Tucson Water
One Water 2100 Master Plan

Technical Memorandum: The Benefits and Costs of Tucson Water's Reclaimed Water System

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Galardi-Rothstein Group
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One Water 2100 Master Plan

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Technical Memorandum

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Commonly Used Abbreviations and Acronyms

AC	Acre
AFY	Acre-Feet Per Year
AMA	Aquifer Management Area
AWWA	American Water Works Association’s
BCA	Benefit-Cost Analysis
CAP	Central Arizona Project
CCF	Hundred Cubic Feet
COS	Cost of Service
CPI	Consumer Price Index
CWAC	Citizen Water Advisory Committee
FY	Fiscal Year
GMA	Groundwater Management Act (1980), State of Arizona
GPCD	Gallons Per Capita Per Day
IGA	Intergovernmental Agreement
IMPLAN	IMpact Analysis for PLANning model
I/O	Input-Output
M	Million
MG	Million Gallons
MGD	Million Gallons Per Day
MRIO	Multi-Regional Input-Output
MSA	Metropolitan Statistical Area
NPR	Nonpotable Reuse
O&M	Operation and Maintenance
PCRWRD	Pima County Regional Wastewater Reclamation Department
RWS	Reclaimed Water System
SHARP	Southeast Houghton Area Recharge Project
TBL	Triple Bottom Line
TM	Technical Memorandum
USD	United States Dollars

1. Executive Summary

This Technical Memorandum (TM) provides a summary of findings from our analyses of the *Benefits and Costs of the Tucson Water Reclaimed Water System*. Our study is a component of Tucson Water's broader *One Water 2100* (1W2100) master plan. This Executive Summary draws on analyses developed in the sections that follow and a set of supporting appendices describing the objectives, methods, data, and findings of our analyses.

The intent of our analyses is to provide an objective empirical basis for evaluating the benefits and costs of the Reclaimed Water System. The analysis is intended, in part, to inform an upcoming review of the reclaimed system water rates and rate structure. Portions of our analysis may also inform and guide deliberations regarding the utility's approach to recycled water resources.

1.1 Reclaimed Water System Overview

Tucson Water, a department of the City of Tucson, has successfully developed and operated the Reclaimed Water System since the mid 1980s. The framework for the reuse program was established under an Intergovernmental Agreement (IGA), signed in 1979 by the City of Tucson and Pima County (in which Tucson is located). Under the terms of the IGA, the City became the primary provider of potable and recycled water for Tucson and portions of the Tucson Water service area in Pima County that lie outside of City limits. Under the IGA, Pima County became the primary provider of wastewater management services throughout the greater Tucson region.

The Reclaimed Water System repurposes highly treated effluent derived from the Pima County Regional Wastewater Reclamation Department (PCRWRD). Tucson's mature water reuse program delivers between 14,000 and 20,000 acre feet per year (AFY) of recycled water to more than 900 sites via a network including approximately 200 miles of purple pipe. The Reclaimed Water System delivers recycled water for nonpotable applications, including turf and agricultural irrigation, groundwater recharge, and ecologic restoration. Area golf courses are the largest users of Reclaimed Water System waters, accounting for approximately 9,000 AFY.

1.2 Reclaimed Water System Costs and Cost Recovery

It is common practice across the United States (and other nations) to sell reclaimed water for nonpotable reuse at rates that recover revenues that are less than the full "cost of service" of producing and distributing high quality, fit-for-purpose product water. Pricing nonpotable reclaimed water at less than its full cost of service occurs for numerous well-established reasons, including a need to create customer demand given the relatively attractive price of available substitute water sources, such as potable supplies and self-supply (e.g., well pumping) (Cristiano and Henderson, 2009; AWWA 2017, 2019; Raucher et al., 2019).

Annualized capital and yearly operation and maintenance expenses for the Reclaimed Water System amount to $13 million per year, while annual revenues from the recycled water sales amount to about $8 million to $11 million. The resulting revenue shortfall of $2 million to $5 million per year (i.e., the annual deficit relative to the cost of service) is covered largely through cross-subsidies from potable customers.

Selling reclaimed water at a discount implies that its users are being subsidized by other parties, typically the customers of the local potable system (as is the case in Tucson) and/or wastewater systems. These "cross-subsidies" often are well justified by the benefits the various parties receive from the reclaimed water system, including avoiding the expense of expanding the potable system to meet nonpotable demands. This Technical Memorandum explores the extent to which the benefits and the associated beneficiaries compare to the Reclaimed Water System's costs and the allocation of those costs.

1.3 Reclaimed Water System Benefits and Beneficiaries

The Reclaimed Water System provides a range of valuable benefits to the residents, businesses, and other entities in the region. The Reclaimed Water System (1) facilitates regional population and economic growth by providing a reliable and locally controlled water source, (2) reduces demands on the potable water supply system, (3) contributes to stored groundwater reserves while (4) reduces groundwater depletion and subsidence, (5) restores native riparian habitat, and (6) supports green spaces that enhance the quality of life for the residents of and visitors to the City of Tucson and broader region.

Our analysis has estimated the following benefits provided by the Reclaimed Water System, as detailed in subsequent sections and appendices of this TM (all dollar amounts stated in 2021 US Dollars, unless otherwise stated):[1]

1. Avoided Costs (cost savings). With the needs of large irrigation customers being met with reclaimed water, seasonal peaks in potable water demand are significantly reduced. Absent the Reclaimed Water System, Tucson Water would have needed to expand its potable supply capacity by 35 million gallons per day (mgd) to meet total water system peak season demands. The additional cost of potable system expansion would have amounted to an estimated $181.5 million in capital outlays and $26.2 million in annual operation and maintenance expenses (Mayer, 2017). The associated benefit for a typical City of Tucson single family household is $91 per year in potable water cost savings (Mayer, 2017). Another added benefit is that certain capital improvements to the potable system may be delayed because of lower total and seasonal potable water demands (Thomure and Kmiec, 2008).

2. Water Supply Resilience. The Reclaimed Water System has helped stabilize and restore groundwater levels in the regional aquifer, through its contribution to groundwater recharge and by offsetting demands on the potable system. The source of reclaimed water (treated effluent from indoor water use) is drought-resistant, locally generated, and locally controlled, thereby enhancing the resilience and reliability of the regional water supply portfolio.

[1] Dollar values updated to 2021 values using the Consumer Price Index (per https://www.bls.gov/data/inflation_calculator.htm)

The dollar value of enhanced supply reliability and resilience is difficult to quantify, yet there is credible empirical evidence, generated by a suite of relevant economic studies, that reliability and resilience values may be substantial. Supply reliability has been shown in other locations to have considerable economic value to regional households and businesses, E.g., on the order of $45 per household per year to avoid 20% water use restrictions in one year out of the next 20 years (Raucher et al., 2013). In terms of regional economic activity, the value of reducing a potential regional water supply shortfall from 25% to 15% (i.e., reducing the shortfall from 25% to 15% of annual demand) has been shown to exceed $500,000 per AFY in terms of regional economic output in California's Bay Area (e.g., M Cubed, 2008).

3. Contributions to Banked Water Storage. Tucson Water's active groundwater storage program has been enhanced by the Reclaimed Water System. Net groundwater recharge attributable to the Reclaimed Water System averages between 8,000 and 9,000 AFY. If that net additional groundwater storage were to be replaced with Central Arizona Project (CAP) water, at an expense of $372/AF (Malcolm Pirnie/Arcadis, 2013), then the value provided by the Reclaimed Water System (expressed here as an avoided cost) would amount to between $3.0 million and $3.4 million per year. In total, one year of Tucson Water's water supply has been stored due to direct accumulated contributions by the Reclaimed Water System (Reclaimed Water Annual Report, draft, 2020).

4. Enhanced Ecosystems and Related Recreational, Aesthetic, and Quality of Life Benefits. Several important but hard-to-quantify ecosystem and social "quality-of-life" benefits for the region are derived from the Reclaimed Water System. The Sweetwater Wetlands, Santa Cruz River Heritage Project, and Southeast Houghton Area Recharge Project (SHARP) are key examples, providing high quality recreational, aesthetic, educational, cultural, wildlife and ecosystem restoration values to the community.

As one example, Audubon Society-led weekly bird watching tours at the Sweetwater Wetlands generate a nonmarket benefit of more than $110,000 per year for an estimated 1,500 annual participants. And, by helping to "green" portions of the community, the Reclaimed Water System is likely to alleviate some urban heat island impacts which may pose significant adverse health risks and discomfort, and higher energy use, especially under climate change.

The Santa Cruz River Heritage Project provides another important Reclaimed Water System-enhanced environmental and community asset. Reclaimed Water System discharge to the dry riverbed, beginning in 2019, has brought a surprising diversity and abundance of riparian life to the otherwise dry channel. This flowing stretch of river is located in the heart of Tucson and runs alongside a popular bike and walking trail. The Reclaimed Water System-based enhancements to the Santa Cruz River provide aesthetic, ecologic, cultural, and educational value to many residents as well as visitors to the region.

5. Regional Economic Impact Benefits. The Reclaimed Water System supports many economic activities and sectors, including the destination golf sector in the Tucson service area. Expenditures made by golfers traveling to the Tucson metro area provide significant revenues for golf courses and associated resorts, and their spending also generates an appreciable economic stimulus for the City and the rest of the Tucson Water service area.

Golf course and related resort owners and investors, as well as the local government entities that host them, realize large financial gains generated by access to Reclaimed Water System water for golf course turf irrigation. For example, the Ritz-Carlton resort and golf courses at Dove Mountain had revenue projections that indicated that the capital investment in the resort could be recovered in fewer than five years (Thomure and Kmiec, 2008)

Economic benefits also extend more widely across the region's sectors. Our regional economic impact analysis[2] estimates that golfers traveling to the region contribute an average of $2,805 per trip, and $49.4 Million per year in total, to metro area goods and services. The associated stimulus to the regional economy – consisting of direct, indirect, and induced impacts – includes an estimated 550 jobs added in the Tucson Water service area (144 of these added jobs are within the City of Tucson), labor income gains of $16.5 million annually ($5.2 million within the City), overall economic output gains of $48.4 million annually ($16.1 million within the City), and tax revenue enhancements of $7.1 million ($1.9 million for the City).

The portion of the annual economic stimulus benefits realized by and within the City of Tucson, derived solely from subsidized Reclaimed Water System use at golf courses located *outside* of City limits, amounts to an estimated 55 added jobs, $2.5 million in added labor income, $8.5 million annually in economic output, and $46,000 in added tax revenues.

In addition, local residents also enjoy the "nonmarket benefits" of irrigated golf courses (i.e., for recreational user days that are highly valued, and for aesthetic purposes). And the spending locals make related to their golf course activities also helps sustain and stimulate the City and regional economies. These local golfer benefits are not included in the empirical values provided above.

6. Additional Benefits Provided by the Reclaimed Water System. In addition to the benefits described above, the Reclaimed Water System provides other beneficial values to the region. For example, by wheeling recycled water to other users and their beneficial uses, Tucson Water enables recycled water benefits to be realized in the Town of Oro Valley and served Pima County facilities.

The benefits derived from the Reclaimed Water System are summarized in the following Tables ES-1 and ES-2 (next page).

[2] The regional economic impact analysis applied here applies the IMPLAN model, which is widely used and accepted across the U.S. Additional detail is provided in Appendix C.

Table ES-1 Key Benefits provided by the Tucson Reclaimed Water System

Type of Benefit	Description	Level and Value	Beneficiaries
Avoided costs (cost savings) from not needing to expand or upgrade the Tucson Water potable water system to meet peak season system demands.	Reduced potable water bills for residential customers.	$91 annual savings on potable water bills per average single-family household in the City of Tucson. (Presumably similar benefits to other potable customers)	Potable water system customers in City of Tucson, and potable customers in the rest of Tucson Water's service area
Recreational opportunities and aesthetic values at Sweetwater Wetlands, Santa Cruz River Heritage, and other sites using reclaimed water to create, restore, and/or enhance riparian and other natural habitats and public greenspace.	Walking, biking, birding and wildlife observation, school field trips, and other activities enabled and/or enhanced by reclaimed water use at local sites.	1500+ user days annually for Audubon-sponsored weekly Sweetwater birdwatching tours, with an approximate nonmarket value of $110,000 to participants. Additional recreational and related benefits for other users of sites created or enhanced by provisions of reclaimed waters.	All recreational users of Reclaimed Water System-supported amenities and resources, including City and Pima County residents, as well as visitors and tourists from outside the region.
Contributed to reduced risk of subsidence-related damages to City/public infrastructure (e.g., roads, bridges, water, and sewer lines) and private property	Avoided expense of disruption and repair costs from damage to roads, bridges, buildings, etc.	Monetary estimates are not available, however, subsidence-related damages can be very expensive to repair	Municipal entities and taxpayers, businesses, households, and other entities across the region
Enhanced water system reliability, resilience, and sustainability	Increased ability of total water supply system to meet demands in times of drought or other risks	Monetary estimates are not available for Tucson region, however studies elsewhere in the western U.S. indicate a high value of avoiding water shortages > 15% of demand	All households, businesses, municipal and other entities relying on Tucson Water-provided water.
Local and regional economic stimulus (golf course-related)	Reclaimed Water System supports golf-related tourism sectors, with beneficial economic impacts to the City of Tucson and region.	Local spending by visiting out-of-region golfers generates: $49 million in additional revenues for regional businesses $16.5 million in added regional employment income $48.4 million in added regional economic output $7.1 million in added tax revenues.	City of Tucson economic benefits amount to: 144 added jobs (26% of total job gains) $5.2 million in labor income (32% of total) $16.1 million in added economic output (33% of total) $1.9 million added tax revenue (27% of total)
Ecosystem and related other "greening" benefits	Riparian habitat restoration	Monetary nonmarket value estimates not available	Flora and fauna, and human residents

Table ES-2 Overview of Key Benefits and Costs for the Reclaimed Water System (Annualized 2021 US Dollars)

Benefits		
Benefits: Monetized	**Estimated Value**	**Comments**
Avoided Costs for Potable System	$37 Million per year ($11M in annualized capital outlays, plus $26M in annual O&M expenses)	Approximately $91 per year savings for a single-family residential household in City
Banked storage in groundwater (average of about 9000 AFY)	$3.0 to $3.4 M/year (on average)	Based on cost of acquiring and groundwater storage of CAP water
Audubon-led birding outings at Sweetwater facility	$0.1 M/year	Does not include other birding, wildlife observation, or other recreational or educational activities at Sweetwater
Revenues for Reclaimed Water Sales	$9 Million per year	Based on 2019-2020 rates
Regional economic impacts from nonlocal golf course visitors (associated with Reclaimed Water System-enabled golf course turf irrigation)	$8.5 million in added regional economic output (as well as 550 added jobs and $7.1 M in added tax revenues)[3]	Based solely on economic impact of nonlocal visitors to region with express purpose of trip being golf
Benefits: Not Quantified	**Description**	**Comments**
Enhanced diversification and sustainability of water portfolio	More reliable and resilient supply portfolio for the served region	Also aids in restoring groundwater levels
Enhanced ecosystems and related recreational, aesthetic, and quality of life benefits.	Sweetwater Wetlands, Santa Cruz River Heritage Project, and Southeast Houghton Area Recharge Project as examples	Providing recreational, aesthetic, educational, cultural, wildlife and ecosystem restoration values to the community.
Total Benefits	**>$48 million per year [3]**	Does not include nonmonetized and regional economic impact benefits
Costs		
Total Costs (Combined annualized capital and yearly O&M expense)	**$13 Million per Year** ($4 Million per year revenue shortfall)	Revenues from RWS Customers: $9 million/year based on 2019-2020 Reclaimed Water System rates and sales.

