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DRAFT Guidelines for Preparing Economic Analysis for Water Recycling Projects

Prepared for the State Water Resources Control Board

Economic Analysis Task Force for Water Recycling in California

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Guidelines for Economic Analysis of Water Reuse Projects

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1. INTRODUCTION

An economic analysis is used to determine whether a proposed project will be a worthwhile investment. The analysis takes a perspective beyond that of the proponent and accounts for all benefits and costs regardless of who is affected. Completing an economic analysis allows for fair comparisons to be made between alternatives and demonstrates why a proposed project can be considered the best solution to meet a given objective. The economic analysis differs from a financial analysis in that economic analysis is the primary step used to determine whether to proceed with a project. When observed from society's perspective, does the project generate sufficient benefits in excess of costs to warrant consideration for investment? The financial analysis employs accounting procedures to evaluate funding strategies and cash flows to determine viability and stability of a project or plan.

1.1 Purpose of this Document

This economic analysis guidance document provides an easy-to-follow orientation and method for completing economic and financial analyses for water recycling projects in California based on relevant state and federal guidelines. The intended users of this document are personnel in water utilities, consulting engineers responsible for preparing economic and financial analyses of water recycling projects, and state and federal staff responsible for reviewing economic analysis for water recycling projects.

This document was prepared under contract with the State Water Resources Control Board by the University of California with guidance from the Economic Analysis Task Force (EATF). The work was driven by recommendations from the Governor's 2002 Recycled Water Task Force and the State Water Board's Water Recycling Funding Program (WRFP) 2007-2008 Strategic Plan. Recommendations from the afore-mentioned programs included the formation of the EATF and coordination among state and federal agencies in their funding processes and procedures. The agencies included were the:

- State Water Resources Control Board (SWRCB),
- California Department of Public Health (CDPH),
- California Department of Water Resources (DWR),
- California Public Utilities Commission (CPUC), and
- U.S. Bureau of Reclamation (Reclamation).

1.1.1 Background on Water Recycling in California

Funding of water recycling in California began in the 1960s with construction of Water Factory 21 in Orange County and a tertiary treatment facility constructed by Contra Costa County Sanitation District. In the following decade, the Clean Water Construction Grant Program of 1972 allotted construction funding for recycling facilities from both federal and state sources totaling 75% and 12.5% of construction costs respectively. Funding decisions were primarily based on the *cost effectiveness* of a project, as this was the method outlined by the Code of Federal Regulations (40CFR35 Appendix A Subpart E revision 2006).

In 1977 the SWRCB adopted the Policy and Action Plan for Water Reclamation in California. The plan promoted recycled water as a water supply source in water-short areas and encouraged DWR to assist in implementing this policy. SWRCB Grants Management Memorandum 9.01 (SWRCB 1977) provided the mechanism for state funding. Amendments to the 1978 Clean Water Act limited federal funding to the National Pollutant Discharge Elimination System (NPDES) and eliminated funding for water recycling.

Since the 1970s, state bonds have played a key role in funding water recycling projects. The 1978 Bond Law required cost effectiveness criteria for funding; and later in 1984 and 1988, loans required this cost-effectiveness be relative to other water sources. In 1996 and 2000, bond laws permitted the SWRCB to enter into agreements for water recycling loans and grants, keeping the criteria as cost-effectiveness of a project compared to other alternatives. Most recently, the bond law of 2002 provided grants without specific funding criteria requirements. Loans under the State Revolving Fund (SRF, since 1988) have provided funds only for recycled water projects that are cost effective.

Title XVI of P.L. 102-575 (Title XVI) directed the Secretary of the Interior to investigate and identify opportunities for water reclamation and reuse. Originally, Title XVI authorized Reclamation to participate in construction of 5 water recycling projects, 4 of which were in California. In 1996, Congress enacted the Reclamation Recycling and Water Conservation Act (P.L. 104-266), which amended Title XVI and authorized Reclamation to participate in an additional 18 projects, 10 of which were in California. Additional amendments to Title XVI since 1996 resulted in 53 authorized projects to date (2010), 36 of which are in California. Each project must be authorized individually by Congress. The federal cost-share is generally limited to $20 million per project. The Title XVI Act and amendments give the Secretary the authority to provide up to 25% cost-share to non-federal entities for design and construction of facilities; up to 50% of the cost of feasibility studies; and up to 50% of the cost of demonstration projects.

Reclamation has implemented statutory requirements for Title XVI feasibility studies through internal Directives and Standards. Those directives and Standards list the information that must be addressed prior to any finding by Reclamation that the feasibility study is complete. Once the project has received a Congressional authorization and meets the program requirements, that project is eligible to receive funding.

1.1.2 Uses of Economic Valuation in Water Recycling

In 1979, the SWRCB adopted the Interim Guidelines for Economic and Financial Analyses of Water Reclamation Projects (Ernst and Ernst, 1979). This 83-page document provided abundant detail beyond what applicants would commonly employ. Since 1985, the seven-page Water Reclamation Loan Program Guidelines (1985 and further updates) has been used. In 1993, the external program review panel recommended revision of these cost-effectiveness procedures and suggested changes. Later work groups (2004) removed cost-effectiveness as a funding criterion.

Reclamation follows internal Directives and Standards for Title XVI Projects and has developed final funding criteria for the Title XVI Program. Reclamation does not use the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (Principles and Guidelines) to determine eligibility for Title XVI Projects. However, currently Reclamation incorporates an economic analysis using methodologies from the Principles and Guidelines as a factor in determining the priority in which projects will be funded. In other words, even though a Title XVI application does not require a detailed economic analysis using the Principles and Guidelines, the review process may award more points to a project as the level of detail in the economic analysis increases.

1.2 Economic Analysis and Financial Analysis

The purpose of this document is to outline a basic methodology to complete an economic and financial analysis for water recycling projects. Before proceeding, it is important to explain the difference between the two analyses. The economic analysis of a project is concerned with the viability of a project from a societal perspective and answers the questions of whether it is economically rational to proceed with the project. An economic analysis is concerned with the broader benefits and costs associated with a project. The financial analysis is concerned with the ability of the proponent to raise funds and repay the project costs, or answering the question, “is the project financially feasible?”.

. The economic analysis considers all benefits and costs associated with a project, and determines the project’s overall value to society. A financial analysis is concerned with the ability of a project to generate enough revenue to pay back all the incurred financial costs. Conducting economic and financial analyses have important distinctions. Table 1 provides a comparison of the most important aspects.

Table 1-1. Key Aspects of Economic and Financial Analyses

Aspect	Economic analysis	Financial Analysis
Analysis perspective	Accounts for all benefits and costs "to whomsoever they shall accrue"	Accounts only for benefits and costs realized by a project proponent.
Inflation adjustment	Uses real prices which exclude general inflationary effects but accounts for individual resource price changes different from the general inflation rate (labor, energy).	Uses nominal prices which include inflationary effects
Discount rate	Calculate net present value using two real (no inflation) discount rates: 1) the consumption discount rate of 3% and 2) return to private capital of 7%.	Not Applicable
Interest Rate	Not Applicable	Nominal (includes inflation) cost of borrowing money

1.2.1 Accounting Perspective

The accounting perspective identifies who the benefits and costs accrue to when conducting the economic or financial analysis. The fundamental principle of the proper accounting perspective for the economic analysis is to use the widest possible geographical definition of who will benefit and bear the cost of the project. For water reuse projects, this will probably be the national level if federal funding in involved, or state level if the project is state funded. An international perspective may also be necessary if the project affects international watersheds or river basins.

It is important that the economic analysis account for benefits and costs that are realized outside of the proposed projects agency. While it makes sense to include all benefits in an economic analysis, including all project costs may be harmful to the project's economic viability. The incentive to narrow the accounting perspective to preclude costs that are borne outside of the project area is great if the resulting analysis will indicate that the project is economically viable.

1.2.2 Inflation Adjustment

In both the economic and financial analysis, project values need to be adjusted for price changes that match the type of discount or interest rate being used. Real (non-inflated) prices have to be used if real discount or interest rates are used. In the economic analysis, real prices should be used along with a real discount rate with the following adjustment. If the price level of a specific category of costs, such as energy or labor, are projected to be different than the general inflation projections then those adjustments need to be made. One option is to use the Consumer Price Index available at: **http://www.bls.gov/cpi/**.

In a financial analysis, costs and revenues projected prices include inflation and a nominal (includes inflation) interest rate is employed to determine financial feasibility.

1.2.3 Discount Rate

The discount rate is used to determine the present value of a projected stream of current and future benefits and costs. It accounts for the time value of money and can include inflation and risk. The discount rate is important in determining the economic feasibility of a project. Discounting affects the net present value of a project when there is a significant difference in the timing of benefits and costs such as large initial investment costs and long delays in benefits. In an economic analysis, prices and the discount rate are not adjusted for inflation.

The selection of a discount rate will be discussed in Chapter 3.

1.2.4 Interest Rate

The interest rate is used in determining the financial feasibility of the project and should reflect the cost of the capital to the proposing agency.

1.3 Who Should Use This Document

This document was designed to aid agencies seeking funding for construction of water recycling projects, in evaluating the economic feasibility of water recycling facilities. The economic evaluation can aid internal decision-making and external applications for grants and loans.

1.4 Document Organization

The document has been divided into three main sections. Chapter 2 outlines elements of integrated water resources planning. General elements for financial and economic analyses are discussed in Chapters 3 and 4 respectively. Examples of financial and economic analyses appear in Chapter 5. If some components of the analyses (e.g. estimation of some types of benefits) require elaboration beyond this Guidance Document, references are provided in footnotes.

Appendix A includes a summary of economic and financial analysis practices for water recycling practices in California among State and Federal agencies. To aid the user, a set of miscellaneous items including quality control practices for the applicant, modeling for estimation of costs and benefits and reference benefits and costs table are shown in Appendix B. Formulae, a List of Acronyms, Glossary and a Unit Conversion Table have been included in Appendices C through E respectively. Lastly, additional resources such as, agency contact information and online documents and links appear in Appendix F.

2. INTEGRATED WATER RESOURCES PLANNING

The purpose of this chapter is to provide a context for economic and financial analyses and to describe the basic foundations that apply to both analyses. The basis for both analyses stems from a whole system planning model called Integrated Water Resources Planning (WRPM) with a fair description presented in Asano *et al.* (2007). IWRP takes a system-wide approach to addressing water resources problems. A framework IWRP in water recycling is depicted in Figure 2-1. In Chapter 2, we briefly discuss the first three steps in the process. Economic and financial analyses, undertaken in the fourth step of the framework, are discussed in Chapters 3 and 4 respectively.

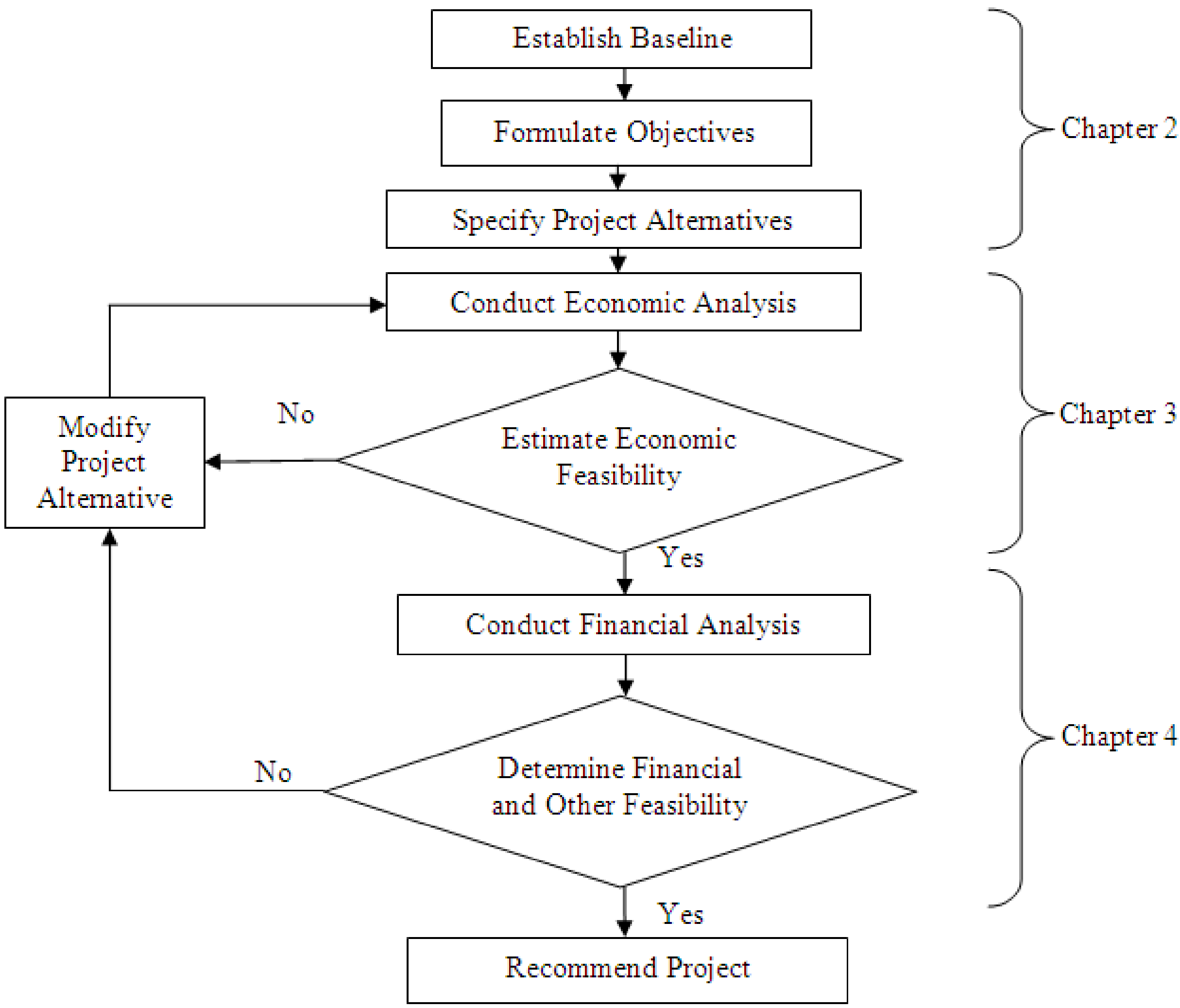

Figure 2-1. Integrated Water Resource Planning Process

The IWRP process establishes a baseline of physical, economic and social parameters to formulate a set of water management objectives and project alternatives. Project alternatives that may or may not include water recycling can meet primary objectives. Water management objectives will vary by agency depending on the resource base, economic and social demand for water. Economic and financial analyses are used to evaluate each project alternative in a systematic and coherent framework.

