Annual Required Investment

Category	CP1	CP2	CP3	CP4	CP5
Average Annual Construction Cost ($ millions)	275.7	228.3	212.8	214.0	214.6
Duration (years)	3	4	5	5	5

Note:
Dollar values are expressed in millions, April 2010 price levels.
Key:
CP = comprehensive plan

For each of the alternatives, the procedure was the same for estimating regional economic impacts. Construction-related direct expenses were entered, and the model then calculated the indirect, induced, and total effects on the regional economy. The output of the model included total industry output, personal income, and jobs, all displayed on an average annual basis.

Results of the Regional Impact Analysis

The following section provides results of regional impact analysis conducted for the SLWRI, with a focus on the three categories of impacts: total industry output, personal income, and employment.

Total Industry Output

Table 7-3 presents the results of the regional economic model by alternative. Under the alternatives, the direct benefit to construction industries would range from $212.8 million (for CP3) to $275.7 million (for CP1) per year. These direct impacts would yield indirect impacts, largely to input supply and construction support industries, ranging from $56.4 million (CP3) to $73.1 million (CP1). Induced impacts, or the change in overall output throughout the region as a result of greater household spending, would yield an additional $64.5 million (CP3) to $83.5 million. The combined total of direct, indirect, and induced impacts will result in a total annual economic impact of $333.7 million for CP3, up to $432.3 million for CP1.

Table 7-3. Annual Regional Economic Impacts of Construction Activity on Total Industry Output

Effects	CP1 ($ millions)	CP2 ($ millions)	CP3 ($ millions)	CP4 ($ millions)	CP5 ($ millions)
Direct	275.7	228.3	212.8	214.0	214.6
Indirect	73.1	60.5	56.4	56.7	56.9
Induced	83.5	69.2	64.5	64.8	65.0
Total per Year[1]	432.3	356.0	333.7	335.5	336.5
Duration (years)	3	4	5	5	5
Aggregate Total[1]	1,296.9	1,431.9	1,668.4	1,677.8	1,682.5

Note:
Dollar values are expressed in millions, April 2010 price levels.
[1] Totals may not sum because of rounding.
Key:
CP = comprehensive plan

The duration of the construction period is important to recognizing the full aggregate impact of the project. CP3, CP4, and CP5 are all nearly the same in annual impact, but each takes five years to complete, so the aggregate impact for each is nearly $1.7 billion during the entire construction period. CP2, at $358.0 million, has a greater annual impact than CP3, CP4, and CP5, but its duration is four years, so the aggregate impact is $1.4 billion. CP1 has the highest annual impact, but construction lasts only three years, so has the lowest aggregate impact at $1.3 billion.

Personal Income

The second measure of regional impacts is “personal income,” the sum of employee compensation and proprietor income, and a measure of benefit for the RED account. Results for this category are shown in Table 7-4.

Table 7-4. Annual Regional Economic Impacts of Construction Activity on Personal Income

Effects	CP1 ($ millions)	CP2 ($ millions)	CP3 ($ millions)	CP4 ($ millions)	CP5 ($ millions)
Direct	126.1	104.4	97.3	97.9	98.2
Indirect	29.8	24.7	23.0	23.1	23.2
Induced	27.6	22.9	21.3	21.4	21.5
Total per Year[1]	183.6	152.0	141.7	142.5	142.9
Duration (years)	3	4	5	5	5
Aggregate Total[1]	550.7	608.0	708.4	712.4	714.4

Note:
Dollar values are expressed in millions, April 2010 price levels.
[1] Totals may not sum because of rounding.
Key:
CP = comprehensive plan

Construction-related expenditures would lead to direct impacts on personal income in the region ranging from $97.3 million annually under CP3, to $126.1 million under CP1. This change in personal income would lead to indirect impacts of $23.0 million (CP3) to $29.8 million (CP1). Induced impacts on personal income would amount to an additional $21.3 million (CP3) to $27.6 million (CP1) annually. The total impact on personal income in the region ranges from $141.7 million for CP3 to $183.6 million annually.

Accounting for the duration of construction, a similar ranking of alternatives occurs for personal income impacts as for total industry output. CP5 is highest at $714.4 million, followed closely by CP4 ($712.4 million) and CP3 ($708.4 million) across five years. CP2 is next at $608.0 million (over four years), and CP1 is lowest in aggregate impact at $550.7 million over three years.

Employment

Employment impacts are measured in total jobs, whether full- or part-time, in the businesses producing the output. Direct impacts are those related to construction, and establishments that sell construction goods and perform construction services. Employment is included in the RED account. Table 7-5 summarizes regional employment impacts from the project based on construction activity.

Table 7-5. Annual Regional Economic Impacts of Construction Activity on Employment (Jobs)

Effects	CP1	CP2	CP3	CP4	CP5
Direct	450	370	350	350	350
Indirect	580	480	450	450	460
Induced	790	650	610	610	610
Total per Year[1]	1,820	1,510	1,410	1,410	1,420
Duration (years)	3	4	5	5	5

Note:
[1] Totals may not sum because of rounding.