[3] Regional economic stimulus values are not appropriate to include in the monetized benefits total, as they may be diverting economic activity from other regions (e.g., Phoenix). However, these values are important for the City of Tucson and Pima County.

2. Introduction

2.1 Background

Tucson Water has successfully developed and operated an extensive Reclaimed Water System since the mid 1980s. Repurposing effluent derived from the Pima County Regional Wastewater Reclamation Department (PCRWRD); the Tucson Water Reclaimed Water System network consists of approximately 200 miles of purple pipe serving more than 900 sites. In total, the Reclaimed Water System delivers between 15,000 and 20,000 Acre-Feet per year (AFY) of recycled water for nonpotable applications, including turf and agricultural irrigation, groundwater recharge, and ecologic restoration.

The Reclaimed Water System has provided a mix of important benefits to the region. By providing a reliable supplemental water supply in the 1980s, at a time when regional economic development was outpacing sustainable groundwater extraction, the Reclaimed System has facilitated regional population and economic growth, reduced demands on the potable water supply system, contributed to reducing groundwater depletion and subsidence, helped restore native riparian habitat, and supported green spaces that enhance the quality of life for the residents of and visitors to the City of Tucson and the broader region.

While the Reclaimed Water System has provided a range of important benefits, it also imposes a cost. For numerous well-established reasons – including an initial need to attract customer demand by pricing recycled water at less than potable water rates -- reclaimed water for nonpotable reuse typically is sold at rates that are less than the full cost of producing and distributing high quality, fit-for-purpose product water (e.g., Raucher et al., 2019).

Selling reclaimed water at a discount implies that its users are being subsidized by other parties, typically the customers of the local potable and/or wastewater systems. These "cross-subsidies" often are well justified by the benefits the various parties receive from the reclaimed water system, including avoiding the expense of expanding the potable system to meet nonpotable demands. And, as nonpotable water reuse systems mature, and customer demands and long-term contracts become well established, the level of cross-subsidies may be periodically reviewed and adjusted to align rates more closely with the cost of service.

2.2 Objectives

The objective of this Technical Memorandum, and associated supporting appendices, is to provide a technically sound, unbiased empirical basis for evaluating the equity and efficiency of current and potential future Reclaimed Water System rates (and associated cross-subsidies). This analysis is intended to inform an upcoming review of the Reclaimed Water System's rates and rate structure, and any associated cross-subsidies. To support this objective, this report contains information that:

1) Describes and estimates the beneficial values provided by the Reclaimed Water System as well as its beneficiaries throughout Tucson Water's service area.

2) Provides a sound financial framework for establishing the true cost of service for the Reclaimed Water System, and then compares the historical annual costs to revenues received from users of the Reclaimed Water System (both contract and standard customers) to identify the amount and factors contributing to the "subsidy".
3) Evaluates how the size of the subsidy might change if the rate framework were changed to reflect a slightly modified set of reuse pricing principles and approaches.
4) Assesses the extent to which the Reclaimed Water System cross-subsidies align with the benefits and beneficiaries of the Reclaimed Water System.

The information developed is applied to examine: (1) the "*efficiency*" of the Reclaimed Water System in terms of whether the benefits provided by the system outweigh its costs; and (2) the "*equity*" or "fairness" of how well who pays for the system aligns with who benefits from the services and other values the Reclaimed Water System provides the community. Insights from these evaluations can then be applied in deliberations on upcoming rate-setting and cost-sharing agreements across the jurisdictions and customer classes served by the system.

3. The Origins and Rationale for Developing the Tucson Water Reclaimed Water System

Establishment of the Reclaimed Water System was facilitated in the Tucson/Pima County region by an Inter-Governmental Agreement (IGA), forged in 1979 between the Pima County Regional Wastewater Reclamation Department (PCRWRD) and the City of Tucson (located within the eastern portion of Pima County). A brief history and description of the partnership is provided in Appendix A. The agreement entailed having the county take on exclusive responsibility for wastewater management in the region, assigned 90% of the wastewater effluent from Pima County's facilities to the City, and designated the City of Tucson's Water Department for taking on sole responsibility for water supply provision (including reclaimed water) for the City as well as portions of the surrounding county.

There were numerous factors and pressures leading to the IGA and key institutional arrangements within it (see Appendix A). Underlying the details and allocation of responsibilities, the main driver for developing the Reclaimed Water System was the widely recognized need to provide a new, reliable, and sustainable local source of water for the rapidly growing population and economy of the arid desert region that has no viable significant source of surface water supply and receives an average of less than 10.6 inches of precipitation annually.

The greater Tucson area experienced rapid growth following World War II, relying almost exclusively on local groundwater sources to supply the expanding population and economy. By the late 1970s, it was clear that the region was at considerable risk of running short of water by unsustainably drawing down local aquifers. Groundwater levels had declined by 100 to 200 feet (and as much as 400 feet in some areas), and the region was suffering from the associated decline in water quality, and from extensive subsidence (which can cause significant damage to infrastructure and natural systems). The ability to sustain the region's population and economy – much less grow them as its leaders desired – was very much in question.

In addition, State of Arizona legislative initiatives were in progress, culminating in the 1980 Groundwater Management Act (GMA, or Act). The Groundwater Management Act mandates reliance on sustainable water resources, and it established the Tucson Aquifer Management Area (AMA). The Act requires that groundwater use be replaced with renewable water supplies such that the "safe yield" of aquifers in portions of the State designated AMAs, including the Tucson AMA, is achieved by 2025.

A new, sustainable water supply was needed, and reclaimed water was recognized as being available and feasible as a core part of the solution. Tucson Water started producing and distributing reclaimed water to large turf customers in 1984. Tucson Water also started importing Colorado River surface water via the Central Arizona Project (CAP) in 1992 to 1994, and it resumed CAP imports after the Clearwater Program began operation in 2001. Currently, CAP water, groundwater, and reclaimed water comprise Tucson's water supplies, with groundwater still being tapped to meet peak water demands and other contingencies.

Accordingly, from the outset, it was widely recognized that there were important benefits for the region to be realized from developing a successful Reclaimed Water System. This report examines the types and magnitudes of these benefits, by applying a Triple Bottom Line (TBL) perspective to address the questions:

- What are the valuable financial, social, and environmental benefits – both monetizable and qualitative -- associated with the successful deployment of the Reclaimed Water System?
- What is the actual cost of service for producing and delivering reclaimed water to system customers, and who bears these costs?
- Who are the primary beneficiaries of the Reclaimed Water System, and who bears the costs (i.e., how well are the cost allocations aligned with benefits and beneficiaries)?

The section that follows briefly describes the core concepts and process for developing the TBL-based benefit-cost analysis for the Tucson Reclaimed Water System. Subsequent sections provide empirical evaluations of benefits and costs.

4. Approach for Assessing the Beneficial Value of the Tucson Water RWS

This portion of the TM establishes the basic principles for the economic benefit-cost analysis performed here, including the importance of establishing a useful baseline and applicable timeframe for the analysis. This portion of the report also provides a qualitative overview of the key types of benefits and costs associated with the Reclaimed Water System.

4.1 Establishing the Baseline and Timeframe

In assessing the benefits and costs of the Reclaimed Water System, several core economic principles and practices apply. First, the analysis is *comparative*, meaning that we are examining the benefits and costs of the current Reclaimed Water System relative to an alternative of not having the Reclaimed Water System. This is referred to as *establishing the baseline*, where the baseline reflects the situation in which Tucson would *not* have developed, maintained, and operated the Reclaimed Water System (i.e., it is the "without" Reclaimed Water System scenario).

Another key aspect of developing a sound benefit-cost analysis (BCA) is establishing a useful *timeframe* for the analysis. The analysis may be *retrospective* (looking backward to what might have been), or it can be *prospective* (looking forward from today into the future). There are challenges in applying either timeframe. For example:

- A *retrospective* of the Tucson Water Reclaimed Water System would entail hypothesizing how the region would have developed (or not) over the course of the past 40 years if no Reclaimed Water System had been developed – a highly challenging and largely hypothetical exercise. What would the region's economy and population look like today absent 40 years of Reclaimed Water System supply? What actions would have been deployed absent the Reclaimed Water System to comply with the Groundwater Management Act and related Aquifer Management Area requirements? What benefits would have been forgone? What costs were incurred or avoided?

- A *prospective* analysis entails starting from the present and predicting the future. The question addressed is: What would happen if the existing Reclaimed Water System was shut down or scaled back considerably, or redeployed to other uses (e.g., applied primarily for stream restoration instead of turf irrigation focused largely on golf courses)?

This study applies a forward-looking prospective analysis, meaning that it focuses on the current program and circumstances as a means of informing deliberations about potential future directions for the Reclaimed Water System program, and associated deliberations regarding cost recovery and rates. However, the analysis also incorporates some retrospective aspects to establish the relevant baseline. In this hybrid approach, the retrospective aspect entails assuming, that absent the Reclaimed Water System (i.e., the baseline), the City and County would be supporting the existing level of population and economic development as has occurred over the past 40 years, but they would have done so by deploying an alternative water supply (i.e., an expanded potable supply) rather than the Reclaimed Water System to meet the total water demands of the service area.

4.2 Defining Applicable Types of Triple Bottom Line Benefits: Conceptual Discussion

This economic analysis applies a Triple Bottom Line (TBL) perspective that articulates a broad range of applicable financial, social, and environmental benefits and costs associated with the reclaimed water system. These TBL benefits and costs are compared to a baseline alternative of not having reclaimed water available. The analysis also entails describing who receives the key benefits, and who pays for the system.

This section of the TM provides a conceptual discussion of the types of benefits and costs that are attributable to the Reclaimed Water System. Empirical evaluation of applicable benefits and costs are developed in Sections 5 and 6, respectively.

4.2.1 Avoided Costs

One of the primary benefits that typically arises from a water reuse project is the avoided costs arising from being able to eliminate or postpose expanding and upgrading the community's potable water system and/or its wastewater system. Avoided costs typically entail both the (1) capital investment and other upfront costs that would be incurred by the potable water supply and wastewater systems, as well as (2) ongoing operation and maintenance (O&M) costs.

For example, a nonpotable water reuse project often reduces the need to add new potable sources to the community's water supply portfolio – new sources that, absent the reuse system, would be needed to meet growing community water demands. The nonpotable reuse system typically reduces peak season and peak hour demands faced by the potable system, with associated cost savings from not having to upsize the potable water distribution and pumping system. The benefit of these cost savings ultimately accrues to the potable utility customers in the form of water bills that are lower than they otherwise would have been. As detailed in Section 5.1 (and Appendix B), the avoided cost of expanding the potable supply is a considerable monetized benefit arising from the Reclaimed Water System.

Likewise, wastewater system costs may be avoided by creating a reclaimed water system to reuse wastewater effluent that would otherwise require additional treatment to meet increasingly stringent discharge permits. Thus, wastewater system upgrade and/or expansion costs may be avoided or postponed by investing in a water reuse program. Under such a scenario the wastewater utility customers accrue these benefits by having lower wastewater bills than they would have faced otherwise. In the case of the Tucson Water Reclaimed Water System, however, there may be limited wastewater-related avoided costs as, under the terms of the IGA, Pima County has incurred considerable expense to comply with increasingly stringent effluent discharge regulations even though the treated effluent is recycled rather than directly discharged.

Avoided costs are often significant because obtaining new potable water supplies typically would have been an expensive proposition. However, *these cost savings often are overlooked because avoided costs do not appear on any agency's fiscal accounting ledger*. Utility fiscal accounts do an excellent job of tracking expenses that are incurred, but there is no place on a utility's standard accounting ledger for expenses that are avoided due to wise investments in reuse or other cost-saving activities. For our analysis of the Tucson Reclaimed Water System, we examine the avoided costs that would have been incurred to expand the potable system to supply water to the customers who purchased Reclaimed Water System water.

4.2.2 Enhanced Regional Water Supply Reliability and Resiliency Benefits

Diversifying the regional water supply portfolio by including reclaimed water is a valuable way to increase the community's water reliability and resilience. Reclaimed water provides advantages in that it is a locally generated supply and one whose source water is largely drought insensitive.

- As a local supply source, the quantity and quality of the available supply is not subject to potential disruption as may be associated with waters imported from outside the region. For example, imported water supplies -- such as a Central Arizona Project imported surface water from the Colorado River system -- may be periodically curtailed by regulatory limits, political pressures, or natural events such as droughts, seismic disruption, or wildfire. For 2021, CAP allocations statewide were expected to be reduced by 18% due to drought-related impacts on the Colorado River system (Davis, 2021). Although the impact on Tucson Water's CAP allocation is expected to be minimal (i.e., in Tier 1, Tucson's allocation of CAP water was not reduced in 2021), prolonged severe drought conditions continue to adversely impact the Colorado River system.
- As a supply derived from wastewater effluent generated by local indoor water use, there is little fluctuation in the quantity of available source waters. Indoor water use is generally stable regardless of drought conditions. This is because drought-related water supply shortages typically result in curtailments that focus on limiting outdoor uses and typically have modest impacts on indoor water use.

Having a locally generated and controlled supply of effluent, with reliable yields from season to season and year to year, means that the reclaimed supply is more reliable (a predictable, stable yield) and more resilient (avoiding risks imposed by external events). There is real economic value in including a reliable and resilient water supply option in the community's water supply portfolio, as demonstrated by several empirical investigations.

Residential customers value the increased certainty that they will not face water use restrictions that are as severe or frequent as they might otherwise. Business entities likewise value the enhanced certainty (reduced uncertainty) about the availability of a reliable water supply for operating their enterprises, which may incentivize companies to maintain or expand their operations in the region, and may attract new businesses to the region. Raucher et al. (2013, 2015) provides a review of the relevant empirical and conceptual studies on the value of water supply reliability for residential and business customers, and they also offer empirical estimates based on statistically significant analysis.

4.2.3 Contributions to Water Banking via Groundwater Storage and Subsidence Management

The RWS provides water that is applied to (and credited for) groundwater recharge, which has value to the community by contributing to the replenishment of local groundwater resources. Replenishing local aquifer systems contributes to higher regional groundwater levels, reduced subsidence, and increased City of Tucson banked water reserves. Additionally, groundwater replenishment enables Tucson Water to accrue aquifer recharge credits. These recharge credits provide Tucson Water with additional flexibility for drawing additional groundwater in times of need.

Groundwater recharge is accomplished through the direct use of reclaimed water to supplement groundwater banking through net positive recharge at the Sweetwater Wetlands facility. Positive net recharge at the facility occurs in years when Reclaimed Water System recharge volumes in periods of relatively low reclaimed water demand exceed withdrawals to meet peak season Reclaimed Water System demands. On average, Tucson Water receives credits for a net 8,000 to 9,000 AFY of groundwater recharge using Reclaimed Water System water. Groundwater recharge also is conducted at other locations, including the Santa Cruz River Heritage Project, arising from the use of reclaimed water to provide instream flows to targeted portions of the Santa Cruz River.