2.1 Establish Baseline

The baseline describes what would happen in the area without the proposed program, policy or project. It is used as a benchmark to compare project alternatives. A clear definition of the baseline helps describe the issues and therefore how the proposed recycling project may address the issues. The baseline begins by describing the current situation, but then continues to describe how future projections will affect all key parameters for the planning period.

The foundation of an economic analysis is to use a “with versus without” context in which the water reuse project can be compared to no new project. Establishing the baseline is first step in conducting this comparative analysis since it specifies the “without” condition. The baseline should contain assumptions about the future that is generally held with the community. For example, one area that may elicit alternative views is projections of population and economic activity that drive water use projections. Achieving reasonable consensus on the baseline assumptions is important in evaluating water reuse projects.

2.1.1 Land Use Plans

Land use planning establishes guidelines for development or conservation of an area to achieve long term objectives and goals. Land use plans provide the basis for projecting future population and infrastructure demands. Land use planning has always been considered a local responsibility and is the dominant parameter in determining future population and economic activity. Defining water problems, formulating objectives and specifying project alternatives need to be consistent with local land use plans.

2.1.2 Population Projections

Changes in population, income and employment will increase water demands as well as wastewater discharge. Population projections for the state, counties and cities can be found through the California Department of Finance web site in the section of reports and research papers (http://www.dof.ca.gov). Assumptions regarding the increase in the population served by the proposed project should be consistent with the Department of Finance population projections.

2.1.3 Wastewater Projections

As population, economic activity, and water use changes over time, wastewater disposal needs will also change. Wastewater treatment facilities may need to increase capacity or new facilities may need to be constructed. The baseline analysis should include variations in wastewater flows that will result in changes in the volume of recycled water available. Changes in treatment standards can also trigger plant modifications.

2.1.4 Institutional, Legal and Regulatory Requirements

Institutional setting and established regulations need to be considered when examining potential solutions for water and wastewater needs. Local, state, and national policies affect the construction of water recycling projects. Institutional agreements and rules affect the construction, operation, and liability of water recycling activities (USEPA 2004).Water quality guidelines and standards affect the treatment necessary for specific end uses.

2.1.4.1 Recycled Water Regulations and Standards

The “Purple Book” is used to assist the California Department of Public Health (CDPH) in evaluating water recycling projects and contains excerpts from the Health and Safety Code (2001) and the Water Code (See Appendices A for agency documents and Appendix F for additional resources).The health and safety code covers guidelines for sanitary districts, housing regulations regarding gray water use, and provisions on augmenting of sources through recycled water and standards for cross connections.

2.1.4.2 Wastewater Regulations and Standards

Sections 13510-13512 of the California Water Code (CWC) promote water recycling to the maximum extent possible to supplement surface and groundwater supplies. Protection of public health is a condition in recycled water use, covered by the CWC sections 13521, 13522 and 13550(a)(3). A report should be filed with the appropriate regional water board and the regional water board will determine the necessary requirements for the proposed use. The regional water boards should consult and consider the recommendations of CDPH. The 1996 Memorandum of Agreement between the SWRCB and the CDPH provides a framework for collaboration and delineates areas of responsibility and authority on water recycling and wastewater discharge.

2.1.4.3 Drinking Water Regulations and Standards

The CDPH oversees coordination with the SWRCB of the potential effects of water recycling on human health. The drinking water-related statues (often referred as the Blue Book) are a compilation of the Food and Agricultural Code, the Health and Safety Code, the Public Resources Code and the Water code. Drinking water-Related Regulations are from Title 17 and Title 22 of the California Code of Regulations.

2.1.4.4 Local Agency Formation Commissions

California requires Local Agency Formation Commissions (LAFCo) at the county level to oversee the orderly formation of local government agencies that affect land use. The objective of the LAFCo is to preserve agricultural and open space, discourage sprawl, and assure efficient local government services. LAFCos are responsible for changes in service area and services provided by special districts.

2.1.4.5 Water Rights

Water rights will influence the quantity of water treated. For example, water recycling may reduce downstream flows. If downstream users have senior water rights to the applicant or environmental legislation requires minimum flows, the applicant will need to consider these limitations. Legal action may seek to ameliorate or compensate for harm to downstream uses.

To elaborate on water rights, water rights are usufructuary, or rights for use, but not for absolute ownership. California has two doctrines for surface water rights, the riparian doctrine and the prior appropriation doctrine. Riparian rights are linked to property rights of riparian land owners to a reasonable use of water in the stream under certain constraints. Appropriative rights follow the principle of “first in time first in use” and distinguish between senior and junior appropriators. In most areas of California, overlying land owners may extract percolating ground water and put it to beneficial use without approval from the State Board or a court. California does not have a permit process for the regulation of ground water use. In several basins, however, groundwater use is subject to regulation in accordance with court decrees adjudicating the ground water rights within the basins.

The California Supreme Court decided in the 1903 case Katz v. Walkinshaw that the “reasonable use” provision that governs other types of water rights also applies to ground water. Prior to this time, the English system of unregulated ground water pumping had dominated but proved to be inappropriate to California’s semiarid climate. The Supreme Court case established the concept of overlying rights, in which the rights of others with land overlying the aquifer must be taken into account. Later court decisions established that ground water may be appropriated for use outside the basin, although appropriator’s rights are subordinate to those with overlying rights.

2.2 Formulate Management Objectives

The baseline establishes the assumptions on future economic growth, resource systems, and environmental and social conditions. This framework will serve as the basis for formulating water management objectives. DWR through the California Water Plan has developed a set of water resource management objectives that may apply to most regional or local conditions (DWR 2009). Stated objectives can then be met with alternative management strategies. This framework can be used to formulate the agency water management objectives and strategies that include alternative projects, programs or policies. DWR has derived the following six broad management objectives:

- Reduce water demand

- Improve operation efficiency and transfer of water
- Increase water supply
- Improve water quality
- Practice resource stewardship
- Improve flood management

The second step in the IWRP process is to select the water management objectives that best reflect the agency setting. Management objectives that would probably be of interest to most water agency would be to reduce water demand, increase water supply, and improve water quality.

The next step in the IWRP process is to specify project alternatives that will achieve the stated management objectives.

2.3 Specify Project Alternatives

DWR suggests that resource management strategies be employed to develop project alternatives. In summary, the intent of resource management strategies:

"…is to prepare plans that are diversified, satisfy regional and state needs; meet multiple economic, environmental, and societal objectives, include public input, address environmental justice, mitigate impacts; protect public trust assets, and are affordable." (DWR 2009, 1-7)

DWR is charged with the development of resource management strategies to meet regional and local water related problems. Participants include representatives from state agencies and organizations representing diverse interests to develop a comprehensive approach to water problems. They are tasked with collecting land use data and developing water use estimates required for statewide and regional water planning. They accomplish this by conducting surveys of agricultural, urban and environmental land uses, collecting weather and other data required to make water use estimates. This information provides a sound basis for projecting future water supply and demand at the regional and local level. DWR (2009) provides in Table 1-1 potential benefits of alternative strategies that could achieve water management objectives.

2.3.1 Projects to Reduce Water Demand

2.3.1.1 Improving agricultural and urban water use efficiency is a strategy to reduce water demand. Appendix B provides cost ranges from DWR (2009) and other sources for water demand reductions. Improve Agricultural Water Use Efficiency

Agricultural water use efficiency includes water application and delivery hardware upgrades, efficient water management techniques, and reduction in crop water consumption. A range of values for improving agricultural water use efficiency from the California Water Plan Update 2009 is presented in Appendix B.

2.3.1.2 Improve Urban Water Use Efficiency

Improved urban water use efficiency can be achieved by technological and behavioral improvements that reduce residential, commercial, industrial and institutional water use (DWR 2009). The California Water Plan 2009 Update provides a range of costs for urban water use efficiency improvements (Appendix B).

2.3.2 Projects to Increase Water Supply

Increasing the available water supply can be accomplished by employing a combination of storage, management, and technology applications.

2.3.2.1 Conjunctive Management and Groundwater Storage

Conjunctive water management use refers to managing surface water and groundwater together rather than separately to maximize total benefits (DWR, 2009) Time of availability and location play important roles in improving the opportunity of use, overall supply reliability and long term sustainability of the resource. Projects to facilitate conjunctive use can include conveyance systems, recharge and extraction facilities.

The benefits and costs of the conjunctive management are highly variable due to the wide range of circumstances of a program.

2.3.2.2 Desalination

Desalination is the physical removal of sufficient salts from a water supply to make it useable for beneficial activities (DWR, 2009). The principal method of desalination is reverse osmosis that removes pollutants and well as salts. Desalination produces a reliable water supply and will become a more important water supply alternative as natural water supplies become stretched to meet competing uses, and costs decline due to improvement in the technology.

The cost of desalination depends mostly on the quality of the water supply. Ranges of cost for desalination of groundwater, wastewater and seawater from the California Water Plan 2009 Update (DWR 2009) are presented in Appendix B. Although technological advance has lowered costs of desalination over time, this water supply technology uses considerable amounts of electricity.

2.3.2.3 Precipitation Enhancement

Cloud seeding artificially stimulates clouds to produce more rainfall than they normally would produce (DWR 2009). The procedure is primarily used to improve hydroelectric operations because of the benefits of such a procedure is spatially dispersed. The amount of water produced by cloud seeding is difficult to measure but estimates range from 2 to 15 percent increase in precipitation. According to the California Water Plan Update 2009, the cost of cloud seeding is considerably low compared to alternative water supply sources (Appendix B).

2.3.2.4 Recycled Municipal Water

Reusing treated municipal wastewater from commercial, industrial, institutional and domestic sources for beneficial uses can be part of a strategy to meet future demand. The process usually results in a decrease in the use of freshwater supplies (DWR 2009). Benefits of recycling wastewater include reduced supply cost and improved reliability. DWR also claims that significant energy saving can be realized when compared with importing additional water supplies. The cost of recycled water depends on treatment and distribution costs, and water quality required by the end user. Some cost estimates from the California Water Plan Update 2009 are presented in Appendix B.

2.3.2.5 Surface Storage

Reservoirs that collect and store water has been the principle method of meeting a constant demand with a variable supply (DWR 2009) . This alternative includes the construction of new dams and the modification of existing facilities to increase capacity. Reservoirs also provide additional benefits of hydroelectric power, flood management, recreation and operational flexibility.

DWR did not provide a cost range of additional surface storage projects due to highly variable nature of regional circumstances and beneficiaries.

2.3.3 Projects to Improve Water Quality

Water quality restricts water supply to specific uses. Therefore improving water quality expands the useable water supply.

2.3.3.1 Drinking Water Treatment and Distribution

Alternatives for providing drinking water include basic chlorine disinfection, surface water filtration, membrane filtration, ultraviolet light, ozone and dilution with high quality water. Costs of providing drinking water treatment reported by the Metropolitan Water District are presented in Appendix B.

2.3.3.2 Groundwater and Aquifer Remediation

Conjunctive management (use) refers to the coordinated and planned use and management of both surface water and groundwater resources to maximize the availability and reliability of water supplies in a region to meet water supply objectives. Managing both resources together, rather than in isolation, allows water managers to use both resources for maximum benefit. Water is stored in the groundwater basin for later and planned use by intentionally recharging the basin when excess water supply is available. For example, recycled water may be used to supplement surface water supplies or be used to recharge groundwater basins.