Key:
CP = comprehensive plan

Approximately 350 additional construction sector jobs in the region would be a direct result of project construction for CP3, CP4, and CP5. This would take place over a five year period. Approximately 370 jobs annually over four years would result from CP2. Finally, approximately 450 jobs would be added from CP1, but for only three years. An additional 450 jobs (CP3 and CP4) to 580 jobs (CP1) in the region would be generated in construction support and input industries. As a result of increased household spending, an additional 610 jobs (CP3, CP4, and CP5) to 790 jobs (CP1) would result. In total, approximately 1,410 jobs (CP3 and CP4) to 1,820 jobs (CP1) in the region would be generated.

Detailed Results from the Regional Impact Model

The following tables (7-6 through 7-20) provide detailed output from the IMPLAN regional model for the four-county area. The tables provide details on the effects within aggregate sectors of the local economy. The details are presented in unadjusted form (i.e., to single dollars) as direct output from the model, which implies a higher level of precision in measurement than is realistic.

Table 7-6. CP1 Regional Economic Impacts on Total Industry Output

Industry	Direct ($ millions)	Indirect ($ millions)	Induced ($ millions)	Total ($ millions)
Agriculture, Forestry, Fishing, & Hunting	0.0	1.4	0.7	2.0
Mining	0.0	0.3	0.2	0.5
Utilities	0.0	0.8	1.3	2.1
Construction	275.7	0.7	0.9	277.2
Manufacturing	0.0	9.5	1.9	11.4
Wholesale Trade	0.0	3.9	3.0	6.9
Retail Trade	0.0	3.9	11.9	15.8
Transportation & Warehousing	0.0	4.0	2.1	6.1
Information	0.0	2.6	3.1	5.7
Finance & Insurance	0.0	3.7	7.0	10.7
Real Estate & Rental	0.0	6.1	17.2	23.3
Professional, Scientific, & Tech Services	0.0	23.6	2.5	26.1
Management of Companies	0.0	1.2	0.6	1.8
Administrative & Waste Services	0.0	3.2	1.5	4.8
Educational Services	0.0	0.0	0.9	0.9
Health & Social Services	0.0	0.0	15.6	15.6
Arts, Entertainment, & Recreation	0.0	0.2	1.1	1.3
Accommodation & Food Services	0.0	1.4	5.8	7.2
Other Services	0.0	5.8	4.0	9.7
Government & Non-NAICS	0.0	1.0	2.3	3.4
Totals[1]	275.7	73.1	83.5	432.3

Note:
Dollar values are expressed in millions, April 2010 price levels.
[1] Totals may not sum because of rounding.
Key:
CP = comprehensive plan

Table 7-7. CP2 Regional Economic Impacts on Total Industry Output

Industry	Direct ($ millions)	Indirect ($ millions)	Induced ($ millions)	Total ($ millions)
Agriculture, Forestry, Fishing, & Hunting	0.0	1.1	0.5	1.7
Mining	0.0	0.2	0.1	0.4
Utilities	0.0	0.7	1.1	1.7
Construction	228.3	0.5	0.7	229.6
Manufacturing	0.0	7.8	1.6	9.4
Wholesale Trade	0.0	3.2	2.5	5.7
Retail Trade	0.0	3.2	9.9	13.1
Transportation & Warehousing	0.0	3.3	1.8	5.1
Information	0.0	2.1	2.6	4.7
Finance & Insurance	0.0	3.1	5.8	8.9
Real Estate & Rental	0.0	5.0	14.2	19.3
Professional, Scientific, & Tech Services	0.0	19.5	2.1	21.6
Management of Companies	0.0	1.0	0.5	1.5
Administrative & Waste Services	0.0	2.7	1.3	3.9
Educational Services	0.0	0.0	0.7	0.7
Health & Social Services	0.0	0.0	12.9	12.9
Arts, Entertainment, & Recreation	0.0	0.1	0.9	1.1
Accommodation & Food Services	0.0	1.1	4.8	5.9
Other Services	0.0	4.8	3.3	8.1
Government & Non-NAICS	0.0	0.8	1.9	2.8
Totals[1]	228.3	60.5	69.2	358.0

Note:
Dollar values are expressed in millions, April 2010 price levels.
[1] Totals may not sum because of rounding.
Key:
CP = comprehensive plan

Table 7-8. CP3 Regional Economic Impacts on Total Industry Output

Industry	Direct ($ millions)	Indirect ($ millions)	Induced ($ millions)	Total ($ millions)
Agriculture, Forestry, Fishing, & Hunting	0.0	1.0	0.5	1.6
Mining	0.0	0.2	0.1	0.4
Utilities	0.0	0.6	1.0	1.6
Construction	212.8	0.5	0.7	214.0
Manufacturing	0.0	7.3	1.5	8.8
Wholesale Trade	0.0	3.0	2.3	5.3
Retail Trade	0.0	3.0	9.2	12.2
Transportation & Warehousing	0.0	3.1	1.7	4.7
Information	0.0	2.0	2.4	4.4
Finance & Insurance	0.0	2.9	5.4	8.3
Real Estate & Rental	0.0	4.7	13.3	18.0
Professional, Scientific, & Tech Services	0.0	18.2	1.9	20.1
Management of Companies	0.0	0.9	0.4	1.4
Administrative & Waste Services	0.0	2.5	1.2	3.7
Educational Services	0.0	0.0	0.7	0.7
Health & Social Services	0.0	0.0	12.1	12.1
Arts, Entertainment, & Recreation	0.0	0.1	0.9	1.0
Accommodation & Food Services	0.0	1.1	4.5	5.5
Other Services	0.0	4.4	3.1	7.5
Government & Non-NAICS	0.0	0.8	1.8	2.6
Totals[1]	212.8	56.4	64.5	333.7