Groundwater recharge and related water banking provide considerable benefits to the region. The City estimates it now has banked approximately 50-years of water supply through its groundwater banking program, using a portion of its CAP water allocations and reclaimed water. As of 2017, Tucson Water estimates it has stored enough reclaimed water to meet one year of demand (2018 Status of the Aquifer Report, Tucson Water).

4.2.4 Enhanced Ecosystems and Related Recreational and Aesthetic Opportunities

The Reclaimed Water System supports several recreational and aesthetic values and natural functions that enhance ecosystems and provide valuable opportunities for life-enhancing activities for community members. More specifically, the Reclaimed Water System supports several natural systems, including the Sweetwater Wetlands, riparian habitat through portions of the Santa Cruz River via the Santa Cruz River Heritage Project (through downtown Tucson), and the Southeast Houghton Area Recharge Project (SHARP). The Sweetwater Wetlands, for example, provide valuable benefits for community members and others who visit the site for its educational facilities, excellent birdwatching opportunities (including numerous Audubon Society-led birdwatching tours), walking, biking, and other outdoor activities.

4.2.5 Regional Economic Impacts (Multiplier Effects)

The availability of reclaimed water has enabled the Tucson region to develop as a premier destination for golf, thereby drawing in considerable revenues from visitors traveling to the area to engage in the sport and related activities. Tourism-related expenditures brought into the region for lodging, meals, green fees, retail shopping, and other activities stimulate a "multiplier effect" on the regional economy, providing what economists refer to as direct, indirect, and induced economic benefits. These benefits take the form of increased regional economic output, employment, income, and tax revenues. While these economic impacts are not included within benefit-cost analyses (because they reflect a transfer of economic gains from one location to another, rather than a net gain for the national economy), they are nonetheless relevant and important for local and regional entities. As shown in Section 5.4 and Appendix C, the regional economic benefits for the Tucson region arising from the influx of golf-related tourism is significant.

4.3 Defining Applicable Reclaimed Water System Costs

As with most water projects, the RWS has required a mix of upfront expenses (capital outlays) to build the system, as well as recurring, ongoing expenses to operate and properly maintain the system (O&M costs). All these costs need to be recognized and combined within a standard accounting framework to assess the "cost of service" for the Reclaimed Water System RWS. This may be accomplished through a "present value" approach, in which costs incurred in each year are tracked (or estimated for future years), and then discounted back to a base year. An alternative (but essentially equivalent) approach entails annualizing the one-time capital expenses and adding them to the annual O&M costs to develop a "total annualized cost" over the multi-year project period (e.g., 20 or 30 years).

A conceptual discussion of the costs is provided in sections 4.3.1 through 4.3.3, below. Section 6 of this TM provides an empirical evaluation of the estimated cost of service for the Tucson Reclaimed Water System. It also describes the "cross-subsidy" provided by potable water ratepayers, and associated rate setting issues. Appendix D provides a discussion of rate-setting principles and approaches for pricing recycled water.

4.3.1 Capital and other Upfront Costs

Developing the Reclaimed Water System required several upfront investments including permitting, planning, and related project development expenses, as well as the actual expense of building the facilities (e.g., acquiring land and rights of way, constructing facilities, acquiring and installing treatment process equipment, and developing the pipelines and pump stations needed for conveyance of the product water to customers). Most of these capital expenses are large one-time expenditures, or for long-lived assets that will not need to be replaced for decades (e.g., treatment equipment and pipelines typically last for two or more decades before requiring significant replacement, and distribution pipelines may last a century).

Large capital projects often are financed (at least in part) through debt service spread over 20 years or more, and often at favorable rates of interest (e.g., through government-subsidized loan programs such as the federal State Revolving Fund). Grants may be available to help offset a portion of the capital expense.

4.3.2 Operations and Maintenance (O&M) Costs

The Reclaimed Water System incurs ongoing expenses for operating and maintaining the system. The O&M costs include direct expenses for energy, staffing, and other materials and services associated with reclaimed water production and distribution, as well as operational and other support services.

4.3.3 Opportunity Costs

The funds devoted to developing and operating the Reclaimed Water System could have been deployed for other beneficial purposes, if not directed at building and maintaining the Reclaimed Water System.

The concept of opportunity costs reflects the foregone value that would have been obtained had the money been directed to these other activities. For example, the affordability of water is an increasingly pressing issue for lower-income households served by many public water systems. An opportunity cost of the historical and current arrangements for financing the Reclaimed Water System is that some funds used to develop the Reclaimed Water System could have been otherwise dedicated to addressing water access and affordability issues impacting Tucson's most economically disadvantaged.

In terms of the opportunity costs associated with low-income water affordability, the salient issue is not whether the Reclaimed Water System provides tangible (and intangible) benefits to all Tucson Water customers (as outlined in this Technical Memorandum). Rather, an underlying question is whether the extent of subsidy employed to date, and embedded in current rate setting practice, could and should be altered to provide funding for other purposes like more pronounced and substantive redress of low-income water affordability challenges.

Central to this question are several considerations (some of which fall outside the scope of this review) including:

- Whether the extent of subsidy provided to the Reclaimed Water System may be reduced without adversely impacting benefits accrued (as described herein). In other words, are subsidies at current levels required, or may reclaimed system development and operation, supported by local regulation, proceed with reduced levels of subsidy?
    - Tucson Water's historic levels of subsidy (with rates recovering approximately 70 percent of allocated costs over the last 5 years) are marginally higher than the average among a national survey of reclaimed water systems (Carpenter et al., 2008).
    - Tucson Water's reclaimed water system is relatively mature with a supporting regulatory structure, community acceptance, and substantial infrastructure in place – all dampening the need for incentives to prompt accessing the reclaimed system.
- What are the legal and institutional constraints on how funds allocated for Reclaimed Water System development could be redirected for other purposes like funding low-income water affordability measures?
- What are the tangible (and intangible) benefits that may accrue from redirecting the Reclaimed Water System subsidy to instead support alternative purposes, like low-income water affordability program funding, as compared to the benefits that may be foregone by truncating the reclaimed system subsidy?

In general, there seems little question that Tucson Water's historical policies to advance Reclaimed Water System development have led to profound tangible and intangible benefits (unavailable from investment in alternative water supply sources). In this respect, historic opportunity costs were overwhelmed by the investment returns from supply diversification. Yet, with the development and maturation of the Reclaimed Water System, with its attendant delivery of disproportionate benefits to reclaimed water users, key questions arise as to whether historic subsidies should be moderated and related funds redirected to other Tucson Water service delivery imperatives.

4.4 Benefits approach summary

The Reclaimed Water System provides a wide array of benefits to the people, businesses, and communities in the greater Tucson region. The Reclaimed Water System also imposes costs borne by its reuse customers and, through subsidized rates, customers of the City's potable system. The next portions of this report focus on (1) describing the types and estimated size of the benefits, (2) assessing how those benefits are distributed across locations and parties who directly or indirectly are the beneficiaries of the RWS, (3) estimating the actual cost of service for the reclaimed system, and (4) how the allocation of costs and subsidies aligns with the scale and distribution of benefits.

5. Empirical and Qualitative Assessment of Applicable Benefits

This section of the TM provides empirical information regarding the magnitude of the types of benefits and avoided costs that could be readily and reliably estimated for the Tucson Water Reclaimed Water System.

5.1 Potable System Avoided Costs as Benefits Attributed to the Reclaimed Water System

The primary avoided cost arising from the Reclaimed Water System is the estimated expense that would have been incurred by expanding the potable supply (in lieu of developing the Reclaimed Water System) to offset the approximately 35 mgd of peak period reclaim water demand (reclaimed system peak demand was 30.5 mgd in 2012, estimated at 35 mgd for 2021, and projected peak day demand for 2030 is 41 mgd, per Malcolm Pirnie, 2013). That is, we apply an "*avoided cost*" approach to determine the value to the community of having 35 mgd of reclaimed water as an offset to needing to expand the potable system to meet an additional 32 mgd of potable water demands.

Facilitating this assessment is the availability of a recent analysis of the financial benefits of the water conservation/demand management programs implemented by Tucson Water. The report, *Water Conservation Keeps Rates Low in Tucson, Arizona: Demand Reductions Over 30 Years Have Dramatically Reduced Capital Costs in the City of Tucson,* was prepared by Peter Mayer for the Alliance for Water Efficiency (Mayer, June 2017). Mayer estimated that the amount of potable peak demand period water saved through the demand management programs between 1989 and 2015 was 35 mgd. This reduction in peak demand is similar in size to the potable water demand offset provided by the Reclaimed Water System. This similarity in scale enables us to interpret the values derived in the Mayer 2017 report for our purposes of estimating financial benefits derived from the Reclaimed Water System – in the form of avoided costs for the potable system. The methodology and data applied by Mayer is summarized in Appendix B.

Interpreting the Mayer 2017 study enables us to assess the water supply alternative that presumably would have been selected to meet total regional water demands if reclaimed water was not developed. The results of the Mayer study show that, as of 2015, Tucson customers paid combined water and wastewater rates that are at least $133 lower than they would have been if Tucson residents had not lowered demand on the potable system by 35 mgd. As Mayer notes: "Essentially, by conserving water each water and wastewater customer has avoided the costs of acquiring, delivering, and treating additional water supplies that would have been necessary to provide a reliable water supply to a growing population" (Mayer, 2017).

Of this estimated savings, Mayer attributes 62.6% of this savings to the water supply component of avoided costs, for an average potable water supply cost savings of $83.26 per household, in 2015 dollars. Mayer also notes that Tucson Water's potable rates were 17.7% lower in 2017 than they would have been absent the 35 mgd savings. Updating to current year values, avoided costs from reducing the need to expand the potable system amounts to <u>$90.75 in annual average water bill savings per</u>

household for Tucson Water customers, in 2021 dollars (updated using the CPI). The remaining 37.4% of conservation-related savings are attributed to wastewater program avoided costs (which do not apply to our analysis of the Reclaimed Water System, although they do represent a savings enjoyed by City and outside-of-city customers of the Pima wastewater system).

Similarly, by developing the Reclaimed Water System, the associated reduction in customer use of *potable* water has extended the City's water supply decades into the future. This in turn helped Tucson avoid purchasing additional water supplies, defer investments in new large-scale infrastructure and system expansion projects, and has been able to scale down the size of new water supply facilities. As such, savings for potable system customers is estimated to be $91 per year for an average single-family household.[4]

5.2 Reliability and Resiliency Benefits, and Groundwater Storage Values

As noted previously, in section 4.2.2 and 4.2.3, the Reclaimed Water System provides the community with enhanced reliability and resiliency of the region's water supply portfolio, by including a locally generated and controlled, and climate-independent, water source. Additional groundwater recharge and storage/banking benefits accrue as well. Through 2020, Tucson Water has stored over 35,000 acre-feet of reclaimed water underground for future use (per Dee Korich, Tucson Water).

Empirical estimation of the full value of these benefits for the Tucson Reclaimed Water System is limited by the available data. Nonetheless, credible empirical studies conducted in other locations suggest the reliability enhancement values for Tucson Water's business and residential customers may be significant – E.g., on the order of $45 per year per household to avoid 20% water use restrictions in one year out of the next 20 years (Raucher et al., 2013).[5] In terms of regional economic activity, the value of reducing a potential regional water supply shortfall from 25% to 15% (i.e., reducing the shortfall from 25% to 15% of annual demand) has been shown to exceed $500,000 per AFY in terms of regional economic output in California's Bay Area (e.g., M Cubed, 2008).

In addition, Tucson Water's active groundwater recharge program has been enhanced by its use of the Reclaimed Water System, thereby providing the region with the value of a more reliable and sustainable supply (and associated regional economic benefits). Net groundwater recharge attributable to the Reclaimed Water System averages between 8,000 and 9,000 AFY (Scully, 2021). If replaced with CAP water at a cost of $372/AF for the CAP water and expense of groundwater recharge (per Malcolm Pirnie/Arcadis, 2013), then the value of recycled water to the community equals an additional $3.0-$3.4 million per year.

[4] In the context of opportunity costs discussed in Section 4.3, low-income customers also benefit from the savings on water rates associated with the reclaimed water system. However, the current policy question is would/could greater benefits to low-income customers be rendered by reducing the level of subsidy to reclaimed water customers and instead using those subsidy funds to directly provide low-income water customer assistance.
[5] For example, if modest-level water use restrictions were likely to be imposed in 5 of the upcoming 20 years, then the typical household would have a willingness to pay an extra $225 per year (5 * $45) to reduce that risk.

5.3 Recreational, Aesthetic, Ecologic, and Related Quality-of-Life Benefits

In addition to avoided costs and water supply reliability benefits – which are highly valuable in their own right – several other aspects of recycled water use benefit the region, although these are more difficult to quantify. Among these are ecosystem, recreation, and related social "quality-of-life" benefits. The importance of these often nonmonetized benefits is reflected in the fact that the US Water Alliance recently awarded the City of Tucson its 2021 prize for *Outstanding Public Sector Organization.* The Alliance specifically cited Tucson's recycled water and "green stormwater" programs in recognizing the city for its work advancing sustainable, integrated, and inclusive solutions to water challenges. (US Water Alliance, 2021). Ecosystem restoration and recreation are accomplished with recycled water through three notable projects, as described below.

Originally, the filter backwash flow from production of recycled water at Tucson Water's Sweetwater Recycled Water Facility was used to create and maintain the Sweetwater Wetlands. With improved water quality from the Pima County Water Reclamation Facilities, the filters are no longer required, so the Sweetwater Wetlands are now maintained with water from the recycled water system.

The Sweetwater wetlands provide numerous additional recreational uses, including an education program, self-guided tours, field trips, and individual birding and wildlife viewing opportunities. The site is 60 acres and contains paved and unpaved paths open to the public. There are self-guided tours offered through Tucson Water and Arizona Project WET, in which users can use a QR code reader app to view the Wetlands in a scientific way. The Tucson Audubon Society offers weekly birding field trips, and the site is a popular birding site, as it attracts a wide variety of species, several that are hard to find in the broader desert area (personal communication, Luke Safford).

The site is open to the public, and data are not available on the total number of users at the site. However, we can estimate the monetary value of the guided trips conducted by the Tucson Audubon Society. Tucson Audubon Society keeps data on the number of visitors who participate in their weekly field trips. On average[6], about 1,500 participants join their guided trips each year. To estimate monetized values associated with this recreation, we apply the consumer surplus value for wildlife viewing from the publicly available Recreation Use Values Database. The average consumer surplus value for wildlife viewing is $74.50[7] per individual trip (Oregon State University College of Forestry, 2016). Multiplying this value by the number of guided field trips taken with the Tucson Audubon Society at Sweetwater Wetland, we estimate the value of the guided field trips at around $111,000 per year, ranging from $105,000 to $120,000.

There are also anecdotal data sources available that do not quantify or monetize the recreational use at the recycled water-supported sites and indicate these sites provide enhanced recreational opportunities through improved aesthetics and variety of species. The website "eBird" is an online portal for birders to record species sightings and rank birding sites. Sweetwater Wetlands is listed as among the top 4 "hotspots" of birding sites within Arizona.