2.3.3.3 Matching Water Quality to Use

Matching water "quality to use" is a management strategy that recognizes that not all water uses require the same quality water. A water quality constituent often is only considered a contaminant when that constituent adversely affects the intended use of the water. The California water code governs the water quality standards to minimize the risks to human health, while the State Water Board regulations on wastewater quality aim to minimize the risks to environmental health. Adhering to the regulations under California Title 22, recycled water can be treated to meet a wide range of water quality standards that can be matched to different beneficial uses.

2.3.3.4 Pollution Prevention

The Federal Clean Water Act (CWA) requires each state to adopt a statewide antidegradation policy and procedures for its implementation. California antidegradation policy was adopted by the State Water Board as resolution No. 68-16, which establishes the requirement that state water discharges be regulated to achieve the "highest water quality consistent with maximum benefit to the people of the state." The use of recycled water for beneficial use is consistent with the aims of the state antidegradation policy and provides an economic benefit to the state.

2.3.3.5 Salt and Salinity Management

Beneficial use discussions sometimes leave the impression that water supports one set of uses and then becomes a waste. However, most state communities routinely reuse, reclaim and recycle water multiple times. There is often a high demand for recycled water for landscape and agricultural irrigation, but salt concentrations must be managed to protect the beneficial use or the potential water supply may be lost. The state's Recycled Water Policy, adopted by the State Water Board in May 2009, identifies the need for every groundwater basin/sub-basin to have a salt/nutrient management plan.

Sustainable salt management in any hydrologic region in California protects water resources that may be serving multiple regions in the state. For example, salinity control in the Sacramento Basin may have a relatively small direct benefit in this watershed. However, reducing salt loads in tributary rivers to the Delta could provide a significant benefit to those receiving water through the California Aqueduct (that includes much of southern California) and the Delta-Mendota Canal (much of the San Joaquin Valley). Those benefits include higher drinking water quality, avoided costs, continued ability to produce food and fiber, habitat maintenance, and reduced pre-treatment costs for industries requiring low salinity water supplies.

It's extremely difficult to estimate the cost of sustainable salt management in California. Ideally, salinity control should be incorporated into a broader effort that protects and expands water supplies, optimizes water use, protects fisheries and other habitats, or stores water for future use. Salt management methods vary in effectiveness and cost, depending upon the volume and concentration of salts (expressed as total dissolved solids or TDS – this includes organics, inorganics and colloidal suspensions), type of salt, the desired salt concentration after treatment, and the type of management strategy used.

2.3.3.6 Urban Runoff Management

The primary benefits of urban runoff management are to reduce surface water pollution and improve flood protection. Additional benefits may be to increase water supply through groundwater recharge in areas with suitable soil and geological conditions, and where pollution prevention programs are in place to minimize the impact on groundwater. Groundwater recharge and storm water retention sites can also be designed to provide additional benefits to wildlife habitat, parks and open space.

3. ECONOMIC ANALYSIS

Economic analysis is a systematic approach to determining the optimum use of scarce resources, involving comparison of two or more alternatives in achieving a specific objective under the given assumptions and constraints. It takes into account value of resources employed and attempts to measure the private and social costs and benefits of a project to the community or economy.

In contrast to a financial analysis (Chapter 4), the economic analysis takes a broader perspective, including in principle all benefits and costs "to whomsoever they accrue" from the completion of a project (Raucher, 2006). The economic analysis is a more comprehensive investigation on the impacts of the proposed project. With economic analysis it is possible to answer questions such as will project benefits exceed project costs, and who will benefit and who will pay?

A "full social cost accounting" that identifies and accounts for all benefits and costs of a proposed project is recommended for Economic Analysis (Asano *et al.*, 2007). The process should include benefits and costs that directly affect the proposing agency and the effects of the project on individuals, households, businesses outside of the agency purview. It should also include the benefits and costs that cannot be readily measured using observable market prices and costs.

The economic analysis can be separated into eight major steps outlined below in Figure 3 1. While these steps are not comprehensive and represent broad categories in the process, they encompass the most commonly used stages in economic analysis. In the first step, all project benefits and costs are identified regardless of responsibility, timing or location. In the second step, they are quantified or described if they cannot. In the third step, the time horizon or project life is selected. The discount rate is selected in the fourth step, and decision criteria are selected in step five. Steps three, four and five do not have to be performed in order. Step six is an optional risk analysis. The sensitivity analysis is conducted in step seven and the economic feasibility is estimated in step eight.

3.1 Identify Benefits and Costs

The first step of the economic analysis is to identify the costs and benefits of the project. Benefits and costs are of two types: 1) those that directly affect the agency, and 2) those that impact parties outside of the agency.

3.1.1 Direct Benefits and Costs

Direct costs are generally considered to be benefits directly realized by the agency and out of pocket costs to build and operate the water recycling facility.

3.1.1.1 Additional Water Supply

Reclaimed water represents an additional water supply that could serve to replace the development of other water sources and should be compared with developing alternate water supply sources. Alternatives could include groundwater, surface water, transfers, purchases, desalination, or water conservation (Asano *et al.*, 2007, 1388)

As indicated by the portfolio analysis described in Chapter 2, the additional water supply can also increase the reliability by providing water during droughts, The additional water supply can also improve water quality, increase operational flexibility, reduce flood impacts, decrease energy demand, expand recreational opportunities, and reduce groundwater overdraft.

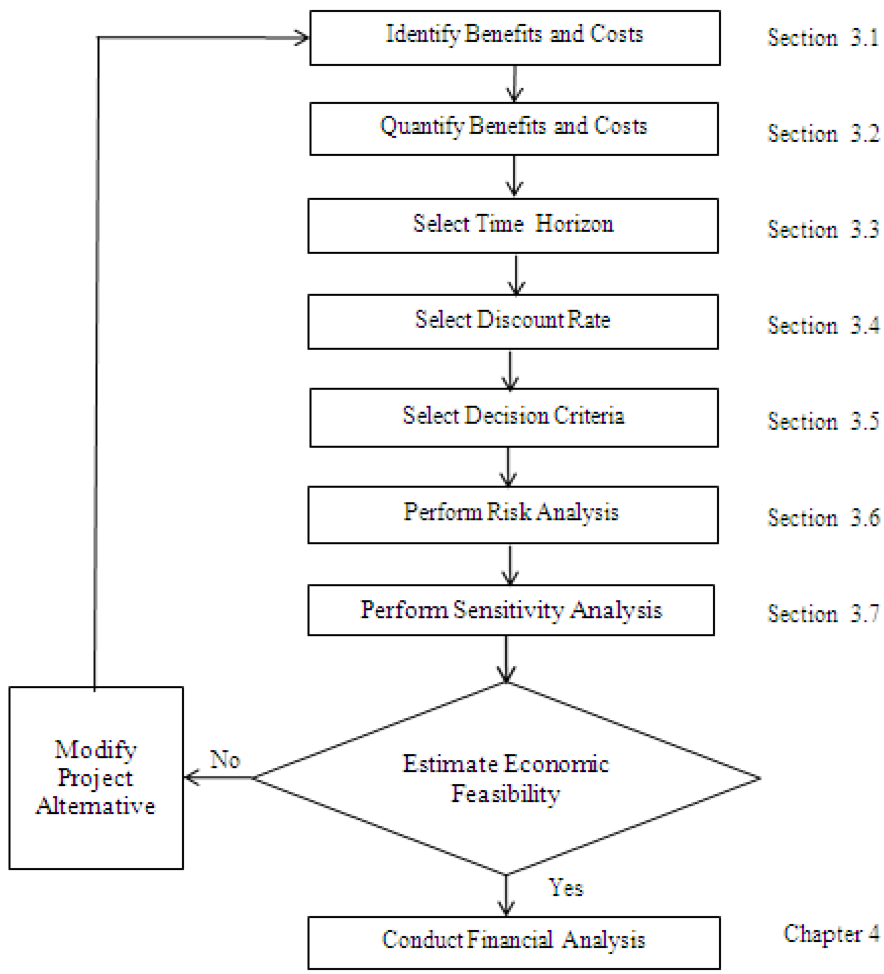

Figure 3-1. Economic Analysis of a Project Alternative

3.1.1.2 Reliability

Reclaimed water improves the reliability of existing water supply systems. Additional reuse water makes the system less sensitive to drought conditions. Increase in water supply reliability reduces the probability of water use restrictions, which has a direct value in the industrial and commercial water users and serves as an attraction for future economic development.

3.1.1.3 Local Control

Water supplies that originate outside of the agency's jurisdiction are subject to the decisions and policies of those providers. Reuse projects could also reduce energy consumption and air pollution by reducing the need to import large amount of water.

Increasing the degree of local control is an important consideration in evaluating a water reuse project.

3.1.2 Indirect Benefits and Costs

Indirect benefits and costs are realized by parties outside of the proposing agency and they are not considered in the financial analysis of the proposed project. In economics, indirect effects of economic decisions are called "externalities". Externalities occur when the all of the effects of a transaction are not reflected in the market price of goods and/or resources. In the case of indirect or external benefits, the responsible agency does not receive true worth of the action and produces less of the product than would be optimal. In the case of external costs, the opposite is true. The true cost of the agency's actions is not reflected in the cost and more of the product is produced than is optimal.

In the case of water reuse projects, potential indirect benefits and costs result from changing the existing surface water and groundwater hydrology and changes in water quality.

3.1.2.1 Environmental Changes

Water recycling may reduce surface water diversions resulting in a more naturally occurring flow regime and enhanced water quality for species. More natural conditions can help natural species thrive and aid in the restoration of deteriorating habitats. Benefits are not only for the species but also for users of national parks and other outdoor locations that rely on these environments. Environmental benefits are produced if reclaimed water use will help enhance, develop, or improve a surface water body, habitat or ecosystem (Raucher, 2006). Costs can result from reduced flows negatively affecting downstream habitats.

Recent improvements in wastewater treatment have resulted in a higher quality discharge and subsequent improvements to the water quality of receiving waters. The benefits of increased water quality include improved instream flows, and riparian and wetland habitats. This enhances water based and passive recreational use opportunities.

Water reuse projects can have a positive or negative effect on streamflow. Positive effects of water reuse project include the prevention of critical low-flow conditions by postponing diversions and the reduction of surface water diversions, which results in a more naturally occurring flow regime and enhanced water quality for species.. More natural conditions can help natural species thrive and aid in the restoration of habitats. Enhancing streamflow affects riparian habitat that supports plants that in turn provide flood controland water quality improvement by filtering contaminants and taking up nutrients. Ecological benefits that include enhanced critical wildlife habitats for threatened or endanger species can have a substantial monetary value. Fishing and boating can also have high monetary value. Water reuse projects can also negatively affect streamflow by increasing total consumptive use of the existing streamflow. The negative effects on streamflow will probably be resolved by changes in water rights.

Water reuse projects can play a critical role in the preservation and enhancement of wetlands. Wetlands represent vast array of benefits. Wetland habitat supports a variety of species of microbes, plants, insects, amphibians, reptiles, birds, fish and mammals. Wetlands provide flood control, improve water quality by filtering contaminants, recharge groundwater, prevent shoreline erosion, and facilitate recreational opportunities.

Water reuse projects have the potential of significantly changing the hydrology of the region. If water recycling reduces groundwater pumping and overdraft will be reduced, economic benefits will result. Minimizing overdraft may avoid subsidence or minimizing the rate of saltwater intrusion to the aquifer can represent a critical benefit to region (Raucher, 2006). Water reuse projects can also play a critical role in a conjunctive water management program. Benefits would be a reduction in subsidence and avoiding increased pumping costs.

3.1.2.2 Recreation

A water recycling facility may create or enhance recreational facilities such as sports fields, urban parks or greenbelts. Benefits are accrued to ballplayers, picnickers and other users of recreational facilities irrigated with recycled water. Aesthetic benefits for residents living in the nearby of these facilities and carbon sequestration benefits may also be significant.

3.1.2.3 Nutrient Value

Benefits may result from the nutritional value provided if reclaimed water is used for agriculture and nutrient content acts as a fertilizer. Reduced fertilizer use can improve underlying groundwater quality.

Conversely, higher nutrient content in applied water could also have negative effects on the underlying soil and groundwater.

3.1.3 Economic Impact Analysis and Equity Assessments

An economic impact analysis identifies groups that benefit or are harmed by the project and then measures the magnitude of those changes. These changes are estimated across broadly defined economic sectors that include industry, consumers and governments. The analysis measures direct and indirect impacts. Impacts are measured by changes to gross regional product, income, employment government revenues and expenditures, and prices. The assessment requires that the projected levels of the preceding variables be compared with the baseline levels.

An equity assessment focuses on the negative impacts of the project and the effect on the income and employment of disadvantaged sub-populations. In an equity assessment, income and employment impacts on small businesses, small government jurisdictions, small not-for-profit organizations, socially disadvantaged populations, economically disadvantaged populations are estimated.