Note:
Dollar values are expressed in millions, April 2010 price levels.
[1] Totals may not sum because of rounding.
Key:
CP = comprehensive plan

Table 7-9. CP4 Regional Economic Impacts on Total Industry Output

Industry	Direct ($ millions)	Indirect ($ millions)	Induced ($ millions)	Total ($ millions)
Agriculture, Forestry, Fishing, & Hunting	0.0	1.1	0.5	1.6
Mining	0.0	0.2	0.1	0.4
Utilities	0.0	0.6	1.0	1.6
Construction	214.0	0.5	0.7	215.2
Manufacturing	0.0	7.3	1.5	8.8
Wholesale Trade	0.0	3.0	2.3	5.3
Retail Trade	0.0	3.0	9.3	12.3
Transportation & Warehousing	0.0	3.1	1.7	4.7
Information	0.0	2.0	2.4	4.4
Finance & Insurance	0.0	2.9	5.4	8.3
Real Estate & Rental	0.0	4.7	13.4	18.1
Professional, Scientific, & Tech Services	0.0	18.3	1.9	20.2
Management of Companies	0.0	0.9	0.4	1.4
Administrative & Waste Services	0.0	2.5	1.2	3.7
Educational Services	0.0	0.0	0.7	0.7
Health & Social Services	0.0	0.0	12.1	12.1
Arts, Entertainment, & Recreation	0.0	0.1	0.9	1.0
Accommodation & Food Services	0.0	1.1	4.5	5.6
Other Services	0.0	4.5	3.1	7.6
Government & Non-NAICS	0.0	0.8	1.8	2.6
Totals[1]	214.0	56.7	64.8	335.6

Note:
Dollar values are expressed in millions, April 2010 price levels.
[1] Totals may not sum because of rounding.
Key:
CP = comprehensive plan

Table 7-10. CP5 Regional Economic Impacts on Total Industry Output

Industry	Direct ($ millions)	Indirect ($ millions)	Induced ($ millions)	Total ($ millions)
Agriculture, Forestry, Fishing, & Hunting	0.0	1.1	0.5	1.6
Mining	0.0	0.2	0.1	0.4
Utilities	0.0	0.6	1.0	1.6
Construction	214.6	0.5	0.7	215.8
Manufacturing	0.0	7.4	1.5	8.8
Wholesale Trade	0.0	3.0	2.3	5.3
Retail Trade	0.0	3.0	9.3	12.3
Transportation & Warehousing	0.0	3.1	1.7	4.7
Information	0.0	2.0	2.4	4.4
Finance & Insurance	0.0	2.9	5.4	8.4
Real Estate & Rental	0.0	4.7	13.4	18.1
Professional, Scientific, & Tech Services	0.0	18.4	1.9	20.3
Management of Companies	0.0	0.9	0.4	1.4
Administrative & Waste Services	0.0	2.5	1.2	3.7
Educational Services	0.0	0.0	0.7	0.7
Health & Social Services	0.0	0.0	12.2	12.2
Arts, Entertainment, & Recreation	0.0	0.1	0.9	1.0
Accommodation & Food Services	0.0	1.1	4.5	5.6
Other Services	0.0	4.5	3.1	7.6
Government & Non-NAICS	0.0	0.8	1.8	2.6
Totals[1]	214.6	56.9	65.0	336.5

Note:
Dollar values are expressed in millions, April 2010 price levels.
[1] Totals may not sum because of rounding.
Key:
CP = comprehensive plan

Table 7-11. CP1 Regional Economic Impacts on Personal Income

Industry	Direct ($ millions)	Indirect ($ millions)	Induced ($ millions)	Total ($ millions)
Agriculture, Forestry, Fishing, & Hunting	0.0	0.2	0.1	0.4
Mining	0.0	0.1	0.0	0.1
Utilities	0.0	0.1	0.2	0.3
Construction	126.1	0.3	0.3	126.8
Manufacturing	0.0	2.1	0.3	2.4
Wholesale Trade	0.0	1.5	1.1	2.6
Retail Trade	0.0	1.7	5.2	6.9
Transportation & Warehousing	0.0	1.5	0.8	2.3
Information	0.0	0.5	0.6	1.0
Finance & Insurance	0.0	1.0	1.8	2.9
Real Estate & Rental	0.0	1.1	0.9	2.1
Professional, Scientific, & Tech Services	0.0	14.2	1.2	15.4
Management of Companies	0.0	0.5	0.2	0.7
Administrative & Waste Services	0.0	1.7	0.8	2.4
Educational Services	0.0	0.0	0.3	0.4
Health & Social Services	0.0	0.0	8.7	8.7
Arts, Entertainment, & Recreation	0.0	0.1	0.4	0.5
Accommodation & Food Services	0.0	0.4	1.9	2.3
Other Services	0.0	2.2	1.5	3.7
Government & Non-NAICS	0.0	0.5	1.1	1.6
Totals[1]	126.1	29.8	27.6	183.6

Note:
Dollar values are expressed in millions, April 2010 price levels.
[1] Totals may not sum because of rounding.
Key:
CP = comprehensive plan