[6] Data provided by Luke Safford on 6/25/2021. We calculated the average number of participants from 2017 – 2019, the years in which the tours were fully operational.
[7] Converted to 2021 USD using the Consumer Price Index calculator.

Another notable site providing recycled water-generated ecological and recreational benefits is the Santa Cruz River Heritage Project. Launched in June 2019, the Heritage Project reintroduced perennially flowing water into the otherwise dry Santa Cruz River after an 80-year absence. The restored river is not only vital to the environment, but also to Tucson's history, culture, and identity. The project provides enhanced recreational opportunities through improved aesthetics and an increased variety of vegetation and wildlife since recycled water has been added, starting in 2019. The Santa Cruz River Heritage Project site is along the Tucson "Loop" trail, and while the increased flow from Reclaimed Water System does not directly provide additional recreational use, the habitat enhancements improve recreators' enjoyment of the area. As noted in James (2021), "[after 2 years of water Reclaimed Water System discharge] a portion of the Santa Cruz that hadn't flowed continuously since the early 1900s is once again teeming with life: cattails, dragonflies, red-spotted toads, red-winged blackbirds."

In addition, the South Houghton Area Recharge Project (SHARP) is a 40-acre recharge and recycle water project comprised of three recharge basins receiving recycled water from the Houghton Reclaimed Reservoir. This water soaks into an area of the aquifer that has declined in the past years. SHARP also provides opportunities for community recreation and interaction. It is the first recharge project in Tucson open to the public, and it provides green space for walking, running, and biking (US Water Alliance, 2021).

While difficult to express in monetary terms, the benefits provided by the Sweetwater Wetlands, Santa Cruz River Heritage, and Southeast Houghton Area Recharge projects clearly represent considerable recreational, aesthetic, and educational value for the community. Compounding the value provided by recycled water, these projects also help alleviate the "heat island" impact of urban hardscape, which is predicted to intensify risks to public health and well-being under changing climate conditions.

5.4 Regional Economic Impacts Associated with the RWS

The assessment of who benefits from the Reclaimed Water System is examined in greater depth by exploring how the benefits created are magnified and distributed through the region's economies (e.g., between the City and entities outside of City limits served by Tucson Water). Appendix C describes in greater detail both the methodology and empirical results for how the provision and pricing of reclaimed water translate into "regional economic impact" benefits (e.g., employment, income, output), and how those benefits are distributed between the in-City and outside of city limits Tucson Water service area.

5.4.1 Methodology

The technical approach entails applying the well-regarded and widely applied "IMPLAN" regional economic input-output (I/O) model to address the question, "How does the local economy within the City of Tucson – and the local economy in the service area beyond city limits – realize regional economic multiplier beneficial outcomes arising from the direct, indirect and induced economic impacts of enterprises supported by the Reclaimed Water System?"

The empirical approach examines the level of tourism drawn to the Tucson area as a destination golf location. The number of visitor trips drawn by local reclaimed water-reliant golf courses and associated visitor expenditures are allocated between within- and beyond city limits. IMPLAN model runs then provide credible estimates of how that tourism-driven spending translates into valuable local economic outcomes including increased output, employment, labor income, and local tax revenues.

5.4.2 Regional Economic Impact Benefit Estimates

As detailed in Appendix C, there currently are 19 golf courses supplied by the reclaimed system. Six of these are within City limits, and the remaining 13 are located within the service area beyond city limits. An estimated 14,684 golfing destination trips to the reclaim-using golf courses are estimated, with nearly 12,000 of these attributed to service area golf destinations outside of city limits. An average expenditure of more than $2,800 per golf-driven trip translates into more than $41 million annually being added to the local economies in the form of *direct* economic impacts.

As golf courses, hotels, restaurants, and other enterprises provide their goods and services to visiting golf-oriented tourists, these local businesses spend portions of their increased revenues on the intermediate goods and services they require to meet the added demand. The portion of that *indirect* spending on local labor and other local services and commodities in turn provides additional economic stimulus within the regional economies, in the form of a further round of spending[8]. This additional round of *induced* spending – such as additional expenditures made by households for whom incomes have increased from the direct and indirect demands – then further stimulates the local economies. Regional economic impact/multiplier benefits to both the City and the broader region are estimated and summarized below.

Local spending by visiting out-of-region golfers is estimated to generate for the service area economies as a whole:

- 555 added jobs per year
- $16.5 million in added regional employment income per year
- $49 million in additional annual revenues for service area businesses
- $48.4 million in added regional economic output annually
- $7.1 million in added tax revenues per year.

For the City of Tucson, the portion of these total estimated annual economic gains that are expected to be realized within city limits include:

- 144 added jobs per year (26% of total job gains)
- $5.2 million in annual labor income (32% of total)
- $16.1 million in added yearly economic output (33% of total)
- $1.9 million added tax revenue per year (27% of total)

Additional details are provided in Appendix C.

[8] Note that the portions of direct, indirect, and induced spending that is directed to goods and services provided from *outside* of the local region are *not* included in the estimation of local economic impacts.

5.5 Summary of Reclaimed Water System Benefits

A summary of the benefits provided by the reclaimed water system is provided in Table 5-1. The benefits that can be reasonably monetized amount to more than $49 million annually, or $40 million per year if annual revenues are excluded. Additional important benefits that cannot be readily quantified or monetized also are described.

Note that these monetized "total benefit" estimates do *not* include the regional economic impact benefits (including $41 million in local expenditures by destination golf visitors, nor the additional $5.8 million added to Tucson-area regional economic output). The economics profession discourages including inter-regional transfers of economic activity within benefit-cost analyses, as these results reflect a redistribution of economic activity across locations within the United States and not a net gain in overall national economic values. Nonetheless, these regional economic impact gains are important and relevant for the City of Tucson and its broader service area, and they are developed and presented in this assessment to help inform local policy deliberations.

Table 5-1 Key Benefits provided by the Tucson Reclaimed Water System

Benefits		
Benefits: Monetized	**Estimated Value**	**Comments**
Avoided Costs for Potable System	$37 Million per year ($11M in annualized capital outlays, plus $26M in annual O&M expenses)	Approximately $91 per year savings for a single-family residential household in City
Banked storage in groundwater (average of about 9000 AFY)	$3.0 to $3.4 M/year (on average)	Based on cost of acquiring and groundwater storage of CAP water
Audubon-led birding outings at Sweetwater facility	>$0.1 M/year	Does not include other birding, wildlife observation, or other recreational or educational activities at Sweetwater
Revenues for Reclaimed Water Sales	$9 Million per year	Based on 2019-2020 rates
Regional economic impacts from nonlocal golf course visitors (associated with Reclaimed Water System-enabled golf course turf irrigation)	$8.5 million in added regional economic output (as well as 550 added jobs and $7.1 M in added tax revenues)[9]	Based solely on economic impact of nonlocal visitors to region with express purpose of trip being golf
Benefits: Not Quantified	**Description**	**Comments**
Enhanced diversification and sustainability of water portfolio	More reliable and resilient supply portfolio for the served region	Also aids in restoring groundwater levels
Enhanced ecosystems and related recreational, aesthetic, and quality of life benefits.	Sweetwater Wetlands, Santa Cruz River Heritage Project, and Southeast Houghton Area Recharge Project as examples	Providing recreational, aesthetic, educational, cultural, wildlife and ecosystem restoration values to the community.
Total Benefits	**>$48 million per year[7]**	Does not include nonmonetized and regional economic impact benefits

[9] Regional economic stimulus values are not appropriate to include in the monetized benefits total, as they may be diverting economic activity from other regions (e.g., Phoenix). However, these values are important for the City of Tucson and Pima County.

6. Empirical Assessment of Reclaimed Water System Costs

This section provides an empirical estimate of "cost of service" for providing reclaimed water to the system's customers. The size and allocation of the estimated cross-subsidy from potable water customers is also provided. In addition, Appendix D provides an overview of principles and guidelines for recycled water rate setting.

6.1 Current Rate Setting Framework

Historically, Tucson Water has updated water rates on an annual or biennial basis following standard industry cost-of-service rate setting methods. Under the current framework, annual utility revenue requirements are determined for one or more budget "test" years based on a "cash needs" approach. Cash-needs revenue requirements include O&M expenses, taxes, and capital costs (debt service and annual rate funded capital improvements).

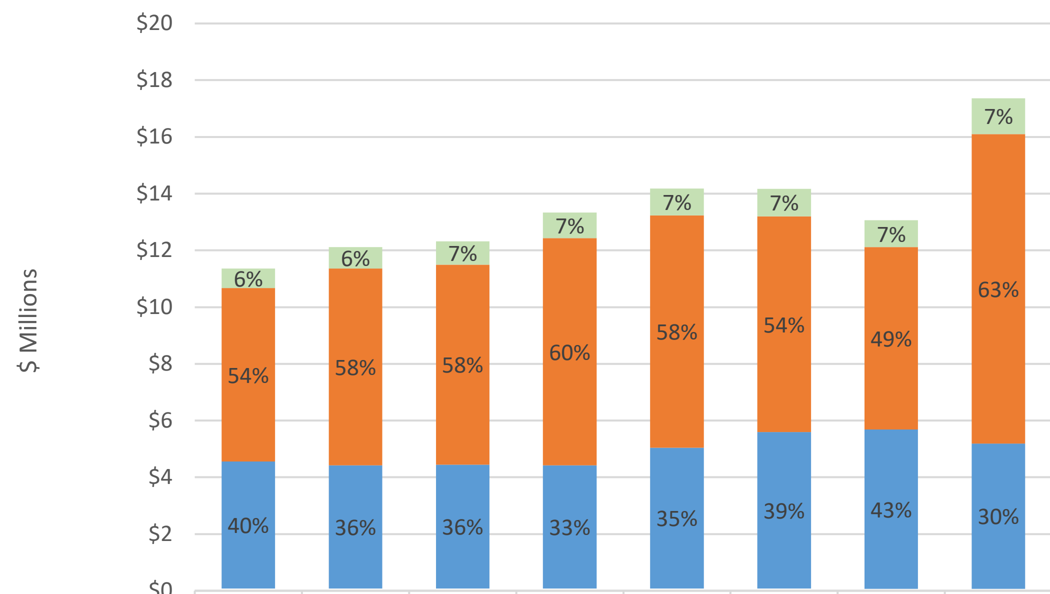
Annual revenue requirements are then allocated among different utility services including potable and reclaimed water services, customer billing, and meter-related services. Potable water costs are further allocated to individual customer classes based on average and peak water usage characteristics.
For the reclaimed water system, the basic rate-setting framework does not differentiate among reclaimed water customers when estimating costs of service; however, rates for some customers (e.g., wheeled water and interruptible service) are determined according to provisions established in negotiated contracts.

6.2 Historical Reclaimed Water System Costs

Figure 6-1 provides a summary of reclaimed water system cost components as determined by each rate update over the past decade (with dollar values in millions). Rate updates were performed annually through fiscal year (FY) 2017 and then were performed every two years through FY 2021. The last *adopted* cost-of-service analysis was completed in 2019 and it established reclaimed water rates for standard (i.e., non-contract) customers for FY 2019 and FY 2020. In early 2020, an updated cost-of-service analysis was performed for the FY 2021 test year; however, the resulting rates were not implemented due to the COVID-19 pandemic and City Council's decision to temporarily suspend rate increases. While the rates were not adopted, the FY 2021 reclaimed cost of service results are included in this report for comparison because they are part of the public record[10] and they represent the most recent reclaimed water system cost estimates.

[10] See Mayor and Council Memorandum: *Tucson Water's Five-Year Financial Plan, Rate Revision Process, and Proposal of FY2021-FY2024 Water Rate Schedule (City Wide and Outside City),* March 3, 2020.

Figure 6-1 Annual Reclaimed Cost of Service Components (2012-2021)



	2012	2013	2014	2015	2016	2017	2019	2021
Total	$11.3	$12.0	$12.2	$13.3	$14.1	$14.1	$13.0	$17.3
Other	$0.7	$0.8	$0.8	$0.9	$1.0	$1.0	$1.0	$1.3
Capital	$6.1	$6.9	$7.1	$8.0	$8.2	$7.6	$6.4	$10.9
O&M	$4.5	$4.3	$4.4	$4.3	$5.0	$5.5	$5.6	$5.1
Reclaimed % Total COS	7.7%	7.8%	7.8%	7.8%	7.9%	7.8%	6.2%	7.2%

O&M Capital Other

Total reclaimed water system costs increased at a compound average annual rate of 4.9 percent between 2012 and 2021, which was slightly lower than the average annual increase in total Tucson Water revenue requirements of 5.7 percent. Therefore, the reclaimed system's share of total costs decreased slightly from 7.7 percent to 7.2 percent, as shown in Figure 6-1. The individual revenue requirement components and allocation methods are discussed in the subsections that follow.

6.2.1 Operation and Maintenance Costs

Direct costs for reclaimed water production and distribution include energy, staffing, and other materials and services costs which are budgeted and tracked within a distinct "object code" within Tucson Water's financial system. These direct costs made up over 70 percent of the $5.6 million in reclaimed water O&M costs in FY 2019. Other O&M costs include direct operational and engineering support costs which are allocated to reclaimed water based on staff estimates (in the case of water quality lab and water production plant operations) or in proportion to fixed asset value (in the case of engineering and planning costs). Consistent with standard industry practice, a portion of Tucson Water's general administration and overhead costs are also allocated to reclaimed water customers on an indirect basis (i.e., in proportion to directly allocated costs).

Reclaimed water O&M costs increased at a compound average annual growth rate of 3.3 percent between FY 2012 and FY 2019. Costs increased significantly between 2015 and 2017, in part due to the reclassification of some capital improvement costs such as O&M and increases in power and other direct reclaimed water system costs. In FY 2021, allocated reclaimed water O&M costs decreased by about nine (9) percent compared to the adopted FY 2019 cost of service results, reflecting a re-allocation of 20 percent of reclaimed production and distribution costs to potable water service to account for the portion of reclaimed water that is filtered into the potable water system through SHARP and Heritage facilities.