3.2 Quantify Benefits and Costs

In the second step, benefits and costs are quantified in monetary terms or alternatively qualitatively described. Benefits and costs should be quantified for each category of user or project participant. Project participants to consider are the water supplier, wastewater agencies, customers, and society. A project participant's point of view is different from the accounting perspective. The accounting perspective describes the physical range that is being considered whereas the points-of-view of project participants describe groups within the physical range that will be affected by the project.

3.2.1 Methods to Value Additional Water Supplies

Water recycling may help avoid or postpone investments in expanding water supply and wastewater capacity. Possible avoided costs include reduced imports or delayed capital expenditures on acquiring new freshwater sources. Operation and maintenance costs can also be reduced as no additional potable water treatment could be required. In many cases, the value of reuse water can be derived from the marginal cost of new water supplies. The avoided cost of the alternative should be part of the baseline analysis.

In accounting for avoided costs, there is a risk of double counting benefits. It is important when identifying benefits and avoided costs that it is only counted once in the economic analysis. For example, double counting can occur when the benefit of reuse is accounted for as a future cost saving and the sale of water also shown as a benefit.

Out-of-pocket life cycle costs to the agency should be used to value the direct project costs. This includes the cost of capital equipment, operational and maintenance costs, water supply acquisition costs, treatment and distribution costs, overhead and administration fees. Cost sharing arrangements and any public subsidies also need to be included.

3.2.2 Methods to Value Water Supply Reliability

Water customers value a water supply that will not be interrupted in periods of drought and water reuse projects provide greater water supply reliability. Raucher (2006) provides guidance in estimating the value of water supply reliability (p 28, 145). Studies have been done to estimate the value of water supply reliability based on customers "stated preferences" and "revealed preferences". Stated preferences are opinions elicited directly from customers. Revealed preferences are derived by observing actual market choices made by the customers. Results from both approaches are presented with the recommendation that the conditions of the estimates be considered before using specific values. Both approaches to value have strengths and limitations, and they are discussed by Raucher (2006).

3.2.3 Methods to Value Local Control

Placing a monetary value on local control is generally difficult since it depends on the sources and conditions of the existing water supply. The value of reducing the importance of outside rules and policies can probably best be valued by describing what management or operational decisions would be effected and the extent of the increased flexibility the water reuse project would bring. Documenting past experiences that would be different if the water reuse project existed would be helpful to understand the value of improving local control.

3.2.4 Methods to Value Environmental Changes

The literature on valuing environmental changes is extensive and varied but is relatively difficult to employ in this type of analysis. Raucher (2006) suggests several practical procedures to environmental changes and they are summarized here (p. 119). To facilitate evaluation, environmental changes were organized into the following categories.

- Water quality
- Groundwater
- Endangered species habitat
- Wildlife habitat
- Coastal Ecosystem
- Wetland

3.2.4.1 Water Quality

Water reuse projects will directly reduce treatment plant discharges that may improve the quality receiving water course. Improved water quality increases the extent and the number of the beneficial uses. A good example of the effects of increased water quality is shown in the quality standards required for various water uses. In irrigated agriculture, improvements in water quality result in increased crop yields in addition to a wider variety of crop selection.

The value of improved water quality is typically embedded in the value of the beneficial use which in economics is called a derived value but direct values of water quality have been estimated by surveying affected populations. Raucher has reported results from a number of studies on the willingness to pay for improved water quality (Raucher, 2006, 123) The following reported values are presented as examples of the values that could be used for valuing water quality improvement for water reuse projects. The total value of improved water quality would depend on the number of households or residents in the project area.

Appendix B of this document presents willingness to pay ranges of values for residents of Ohio, Ontario, Pennsylvania and North Carolina from Raucher *et al.* (2006). If these values are sufficient to warrant further consideration in the case of the proposed project, estimates can be made ether by direct survey or transferring values from existing studies.

3.2.4.2 Groundwater

Increases in stream flow that affect the recharge and quality of groundwater is a benefit to the proposed project. Raucher reported results from a number of studies on groundwater quality (p.126). Some studies provide willingness to pay for improved groundwater quality for secure uncontaminated groundwater, restoring contaminated groundwater in different locations. These are presented in Appendix B. Many more studies exist on the value of groundwater and related quality and alternative methods of estimating value of specific aquifers exist.

3.2.4.3 Endangered Species Habitat

Aquatic wildlife habitat is sensitive to changes in water quality. Values of the habitat is derived from the value of the species. A number of studies have been done to estimate the willingness to pay of threatened and endangered species (Raucher, 2006, 129). A survey of values for preserving endangered species in different locations is provided in Appendix B.

3.2.4.4 Wildlife Habitat

Wildlife diversity and the necessary wildlife habitat is important in the general welfare of the region. The value of preserving an adequate level of water quality has been estimated in a number of published studies. Appendix B provides survey responses for protection of water supply in Mono Lake and the Pacific Northwest as examples.

3.2.4.5 Coastal Ecosystems

The ecological health of coastal and estuarine ecosystems is important to individuals, environmental groups and recreationists most of which may not reside in the agency's service area. Coastal ecosystems values for improvement estuaries in North Carolina, shore beach maintenance in Chicago and coastal ponds in Massachusetts are presented in Appendix B.

3.2.4.6 Wetlands

Wetlands are intrinsically linked to surface water and groundwater. Improvements in water quality will directly result in economic benefits due to the vast array of unique goods services provided by wetlands. Wetlands are supported by worldwide organizations and environmental groups have begun efforts to preserve and enhance these critical areas (Mitsch and Gossenlink, 2000).

The literature of estimating the value wetlands is substantial with over 200 estimates that have been derived from 80 studies worldwide. Raucher *et al.* (2006) has summarized a number of these studies for Ohio, Kentucky and New England. A compilation of these values is presented in Appendix B. Other values are also presented in Ghermandi *et al.* (2008).

3.2.5 Estimating Economic Impacts and Conducting an Equity Assessments

Water reuse projects do have the potential of affecting the income and employment of the broader population. In most cases these impacts will not be significant but the potential does exist. Estimating the total economic impacts of potential projects can be estimated using existing models (Table 3-1).

The most robust approach is a computable general equilibrium model (CGE). However the expense and time of applying this approach is prohibitive except for cases that have long-term economic impacts and have broad geographical significance.

The REMI model possesses the capability of accurately estimating economic impacts for the necessary geographic scale. It is readily available on a timely basis but it is expensive for this purpose.

The IMPLAN model is a good alternative to assess direct and indirect economic effects of potential projects. It is readily available at a reasonable cost. Using the model requires some training that is available through the distributor.

The least expensive approach is the RIMS model that is available from the US Dept of Commerce. However it requires a familiarity with input-output analysis and how an analysis should be conducted.

Table 3-1. Economic Impact Models

Model Name	Project Manager	Description
Regional Economic Models Inc. (REMI)	Regional Economic Models Inc	An integration of multiplier, econometric and general equilibrium models.
Impact Analysis for Planning (IMPLAN)	Minnesota IMPLAN Group	A input-output multiplier model using Social Accounting Matrixes over a particular geographic region to investigate the consequences of projected economic transactions among industry and institutions.
Regional Input Output Modeling System (RIMS)	U.S. Bureau of Economic Analysis	An input-output model for the U.S. showing industry inputs purchased and products sold among 500 sectors.

The US EPA recommends completing an "equity assessment" to examine how costs and benefits affect the population and the regional (or national) income and wealth. The assessment suggests a three-step equity assessment: 1) define scope of the equity analysis; 2) define distributional variables, 3) measure equity consequences. The populations to consider are grouped into four categories: individuals, businesses, not-for-profit organizations, or governments. Disadvantaged sub populations within these groups are of particular interests as they might be under-represented, vulnerable or economically disadvantaged. Equity categories to examine include entity size, minority status, income level, childhood status, gender, type and physical sensitivity. More details on conducting equity assessments can be found in the Guidelines for Preparing Economic Analysis (USEPA 2010).

3.2.6 Estimation of potential financial burdens to non-participants

In some cases, unintended financial burdens may occur for project non-participants as a result of a water recycling projects. However, these costs are not part of the recycling project's proponent financial analysis, and are rather economic costs of the project. Affected non-participants may be the water supplier (either local supplier or wholesaler) or downstream water users. This is the case of potable water wholesalers and retailers that may lose revenues from water sales as the new recycling facility starts operations and takes some market share. In the second scenario, water recycling may reduce the water volume available for downstream users. If downstream communities rely on this water for their water supply, reductions in upstream flow will affect the finances of downstream water suppliers. In both these scenarios, recycled water may affect non-participant freshwater rates. Fresh water prices can increase as estimated water use decreases and fixed costs remain roughly constant, thus increasing financing costs to non-participants. Fresh water demand also can be reduced relative to recycled water, thus reducing the supplier's revenue. The example in Chapter 5 illustrates impact to project non-participants could be taken into account in the economic analysis.

3.3 Select Time Horizon

Selecting the time horizon of the economic analysis should be based on stated criteria and not be arbitrary. Basically, the time frame should be long enough to cover the expected life of the projects capital investments or when the net benefits of the project are expected to be negligible when discounted to the present.

3.4 Select Discount Rate

Discounting makes benefits and costs that occur in different time periods comparable by expressing their values in present terms. This is accomplished by using a discount rate. A discount rate accounts for the opportunity cost of using money now versus in the future. The discount rate reflects that a dollar used now is worth more than a dollar in the future; therefore, benefits and costs that accrue early in the project are worth more than those realized later. The discount rate is not the same as the rate of inflation. When completing an economic analysis, all benefits and costs should be adjusted using the discount rate so that they are recorded in present value dollars or constant dollars. The use of constant dollars avoids the need to account for inflation in costs and benefits. As the discount rate increases, the present value of money decreases.

The discount rate used is often constrained by regulations or agency. For example, Reclamation and USACE are subject to federally-established rates. DWR and the SWRCB currently use a 6% discount rate. The USEPA (2000) suggests using the consumption rate of interest for inter-generational discounting when changes in consumption flows rather than in capital stock occur in a project. Based on government backed securities these rates are currently around 3 percent. When changes in capital stock are more likely, the rate of interest of private capital is more appropriate. Currently the Office of Management and Budget estimate the opportunity cost of private capital is 7 percent.

Discount and interest rates are commonly controversial in economic and financial analyses. Decisions on millions of dollars rely on this parameter. Therefore, a sensitivity analysis using different discount rates is sometimes appropriate. USEPA (2000) suggests displaying the time paths of benefits and costs projected over the project time horizon without discounting, discounting using the consumptive rate of interest (3 percent) and the rate of return on private capital (7 percent). This defines the extent of the results to the feasible range of discount rates. Select Decision Criteria.

3.5 Select Decision Criteria

There are a number of decision criteria that can be employed in economic analysis. Usually one decision criterion suffices to assess the economic feasibility of a project. Among the most widely used ones is the Net Present Value (NPV). In this section we describe common decision criteria with additional references.

3.5.1 Net Present Value

Net present value (NPV) is the difference between the benefits and costs of a project. To ensure fair comparisons, all benefits and costs are adjusted using a discount rate. If the NPV is positive, the benefits of the project exceed its expected costs and the alternative is desirable relative to no action (a common base case). In general, alternatives with the highest ENPV per unit budget cost should be funded.

3.5.2 Benefit Cost Ratio

Similar to NPV, the benefit-cost ratio sums total benefits and costs using the discount rate. However, rather than subtracting the costs from benefits, they are presented as a ratio of benefits to costs. A ratio greater than one indicates benefits exceed costs and the project is economically justifiable (DWR 2008). The drawback to using benefit-cost ratios is the issue of accounting for negative costs. Negative costs will lower the sum of costs and artificially inflate the ratio. In ENPV the net effect of the negative costs would be the same (Lund, 1992).

3.5.3 Annualized Net Benefits

The Annualized Net Benefits (ANB) criterion is equivalent to the NPV method in its formulation (Sassone and Schaffer, 1978). The difference is that it transforms a fluctuating time stream of net benefits into annualized values.

3.5.4 Internal Rate of Return

The goal of the internal rate of return (IRR) is to determine what discount rate will result in net benefits equaling the net costs. The IRR approach uses the net present value formulation to sum costs and benefits. However, the NPV is set equal to zero and the discount rate that equates benefits and costs is determined. The resulting discount rate can then compared to the discount rates that could be applied. If the computed discount rate is greater than the selected discount rate the project is considered justified (as mentioned above, a higher discount rate lowers the present value).

3.5.5 Expected Net Present Value

By specifying risk in the form of estimated probabilities, NPV becomes expected net present value (NPV). The benefit of using ENPV is that it accounts for risk by using probabilities for sets of parameter values (scenarios). Estimating these probabilities may require specialized statistical skills. Using the probabilities estimated for each scenario, a single value for ENPV can be calculated.

3.6 Risk Analysis

In some projects a Risk Analysis may be required. Risk analysis uses probability distribution functions to show a range of outcomes. As demonstrated with expected net present value, the probability can be incorporated into the calculation. The methods to perform a risk analysis in connection with an economic analysis are out of the scope of this document.