Table 7-12. CP2 Regional Economic Impacts on Personal Income

Industry	Direct ($ millions)	Indirect ($ millions)	Induced ($ millions)	Total ($ millions)
Agriculture, Forestry, Fishing, & Hunting	0.0	0.2	0.1	0.3
Mining	0.0	0.1	0.0	0.1
Utilities	0.0	0.1	0.2	0.3
Construction	104.4	0.3	0.3	105.0
Manufacturing	0.0	1.7	0.3	2.0
Wholesale Trade	0.0	1.2	0.9	2.1
Retail Trade	0.0	1.4	4.3	5.7
Transportation & Warehousing	0.0	1.3	0.7	1.9
Information	0.0	0.4	0.5	0.8
Finance & Insurance	0.0	0.9	1.5	2.4
Real Estate & Rental	0.0	0.9	0.8	1.7
Professional, Scientific, & Tech Services	0.0	11.8	1.0	12.8
Management of Companies	0.0	0.4	0.2	0.6
Administrative & Waste Services	0.0	1.4	0.6	2.0
Educational Services	0.0	0.0	0.3	0.3
Health & Social Services	0.0	0.0	7.2	7.2
Arts, Entertainment, & Recreation	0.0	0.1	0.4	0.4
Accommodation & Food Services	0.0	0.4	1.6	1.9
Other Services	0.0	1.8	1.3	3.1
Government & Non-NAICS	0.0	0.4	0.9	1.3
Totals[1]	104.4	24.7	22.9	152.0

Note:
Dollar values are expressed in millions, April 2010 price levels.
[1] Totals may not sum because of rounding.
Key:
CP = comprehensive plan

Table 7-13. CP3 Regional Economic Impacts on Personal Income

Industry	Direct ($ millions)	Indirect ($ millions)	Induced ($ millions)	Total ($ millions)
Agriculture, Forestry, Fishing, & Hunting	0.0	0.2	0.1	0.3
Mining	0.0	0.1	0.0	0.1
Utilities	0.0	0.1	0.2	0.3
Construction	97.4	0.3	0.3	97.9
Manufacturing	0.0	1.6	0.3	1.9
Wholesale Trade	0.0	1.1	0.9	2.0
Retail Trade	0.0	1.3	4.0	5.3
Transportation & Warehousing	0.0	1.2	0.6	1.8
Information	0.0	0.4	0.4	0.8
Finance & Insurance	0.0	0.8	1.4	2.2
Real Estate & Rental	0.0	0.9	0.7	1.6
Professional, Scientific, & Tech Services	0.0	11.0	0.9	11.9
Management of Companies	0.0	0.4	0.2	0.6
Administrative & Waste Services	0.0	1.3	0.6	1.9
Educational Services	0.0	0.0	0.3	0.3
Health & Social Services	0.0	0.0	6.7	6.7
Arts, Entertainment, & Recreation	0.0	0.1	0.3	0.4
Accommodation & Food Services	0.0	0.3	1.5	1.8
Other Services	0.0	1.7	1.2	2.9
Government & Non-NAICS	0.0	0.4	0.8	1.2
Totals[1]	97.4	23.0	21.3	141.7

Note:
Dollar values are expressed in millions, April 2010 price levels.
[1] Totals may not sum because of rounding.
Key:
CP = comprehensive plan

Table 7-14. CP4 Regional Economic Impacts on Personal Income

Industry	Direct ($ millions)	Indirect ($ millions)	Induced ($ millions)	Total ($ millions)
Agriculture, Forestry, Fishing, & Hunting	0.0	0.2	0.1	0.3
Mining	0.0	0.1	0.0	0.1
Utilities	0.0	0.1	0.2	0.3
Construction	97.9	0.3	0.3	98.4
Manufacturing	0.0	1.6	0.3	1.9
Wholesale Trade	0.0	1.1	0.9	2.0
Retail Trade	0.0	1.3	4.0	5.4
Transportation & Warehousing	0.0	1.2	0.6	1.8
Information	0.0	0.4	0.4	0.8
Finance & Insurance	0.0	0.8	1.4	2.2
Real Estate & Rental	0.0	0.9	0.7	1.6
Professional, Scientific, & Tech Services	0.0	11.0	0.9	12.0
Management of Companies	0.0	0.4	0.2	0.6
Administrative & Waste Services	0.0	1.3	0.6	1.9
Educational Services	0.0	0.0	0.3	0.3
Health & Social Services	0.0	0.0	6.7	6.7
Arts, Entertainment, & Recreation	0.0	0.1	0.3	0.4
Accommodation & Food Services	0.0	0.3	1.5	1.8
Other Services	0.0	1.7	1.2	2.9
Government & Non-NAICS	0.0	0.4	0.8	1.2
Totals[1]	97.9	23.1	21.4	142.5

Note:
Dollar values are expressed in millions, April 2010 price levels.
[1] Totals may not sum because of rounding.
Key:
CP = comprehensive plan