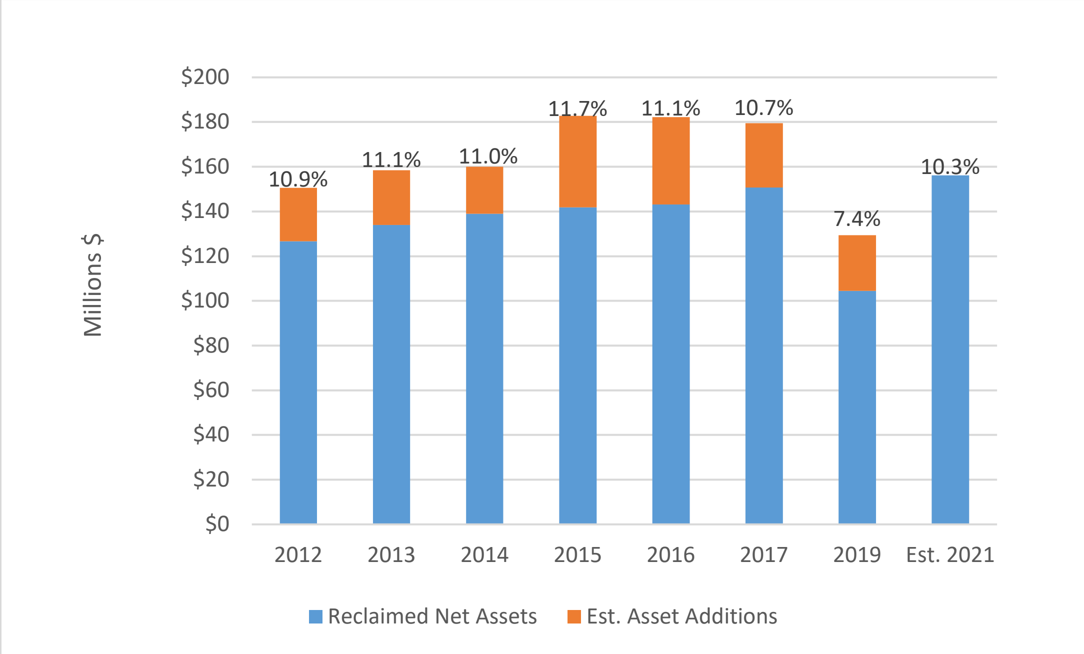
6.2.2 Capital Costs

Tucson Water's annual capital requirements include debt service and current revenue funded capital improvements. Consistent with industry practice, capital costs are allocated to different service categories (including the reclaimed water system) in proportion to system fixed asset values. Specifically, debt service costs are allocated to the reclaimed water system in proportion to net plant investment, and current revenue-funded capital costs are allocated in proportion to annual depreciation expense.

As shown in Figure 6-1, allocated reclaimed water system capital costs have fluctuated significantly over the past 10 years. While capital costs have generally increased for Tucson Water as a whole, the portion allocated to reclaimed has fluctuated due to changes in the share of asset values attributable to reclaimed, as shown in Figure 6-2. Before the most recent cost-of-service analysis conducted in 2020 (for the FY 2021 test year), system asset values used for allocations included existing net plant value plus two years of *estimated* capital improvement expenditures. The reclaimed system's share of total asset value grew between 2012 and 2015 from 10.9 percent to 11.7 percent, driven primarily by an increase in estimated asset additions. Between 2016 and 2019, estimated reclaimed asset additions decreased, leading to a decrease in capital costs and share of total asset value.

Reclassification of a portion of net assets for the 2019 cost-of-service study further contributed to a significant decline in reclaimed water system share of capital costs under the adopted rates; however, the most recent (2021) study reflected reclaimed net assets consistent with the pre-2019 values. Furthermore, the basis for determining asset value for capital cost allocation purposes was changed in 2020 to eliminate the estimated asset additions given the variability of those costs and because the estimates were not an accurate predictor of near-term increases in asset values.

Figure 6-2 Reclaimed Capital Asset Value and Share of Tucson Water Total Asset Value



6.2.3 Other Costs

Other costs included in annual reclaimed system revenue requirements include taxes (both utility and payment in lieu) and customer service and meter costs. Taxes are allocated on an indirect basis within the cost-of-service framework; therefore, the reclaimed system portion fluctuates in proportion to directly allocated costs. Meters and customer service costs are allocated to reclaimed water customers based on the number and size of meters. In total, other costs represent four to seven percent of annual allocated reclaimed water system costs.

6.3 Reclaimed Water Sales

Historical reclaimed water system revenues are a function of sales volumes and rates. Figure 6-3 shows historical estimated sales volumes[11] for standard and special contract customers between 2012 and 2021. Estimated sales volumes decreased significantly (almost 30 percent) between 2012 and 2017. However, during that same time, some golf course customers were transitioned to the standard reclaimed rates; thus, the portion of total reclaimed sales volume subject to the standard rates increased between 2012 and 2017.

Since 2017, sales volumes have increased, though most of that increase has been from special service customers (wheeling and interruptible services) whose contracts provide for significantly lower rates. For 2021, both the estimated and actual volumes are shown, as actual volumes were significantly higher

[11] The annual sales volumes shown in Figure 6-3 are estimated values developed for each rate update. The estimated volumes were used to project annual revenue from existing reclaimed water rates for comparison against the allocated reclaimed costs to determine the annual support provided from potable water customer rates.

than estimates. Because each rate process is based on a future (budgeted) test year, estimated volumes and resulting revenues are used to estimate required potable system support.

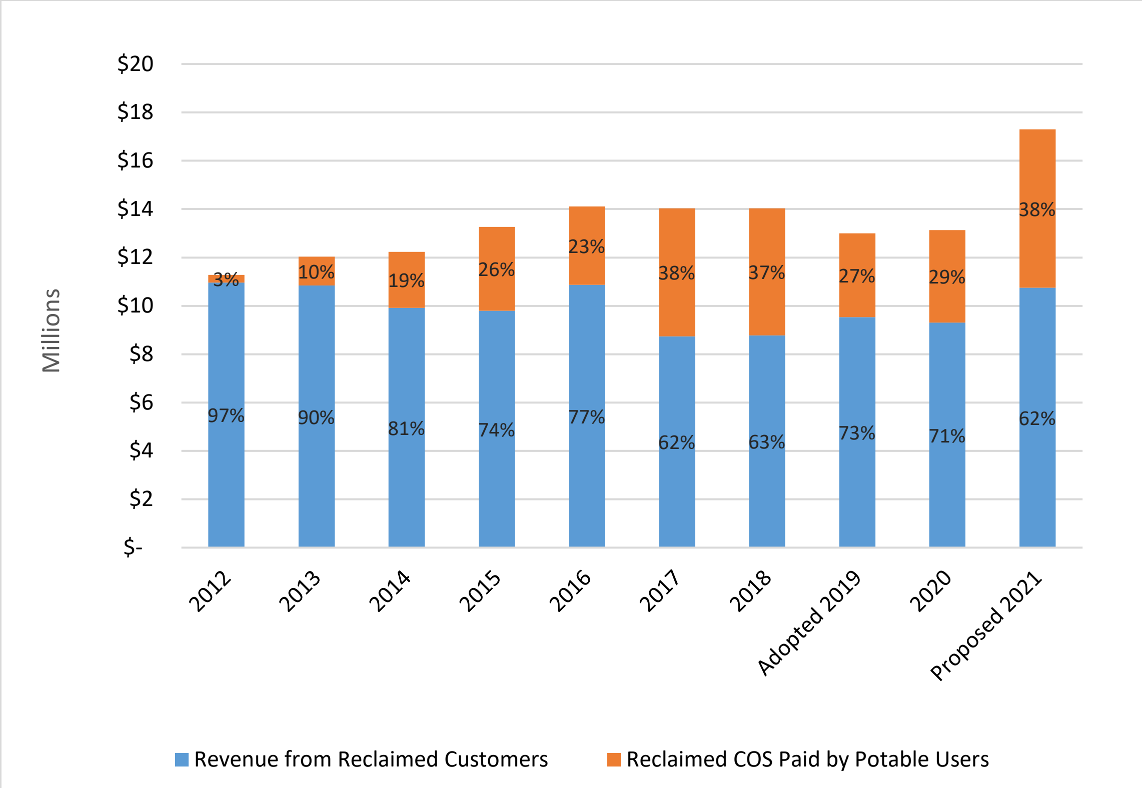
Figure 6-3 Reclaimed Water Sales Volumes (2012-2021)

6.4 Reclaimed Water System Revenues and Incentives (Subsidy)

Figure 6-4 shows the extent to which historical annual reclaimed water system costs were estimated to be funded by reclaimed water system revenues versus incentives paid by potable system customers. As was discussed in preceding sections, reclaimed water system costs increased significantly between 2012 and 2017 (about 25 percent), while estimated reclaimed sales volumes decreased (almost 30 percent), resulting in a significant increase in the reclaimed incentive paid by potable water users (from 3 percent in 2012 to about 38 percent in 2017).

During the same period, concerns were raised by members of the Citizen Water Advisory Committee (CWAC) about the difference between the standard reclaimed rates and lower contract rates charged some golf courses. Based on recommendations from the CWAC, the standard rate increases were limited to a 2.2 percent increase in 2015 to allow the golf course rates (which per the contracts, escalated annually consistent with Tucson Water's overall revenue requirements) to reach standard rate levels by 2017.

Figure 6-4 Reclaimed Revenues and Incentives Paid by Potable Users



The golf course contract and standard rates are shown in Table 6-1. Overall, the rates charged golf course customers subject to the contracts increased 30 percent between 2012 and 2017, while the standard reclaimed rate increased only about 2.2 percent.

Table 6-1 Reclaimed Standard and Contract Rates ($/ccf)

Fiscal Year	Golf Course Contract Rate	Reclaimed Standard Rate
2012	$1.43	$1.83
2013	$1.53	$1.83
2014	$1.64	$1.83
2015	$1.75	$1.87
2016	$1.81	$1.87
2017	$1.87	$1.87
2018	$1.87	$1.87
2019	$2.00	$2.00
2020	$2.13	$2.13
Proposed 2021	$2.25	$2.25

With the rate update in 2019, the estimated portion of reclaimed water system costs paid by reclaimed customer rates increased to over 70 percent, reflecting increases in both reclaimed rates and sales volumes, and a reduction in allocated capital costs. However, the 2021 update projected a significant increase in reclaimed costs supported by the potable rates due to an increase in allocated costs.

6.5 Alternative Rate Setting Frameworks

Two alternative rate setting frameworks are considered for further evaluating reclaimed costs of service and potential subsidies. Both approaches follow accepted rate-setting practices and have been used previously by Tucson Water for rate-related purposes. The first approach ("utility basis" revenue requirements) has implications for the total cost allocated to the reclaimed system, while the second approach (cost allocation to subclasses within the reclaimed system) considers potential intra-class subsidies at existing reclaimed cost of service levels.

6.5.1 Utility Basis Approach

As discussed previously, Tucson Water's regular rate-setting approach establishes annual revenue requirements using a cash needs approach. Another approach used in the water industry generally, and by Tucson Water in some special rate-setting contexts (e.g., for establishing potable water wheeling rates), is the utility basis approach. The major difference between the utility basis approach and the cash needs approach is the way in which capital costs are calculated. Unlike the cash needs approach, the utility basis includes depreciation and a return on rate base as the capital component for determining capital-related revenue requirements as opposed to actual cash expenses for debt service and current revenue funded "pay-as-you-go" capital.

Table 6-2 restates the reclaimed water system revenue requirements as utility basis for FY 2019 (the test year for the last adopted rates) and for two variations for FY 2021 (the test year for the most recent rate analysis). Reclaimed water system O&M costs are the same as under the current rate setting framework. Capital costs include estimated depreciation and a return on rate base calculated from the net assets discussed previously and shown in Figure 6-2. A variation for FY 2021 is that capital asset value is discounted by 20 percent (consistent with O&M) to reflect the benefit to the potable system related to SHARP and Heritage.

Table 6-2 Alternative Rate Approach: Utility Basis Revenue Requirements[1]

		FY2021		
Revenue Requirement Component	**Assumptions**	80% Assets	100% Assets	**FY2019**
O&M		$5.1	$5.1	$5.6
Net Assets		$124.9	$156.2	$104.5
Capital				
Depreciation[2]	1.6%	$2.0	$2.5	$1.7
Return on Rate Base[3]	2.6%	$3.3	$4.1	$2.8
Subtotal Capital		$5.3	$6.6	$4.4
Other		$0.7	$0.7	$0.5
Total Requirements		**$11.1**	**$12.4**	**$10.5**
Revenue (Projected)		$10.2	$10.2	$9.0
Difference		-$0.9	-$2.2	-$1.5
% Support from Potable Rates		7.7%	17.6%	-14.1%
% Support from Potable Rates (Current Framework)		38.8%	38.7%	27.9%

[1]Excludes Meter & Services costs
[2]From Tucson Water
[3]Average cost of debt from vail wheeling analysis

The assumed rate of return on assets is equal to the average cost of debt outstanding (2.6 percent), consistent with calculations from Tucson Water's most recent potable wheeling rate analysis. The assumed rate of return is a policy decision. The average cost of debt is used for illustration purposes since it has been used in other contexts.

As shown in Table 6-2, the capital costs differ significantly between FY 2019 and FY 2021 due to the differences in net assets discussed previously. However, in both test years, the overall revenue requirements for the reclaimed system under the utility basis are significantly less than the cash basis. For FY 2021, utility basis requirements total $12.4 million, compared to $16.7 million under the current cash basis framework[12]. If capital costs are discounted, then reclaimed costs are reduced further to $11.1 million.

With the reduction in revenue requirements under the utility basis approaches, the percent of costs recovered from potable users would have been estimated to be between -14 percent and 17 percent for FY 2019 and FY 2021, compared to 27-38 percent under the current framework.

6.5.2 Costs by Function and Subclass Approach

As discussed previously, the reclaimed water system serves both standard and contract rate customers. Standard rates are set as part of Tucson Water's regular rate-setting process which includes consideration of both the updated cost-of-service analysis and policy considerations (i.e., potable rate incentives). Rates for contract customers are updated according to the specific provisions of individual contracts. While some of the contract rates are based on elements of the cost-of-service framework, the revenue requirements are generally more limited; for example, rates for wheeling and interruptible service customers exclude capital costs entirely.

While a comprehensive cost-of-service study for reclaimed customers is outside the scope of this study, information developed for prior studies has been used to estimate potential intra-class subsidies for reclaimed customers and the extent to which rates paid by standard rate customers (which include golf courses) are aligned with estimated costs of service.

6.6 Functional Allocation of Reclaimed Water System Costs

Tucson Water provides different levels of service to customers within the reclaimed water system class. For example, wheeling customers require only distribution of reclaimed water, while standard customers require both production of the water, as well as distribution. Current contracts require that O&M costs are allocated between the production and distribution functions for determining wheeling and interruptible rates. Table 6-3 summarizes estimated costs by function for the FY 2019 and FY 2021 test years[13] based on staff estimates.

[12] Customer service and meter costs are excluded from costs and revenues shown in Table 6-2 because reclaimed customers pay service charges that recover their full estimated cost of service and the charges do not vary between the cash and utility bases.

[13] While the contracts for wheeling customers require use of actual O&M costs, budgeted test year costs are used in this report (and shown in Table 6-3) to be consistent with Tucson Water's current rate setting framework.

Table 6-3 Functional Allocation of Cash Basis Reclaimed Revenue Requirements ($M)

	% Of Total	FY2021	FY2019
Revenue Requirements Restated (Functions)[1]			
O&M [2]			
Production	67%	$3.43	$3.76
Distribution	33%	$1.69	$1.85
Subtotal	100%	$5.12	$5.62
Capital[3]			
Production	18%	$1.96	$1.16
Distribution	82%	$8.95	$5.29
Subtotal	100%	$10.91	$6.45
Taxes			
Production	34%	$0.22	$0.19
Distribution	66%	$0.44	$0.27
Subtotal		$0.66	$0.46
Total Costs	**100%**	**$16.69**	**$12.53**
Production	34%	$5.62	$5.11
Distribution	66%	$11.08	$7.41

[1]Excludes meter & services costs

[2]From Tucson Water 2014 and 2018 special rates analysis

[3]From 2013 A+ model allocations

Allocation of cash basis capital requirements (from Figure 6-1) to production and distribution functions is based on a prior (2013) allocation of fixed assets values to major system functions. Taxes are allocated to functions in proportion to combined capital and O&M costs. Overall, production and distribution costs are estimated to be 34 percent and 66 percent, respectively.