Risk analysis is helpful in estimating the frequency and magnitude of events and the potential associate outcomes. Examining a range of outcomes and probabilities provides a snapshot of likely burdens and benefits for each event. In the context of water recycling, events such flooding events and prolonged droughts, and even longer-term issues such as sea level rise, may change the payoff scheme of a project. Unforeseen new recycled water uses and shifts in consumer preferences towards more or less recycled water may also affect the initial estimates.

A risk analysis can be qualitative on quantitative. Quantitative risk analysis can be deterministic or stochastic. In deterministic analysis, specific point estimates of an outcome are assumed, whereas in stochastic analysis a range of values and its probability distribution are used. Deterministic risk analysis can include worst case, best case and most likely scenarios as single-point estimates. Stochastic risk analysis provides likelihood of outcomes and its consequences. Small projects might benefit less from costly and time consuming risk analysis. Routine calculations through simple spreadsheets for a range of alternatives can be employed instead. Large investment projects involving large consequences can justify allocating more funds to risk analysis.

A Monte Carlo analysis is considered a risk analysis and establishes a range of values for the parameter considered uncertain, and then analyzes random samples of parameter values from probability distributions. Variables have a probability distribution of different outcomes to occur. Probability distributions are deemed a realistic way of representing uncertainty. A deterministic analysis follows for each set of randomly drawn parameter values. The net present values are then averaged to estimate the expected net present value. This approach requires more elaborate estimation of the statistical and correlated properties of each uncertain parameter.

3.7 Perform Sensitivity Analysis

Uncertainty and risk are present throughout the economic analysis as there are no assurances that predictions are accurate. When doing the analysis, areas which are likely to be sensitive need to be clearly identified and addressed (Water Resources Council, 1983). To address risk and uncertainty, sensitivity and risk analyses can be utilized. A sensitivity analysis varies values of key variables, such as the discount rate, to determine the effect on the final outcome.

3.8 Assess Economic Feasibility

Project evaluation compares alternatives over the same period of analysis and using the set discount rate and the chosen decision statistic. Most of the methods mentioned above are similar in the sense a discount rate is used to translate values over time. The difference among the lies in the way costs and benefits are expressed. For the same stream of net benefits the NPV may be lower at higher discount rates, whereas the annual value will be higher or lower depending on the length of time benefits and costs are annualized over. NPV is usually more informative for projects requiring immediate investments but the Annual Value method is useful in comparing different infrastructure with different service life.

4. FINANCIAL ANALYSIS

4.1 Introduction

Financial analysis provides an assessment of a project's monetary desirability (income and expenses) to the water utility over the period of analysis. While a necessary consideration, financial feasibility is not a sufficient condition to build a project. It establishes financial actions necessary for a project's monetary success; however, it does not account for the wider costs and benefits addressed in economic analysis. The financial analysis should be completed if the economic analysis demonstrates that the project is justified.

A financial analysis is used by the proponent to estimate funds needed to construct and operate a project over the period of analysis. A project is considered *financially feasible or solvent* if the agency has sufficient capital for construction, can pay for costs over the repayment period, and estimated revenues can cover operations and maintenance costs and debt service payments over the period of analysis (Ernst and Ernst, 1979).

The proponent's perspective is used for the accounting perspective in a financial analysis. This perspective will identify financial shortfalls which may require external funds and will identify each user's stake in the project. Sources of funds can include local bonds, state or federal loans, or private loans and incentives. In some cases, supplemental financial analyses, from non-participant perspectives, may also be needed.

This chapter outlines a framework for financial analyses of water recycling projects. The chapter begins with a summary of the process, with details for elements addressed in subsequent sections. The basic steps for a financial analysis are shown graphically in Figure 4-1.

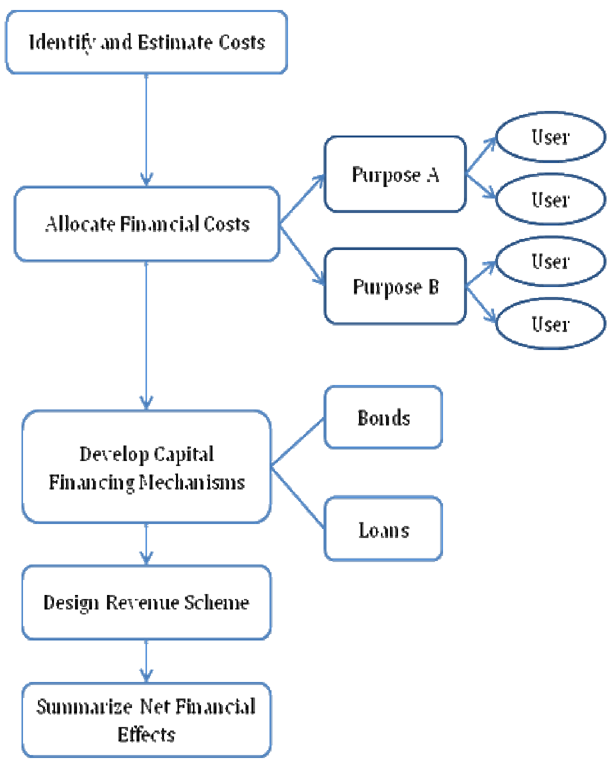

Figure 4-1. Financial analysis process.

To summarize the process, project costs are identified and estimated in monetary terms, typically at market prices (Step 1). Costs are then allocated among project purposes and participants (Step 2). In construction and operation of a new project, two main monetary flows are to be considered: a) capital financing and b) revenues. For capital financing (Step 3), potential sources such as bonds and loans are identified and described in terms of the funds available and repayment requirements. The other funding consideration is revenue sources from the project (Step 4). This formulation allows overall financial assessment of the project for the project proponent (Step 5). A detailed description of each step is presented in the following section (Section 4.2). Step by step guidance is presented in Chapter 5.

4.2 Financial Analysis Process

4.2.1 Identification of Financial Costs

Financial costs are actual *out-of-pocket* costs. These include the capital costs from construction, operations and maintenance costs, and debt service repayments. A non-comprehensive list of potential costs is presented in Table 4-1. Costs are estimated based on expected prices of expenditures and are adjusted in time to include inflation. This contrasts to the economic analysis which uses the discount rate to quantify benefits and costs in constant dollars. It is important to note that *sunk costs*, such as existing debt service payments or existing facility operations and maintenance costs, are not included in the financial analysis since these costs would be incurred with or without the project.

Table 4-1. Financial Costs of a Proposed Recycling Project

Capital Costs	Project Design Costs
	Land purchase
	Planning, design, and engineering
	Materials
	Labor
	Other
	Project construction
	Materials for recycling facility
	Materials for distribution system
	Costs to build system
	Costs to connect users
	Labor
	Environmental Mitigation
	Licenses/Fees/Legal
	Retrofitting costs to convert plant to recycled water

	Retrofitting costs for users Regulatory Costs Administration/Overhead
Operations and Maintenance Costs	Annual Operations Labor Materials Annual Maintenance Labor Materials Training and continuing education Regulatory Costs Cross-connection control and projection
Avoided Costs	Potable water replaced Wastewater disposal costs

4.2.2 Financial Cost Allocation

A project involving water treatment may serve several purposes and users depending on the process and infrastructure. Broad purposes include pollution control and water supply augmentation. Costs can be allocated among users and purposes using the *Separable Costs-Remaining Benefits Method (SCRB)*. With the SCRB method, costs are distributed among project purposes by identifying separable costs for each purpose or participant and allocating joint costs or joint savings in proportion to each purpose's remaining benefits (DWR 2008, p. 48). Sequential steps for the SCRB method are:

1. Estimate benefits for each purpose
2. Estimate *Alternative Costs,* which is the cost of a single-purpose project for each benefit identified in step 1
3. Determine the *Justifiable Cost,* which is the lesser of the two items above. The justifiable cost represents the maximum that can be allocated to a specific purpose.
4. Estimate the *Separable Cost* of each purpose by subtracting the project cost with the specified use omitted (given) from the cost of the multipurpose project.
5. Separable cost of each purpose should be deducted from the justifiable costs to determine its remaining justifiable costs.
6. Estimate purpose's percent share of the remaining sum of justifiable costs of all purposes.
7. Deduct the total separable cost from the total project cost to determine the total remaining *Joint Costs*.

8. Distribute the joint costs proportionally for each purpose by weighting them with percent shares estimated in step 6.
9. Cost allocation to each purpose is the sum of the distributed remaining joint cost and the separable cost.

A step-by-step approach to using the SCRB method is presented in Chapter 5. Other less-used methods include the Alternative Justifiable Expenditures, and Proportionate Use of Facilities methods (DWR 2008).

4.2.3 Capital financing mechanisms

The likelihood of receiving funding depends on the financial standing of the proponent. Therefore, the first step in considering potential financing sources is to assess the proponent's financial standing. A summary of the information needed to assess the financial standing of the proponent is presented in Chapter 5.

In California, water project facilities can be financed through 1) general obligation bonds, 2) tideland oil revenues, 3) revenue bonds, 4) loans and 5) accumulated capital resources. Long term water agency contracts repay most of this debt service. A summary of capital funds, as presented in **Table 4-2.**, will aid financial analysis.

Table 4-2. Hypothetical summary of capital funds (adapted from Ernst and Ernst, 1979)

Source	Projected Amount	Details (i.e. repayment period, interest rate)
Grants		
EPA: Clean Water Grant Program		
State: Clean Water Grant Program		
Bonds and Debt		
General Obligation		
Revenue Bond		
General Funds		
Water District Funds		

4.2.4 Revenue-generating tools to repay costs

Revenue sources are needed to cover the financial costs of a recycling project in the long and short term. As such, potential revenue sources should be identified and quantified. A list of potential sources listed in Asano *et al.* (2007):

- Recycled water delivery charges;
- Recycled water user connection fees;

- Wastewater disposal fees/service charges;
- Regional incentive or rebate programs;
- Fees on new development;
- Property taxes on reclaimed water users and/or all properties in the community; and
- Water use surcharges.

Revenues from recycled water sales are a major mechanism to repay project costs of water recycling facilities. The revenue generated from recycled water deliveries depends on the rate structure for recycled water. Recycled water may be priced below potable water cost if the project is driven by wastewater disposal; or the price may be set near or above the potable water cost if reliability of supply is given a high value.

Projections from the revenue sources should consider the use projections established in Chapter 2. For example, the revenue generated depends on demand projections and market assessment for recycled water, established contracted uses, and potential users. The revenue scheme should account for changes in sales with time. New rate schemes may be desired to raise and stabilize revenues for the new project.

4.2.5 Overall Financial Assessment

Once costs have been allocated and revenues estimated, an overall financial assessment of the project is conducted. This assessment produces an overall net cost (or financial balance) for the project. The net cost is used to modify recycled water rates or other charges or as a basis for seeking external financial subsidy.

4.2.6 Financial contingencies and uncertainties

Uncertainty in water recycling is present in many aspects of a project. There is uncertainty in the amount of water recycled as operating conditions change over time, including the level of treatment needed, capital and O&M costs, financial markets for debt repayment, and recycled water demands as consumer preferences and land uses change. Contingencies can be used to accommodate some of the uncertainties in the financial analysis. In addition, contingency plans should be developed for system failures to supply water or to meet standards. Contingency costs may include cross-connection tests, contingency plans for exceeding water quality standards, and a backup treatment system. A prudent financial analysis may include cost of contingencies for such circumstances.

4.3 Conclusions

The financial analysis is used to establish the financial feasibility by accounting for the proposed costs and projected revenues. The analysis takes the proponent’s perspective. If the proposed recycling facility could potentially affect a non-participant’s finances, a supplemental financial analysis may be needed. To summarize the process, project costs are estimated using market prices. Costs are then allocated among purposes and participants using the *Separable Costs-Remaining Benefits Method* (Appendix B). With the costs clearly itemized and totaled, capital financing sources and revenue schemes are constructed. Finally, with the project costs and revenues outlined, an overall financial assessment can be completed. The financial analysis is completed if the economic analysis demonstrates that the project is justified.

5. ROUTINE FINANCIAL AND ECONOMIC ANALYSIS

5.1 Introduction

This section provides routine economic and financial evaluation methods for water recycling in California. This Economic Analysis Guidance Document is designed to help the reader prepare grant and other funding applications for water recycling projects in California. This section should be used in companion with the provided electronic spreadsheets for economic and financial analysis. Worked examples to use with the presented routine calculations and the spreadsheets can be also found in this chapter.