Table 7-15. CP5 Regional Economic Impacts on Personal Income

Industry	Direct ($ millions)	Indirect ($ millions)	Induced ($ millions)	Total ($ millions)
Agriculture, Forestry, Fishing, & Hunting	0.0	0.2	0.1	0.3
Mining	0.0	0.1	0.0	0.1
Utilities	0.0	0.1	0.2	0.3
Construction	98.2	0.3	0.3	98.7
Manufacturing	0.0	1.6	0.3	1.9
Wholesale Trade	0.0	1.1	0.9	2.0
Retail Trade	0.0	1.3	4.0	5.4
Transportation & Warehousing	0.0	1.2	0.6	1.8
Information	0.0	0.4	0.4	0.8
Finance & Insurance	0.0	0.8	1.4	2.2
Real Estate & Rental	0.0	0.9	0.7	1.6
Professional, Scientific, & Tech Services	0.0	11.1	0.9	12.0
Management of Companies	0.0	0.4	0.2	0.6
Administrative & Waste Services	0.0	1.3	0.6	1.9
Educational Services	0.0	0.0	0.3	0.3
Health & Social Services	0.0	0.0	6.7	6.7
Arts, Entertainment, & Recreation	0.0	0.1	0.3	0.4
Accommodation & Food Services	0.0	0.3	1.5	1.8
Other Services	0.0	1.7	1.2	2.9
Government & Non-NAICS	0.0	0.4	0.8	1.2
Totals[1]	98.2	23.2	21.5	142.9

Note:
Dollar values are expressed in millions, April 2010 price levels.
[1] Totals may not sum because of rounding.
Key:
CP = comprehensive plan

Table 7-16. CP1 Regional Economic Impacts on Employment (Jobs)

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing, & Hunting	0	6	5	11
Mining	0	1	0	1
Utilities	0	1	2	3
Construction	451	6	4	462
Manufacturing	0	38	8	46
Wholesale Trade	0	30	23	52
Retail Trade	0	56	171	227
Transportation & Warehousing	0	25	15	40
Information	0	8	10	17
Finance & Insurance	0	21	38	60
Real Estate & Rental	0	29	38	67
Professional, Scientific, & Tech Services	0	202	25	227
Management of Companies	0	7	3	10
Administrative & Waste Services	0	60	27	86
Educational Services	0	0	20	21
Health & Social Services	0	0	176	176
Arts, Entertainment, & Recreation	0	3	21	24
Accommodation & Food Services	0	24	110	134
Other Services	0	62	78	140
Government & Non-NAICS	0	7	15	22
Totals[1]	451	585	789	1,825

Note:
[1] Totals may not sum because of rounding.
Key:
CP = comprehensive plan

Table 7-17. CP2 Regional Economic Impacts on Employment (Jobs)

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing, & Hunting	0	5	4	9
Mining	0	1	0	1
Utilities	0	1	1	2
Construction	373	5	4	356
Manufacturing	0	32	6	35
Wholesale Trade	0	25	19	40
Retail Trade	0	46	142	175
Transportation & Warehousing	0	21	12	31
Information	0	6	8	13
Finance & Insurance	0	18	32	46
Real Estate & Rental	0	24	32	51
Professional, Scientific, & Tech Services	0	167	21	175
Management of Companies	0	5	3	8
Administrative & Waste Services	0	50	22	67
Educational Services	0	0	17	16
Health & Social Services	0	0	146	136
Arts, Entertainment, & Recreation	0	3	17	19
Accommodation & Food Services	0	20	91	104
Other Services	0	51	65	108
Government & Non-NAICS	0	6	12	17
Totals[1]	373	484	653	1,408

Note:
[1] Totals may not sum because of rounding.
Key:
CP = comprehensive plan

Table 7-18. CP3 Regional Economic Impacts on Employment (Jobs)

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing, & Hunting	0	5	4	9
Mining	0	1	0	1
Utilities	0	1	1	2
Construction	348	5	3	356
Manufacturing	0	30	6	35
Wholesale Trade	0	23	17	40
Retail Trade	0	43	132	175
Transportation & Warehousing	0	20	12	31
Information	0	6	8	13
Finance & Insurance	0	16	30	46
Real Estate & Rental	0	22	29	51
Professional, Scientific, & Tech Services	0	156	20	175
Management of Companies	0	5	2	8
Administrative & Waste Services	0	46	20	67
Educational Services	0	0	16	16
Health & Social Services	0	0	136	136
Arts, Entertainment, & Recreation	0	3	16	19
Accommodation & Food Services	0	19	85	104
Other Services	0	48	61	108
Government & Non-NAICS	0	5	12	17
Totals[1]	348	452	609	1,408

Note:
[1] Totals may not sum because of rounding.
Key:
CP = comprehensive plan

Table 7-19. CP4 Regional Economic Impacts on Employment (Jobs)

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing, & Hunting	0	5	4	9
Mining	0	1	0	1
Utilities	0	1	1	2
Construction	350	5	3	358
Manufacturing	0	30	6	36
Wholesale Trade	0	23	18	41
Retail Trade	0	43	133	176
Transportation & Warehousing	0	20	12	31
Information	0	6	8	14
Finance & Insurance	0	17	30	46
Real Estate & Rental	0	22	30	52
Professional, Scientific, & Tech Services	0	157	20	176
Management of Companies	0	5	2	8
Administrative & Waste Services	0	46	21	67
Educational Services	0	0	16	16
Health & Social Services	0	0	136	136
Arts, Entertainment, & Recreation	0	3	16	19
Accommodation & Food Services	0	19	85	104
Other Services	0	48	61	109
Government & Non-NAICS	0	6	12	17
Totals[1]	350	454	612	1,416

Note:
[1] Totals may not sum because of rounding.
Key:
CP = comprehensive plan

Table 7-20. CP5 Regional Economic Impacts on Employment (Jobs)