The costs by functional category are allocated to reclaimed subclasses in proportion to the estimated sales volume of each group, as shown in Table 6-4. Allocation percentages are provided separately for distribution and production costs since wheeling customers are excluded from production costs.

Table 6-4 Projected Sales Volumes by Subclass

	FY2021	FY2019
Volume (Ccf)		
Standard	3,854,988	3,812,996
Wheeling	442,890	469,812
Interruptible	1,598,309	1,561,916
U of A	116,164	102,144
Total	**6,012,351**	**5,946,868**
Percent of Total (Distribution)		
Standard	64.1%	64.1%
Wheeling	7.4%	7.9%
Interruptible	26.6%	26.3%
U of A	1.9%	1.7%
Total	**100.0%**	**100.0%**
Percent of Total net of Wheeling (Production)		
Standard	69.2%	69.6%
Wheeling	0.0%	0.0%
Interruptible	28.7%	28.5%
U of A	2.1%	1.9%
Total	**100.0%**	**100.0%**

The percentages by class and function from Table 6-4 are used to allocate the requirements from Table 6-3 to reclaimed subclasses. The results are shown in Table 6-5, along with the estimated revenue and subsidy for each subclass.

As shown in Figure 6-4, the overall reclaimed incentives (subsidies) estimated to be paid by potable water users in the 2019 and 2021 rate updates ranged from 27 percent to 38 percent. Based on the cost allocations shown in Table 6-5, the standard rate customer costs are being subsidized at a significantly lower rate (8 percent to 21 percent) compared to contract customer costs. The higher subsidies for contract customers result primarily from the inclusion of capital costs in the allocated costs shown in Table 6-5, given the contract rates are calculated based on O&M costs only.

To the extent that there are cost-based reasons for exclusion of some or all capital costs from the contract rates (e.g., prior capital contributions or limitations on facilities used), relatively more of the subsidy would be attributed to the standard rate customers. As previously noted, a comprehensive review of contract customer levels of service and prior infrastructure funding arrangements is beyond the scope of this study. The allocations provided in Table 6-5 reflect consideration of service functions only.

Table 6-5 Costs by Subclass Approach

	Annual Costs		% From Potable	
	FY2021	**FY2019**	**FY2021**	**FY2019**
Estimated Costs by Subclass				
Standard (Prod + Distribution)	$10.99	$8.31		
Wheeling (Distribution only)	$0.82	$0.59		
Interruptible (Prod +Distribution)	$4.56	$3.41		
U of A (Prod +Distribution)	$0.33	$0.22		
Total	**$16.69**	**$12.53**		
Revenue by Subclass				
Standard	$8.67	$7.63		
Wheeling	$0.30	$0.32		
Interruptible	$1.25	$1.08		
U of A	$0.01	$0.01		
Total	**$10.22**	**$9.03**		
Subsidy by Subclass (w/Allocated Costs)				
Standard (Prod + Distribution)	-$2.3	-$0.7	-21.1%	-8.3%
Wheeling (Distribution only)	-$0.5	-$0.3	-63.6%	-44.7%
Interruptible (Prod +Distribution)	-$3.3	-$2.3	-72.6%	-68.4%
U of A (Prod +Distribution)	-$0.3	-$0.2	-97.9%	-97.2%
Total	**-$6.47**	**-$3.49**	-38.7%	-27.9%
Total Subsidy as a % of Standard Costs Only (Assuming subsidy is included in standard class costs)	**-$6.47**		37.1%	29.6%

6.7 Cross-subsidy Findings

As discussed in the previous sections, the portion of reclaimed water system costs included in potable system water rates has varied significantly over the last 10 years, ranging from 3 percent to 38 percent of estimated reclaimed costs. In dollar terms, the support from the potable water system is estimated to have ranged from $0.3 million to $5.3 million, based on adopted rates over the 10-year historical period, and $2 million to $5 million in more recent years. The wide range of potable support reflects both changes in allocated reclaimed costs and estimated sales volumes.

The annual reclaimed water system costs included in the potable water rates can be converted to an estimated typical household cost by dividing the subsidy by the annual potable water sold to determine a cost per unit of volume and then multiplying that rate by typical annual usage of 96 hundred cubic feet. The estimated annual household bill that provides a cross-subsidy to the reclaimed system ranges from less than $1.00 to over $13.00 over the 10-year period, with the last couple of years estimated to be $9-$10 per year.

7. Conclusions

The Tucson Reclaimed Water System provides the City and portions of Pima County beyond city limits with a variety of valuable benefits, including:

- Significant cost savings (largely by avoiding the need to expand the potable system to meet large peak season irrigation demands).
- Enhanced water supply portfolio diversification and associated system wide improvements in reliability, resiliency, and local control.
- Increased groundwater storage and aquifer recovery.
- Recreational, educational, cultural and ecosystem values through streamflow restoration, wetland services, and enhanced green spaces.
- Regional economic impact benefits through direct, indirect, and induced stimulus, as reflected in increased City and regional incomes, output, employment, and tax revenues.

These benefits amount to an estimated value of more than $48 million per year, in addition to the regional economic stimulus provided and nonmonetized benefits. These benefits are enjoyed by both potable and reclaimed water system customers within and outside of city limits. And, the benefits exceed the total annualized cost associated with the reclaimed system of $13 million per year based on the most recently adopted cost-of-service study.

While the benefits of the reclaimed system outweigh the costs by a considerable margin, there remains a concern about the equity (fairness) and efficiency aspects of who pays for the reclaimed system. Because the revenues generated by the system do not fully recover all reclaimed system costs (as estimated by the adopted rate-setting framework), a cross-subsidy (incentive) exists and is partially paid by potable system customers and across some classes of reclaimed water system customers. Regarding the cost recovery and associated cross-subsidies/incentives, points to consider include:

- The incentive (or subsidy) paid by potable water users over the past 10 years has increased due to increases in reclaimed system costs, reductions in reclaimed sales volumes, and policy choices to hold standard rates stable for some years to allow prior golf course contract rates to catch up.
- On a per household basis, the estimated cost borne by an average potable system household in Tucson amounts to between $1-$13 per year in most recent years; whereas those same within city potable system households receive an annual estimated benefit of $91 per year due to cost savings the reclaimed system provides by avoiding the need to expand the potable system.
- An alternative cost-of-service framework (e.g., utility basis approach and recognition of potable system benefits in supplying SHARP and Heritage projects) may result in significantly lower allocated reclaimed water costs (thus reducing the estimated subsidy).
- Over a third of reclaimed water annual sales volumes are from special service customers whose rates are set based on contracts whose rate-setting provisions exclude capital costs. A more

detailed evaluation of whether these exclusions align with cost-of-service principles or policy objectives is beyond the scope of this study, which considers reclaimed costs and benefits collectively.

Appendix A
Brief History of the Tucson Reclaimed Water System[14]

A.1 Timeline

1920s	Groundwater extraction's adverse impacts become evident with drying up of the Santa Cruz River, the region's only perennial surface water body. Regional aquifer is the only available water supply source.
1950-1980	Population grows 6-fold, from 77,000 to 450,000, accompanied by rapid economic growth and associated growth in water demands from 10,000 AFY to 80,000 AFY. Groundwater table experiences severe declines. By the latter part of the 1970s, with a strong regional desire to continue growth, the need to develop a sustainable water source is widely recognized at the local and state level. 1979: Inter-Governmental Agreement (IGA) established: Pima County assumes responsibility for wastewater treatment for City of Tucson and transfers rights to 90% of effluent to Tucson; The City transfers its wastewater treatment plants to Pima County to facilitate access to federal grant monies, and Tucson takes on potable and reclaimed water service responsibilities for city and portions of the surrounding county.
1980-2000	Arizona Groundwater Management Act (GMA) (1980) establishes the Tucson "Active Management Area" and requires Tucson to document groundwater pumping levels and identify plans to reach "safe yield" for the regional aquifer. 1984: City of Tucson begins design and construction of a tertiary treatment facility and an 8 mile pipeline to supply nonpotable water to La Paloma Golf Course and Resort, sharing cost with Pima County; Pima County provides effluent to Tucson at fixed cost. 2000: Pima County and City of Tucson agree to create a Conservation Effluent Pool of up to 10,000 acre-feet per year for approved riparian projects, within the Santa Cruz River and elsewhere.
2020-Present	Mature recycled water program is an instrumental part of reliable and largely sustainable regional water supply portfolio that collectively serves ~800,000 City and county residents. Cost allocation and related equity issues continue to be part of on-going discussions between City of Tucson and the portions of Pima County it serves. 2021: Tucson Water awarded the US Water Prize for Outstanding Public Sector Organization by the US Water Alliance in recognition of TW's work (in partnership with Pima County) advancing sustainable, integrated, and inclusive solutions to water challenges.

[14] Much of this appendix is drawn from a report developed for the USEPA Water Reuse Action Plan, Action 2.16, prepared under contract to Eastern Research Group, by E. Rosenblum, S. Spurlock, F. Marcus, and R. Raucher (final draft, 2021)

By the 1970s, depletion of the Tucson region's local groundwater aquifer – the region's only local water supply option -- resulted in significant declines in groundwater levels. The City of Tucson, Arizona, and Pima County, the jurisdiction that surrounds and includes the city, were faced with the dilemma of a growing population and a declining groundwater table.

Both the city and the county had historically run wastewater treatment plants, but in 1979 they agreed to divide their responsibilities. The County took over the treatment of all wastewater and the City assumed responsibility for further treatment of effluent as well as the production and distribution of recycled water. They codified this arrangement with a formal intergovernmental agreement, which has been occasionally amended and stood the test of time. The agreement was amended in 2000 to reflect infrastructure changes, and to allocate water for approved riparian projects. The two agencies together recover the cost of service through recycled water, potable water, and wastewater charges, and they tend to stagger rate increases. The City manages the combined billing for water, sewage, and environmental services.

A.2 Regional Background

The Tucson metropolitan area, in eastern Pima County, is in the hot, arid Sonoran Desert of southern Arizona. Pima County covers 9,200 square miles (about the size of the State of New Hampshire) with a 2020 population of approximately 1.1 million people. The vast majority of the population (approximately 1 million persons) is based within the Tucson Metropolitan Statistical Area (MSA). (ASU, 2021).

Annual precipitation in the county averages less than 10.6 inches, and there are no remaining natural surface water supply sources in the region. Some rivers, like the Rillito and Santa Cruz, used to flow perennially. Now they flow intermittently when fed by stormwater. Until the beginnings of the Reclaimed Water System (RWS) in the 1980's, the only viable water supply was the regional groundwater basin – the Tucson/Avra Valley Aquifer. Given the rapid growth in water demands, the regional aquifer was tapped at unsustainable levels and groundwater levels declined by as much as 400 feet in some areas, leading to a growing concern.

The Tucson region experienced very rapid population and economic growth following World War II, as people flocked to the warm sunny climate to retire, recreate, and/or pursue the economic opportunities afforded by the area's rapid development. The region's population was 77,000 in 1950, growing nearly six-fold to more than 450,000 people by 1980, and then more than doubling again to reach approximately 1 million people by 2020.

Tucson's rapid population and economic growth generated significant increases in water demands. Total water production in the 1940's was less than 10,000 Acre Feet per Year (AFY), grew to approximately 80,000 AFY by 1980, and peaked at more than 130,000 AFY by 2000.

The City of Tucson currently is home to approximately 550,000 people. Tucson Water is a department within the City of Tucson. Mayor and Council make policy decisions and provide staff direction, but the City Manager handles day to day departmental management. The utility's service area extends into neighboring communities and portions of unincorporated Pima County. Tucson Water provides potable water and nonpotable recycled water to customers within City limits as well as portions of unincorporated Pima County beyond city limits. Tucson Water's service area population nearly doubled from approximately 420,000 in 1980, to 780,000 today. Approximately 30% of Tucson Water customers reside outside of City limits.

Pima County's wastewater agency, the Pima County Regional Water Reclamation Department (PCRWRD), is governed by the County Supervisors. Four of the five County Supervisors serve both in- and outside-city areas, promoting a regional ability to view broader shared regional interests (rather than city versus county perspectives).

Appendix B
Methodology and Data Underlying Mayer's 2017 Avoided Cost Analysis

The following text is drawn from Mayer (2017), briefly describing the approach and data used to develop his avoided cost estimates:
Mayer's avoided cost analysis starts with selecting a baseline year, in this case 1989, before demand management measures implemented in Tucson and nationally began reducing per capita water use. Another reason 1989 was selected is that reliable data for both the water and wastewater systems were available going back to that year. Total potable water production in 1989 averaged 96.4 mgd (188 gallons per capita per day (gpcd)).

In step 2 of the Mayer avoided cost analysis, a hypothetical, non-conserving water production is calculated using the 1989 baseline production of 188 gpcd. This non-conserving gpcd assumes that no conservation was implemented, and the historic level of per capita consumption persisted up to 2015 as population increased. This is the key "what if" assumption in the analysis: What if water use patterns from 1989 had persisted and were unchanged today? Total production for this hypothetical, non-conserving scenario is calculated by multiplying 188 gpcd by the population in 2015 and results in a hypothetical, daily water production for Tucson of 134.4 mgd.

The subsequent analysis steps answer the following questions:

1. What system capacity would be needed to produce and deliver an average of 134.4 mgd potable water and to treat 80 mgd of wastewater?
2. How much additional infrastructure would be required?
3. How much additional operational expense would be required?

In step 3, the additional water supply, treatment capacity, transmission capacity, and wastewater treatment and transmission capacity necessary to adequately serve the hypothetical non-conserving level of demand in Tucson was determined. The costs of expanding Tucson's infrastructure to deliver the water needed to meet the hypothetical additional demands were estimated using the best available information from Tucson Water (TW) and Pima County Wastewater Reclamation (PCWRRP) staff and other experts on the cost of securing new supply and constructing new transmission and facilities.

Per footnotes provided throughout his report, Mayer (2017) describes his working closely with relevant staff at TW and PCWRRP to obtain relevant data and other information he applied in developing the avoided cost estimates described below.

B.1 Water Infrastructure

Based on Mayer's working with TW and Pima County staff, Tucson's current peaking factor was derived as 1.4, but under the non-conserving scenario, a slightly higher peaking factor of 1.6 was used to better represent increased outdoor use. The peaking factor of 1.6 was applied to the hypothetical average day demand of 134.4 mgd, to calculate a hypothetical peak day demand of 216 mgd. The Tucson Water system, which primarily pumps recharged Central Arizona Project water from an extensive groundwater aquifer west of Tucson, has the capacity to pump and treat about 240 mgd; sufficient to meet the hypothetical peak day demand. However, because a hypothetical demand of 216 mgd is very close to maximum capacity, the Water System would need new expansion projects such as the Avra Valley Transmission Main Capital Improvement Project. This project would cost $140 million, providing an additional 40 mgd of capacity at an estimated $3.5 million per mgd.

Additionally, under this hypothetical demand scenario, Tucson Water would have also moved forward to develop new recycled water supplies, specifically the North CAVSARP-3. This 7 mgd project had an estimated cost of $2.2 million per mgd, for a total cost of $15.4 million. Both projects were deferred and may be avoided entirely because of the impact of conservation on total supply.