5.2 Screening Level Analysis

In a screening level analysis, the objective is to streamline economic and financial feasibility analysis of a proposed project by reducing information and data requirements to a minimum. This simplification entails stronger assumptions on economic values of fresh water alternatives and treatment costs, more restrictive (uniform) patterns of recycled water *production* and quality, fresh water replacement factor, over the period of analysis. Most elements in the screening level analysis are common between economic and financial analyses. These are:

- Period of Analysis
- Total Capital Cost
- Annual Operation and Maintenance Cost
- Replacement Factor (Recycled Water/Fresh Water)
- Freshwater Alternative Cost
- Average Expected Delivery
- Freshwater Treatment Cost

Other elements specific to economic analysis include the discount rate and salvage value at the end of the period of analysis are not required by the financial analysis. Instead, inflation and interest rates are used for financial analysis. It is assumed that fresh versus recycled water replacement factors, recycled water deliveries (sales), and annual operating and maintenance costs are constant. A project is financially feasible if the estimated net present value is positive. Likewise a project will be financially feasible if the estimated price range to repay the project is positive for all years in the period of analysis. Calculations are shown in a background calculation sheet.

5.3 Economic analysis

Economic analysis compares alternatives that address an identified problem and objective. Projects are valued by quantifying the benefits and costs using monetary terms. The value for each alternative is then compared to the "without project" scenario, the alternatives are ranked, and the best alternative is selected. The financial analysis is completed only on the selected best alternative. Each alternative uses the same period of analysis and baseline conditions to ensure a fair comparison.

5.3.1 Routine Method & Spreadsheet Templates.

In the provided spreadsheets for economic analysis, the individual tabs require the following information:

- Describe the project information;

- Establish the standard assumptions;
- Establish the baseline conditions and define the without project scenario;
- Identify the benefits and costs;
- Quantify the monetized benefits and costs, and describe the qualitative benefits and costs;
- Select a decision criteria
- Numerically evaluate project for the selected decision criteria;
- Complete a sensitivity analysis;
- Summarize the net benefits for the alternatives; and
- Compare alternatives.

This section describes these steps in detail and shows a set of templates to accomplish an economic analysis. This document is designed using the Expected Net Present Value (ENPV) methodology for the evaluation method. Details on the ENPV formulation are provided in Section 3.3.

Step 1: Define the project information

To set the stage for the analysis, the first step is to simply outline information about the agency (or agencies) considering reuse, the individuals completing the analysis, and the type of project being considered. The accounting perspective taken for the entire analysis is the State-wide perspective. This information is tabulated on **Worksheet 1, Project Information**.

Step 2: Establishing standard assumptions

Prior to undertaking the economic or financial analysis, the standard assumptions should be described. The assumptions are accounted for in **Table 2A: Standard Assumptions** on **Worksheet 2, Std Assumptions**.

User Input	Description of cell values that will be used throughout the economic analysis
Period of Analysis	Number of years for which the calculations will be completed for (ie 20, 50, or 100 years)
Installed Capacity	Capacity of the proposed recycling facility in acre feet (AF)
Recycled Water Market Price	Price to be charged for acre foot of recycled water sold. The price should be based on the market assessment for recycled water.

User Input	Description of cell values that will be used throughout the economic analysis
Potable Water Replacement Factor (for RW)	The proportion of fresh water that is replaced by using recycled water. This is presented as a percentage and assumes that the same replacement factor is applicable for all uses.
Project Design Year	The year design begins.
Reference Cost Year (Ref Yr)	Represents the base year in the calculations. Inflation effects in this year are 0. Following this year, inflation is accounted for using the established rate
Project Construction Year	The year construction is intended to begin.
Project First Year of Operation	The intended year the water recycling facility will be functional
Project Last Year of Operation	The last year which the project will operate. The last year of operation is equal to the project construction year plus the period of analysis.
Financing Period	Set by bond and loan schedules. Represents the time frame over which payments are to be made.
Annual Interest Rate	This will be set by the individual bonds and loans used to finance the project. They will be specific to each bond and loan.
Annual Inflation Rate	Inflation rate
Annual Discount Rate	Discount rate

Step 3: Establish baseline conditions and define the without project scenario

As mentioned in Chapter 2, the baseline conditions describe current conditions and future projections that will affect all proposed alternatives. The first step describes the water supply portfolio and the portfolio projections into the period of analysis (**Table 3A: Water Supply Portfolio, Worksheet 3.1, Baseline Portfolio Analysis**). The target delivery volumes quantified here should be based on population and growth projections for the municipality and the resulting water and wastewater demand projections.

Table 3A Water Supply Portfolio

Column	User Input	Description of cell values that will be used throughout the economic analysis
A	Year	Year being evaluated.
B	Target System Deliveries	The anticipated water demand (AF) for each year of the period of analysis.
C	Reduction through Conservation	The estimated volume of water saved through conservation measures
D	Supplies – Local Groundwater	The estimated volume of water supplied from groundwater.
E	Supplies – Local Surface Water	The estimated volume of water supplied from surface water.
F	Supplies – Imported Water	The estimated volume of water supplied from imports.
G	Supplies – Desalination	The estimated volume of water supplied from desalination.
H	Supplies – Existing Recycled Water	The estimate volume of water supplied from current recycled water facilities.
I	Unmet Target Deliveries	The annual shortfall in deliveries. =(Target Water Deliveries – Reduction through Conservation) – (Sum of all Supplies) = (Column B – Column C) – (Sum of Columns D, E, F, G, H)

Given the results of the portfolio analysis, the next step is to describe the "without project" scenario using costs. These are tabulated in **Table 3B: Without Project Condition** on **Worksheet 3.2, Without Project Condition**. Costs considered are:

- Avoided operations and maintenance costs of water supply treatment;
- Avoided operations and maintenance costs of water transmission;
- Avoided operations and maintenance costs of water distribution;
- Avoided operations and maintenance costs of wastewater treatment and disposal; and
- Water Shortage costs.

The economic analysis results are compared to the sum of the avoided operations and water shortage costs. The above tabulation assumes that no additional supplies would be obtained and therefore the utility would avoid the costs of supply treatment, transmission, distribution, and wastewater treatment and disposal and therefore the region would incur a cost for the shortage.

The next step of establishing the baseline conditions is to complete a recycled water market assessment (see **Worksheet 3.3 and 3.3a, Market Assessment)**. The market assessment quantifies the supply and demand for recycled water. The first part of the assessment (**Table 3C: Water Supply Customers)** tabulates the customers by their water use and includes their estimated demand per year. The volume demanded should be calculated for each year (one column for each year) that demands are expected to change. For example, if the demands increase for the first three years, and all subsequent years have the same demands as those in year three, the volume demanded can be calculated for years 1, 2, and 3 only. For each water use, the subtotal of annual demands is calculated. The grand total is equal to the sum of the subtotals. There are three project phases currently in the spreadsheet, more can be added if required.

The second portion of the recycled water market assessment is to describe the intra-annual variations in demand (**Table 3D: Monthly Recycled Water Demands by User Type**). Each year identified in Table 3C should have a corresponding Table 3D. In Table 3D the monthly demand by each user type is tabulated and summed. The annual subtotal for each water use and the annual grand total should equal the subtotals and annual grand total found in Table 3C.

The third portion describes intra-annual variations in the volume of wastewater treated (**Table 3E: Monthly Wastewater Treatment Volumes**). Similar to Tables 3C and 3D, this should be completed for each year that the volumes are expected to change. If the volume treated is expected to be constant throughout the period of analysis, this table only needs to be completed once. The estimated volumes should be based on the wastewater treatment projections.

The final portion of the recycled water market assessment is to compare supply (volume of wastewater treated) to demand (water supply demands). The net balance is calculated for each year in **Table 3F, Recycled Water Net Balance (Supply vs Demand)**. A version of Table 3F should be completed for each year identified in Table 3C has having different recycled water demands. For each of the years identified in the previous three tables as having changing volumes, the monthly balances are calculated. The balance is equal to the difference between supply and demand. If the balance is negative, the volume demanded exceeds the supply and the recycled water facility will not be able to meet its customer commitments. This may require revaluation of demands. If the balance is positive, the supply exceeds the demand and a plan to manage the surplus water should be provided. For example, if surplus water is to be stored, details on storage plans should be included in the economic (and subsequent financial) analysis. If the surplus water will be disposed of, the cost of disposal should be addressed.

Using the projected recycled water demands calculated in the market assessment, the portfolio analysis can be amended. This is done in **Table 3G: Portfolio with Additional Recycled Water** on **Worksheet 3.4, Portfolio with Additional RW**. Columns A through I are the same as those in Table 3A; new columns (J and K) account for the additional recycled water.

Table 3G. Portfolio with Additional Recycled Water

Column	User Input	Description of cell values that will be used throughout the economic analysis
A	Year	Year being evaluated.

Table 3G. Portfolio with Additional Recycled Water

Column	User Input	Description of cell values that will be used throughout the economic analysis
B	Target System Deliveries	The anticipated water demand (AF) for each year of the period of analysis.
C	Reduction through Conservation	The estimated volume of water saved through conservation measures
D	Supplies – Local Groundwater	The estimated volume of water supplied from groundwater.
E	Supplies – Local Surface Water	The estimated volume of water supplied from surface water.
F	Supplies – Import Water	The estimated volume of water supplied from imports.
G	Supplies – Desalination	The estimated volume of water supplied from desalination.
H	Supplies – Existing Recycled Water	The estimate volume of water supplied from current recycled water facilities.
I	Unmet Target Deliveries	The annual shortfall in deliveries. =(Target Water Deliveries – Reduction through Conservation) – (Sum of all Supplies) = (Column B – Column C) – (Sum of Columns D, E, F, G, H)
J	Projected New Recycled Water (RW) Deliveries	The annual demand for recycled water as found in the recycled water market assessment (Grand Total from Table 3D for each year). Only use this value if the net balance (calculate in Table 3F) is greater than or equal to zero. The value needs to be inputted by the user.
K	Final Shortfall	The annual shortfall in deliveries given additional water recycling. =(Unmet Target Deliveries) – (Projected New Recycled Water Deliveries) =Column I – Column J

Step 4: Identify benefits and costs

Step 5: Quantify monetized benefits and costs, and describe qualitative benefits and costs

Steps 4 and 5 may be found under worksheets **4.1 Econ Analysis Id & Quant Ben** and **4.2 Id & Quant Costs** respectively. Information for each of these steps are entered into tables 4A and 4B respectively:
Table 4A: Identification and Quantification of Benefits

Table 4B: Identification and Quantification of Costs.

These tables should be completed for each category of user that will be impacted for each alternative being considered. The points-of-view to consider are: water supply agency, wastewater agency, regional agencies, customers, or society. As mentioned in Chapter 3, care must be taken to avoid double counting. For example, if each customer is paying a connection fee of $100 to the water supply agency, the water supply agency should not be counting revenue from that $100 as a benefit.

Table 4A/4B. Identification and Quantification of Benefits/Costs

Column	User Input	Description of cell values that will be used throughout the economic analysis
A	Item	Number each item – if this is a user input then this column should be shaded.
B	Benefit/Cost	Select a benefit/cost type from the drop down list. (The full list is provided below the excel table).
C	Comments	If this is user input then these cells should be shaded
D	Quantifiable	Is the benefit/cost quantifiable? Select "YES" or "NO" from the drop down list.
E	Probability	The probability associated with each monetized value. The probabilities are included to account for uncertainty in the estimated values. For example, if the benefit from improved water quality is estimated to be $1200 annually, but the range on this estimate is from $500 to $1500, the likelihood or probability of each estimate should be included. The probabilities of the estimates must equal one. To continue with the example, the probability of the benefit being $1200 may be 0.6, $500 may be 0.3, and $1500 may be 0.1. If there is no uncertainty in the value, the probability would be one.

Table 4A/4B. Identification and Quantification of Benefits/Costs

Column	User Input	Description of cell values that will be used throughout the economic analysis
F	Expected Value	The expected value for the benefit/cost for each year based on the estimated value and corresponding probability and is summed for each year for each benefit/cost. =(Probability of the Best Estimate*Best Estimate) + (Probability of the High Estimate*High Estimate) + (Probability of the Low Estimate*Low Estimate) Continuing with improved water quality example from above, the expected value for one year would be: =(1200*0.6) + (500*0.3) + (1500*0.1) = $1020
	Estimates	For each quantifiable benefit/cost, a value and associated probability should be included. Values to use are the high estimate, best estimate, and low estimate. For each estimate, the probability or likelihood of that value is included in Column F (see below). Probabilities are mostly a matter of expert judgment.
	Annual Total Benefits/Costs	The annual total for all benefits and costs. =Sum of the Expected Values for each year

Step 6: Numerically Evaluate Project for the Select Decision Criteria

As mentioned above, the evaluation method used for the templates is Expected Net Present Value (ENPV). This formulation has been built into Tables 4A and 4B. The formula for ENPV is:

$$ENPV = \sum_{i=1}^{N} P_i \sum_{t=1}^{T} \sum_{j=1}^{M} (B_{ijt} - C_{ijt})(1+r)^{-t}$$

Where:

P is the probability of an event

B is the value of the benefit

C is the value of the cost

r is the discount rate

t is time (as years since the reference year).

The evaluation of the project is completed in Table **4C, Project Evaluation** on **Worksheet 4.3, Evaluate Project**. Here, the sum of the annual total of benefits and costs from Table 4A and 4B respectively are discounted and then used to calculate the ENPV. The project should be evaluated for each point of view within each alternative being considered.