Industry	Direct	Indirect	Induced	Total
Agriculture, Forestry, Fishing, & Hunting	0	5	4	9
Mining	0	1	0	1
Utilities	0	1	1	2
Construction	351	5	3	359
Manufacturing	0	30	6	36
Wholesale Trade	0	23	18	41
Retail Trade	0	43	133	177
Transportation & Warehousing	0	20	12	31
Information	0	6	8	14
Finance & Insurance	0	17	30	46
Real Estate & Rental	0	22	30	52
Professional, Scientific, & Tech Services	0	157	20	177
Management of Companies	0	5	2	8
Administrative & Waste Services	0	47	21	67
Educational Services	0	0	16	16
Health & Social Services	0	0	137	137
Arts, Entertainment, & Recreation	0	3	16	19
Accommodation & Food Services	0	19	85	104
Other Services	0	48	61	109
Government & Non-NAICS	0	6	12	17
Totals[1]	351	455	614	1,420

Note:
[1] Totals may not sum because of rounding.
Key:
CP = comprehensive plan

Chapter 8
Environmental Quality Benefits

Environmental Quality Benefits

The SLWRI includes two planning objectives related to the protection and enhancement of environmental goods and services. The first is improving the survival of anadromous fish in the upper Sacramento River, which is a primary planning objective for the SLWRI. The second, ecosystem restoration, is a secondary study planning objective primarily involving restoring environmental resources around Shasta Lake. Enlarging Shasta Dam and Reservoir would contribute to improved anadromous fish survival and reproduction rates by altering seasonal water flows and temperatures in the Sacramento River and other water bodies. The focus of this section is on the first objective, anadromous fish survival. Estimates of features and valuation methods for ecosystem restoration around Shasta Lake are still in progress.

Importance of Anadromous Fish

The number of programs and sums of money dedicated to anadromous fish conservation suggest that society places a high value on salmon restoration. According to the General Accounting Office (GAO), at least 11 Federal agencies and numerous other entities are involved in anadromous fish restoration in the Pacific Northwest. In the Columbia River basin alone, Federal government agencies spent at least $1.8 billion (unadjusted for inflation) between fiscal year (FY) 1982 and FY 1996, according to GAO estimates. Between FY 1997 and FY 2001, these agencies spent $1.5 billion (2001 dollars) to rebuild the Columbia River basin's salmon and steelhead stocks (GAO, 2002).

The Pacific Coastal Salmon Recovery Fund (Pacific Fisheries Management Council, 2006), a fishery restoration program established by Congress, spent $524.4 million from FY 2000 to FY 2005, and $66.5 million in FY 2006 restoring salmon stocks in California, Oregon, and Washington. State matching funds for this program totaled more than $200 million during this period.

Because Chinook salmon are migratory, open-access biotic resources, their value will not be reflected in typical market transactions. Economic practitioners, recognizing that society does value such ecological resources, have developed a variety of nonmarket valuation techniques that may be used in estimating the value of these resources.

Reclamation's 1991 Plan Formulation Report/Final Environmental Impact Statement (PR/FEIS) for the Shasta Outflow Temperature Control Report included an estimation of the recreational (sports) and commercial value of Chinook salmon production. The PR/FEIS also included a harvest model for winter-, fall-, and spring-run Chinook salmon that estimated the portion of fish available for ocean commercial harvest, ocean and sports harvests, and in-river sports harvest of upstream migrants. It applied recreational angler-day values and commercial catch values to estimate the value of fishing under different operating scenarios of the temperature control device (TCD). It is believed that assigning a benefit value to anadromous fish based on sports fishing significantly underestimates the value society assigns to a viable anadromous fish stock. This is because only use values are represented and not nonuse values, which are the values people place on the resource independent of their desires or intentions to use it.

Three studies estimate the nonuse values of salmon restoration in other river basins. An early estimate of salmon restoration programs used the contingent valuation method to estimate the benefits of increased salmon populations in California's San Joaquin River (Hanemann et al., 1991). Loomis (1996) also employed the contingent valuation method to estimate Pacific Northwest states' residents' willingness-to-pay to restore the populations of endangered and nonendangered salmon and steelhead populations in Washington's Elwha River. Layton et al., (1999) researched the value of fishery resource recovery in Washington's Puget Sound and Columbia River basin to Washington residents using a variation on contingent valuation, the censored ranking method. Willingness-to-pay was surveyed for increases in Columbia River migrant (anadromous) fish and Puget Sound anadromous fish populations when told that the stock (1) would otherwise be stable across 20 years, or (2) would otherwise decline across 20 years. Willingness-to-pay under stable population conditions was greater than willingness-to-pay under declining population conditions.

Benefit Derivation

The process used in this evaluation to estimate economic benefits for increasing the populations of anadromous fish along the upper Sacramento River is based on the "least-cost" approach. Under this process, it is estimated that increasing salmon populations is a socially desirable goal, as indicated by the listing of several species as threatened or endangered; the demonstrated expenditures on salmon restoration projects, and the least costly method of attaining increases in salmon populations is sought. Because the increased potential to reduce water temperatures during critical periods provided by additional surface storage is essential to increasing salmon production, the least-cost alternative would be based on the cost of various dam raises operated solely for the purpose of increasing the number of salmon smolt in the Sacramento River.