The total estimated additional cost of water infrastructure required to meet the hypothetical non-conserving demand was set at $155.4 million plus interest. It was assumed this infrastructure would be financed over 20 years at a 2% borrowing rate.

B.2 Water Operations and Maintenance

The current (c 2015) variable costs in the water operations and maintenance budget were found by Mayer to be $51.3 million. Under the non-conserving scenario, it was estimated that Tucson Water's operations budget would be increased by about 30% to $73.8 million, an increase of $22.4 million.

B.3 Impact on Household Water Bills

In 2015, the average single-family home in Tucson used 74,000 gallons of water per year, discharged 63,000 gallons of wastewater per year, and paid a total combined water and wastewater bill of $847 per year. However, under the hypothetical non-conserving scenario the average single-family home in Tucson would have to pay $959 per year for the same service to cover all of the additional infrastructure, operations, and maintenance charges. This additional $133 per year represents a 13.3% increase over current water and wastewater rates. The study attributes 62.6% of this savings to the water supply component of avoided costs, for a potable water supply savings of $83.26 per household (in 2015 dollars), and the remaining 37.4% to wastewater savings. Tucson Water rates were estimated to be 17.7% lower in 2017 than they would have needed to be (and PCRWRD's rates 9.4% lower than would have been necessary) if per capita potable water demand had not been reduced.

Attributing only the water supply portion of the avoided cost, Mayer's (2017) analysis indicates an estimated savings of $91 per average single family residential account ($83.26, updated from 2015 to 2021 dollars)

Appendix C
City and Regional Economic Impacts of Tucson Water's Reclaimed Water System's Golf Courses

This Appendix provides details on our analyses of the regional economic impacts associated with golf visitation at RWS customer golf courses. We describe the objectives, methods, data, and findings of the economic impact analysis.

C.1 Background and Objectives

The 2008 study, *The Importance of the Tucson Water Regional Reclaimed Water System to the Economic Vitality of the City of Tucson-Pima County Region*, asserted that "The largest economic index that is associated directly with the success of the regional reclaimed water program is the destination resort golf industry. Through the use of reclaimed water, the destination resort golf industry can expand and continually invest in ventures throughout the greater Tucson community" (Thomure and Kmiec, 2008. P. 1). This appendix describes the methods and resulting empirical estimates of the beneficial regional economic impacts of tourism at the reclaimed water system's golf course customers and explores the regional distribution of the impacts on the City of Tucson and Pima County.

Golf is important to the City of Tucson and Pima County, and to the state of Arizona. A 2016 study by the University of Arizona estimated the economic impact of Arizona's out-of-state golf tourism had an estimated $1.2 billion in sales, $641 million in value added, and nearly 10,500 jobs earning $382 million in labor income (Duval, D., et al. 2016[15]).

Tucson is known as a destination golf region and, as such, attracts visitors whose primary purpose of the trip is to golf. These visiting golfers then spend money in the region and that influx of nonresident spending provides a positive economic impact on the region.

The economic impact of reclaimed water-supported destination golf is driven by the spending made by golf-related visitors and the resulting impacts on other consumers and businesses in the region. The economic impact includes both direct spending by visitors on golf-related activities, plus the indirect and induced economic multiplier impacts that this direct spending provides in stimulating the local economy.

C.2 Golf Tourism as the Key Driver for the Analysis

There are 18 golf courses that use Tucson-provided reclaimed water, 6 of which are in the city of Tucson and 12 of which are outside of the city limits (Figure C-1). Table C.1 lists the TWS golf course customers, and Table C.2 summarizes the geographic distribution of these courses by type of course.

[15] The study estimated impacts in 2014. Dollars were escalated to 2021USD using the CPI.

Figure C-1 RWS Golf Course Customer

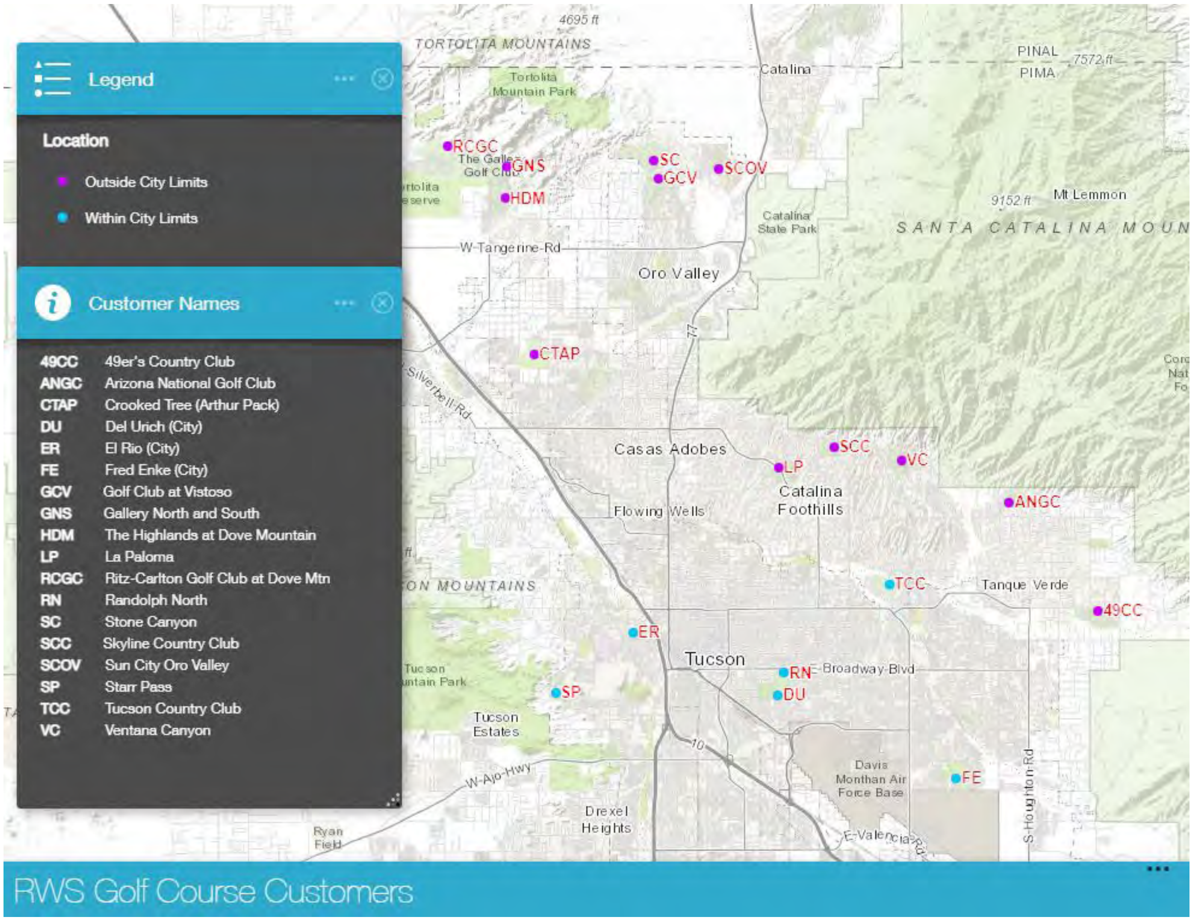


Table C.1 RWS Golf Course Customers

	Type of course	Area	Within city limits
49er's Country Club	Public	Tanque Verde	No
Arizona National Golf Club	Public	Tanque Verde	No
Crooked Tree (Arthur Pack)	Public	Casas Adobes	No
The Highlands at Dove Mountain (previously Heritage Highlands)	Public	Marana	No
Ritz-Carlton Golf Club at Dove Mtn	Private	Marana	No
Gallery North and South	Private	Marana	No
La Paloma	Private	Catalina Foothills	No
Skyline Country Club	Private	Catalina Foothills	No
Ventana Canyon	Public	Catalina Foothills	No
Stone Canyon	Private	Oro Valley	No
Golf Club at Vistoso	Public	Oro Valley	No
Sun City Oro Valley (formerly Sun City Rancho Vistoso Golf Course)	Public	Oro Valley	No
Del Urich (City)	Municipal	Tucson	Yes
El Rio (City)	Municipal	Tucson	Yes
Fred Enke (City)	Municipal	Tucson	Yes
Randolph North (City)	Municipal	Tucson	Yes
Starr Pass	Public	Tucson	Yes
Tucson Country Club	Private	Tucson	Yes

Table C.2 RWS golf course customers by geography and course type

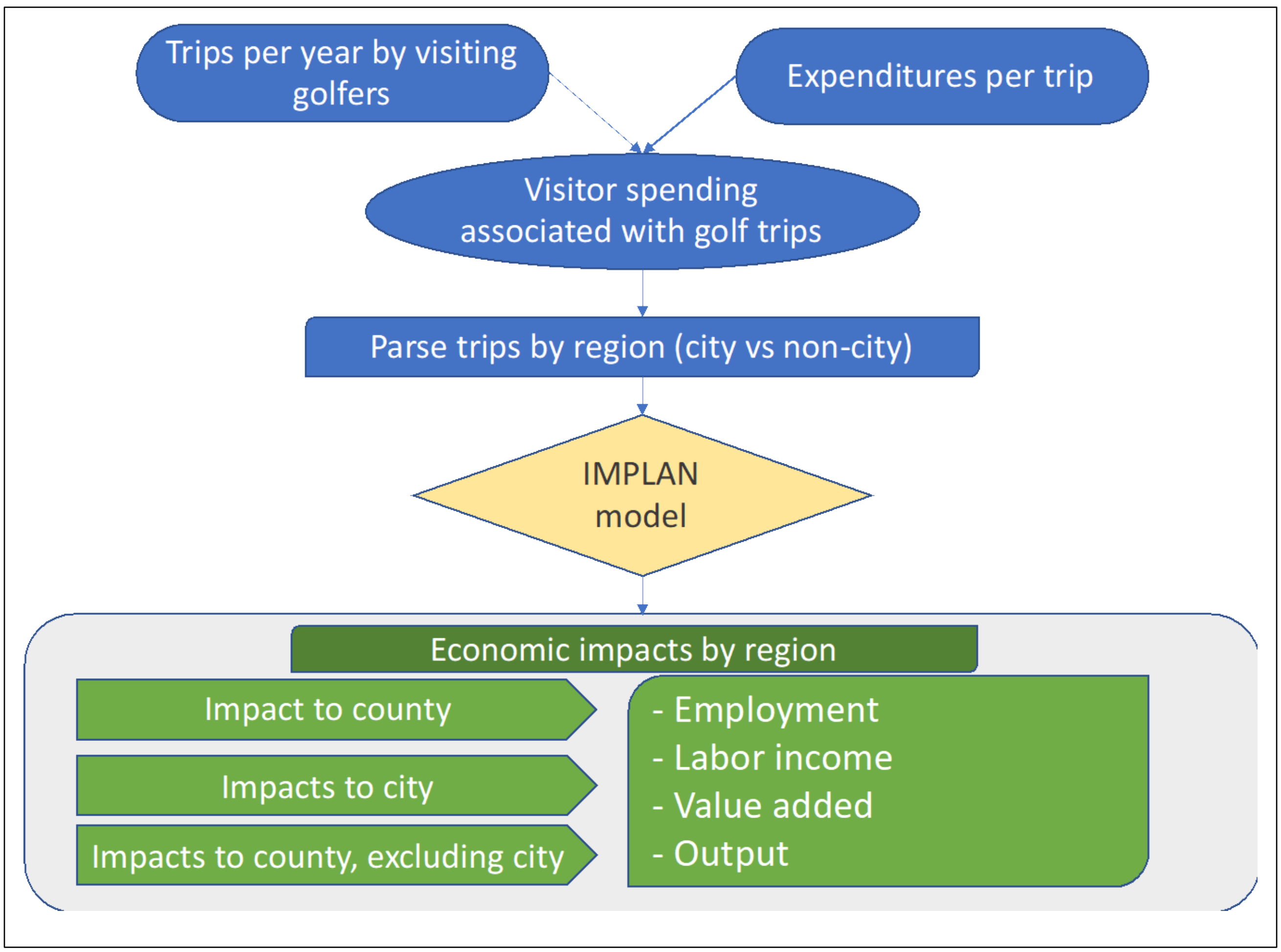
Location	Number of municipal golf courses	Number of Public golf courses	Number of Private golf courses	Total number of golf courses
Within city limits				
Tucson	4	1	1	**6**
Outside city limits				
Casas Adobes	0	1	0	**1**
Catalina Foothills	0	1	2	**3**
Marana	0	1	2	**3**
Oro Valley	0	2	1	**3**
Tanque Verde	0	2	0	**2**
Total outside city limits	**0**	**7**	**5**	**12**
Total	**4**	**8**	**6**	**18**

C.3 Methods

Golfing contributes to the local economy by bringing **outside** money into the economy in the form of **visitor spending**. The total economic impact of golf visits includes direct expenditures and subsequent flow-on impacts, which includes both indirect and induced expenditures. The process and terminology are as follows:

- Direct expenditures include money that tourists spend while visiting the area for golf. These include money spent on golf and other trip expenses such as transportation, food, lodging, and retail purchases.
- Local businesses that benefit from direct spending then, in turn, spend additional money on goods and services that they need to operate their businesses. These are termed indirect expenditures.
- Direct and indirect spending generates employment in the local region, creating additional income for households, which generates further spending known as induced expenditures.
- Figure C-2 presents a flowchart of the analysis.

Figure C-2 Flowchart for estimating economic impacts of visitation associated with RWS golf course customers.



Visiting golfers spend money on several goods and services, including hotel rooms, food, and retail, which affect several local industries, including restaurants, hotels, retail shops, and other tourist-related enterprises. These industries directly affect the economy by purchasing intermediate goods, such as restaurant supplies and wholesale goods, and by providing jobs. The industries that provide intermediate goods and services to the recreation and tourism industry purchase their own intermediate goods and services from other local industries, and the pattern repeats itself. Thus, the original money from visitor spending creates a multiplier effect on the local economy. At every stage, some portion of expenditures goes toward goods or services generated outside the local area. This is known as "leakage" and is incorporated in (i.e., netted out of) the calculations of multiplier effects (Bess and Ambargis, 2011).

This study uses the IMPLAN model (IMpact Analysis for PLANning) to assess the regional economic impacts associated with golf tourism. IMPLAN is an economic input-output (I-O) model, originally developed by the federal government, that contains information on the relationships within an economy, both between businesses and between businesses and final consumers. IMPLAN uses this information to predict changes in overall economic activity resulting from a flow of money into the local economy (e.g., visitor spending). IMPLAN is widely used by academics and the private sector, and it is generally accepted as the standard for economic I-O analysis.

To estimate regional economic impacts, IMPLAN constructs local level multipliers. Multipliers describe the response of the economy to a change in demand or production. Multipliers measure the economic impact of direct effects, as well as how the direct effects ripple through the economy to create indirect and induced impacts. The magnitude of indirect and induced effects depends on the propensity of businesses and households in the region to purchase goods and services from local suppliers. Purchases from local suppliers have ripple effects on the economy, whereas purchases from non-local (outside of the county in this case) suppliers do not result in ripple effects because the money spent for inputs leaves the local economy. IMPLAN accounts for this in the development of local multipliers by assigning regional purchase coefficients to goods and services purchased by individual sectors and households. IMPLAN also reports implications for state and local tax revenues. The model is based on 2019 data, and all input values were inflated to 2019 US dollars (USD) based on the Consumer Price Index (CPI). All model output reported here is updated and provided in 2021 US dollars (based on the CPI).