Table 4C. Project Evaluation

Column	Column Heading	Description of cell values that will be used throughout the economic analysis
A	Year	
B	Annual Benefits	Annual benefits as totaled in the last row of Table 4A
C	Discounted Benefits	Annual benefits discounted using the discount rate (d) identified in Table 2A. = (Annual Total of Benefits)*(1+discount rate)-n =Column B*(1+d)-n Where n equals the years since the first year of operation
D	Annual Costs	Annual costs as totaled in the last row of Table 4B
E	Discounted Costs	Annual costs discounted using the discount rate (d) identified in Table 2A. = (Annual Total of Benefits)*(1+discount rate)-n =Column B*(1+d)-n Where n equals the years since the first year of operation.
F	Net Benefits (Discounted)	=Annual Benefits – Annual Costs =Column C – Column E

Step 7: Complete a Sensitivity Analysis

The sensitivity analysis varies variables such as the discount rate or values for key benefits and costs. To complete the sensitivity analysis, the economic analysis should be re-run with changes to key variables and the change in the net benefit should be recorded. The results are tabulated in **Table 4D: Summary of**

Sensitivity Analysis on **Worksheet 4.4, Sensitivity Analysis**. The sensitivity analysis should be completed for each alternative being considered.

Table 4D. Summary of Sensitivity Analysis

Column	Column Heading	Description of cell values that will be used throughout the economic analysis
A	Variable Name and Values	The parameter being altered and the specific values being used to recalculate the net benefit.
B	Total Monetized Benefit Discounted	Value of the discounted benefit as totaled in Table 4C-Column C after using the respective new values.
C	Total Monetized Cost Discounted	Value of the discounted benefit as totaled in Table 4C-Column D after using the respective new values.
D	Total Monetized Net Benefit Discounted	Value of the discounted benefit as totaled in Table 4C-Column D after using the respective new values.

Step 8: Summarize Net Benefits

The steps covered in Tables 4A, 4B, 4C, and 4D should be completed for each project participant, such as the water supply agency, wastewater agency, and customer. The results from each point-of-view are summarized in **Table 4E, Summary of Net Benefits** on **Worksheet 4.5, Summary of Net Benefits**. The sum of the net benefits in Table 4E describes the overall benefit for the specific alternative and is the value carried into Table 4F (see below). A summary of net benefits table should be completed for each alternative evaluated.

Table 4E. Summary of Net Benefits

Column	Column Heading	Description of cell values that will be used throughout the economic analysis
A	Accrues To	The category of user who will receive the discounted net benefits
B	Net Benefit Discounted	Value of the discounted net benefit as totaled in Table 4C-Column F.
C	Net Benefit Discounted/AF Total RW	The discounted net benefit per the present worth of each acre foot of recycled water delivered. The volumes are based on the portfolio analysis.

Table 4E. Summary of Net Benefits

Column	Column Heading	Description of cell values that will be used throughout the economic analysis
D	Net Benefit Discounted/AF Total Potable Equivalent	The discounted net benefit per the present worth of each acre foot of recycled water delivered. The volumes are based on the portfolio analysis and the potable water replacement factor.

Step 9: Compare and Select an Economically Feasible Alternative

The overall net benefit for each alternative should be compared to the "without project" condition described in Table 3B. In **Table 4F: Comparison of Project Alternatives,** on **Worksheet 4.6, Compare Project Alternatives**, the alternatives should be ranked by the overall net benefit, with the largest net benefit receiving the highest rank. The overall net benefit is the value calculated in Table 4E as the Total Net Benefit Discounted. The ranking can be altered based on the qualitative benefits and costs. If this is done, written justification should be provided. The project is considered economically justified if the overall net benefits are greater than zero. The highest ranking alternative is considered the best economic project. The subsequent financial analysis should be completed on the best economically viable project. If the project is not economically viable, the project is not justified and a financial analysis should not be completed.

Table 4F. Comparison of Project Alternatives

Column	Column Heading	Description of cell values that will be used throughout the economic analysis
A	Rank	Numerical ranking for each alternative
B	Alternative	Name of the alternative evaluated
C	Net Benefit Discounted	Value of the Total Net Benefit Discounted as calculated in the last row of Table 4E.
D	Total Present Worth of Potable Water Delivered	The present worth of potable water delivered. This value is based on the portfolio estimates calculated in Table 3G. The present worth of the volume is recorded at the bottom of Table 3G.

Table 4F. Comparison of Project Alternatives

Column	Column Heading	Description of cell values that will be used throughout the economic analysis
E	Net Benefit/Present Worth of Potable Water Delivered	The discounted net benefit per the present worth of each acre foot of potable water delivered =(Net Benefit Discounted) / (Total Present Worth of Potable Water Delivered) = (Column C) / (Column D)

Supplementary Tables

To aid in quantifying the effect on project non-participants, two supplemental tables are included at the end of the workbook. The first table is to be used when an alternative water supplier exists and sales of recycled water will result in reduced sales for the alternative supplier. For this case the following information is needed: the potable water replacement factor, the alternative supplier's current potable retail price, the potable water price escalation factor, the alternative supplier's marginal cost of water delivery, the cost escalation factor, and the volume of potable sales lost. **Table 4G, Financial Analysis for Alternative Water Supplier Losses,** outlines how to total the total revenue losses felt by the alternative water supplier.

Table 4G. Financial Analysis for Alternative Water Supplier Losses

Column	Input Paramenters	Description of cell values that will be used throughout the economic analysis
A	Year	
B	Potable Price	Potable water price adjusted for the potable water escalation factor (PWEF). =(Potable Water Price/Potable Water Replacement Factor)*(1+PWEF)n n is the time since the first operation year
C	Marginal Costs	Marginal cost of the alternative water supplier adjusted for their cost escalation factor (CEF) =(Marginal Cost of Water Delivery)*(1+CEF)n n is the time since the first operation year

Table 4G. Financial Analysis for Alternative Water Supplier Losses

Column	Input Paramenters	Description of cell values that will be used throughout the economic analysis
D	Net Lost Revenue	Revenue lost each year =(Total Volume of Losses)*(Adjusted Potable Water Price – Adjusted Marginal Costs) =(Total Volume of Losses)*(Column B – Column C)

The second scenario occurs when additional treatment is required by the user to make the water suitable for use. For this situation the following values are needed: the replacement factor, treatment cost for each unit of volume, the volume of recycled water used per year, and the inflation rate (as indicated in Table 2A). **Table 4H, Financial Analysis for User Requiring Additional Treatment**, describes how the assessment is completed.

Table 4H. Supplementary Financial Analysis for User Requiring Additional Treatment

Column	Input Parameters	Description of cell values that will be used throughout the economic analysis
A	Year	User input – or ref other econ workbook location – do not reference outside workbook locations.
B	Rate ($/AF)	Treatment costs adjusted for inflation. =(Treatment Cost/Replacement Factor)*(1+i)n n is the time since the first operation year i is the interest rate from Table 2A
C	User C incurred cost	The cost incurred given the treatment costs and volume of water consumed annually. = Adjusted Treatment Cost * Recycled Water Used = Column B * Recycled Water Used

5.4 Financial Analysis

A financial analysis assesses project financial feasibility and financial impacts on affected project participants and non-participants. Funding sources and fund uses for the project are compared to determine project's solvency. Revenues and/or cash generated from the project should be sufficient to cover capital costs, debt service, operation and maintenance of the water recycling facility. A financial analysis also helps illustrate the rational for what price ranges are to be set for recycled water.

5.4.1 Routine Method & Spreadsheet Templates

As outlined in Figure 3-1 and described in Chapter 3, the steps when completing a financial analysis are as follows:

1. Describe project information
2. Establish the standard assumptions
3. Identify financial costs;
4. Allocate costs;
5. Develop capital financing mechanisms;
6. Design revenue scheme;
7. Complete overall financial assessment; and
8. Estimate adverse impact on non-participants (supplementary financial analysis).

This section describes these steps in detail and shows a set of templates to accomplish a financial analysis. Steps 1 and 2 are described above in the Economic Analysis portion of Chapter 5.

Step 3: Identify financial costs

Potential costs are itemized in terms of capital costs (**Table 5A: Capital Costs**) and operations and maintenance costs (**Table 5B: Operations and Maintenance Costs (Annual)**). Details for Tables 5A and 5B are presented below.

Table 5A and 5B. Description of Costs (5A - Capital Costs; 5B – Operations and Maintenance Costs (Annual))

Column	Column Heading	Description of cell values
A	Description	Description of each cost. A drop down list of potential costs has been included in the spreadsheets.
B	Comments	Any descriptions needed for the listed costs.
C	Cost (yr$)	The cost associated with each item in the reference year dollars
D	Replacement and /or Disposal (yr $)	If applicable, the cost to replace or dispose of a material or piece of equipment. The cost should be listed using reference year dollars.
E	Years until Replacement (relative to ref. year)	The years since the beginning of the period of analysis when the replacement and/or disposal will occur. A separate row should be added for items that will be replaced more than once during the period of analysis. (Note: Replacement costs are not calculated for design costs as there should be no replacement costs in this phase)

Table 5A and 5B. Description of Costs (5A - Capital Costs; 5B – Operations and Maintenance Costs (Annual))

Column	Column Heading	Description of cell values
F	Discounted Replacement Cost	The cost to replace/dispose, discounted to the present value using the specified rate. For the capital costs the interest rate is recommended and for the O&M costs, the inflation rate is recommended. =Replacement Cost/(1 + specified rate)^(Years to Replace) =(Column D)/(1+r)(Column E)
G	Contingency (%)	The percent contingency placed on each relevant cost
H	Contingency ($)	Based on the percentage, the cost to implement the contingency = (Cost + Discounted Replacement Cost)*Contingency =(Column C + Column F)* (Column G)
I	Subtotal ($)	For cost associated with each listed item = Cost + Discounted Replacement Cost + Contingency Cost = Column C + Column F + Column H

In addition to the direct costs, avoided costs are listed (**Table 5C: Avoided Costs**). Avoided costs describe the price and cost associated with current water sources. Avoided water supply costs should be listed for all water sources in the water portfolio.

Table 5C. Avoided Costs

Potable Water Replacement Factor	The proportion of fresh water that is replaced by using recycled water. This is presented as a percentage and assumes that the same replacement factor is applicable for all uses.
Potable Water Price	Price currently charged by the water supplier for potable water.
Potable Water Escalation Factor	The expected percentage rise in the potable water price charged.

Table 5C. Avoided Costs	
Potable Water Cost	The current cost to obtain the water source (i.e. groundwater pumping charges or import charges). The cost for each supply source listed in the portfolio analysis should be included.
Wastewater Disposal Costs	Current charges for wastewater disposal.

With the capital cost summed, the debt service can be calculated in **Table 5D, Project Debt Service**. The initial calculation of the debt service is based on the interest rate set in the standard assumptions (Table 2A).

Table 5D. Project Debt Service (Annual)	
Project Debt Service	Quantifies how much money is needed annually over the financing period. = (Total Project Capital Cost)*(Capital Recovery Factor)
Capital Recovery Factor	Accounts for the compounding nature of interest over time. In the formulation below, r represents the annual interest rate (set in table 2A) and n is the financing period (set in Table 2A). $= [r(1+r)^n] / [(1+r)^n - 1]$

The final component of identifying costs is to complete projections for the costs over the period of analysis. Data from the previous tables will populate this table automatically. The user needs to input the estimated deliveries for each year as found in the economic analysis. The template is provided in **Table 5E, Computation of Total Net Costs.**

Table 5E. Computation of Total Net Costs

Column	Column Heading	Description of cell values
A	Year	Years in the period of analysis
B	Total Recycled Water, AF	Anticipated volume of recycled water provided by the facility and based on demand projections from recycled water market assessment.