As mentioned, designs and cost estimates have been developed for three dam raise scenarios – 6.5 feet, 12.5 feet, and 18.5 feet. In addition, estimates of increases in salmon populations (expressed in habitat units of 1,000 additional smolt per year passing the RBDD) have been developed for the three dam raise scenarios under various reservoir operation assumptions. This analysis using the CalSim and SALMOD models is described in the Modeling Appendix. Included in Table 8-1 is the estimated increase in salmon production (referred to here as habitat units (HU); – 1,000 salmon = 1 HU) presuming that Shasta Dam were raised and operated solely for increased fish production. All of the increased volume would be dedicated to increasing the cold-water pool. Also included in the table is the estimated average annual cost for each of the three dam raises. Figure 8-1 shows plots of dam raises versus annual costs and HUs. The figure includes an equation of the "best fit" line/curve.

Table 8-1. Salmon Production and Annual Cost for Dam Raise Scenarios

Dam Raise (feet)	Habitat Units[1]	Annual Cost[2] ($ millions)
0	0	0[3]
6.5	816	42.0
12.5	1,058	47.6
18.5	1,112	53.1

Notes:
[1] Each habitat unit equals 1,000 additional salmon produced.
[2] Based on 2010 price levels, 100-year period of analysis, 4-1/8 percent interest rate for entire dam raise.
[3] Not applicable. Any dam raise would have an initial significant cost because many costs would be similar with higher dam raises.

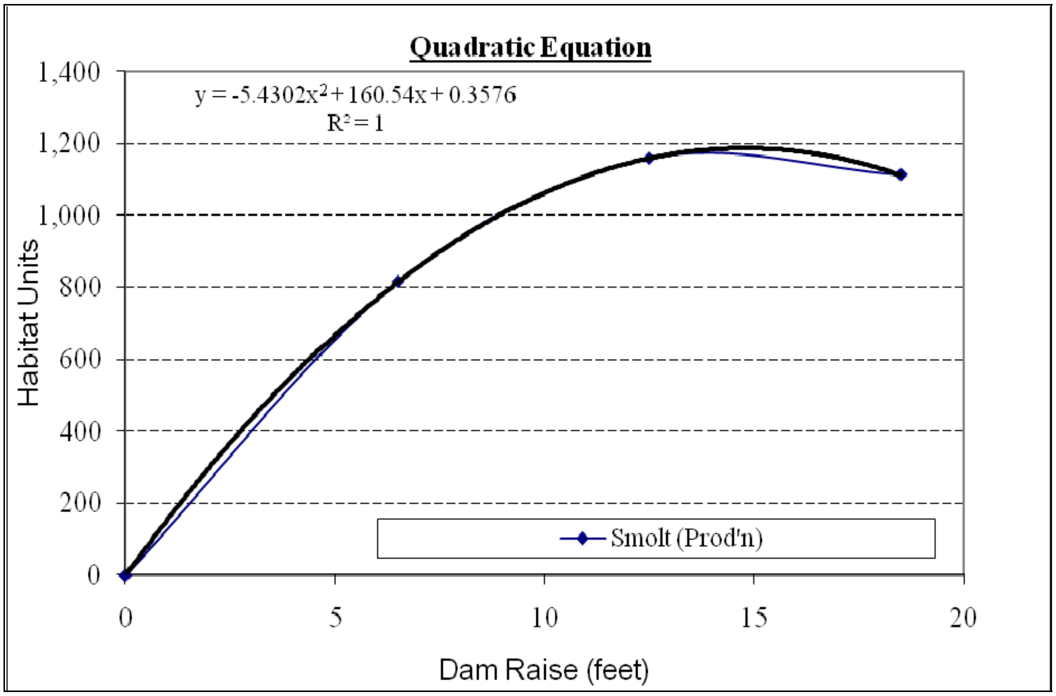

Figure 8-1. Relationship Between Average Annual Costs and Habitat Unit Increase Relative to Dam Raise

As can be seen in Table 8-2, the estimated minimum average annual equivalent cost per HU is $41,073. This cost was identified as the least-cost alternative method of producing a salmon HU, and was applied as a "per HU benefit estimate" to each of the project alternatives. Using this HU value, estimates of relative monetary benefits for each of the comprehensive plans were derived. These benefit values are shown in Table 8-3. As can be seen, the estimated average annual equivalent anadromous fish restoration benefits are $15.1 million for CP1; $9.6 million for CP2; $25.0 million for CP3 and CP5; and $49.2 million for CP4.

Table 8-2. Development of Cost Per Habitat Unit

Dam Raise (feet)	Habitat Units[1]	Annual Cost ($ millions)	Cost per Habitat Unit ($1,000)
2.5	367	38.3	104,434
1.5	228	37.4	163,911
4.5	612	40.2	65,639
6.5	814	42.0	51,644
12.5	1,158	47.6	41,073
18.5	1,111	53.1	47,784

Note:
[1] Each habitat unit equals 1,000 additional salmon produced.

Table 8-3. Least-Cost Alternative Estimates of Average Annual Salmon Smolt Production for Project Alternatives

Description	CP1	CP2	CP3	CP4	CP5
Change in Average Annual Salmon Habitat Units Relative to Without Project Conditions[1]	366.4	233.8	607.5	1198.9	607.5
Total Benefits ($ millions)	15.1	9.6	25.0	49.2	25.0

Note:
Dollar values are expressed in millions, April 2010 price levels.
[1] Each habitat unite equals 1,000 additional salmon produced.
Key:
CP = comprehensive plan

Figure 8-1 depicts the relationship between HU development and average annual costs for dam raises of 6.5 feet, 12.5 feet, and 18.5 feet. Average annual costs increase at the same rate; however, fishery production slows for every unit of dam increase after 12.5 feet. Hence, the least cost per unit of HU (thousands of fish) occurs at 12.5 feet.

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Chapter 9
Benefit Summary

Project accomplishments and benefit estimates pertaining to the 6.5-, 12.5-, and 18.5-foot dam raise alternatives relative to without-project conditions are presented in Table 9-1. Each alternative achieves positive changes in the primary objectives of anadromous fish restoration and agricultural water supply reliability. Each alternative also provides increased benefits for secondary objectives.

Table 9-1. Summary of Benefit Valuation, April 2010 Price Levels

Item	CP1	CP2	CP3	CP4	CP5
Primary Objective Accomplishments					
Water Supply Reliability (TAF/year)[1]	76.4	105.1	133.4	76.4	133.4
Anadromous Fish Survival (HU/year)[2]	366.4	233.8	607.5	1198.9	607.5
Secondary Objective Accomplishments					
Hydropower (GWh/year)	42	68	96	138	96
Flood Control	Incidental	Incidental	Incidental	Incidental	Incidental
Recreation (1,000 visitor days/year)	83	141	224	224	224
Annual Benefits ($ millions)					
Water Supply Reliability (existing conditions)[3]	27.0	25.0	26.7	27.0	26.7
Anadromous Fish	15.1	9.6	25.0	49.2	25.0
Hydropower (existing conditions)[4]	2.4	3.9	5.4	7.7	5.4
Flood Control[5]	Minimal	Minimal	Minimal	Minimal	Minimal
Recreation[6]	3.1	5.2	8.3	8.3	8.4
Total (existing conditions)[7]	47.5	43.7	65.4	92.2	65.5

Notes:
[1] Any dam raise could provide incidental benefits to secondary objectives.
[2] Each habitat unit equals 1,000 additional salmon produced.
[3] Based on existing conditions. Considering future conditions (benefits) would significantly increase indicated values.
[4] Dollar values are expressed in 2007 price levels.
[5] Does not include potential reductions in costs due to dam safety benefits.
[6] For CP5, recreation enhancement benefits assumed equal to annual costs.
[7] Totals may not add because of rounding.
Key:
CP = comprehensive plan
GWh = gigawatt-hour
HU = habitat unit
N/A = not applicable
TAF = thousand acre feet

The size of the benefit estimate for CP4 is largely attributable to the magnitude of the anadromous fish marine sports and commercial fishing benefit. The CP4 project alternative also records fairly large gains in the secondary objective of hydropower generation but some loss in the primary objective of agricultural water supply reliability benefits relative to the CP3 and CP5 project alternatives.

The benefit values shown in Table 9-1 are based on assumptions of stability in the values of the projects' components. Water supply reliability, hydropower generation, anadromous fish restoration, and recreational values are held constant relative to inflation across the projects' 100-year lifespan.

This assumed stability, however, may not be appropriate, especially in regards to hydropower generation and water supply reliability. Projected population and economic growth trends are likely to raise the value of hydropower generation, especially as concerns about global warming restrict the willingness and capacity to meet future electricity generation through fossil fuel technologies. Water supply reliability is also likely to increase in value as future population and economic growth in California place increasing pressure on the State's water supplies.

Table 9-2 summarizes how total benefits vary following possible changes in water supply reliability and hydropower generation benefits (see Table 3-15 and Table 4-2). These benefits estimates are included solely for the purposes of sensitivity analysis. They are not intended for inclusion in NED analysis.

Changes in hydropower generation have relatively minor impacts on total benefits and net benefits. Changes in water supply reliability benefits, on the other hand, have more notable effects. Other things equal, increases in water supply reliability of 1 percent above inflation raise net benefits by approximately $5 million to $7 million. Changes of 2 percent above inflation increase net benefits by approximately $18 million to $20 million.

These net benefit estimates suggest that the SLWRI may be a potentially viable means to address California's future water supply needs. Its capacity to improve anadromous fishery stocks is another valuable component of each of the project alternatives.

Table 9-2. Sensitivity Analysis: Total Average Annual Benefits Following Changes in Water Supply Reliability and Hydropower Generation Benefits

Change in Value Above Inflation		Total Benefits				
WSR	**Hydropower**	**CP1**	**CP2**	**CP3**	**CP4**	**CP5**
No	+ 1%	48.2	44.7	66.9	94.3	67.5
No	+ 2%	49.3	46.4	69.3	97.7	69.9
+ 1%	No change	53.9	49.6	71.8	98.6	72.4
+ 1%	+ 1%	54.6	50.7	73.3	100.7	73.9
+ 1%	+ 2%	55.7	52.4	75.7	104.1	76.3
+ 2%	No change	67.0	61.8	84.8	111.7	85.3
+ 2%	+ 1%	67.7	62.8	86.3	113.8	86.9
+ 2%	+ 2%	68.8	64.6	88.7	117.2	89.3

Notes:
Dollar values are expressed in millions, April 2010 price levels.
Does not include potential reductions in costs due to dam safety benefits.

Key:
CP = comprehensive plan
WSR = Water Supply Reliability

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Chapter 10
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