Table 5E. Computation of Total Net Costs

Column	Column Heading	Description of cell values
C	Potable Water Replaced, per AF	Volume of potable water replaced. = (Total Recycled Water)*(Potable Water Replacement Factor) The Potable Water Replacement Factor is from Table 5C
D	Annual Debt Service, $	From Table 5D, Project Debt Service
E	Cost in Base Year, $	Sum of costs from O&M costs totaled in Table 5B in base year dollars (does not account for inflation).
F	Inflation Factor	Inflation rate (as set in Table 2A), compounded annually. = (Inflation factor in previous year)*(Inflation) The inflation factor in the base year = 1 + r
G	Infl. Adjust. Costs, $	O&M costs adjusted for inflation over the period of analysis. =(Cost in Base Year Dollars)*(Inflation Factor) = Column E *Column F
H	Project Annual Cost, $	Sum of annual cost to run the project = (Debt Service) + (Inflation Adjusted O&M Costs) = Column D + Column G
I	Infl. Adjust. Unit Cost. Per AF	Cost of potable water adjusted for inflation. The cost is based on the maximum water supply cost listed in Table 5C. =(Potable Water Cost)*(Inflation Factor) Potable Water Costs are set in Table 5C
J	Avoided Potable Cost, $	The total avoided potable cost based on the volume of water replaced by recycled water. = (Adjusted Potable Unit Cost)*(Potable Water Replaced) =Column I * Column C

Table 5E. Computation of Total Net Costs

Column	Column Heading	Description of cell values
K	Inflation Factor	Same as above
L	Infl. Adjust. Unit Cost, $/AF	Cost of disposal adjusted for inflation =(Disposal Cost)*(Inflation Factor) Disposal Cost is set in Table 5C
M	Avoided Disposal Cost	The total avoided disposal cost based on the volume of recycled water delivered. =(Adjusted Disposal Unit Cost)*(Total Reclaimed Water) = Column L * Column B
N	Potable price escalation factor	Potable water escalation factor (PWEF) compounded over time. =(1+PWEF)n Potable water escalation factor is set in Table 5C
O	Adjusted Potable Water Price, $/AF	The potable price adjusted for the potable water escalation factor. =(Potable Water Price)*(Potable Escalation Factor) =(Potable Water Price)*Column N Potable water price is set in Table 5C
P	Total Lost Revenue, $	How much revenue from potable water sales is lost from the transfer to recycled water, based on the volume of water replaced by recycled water. =(Potable Water Replaced)*(Adjusted Potable Water Price) =Column C * Column O
Q	Net Cost, $	The annual cost for the project. The total cost over the period of analysis is added in the last row. = (Project Annual Cost) + (Total Lost Potable Revenue) - (Avoided Potable Water Cost) - (Avoided Disposal Cost) = Column I + Column P - Column L - Column N

Step 4: Allocation of Financial Costs and Revenue Effect

Costs are allocated among project objectives and users. Objectives fall into the categories of water supply and wastewater treatment. Costs are allocated among users and purposes using the *Separable Costs-Remaining Benefits Method (SCRB)*. With the SCRB method, costs are distributed among project purposes by identifying separable costs for each purpose or participant and allocating joint costs or joint savings in proportion to each purpose's remaining benefits (DWR 2008, p. 48). As presented in Chapter 4, the process involves the following steps:

1. Estimate benefits for each purpose
2. Estimate *Alternative Costs,* which is the cost of a single-purpose project for each benefit identified in step 1
3. Determine the *Justifiable Cost,* which is the lesser of the two items above. The justifiable cost represents the maximum that can be allocated to a specific purpose.
4. Estimate the *Separable Cost* of each purpose by subtracting the project cost with the specified use omitted (given) from the cost of the multipurpose project.
5. Separable cost of each purpose should be deducted from the justifiable costs to determine its remaining justifiable costs.
6. Estimate purpose's percent share of the remaining sum of justifiable costs of all purposes.
7. Deduct the total separable cost from the total project cost to determine the total remaining *Joint Costs*.
8. Distribute the joint costs proportionally for each purpose by weighting them with percent shares estimated in step 6.
9. Cost allocation to each purpose is the sum of the distributed remaining joint cost and the separable cost.

The first steps of separating the costs for each purpose are completed in **Table 5F, Separation of Costs** which can be found under tab **5.2 Cost Allocation**

Table 5F. Separation of Costs

Row	Column Heading	Description of cell values
1	Total Multiple Purpose Project Cost	The total cost of the project as determined in Step 1
2	Cost with Purpose Excluded	The cost to build the project if the purpose and associated user were excluded.
3	Separable Cost	The cost associated with each purpose-user combination. = (Total Cost) – (Cost with Purpose Excluded) =(Row 1) – (Row 2)

Table 5F. Separation of Costs

4	Total Separable Cost	Sum of all separable costs =Sum(Row 3)
5	Joint Costs	The total amount that cannot be separated to an individual purpose and user. It is the amount that needs to be shared among all purposes and users. = (Total Cost) – (Total Separable Cost) = (Row 1) – (Row 4)

With the costs separated among the purposes and users, the costs can then be allocated. The process is completed in **Table 5G, Cost Allocation**.

Table 5G. Cost Allocation

Row/Column	Column Heading	Description of cell values
1	Benefits (Present Worth)	The value of the benefit provided to each purpose and use. This value is derived from the economic analysis, Summary of Net Benefits (Table 4E).
2	Alternative Cost (Least Cost Alternative)	The cost to build a project to satisfy the same benefit for the purpose and user.
3	Justifiable Cost (lesser of benefits and alternative cost -- must be greater than or equal to Separable Costs)	The minimum of the benefit (Row 1) and the least cost alternative (Row 2) for each purpose and user. To be included in the project, the justifiable cost should be greater than the separable cost (Table 5F, Row 3).
4	Separable Costs	Value derived in Table 5F, Row 3
5	Remaining Justifiable Cost	The benefit to each purpose and user given the associated cost. = (Justifiable Benefit) – (Separable Cost) =(Row 3) – (Row 4)

Table 5G. Cost Allocation

Row/Column	Column Heading	Description of cell values
6	Percent (distribution of remaining benefits)	Proportion of the project that benefits each purpose-user combination. =(Remaining Benefit for each purpose and user) / (Sum of Remaining Benefits) = (Row 5) / (Sum Row 5)
7	Allocated Joint Costs	Distributes the joint cost identified in Table 5G among the purposes and users based on the proportion of the benefits accrued to each purpose and user. = (Joint Cost) * (Proportion of Remaining Benefit) =(Table 5F, Row 5) * (Row 6)
8	Total Allocated Costs (separable costs plus allocated joint costs)	The total cost that is distributed to each purpose and user. The sum of the Total Allocated Costs should equal the Total Project Cost. =(Separable Cost) + (Allocated Joint Cost) =(Row 4) + (Row 7)
9	Percent of Total Costs	The proportion of all costs which is allocated to each purpose and user. =(Total Allocated Cost)/(Sum Total Allocated Costs) =(Row 8)/(Sum Row 8)*100%

Step 5: Development of Capital Financing Mechanisms

Potential financing sources are itemized in **Table 5H, Potential Financing Sources which may be found under tab 5.3 Financing Mechanisms**. The table includes columns for the amount expected, the interest rate for the source, and the repayment period. This tabulation assumes that Grants and General Funds are not repaid and therefore do not have associated interest rates and repayment periods. In addition to listing the funding sources, a summary of the proponent's current debt should be completed. While this will not have a direct effect on the financial analysis calculations, it will likely be a necessary step when applying for external funding.

Table 5H. Potential Financing Sources

Column	Column Heading	Description of cell values
A	Source	Potential source of funds
B	Amount	Expected dollar amount to be received from each source
C	Interest Rate (annual)	The interest rate that will be used for bond or loan repayment
D	Repayment Period (years)	Period over which the bond or loan is to be repaid
E	Capital Recovery Factor	Accounts for the compounding nature of interest over time. In the formulation below, r represents the annual interest rate for the bond or loan and n is the repayment period. = [r(1+r)n] / [(1+r)n – 1]
F	Annual Loan Repayment	Quantifies how much money is needed annually over the repayment period to cover the loan or bond. = (Amount)*(Capital Recovery Factor) =Column B * Column E
G	Comments	Any comments pertaining to the loan.

Step 6: Design of New Revenue Scheme

The first step in defining the revenue scheme is to describe how the net costs will change with the financing sources described in Step 3. This involves calculating a new annual debt service, as done in **Table 5I, New Project Debt Service**. The new project debt service, with grants and general funds, subtracts the sum of the grant and fund money from the total project cost, then calculates the debt service. The period of analysis and interest rate set in the standard assumptions are used for the capital recovery factor, therefore the capital recovery factor is the same as the one listed in Table 5D.

Determination of the revenue scheme and calculation of profits over the period of analysis is done in **Table 5J, Projected Revenue and Net Profit**.

Table 5J. Projected Revenues and Net Profit

Column	Column Heading	Description of cell values
A	Year	

Table 5J. Projected Revenues and Net Profit

Column	Column Heading	Description of cell values
B	Total Recycled Water Deliveries (AF)	Same as listed in Table 5E, Column B. Anticipated volume of recycled water provided by the facility and based on demand projections from recycled water market assessment.
C	Estimated Net Annual Cost	Total cost associated with the project for each year. =Net Cost from Table 5E, Column Q
D	Grants and General Funds Adjusted Net Annual Cost	The Net Annual Cost adjusted for the funds received in the form of grants or general funds. = Estimated Net Cost – Original Debt Service + New Debt Service =Column C – Original Debt Service + New Debt Service Original debt service amount was calculated in Table 5D and has been included at the top of the work sheet. New Debt Service is calculated in Table 5I
E	Adjusted Potable Water Price, $/AF	Same as in Table 5E, Column O
F	Minimum recycled water price, $/FA	The minimum price at which recycled water should be set. This price recovers the net cost of operation. = (Final Net Annual Cost) / (Total Recycled Water Deliveries) = (Column F) / (Column B)
G	Maximum recycled water price, $/AF	Maximum price of water, based on the potable water price. This does not account for the additional value provided by the reliability of the water source. = (Potable Water Replacement Factor (Table 5C)) * (Adjusted Potable Water Price) = (Potable Water Replacement Factor (Table 5C)) * (Column G)

Table 5J. Projected Revenues and Net Profit

Column	Column Heading	Description of cell values
H	Pricing margin available, $/AF	The difference between the maximum and minimum price. = Column I – Column H
I	Based on Cost Recovery Pricing	The estimated revenue generated with the price set to recover the net final costs. =(Minimum Price) * (Total Recycled Water Deliveries) = Column H * Column B
J	Based on Market Assessment Pricing	The estimate revenue generated using the price established in the market assessment. The price is adjusted for the potable water escalation factor (PWEF). =(Estimated Market Price)*(Total Recycled Water Deliveries)*(1+PWEF)^n =(Estimated Market Price)*(Column B)*(1+PWEF)^n The Estimated Market Price is listed in Table 2A The PWEF is listed in Table 5C n is the years since the first year of operation
K	Based on Cost Recovery Pricing	Net balance of funds each year given the revenue generated with the price set for cost recovery. =(Revenue, Price based on cost recovery) – (Final Net Annual Cost) = Column K – Column F
L	Based on Market Assessment Pricing	Net balance of funds each year given the revenue generated with the price set from the market assessment. =(Revenue, Price based on market assessment) – (Final Net Annual Cost) = Column L – Column F

Table 5J. Projected Revenues and Net Profit

Column	Column Heading	Description of cell values
M	Based on Cost Recovery Pricing	Overall balance of funds for each subsequent year. =(Annual Net Balance for the given year) + (Sum of the Annual Net Balance for the previous years) Use values from Column M
N	Based on Market Assessment Pricing	Overall balance of funds for each subsequent year. =(Annual Net Balance for the given year) + (Sum of the Annual Net Balance for the previous years) Use values from Column N

Step 7: Overall Financial Assessment

The overall financial assessment addresses the pricing margin over the period of analysis, the overall cumulative net balance, and the years to generate overall profits. The simple summary presented (**Table 5K: Overall Financial Assessment found under tab 5.5 Overall Fin Assessment**) indicates whether the pricing margin is always positive, what the total profits will be, and the number of years it will take to transition from losing money to making a profit.

5.5 Worked Example and Spreadsheets

A water recycling facility is being considered for a medium-sized municipality. Three agencies will participate in the project: water supply agency A, wastewater treatment agency A, and wastewater treatment agency B. The analysis is based on a 20 year period of analysis and discount rate of 6%. The plant capacity is 2000 AF/year.

Based on population and growth projections, the municipality expects a shortage of water in 2019. The municipality is considering constructing a recycled water facility in 2010 to help mitigate the shortage costs. Without changing their current supply portfolio the estimated cost of the shortage is $5.2 billion. This assumes that the municipality will not bring in additional supplies and will therefore avoid the costs for water supply treatment, transmission, and distribution and wastewater treatment and disposal. The recycled water market assessment predicts sales of 1260 AF in the first year, 1510 AF in the second year, and 1850 AF in the third and subsequent years. The largest demand is expected to be in the summer months.

The estimated total capital cost of $13 million. Design and construction are each estimated to take 2 years beginning in 2009 and the first year of operation is 2010. For the worked example, the annual interest rate (i) has been set at 3% and repayment of the loan will begin once construction has been completed. Once operating, annual costs are expected to increase with inflation, which is set at 2.5% annually. The potable water rate is $350/acre-ft, which will increase at 2% per year. Recycled water replaces 90% of the potable water. The current supply sources are surface water, import water, and groundwater which cost $300/AF,

$600/AF, and $100/AF respectively. Wastewater disposal cost is $50/acre-ft in 2010. The city is responsible for the financing and construction, and will reimburse recycled water users for plumbing changes. Operation and Maintenance Costs are $460,000 per year, with one replacement cost occurring after five years. The example is adapted from Atwater *et al.* (1998).

5.6 Conclusions

The above sections describe how to work through an economic and financial analysis for a water recycling facility. The templates provided represent a simplified schematic for the process and can be elaborated upon for additional details.

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