Our analysis of the economic impacts of golf tourism associated with the RWS golf courses can be summarized in the following steps:

1) We began by estimating the number of **trips per year by visiting golfers** to the golf courses that use reclaimed water for irrigation.
2) Next, we applied estimates of **expenditures per trip** to the number of trips to get an estimate of the amount of money being spent each year by visiting golfers.
3) We parsed the served golf courses by two regions: (1) within the City of Tucson and (2) outside the city to obtain estimates of money being spent by trips to golf courses in each of those areas.

4) Lastly, we used IMPLAN to estimate the economic impacts of the trips from visiting golfers, by region.

Thus, the first step to estimate the economic impacts associated with golf tourism is to obtain data on the number of golfing trips and how much money is spent on each trip. This data is used as primary inputs in the Input/Output analysis model in IMPLAN. This study relied on secondary data published in a 2014 study conducted by the University of Arizona on the *Contribution of the Golf Industry to the Arizona Economy in 2014* for estimates of both **visits per course** and **expenditures per visit** (Duval et al, 2014). Multiplying these together and by the number of courses in each region (i.e., within the city and outside of the city), we estimate the amount of **visitor spending** coming into each region.

C.4 Number of Golf Trips

We focus our analysis on travelers who visit Tucson for the primary purpose of playing golf. Our analysis estimates the economic impact of *outside money* coming into a region; thus, we estimate the economic impact of trips to the region where the **primary purpose of the trip is golf**. [16]

Duval et al, 2014 report the total number of unique visits to Arizona attributable to golf as 306,415 (p. 24). They also report the number of facilities included in their analysis as 313 (p. 63). Doing simple division, we estimate the **number of unique visits per course is 979**. This calculation implicitly assumes all the courses attract the same number of unique visits, which likely is not accurate. To investigate the validity of this assumption, we look at the two portions of the reclaimed water service area separately (i.e., within City limits, and beyond city limits).

Out-of-city golf courses. As shown previously, in Table C.2, there are 12 reclaimed water-using golf courses outside the City boundary; 5 private, 7 public, and 0 municipal. For our analysis, we assume public and private courses attract the same average number of visits as reported in Duval et al (2014). It is important to note that we are interested in the number of unique golf trips to the area, not the number of rounds played at individual golf courses.

Within-city golf courses. Of the 6 reclaimed water-using golf courses within the city, 4 of them are municipal. It is likely municipal courses attract fewer than average visitor golf trips. To account for this, we reduce the assumed number of visitor trips to reclaimed water system-supplied golf courses within the city as follows: we assume that the courses within the city attract 50% of average visits, which equates to an estimated 489 visits per course.

[16] While we rely on Duval et al, 2014 for our estimated number of trips, it should be noted that the number of trips used in that study originally came from a survey conducted by Sport & Leisure Research Group in 2016 that obtained information on golf traveler expenditures and visitation habits to the Tucson and Phoenix/Scottsdale markets. We relied on the Duval et al estimates because they reported the expenditures in the format needed for inputs into the IMPLAN model, specifically **visiting golfers, whose primary purpose of the trip was golf**.

C.5 Trip Expenditures

Duval et al, 2014 provide expenditures per visitor trip by expenditure category (Table C.3). Different sectors of the economy, such as lodging and food service, contribute to the regional economy in varying amounts. IMPLAN includes 546 unaggregated industries. We mapped the expenditure categories in which visiting golfers reported spending money to the appropriate IMPLAN industry (Table C.3).

Table C.3 Expenditures per visitor trip

Expenditure category	Amount per trip	IMPLAN industry
Car rental [a]	$205.24	3450 - Automotive equipment rental and leasing services
Golf	$528.46	3504 - Other amusement and recreation
Lodging/accommodations	$718.38	3507 - Hotels and motel services, including casino hotels
Local transportation	$152.17	3418 - Transit and ground passenger transportation services
Food/dining	$480.10	3509 - Full-service restaurant services
Entertainment [b]	$300.80	3504 - Other amusement and recreation 3502 - Amusement parks and arcades
Shopping/retail	419.94	3409 - Retail services - Clothing and clothing accessories stores
Total expenditures	**$2,805.08**	

a) We scaled rental car to account for a portion of visitors will rent their car outside of the region. We used a ratio of regional transportation costs provided in Dean Runyan Associates, 2018.
b) Entertainment expenditures are split evenly into the two corresponding IMPLAN industries.

C.6 Regional Distributions of the Economic Impacts

To explore how the benefits created are magnified and distributed through the regional economies, specifically between the City and entities outside of City limits served by the RWS, we used IMPLAN's Multi-Regional Input-Output Analysis (MRIO). "Multi-Regional Input-Output (MRIO) analysis makes it possible to track how an impact on any of the 546 IMPLAN Industries in a Study Area region affects the production of all 546 Industries and household spending in any other region in the US (state to state, county to county, zip code to zip code, county to multi-county, county to state, etc.)" (IMPLAN 2021a). We defined our regions as follows:

- All zip codes within the City of Tucson; and
- All zip codes within Pima county, not within the Tucson city limits.

A key assumption of this analysis is the assumption made about where (i.e., in which jurisdiction) the visitor money is being spent. For this analysis, we assume all expenses occur within the jurisdiction within which the trip is allocated. That is, we assume that all trip expenditures associated with visits to golf courses outside of the city limits occur outside the city limits; Likewise, trips for golfing at courses within city limits are assumed here to have all associated tourist expenditures made within city limits. See Section C.6 Caveats and Uncertainties for additional details.

We used IMPLAN's MRIO analysis tool to estimate the impact of tourism within each area, as well as across the jurisdictions, and on the combined broader jurisdictions. To estimate the impacts of visitor spending, in IMPLAN, we modeled a change in ***commodity output*** for the economic sectors in which visit spending occurs. Table C.4 presents a summary of golf visits and expenditures by region.

Table C.4 Summary of golf visits and expenditures by region

	Number of golf courses	Number of trips/golf course	Total number of trips	Expenditures per trip	Annual expendi-tures from golf trips
Out-of-city golf courses	12	979	11,748	$2,805.08	$32.95 M
Within city golf courses	6	489	2,937		$8.24 M
Total	18		14,684		$41.19 M

To explore the full range of benefits, we ran IMPLAN for all combinations of geographic areas and expenditures. This was done so that we could evaluate how expenditures within each area impact the same area (i.e., within City expenditures impacting within City economic outcomes), as well as to reveal how those expenditures impact the other geographic area (e.g., how expenditures made outside of City limits impact the City's economic outcomes) and, finally, how expenditures within the total service area impact the individual and combined jurisdictions.

To provide the desired mix of analyses and results, the following sets of simulations needed to be executed:

- Impacts to the entire region
  - Impacts from golf visitation to all reclaimed water courses (within city and out-of-city courses)
  - Impacts from golf visitation to out-of-city courses
  - Impacts from golf visitation to within-city courses
- Impacts to the City of Tucson
  - Impacts from golf visitation to all reclaimed water courses (within city and out-of-city courses)
  - Impacts from golf visitation to out-of-city courses
  - Impacts from golf visitation to within-city courses
- Impacts to the area within Pima County outside the City of Tucson
  - Impacts from golf visitation to all reclaimed water courses (within city and out-of-city courses)
  - Impacts from golf visitation to out-of-city courses
  - Impacts from golf visitation to within-city courses

In the following section, we present our key findings. Specifically, we provide findings on the (1) overall economic impacts of visitation to reclaimed water-served golf courses to Pima County outside of City limits, (2) the impacts of visitation to all reclaimed-served courses to the City of Tucson, and (3) the impacts of visitation to all non-city courses to the City of Tucson. Supplement A provides the results of all the other combinations.

C.7 Key Findings

Golf visits to the reclaim system customer golf courses contribute **$19.25M in value added** annually to the economy of Pima County and **support 450.7 jobs**. The golf course visits also bring in an estimated additional $7.06M in taxes per year, of which $1.9M is at the local level (e.g., county, sub county special districts).

The full economic impact of all reclaim water customer golf courses on Pima County (including the City of Tucson) is reported in Table C.5a and the tax impacts are reported in Table C.5b.

Table C.5a Economic impacts of reclaimed water golf course visits to Pima County

Impact type	Employment	Labor income ($M)	Value added ($M)	Output ($M)
Direct	450.7	$12.00	$19.25	$33.14
Indirect	69.4	$3.13	$5.07	$10.84
Induced	30.0	$1.35	$2.54	$4.43
Total	550.1	$16.49	$26.86	$48.41

Table C.5b Tax impacts of outside-of-city reclaim-served golf course visits to Pima County

Impact type	City of Tucson (Sub County General)	Sub County Special Districts	County	State	Federal	Total
Direct	$402,600	$702,000	$505,400	$1,570,200	$2,407,800	$5,588,100
Indirect	$48,500	$84,900	$61,100	$208,000	$558,200	$960,600
Induced	$31,900	$55,700	$40,100	$129,700	$258,500	$515,900
Total	$483,000	$842,600	$606,700	$1,907,900	$3,224,500	$7,064,600

We next explore the jurisdictional distribution of the economic impacts by looking at the impacts on the City of Tucson. The Supplement in section C.10 includes the results of the IMPLAN runs for all combinations of jurisdictions and expenditures as described above.

C.8 Economic Impact Benefits for the City of Tucson

This section details the impact of visits to the reclaimed-served golf courses on the City of Tucson. We look at scenarios to explore the benefit of the reclaim water golf courses to the city's economy and tax revenues. We first look at the impact of golf trips to all the reclaim-served golf courses and then separate out the impact of golf trips to the reclaim-served golf courses outside of City limits.

C.8.1. Impacts of all Reclaim Golf Courses on the City of Tucson

As reported in Tables C.6a and C.6b, reclaimed water golf course visitation at all served golf courses contributes $1.35M and $2.42M in value added and output, respectively. The spending provides $1.9M in tax revenue, $127,300 of which is to the City of Tucson.

Table C.6a Economic impacts of all reclaim golf course visits to the City of Tucson

Impact type	Employment	Labor income ($M)	Value added ($M)	Output ($M)
Direct	76.9	$2.11	$3.48	$5.89
Indirect	50.4	$2.33	$3.73	$7.82
Induced	16.8	$0.75	$1.35	$2.42
Total	144.0	$5.19	$8.56	$16.14

Table C.6b Tax impacts of reclaim golf course visits to the City of Tucson and other Jurisdictions

Impact type	City of Tucson (Sub County General)	Sub County Special Districts	County	State	Federal	Total
Direct	$71,000	$123,600	$88,900	$267,300	$368,300	$919,100
Indirect	$38,700	$67,600	$48,700	$160,400	$405,500	$720,800
Induced	$17,600	$30,700	$22,100	$70,000	$135,400	$275,900
Total	$127,300	$221,900	$159,700	$497,600	$909,300	$1,915,800

C.8.2. Impacts of Outside-of-City Limit Reclaim-Served Golf Courses on City of Tucson

We next explore the impacts associated with only the trips to the reclaim-served golf courses outside of the city limits; Specifically, trips to the 12 reclaim-served customer courses outside the city limits. As reported above, these courses attract an estimated **11,748 unique visits attributable to golf**, which brings an additional $32.95M of direct spending to the service area outside of city limits. For purposes of our analysis, we assume this spending occurs outside of city limits. Because of this assumption, there are no direct impacts on the city. As reported in Tables C.7a and C.7b, the indirect and induced economic impacts to the city are $4.18M in value added and $8.45M in output; and contribute $46,200 to city tax revenue.

Table C.7a Economic impacts of non-city RWS golf course visits to the City of Tucson

Impact type	Employment	Labor income	Value added	Output
Indirect	41.8	$1.93	$3.09	$6.50
Induced	13.5	$0.60	$1.08	$1.95
Total	55.3	$2.53	$4.18	$8.45

Table C.7b Tax impacts of non-city RWS golf course visits to the City of Tucson

Impact type	City of Tucson (Sub County General)	Sub County Special Districts	County	State	Federal	Total
Indirect	$32,100	$56,100	$40,400	$133,200	$336,200	$598,000
Induced	$14,100	$24,700	$17,700	$56,100	$109,000	$221,700
Total	$46,200	$80,800	$58,200	$189,300	$445,200	$819,700

C.9 Caveats and Uncertainties

As described in Section C.3, a key assumption to conducting this analysis pertains to where (i.e., in which portion of the service area jurisdiction – within or beyond City limits) the visitor money is being spent. For this analysis, we assume all expenses occur within the geographic portion of the service area of the trip. That is, we assume that all trip expenditures associated with visits to golf courses outside of the city take place in the portion of the service area that is outside of City limits.

We also assume an even distribution of unique visits attributable to each golf course, with the additional assumption that the golf courses within the city (mostly municipal) attract 50% as many trips. The methods needed to obtain better estimates of where golfers spend money and the number of trips from visiting golfers require a primary data collection effort that is outside the scope of this effort.

C.10 Supplemental Information: Economic impacts from other combinations of jurisdictions

In this supplement, we present the results of all the combinations of geographic areas within the service area (i.e., the entire service area across Pima County, within City limits, and outside of City limits) and impacts (visitation at all reclaim system golf courses, within-city reclaim courses and reclaim-irrigated golf courses outside of city limits). Specifically:

- Impacts on the full study area (all of Pima County)
  - Impacts from golf visitation to all RWS courses (within city and out-of-city courses) – included in Key Findings
  - Impacts from golf visitation to out-of-city courses
  - Impacts from golf visitation to within-city courses

- Impacts on the City of Tucson
  - Impacts from golf visitation to all RWS courses (within city and out-of-city courses) – included in Key Findings
  - Impacts from golf visitation to out-of-city courses – included in Key Findings
  - Impacts from golf visitation to within-city courses
- Impacts on the area within Pima County outside the city of Tucson
  - Impacts from golf visitation to all RWS courses (within city and out-of-city courses)
  - Impacts from golf visitation to out-of-city courses
  - Impacts from golf visitation to within-city courses

C.10.1 Impacts from outside-of-city-limits courses on entire Pima County service area

Economic impacts

Impact type	Employment	Labor income ($M)	Value added ($M)	Output ($M)
Direct	373.8	$9.89	$15.77	$27.25
Indirect	57.7	$2.60	$4.22	$9.02
Induced	24.6	$1.11	$2.08	$3.64
Total	456.2	$13.60	$22.07	$39.91

Tax impacts

Impact type	City of Tucson (Sub County General)	Sub County Special Districts	County	State	Federal	Total
Direct	$331,600	$578,400	$416,500	$1,302,900	$2,039,500	$4,668,900
Indirect	$40,300	$70,600	$50,900	$173,000	$463,500	$798,300
Induced	$26,200	$45,700	$32,900	$106,400	$212,500	$423,600
Total	$398,100	$694,700	$500,200	$1,582,300	$2,715,500	$5,890,900

C.10.2 Impacts from within-City courses on full Pima County Service Area

Economic impacts

Impact type	Employment	Labor income ($M)	Value added ($M)	Output ($M)
Direct	76.9	$2.11	$3.48	$5.89
Indirect	11.7	$0.53	$0.85	$1.81
Induced	5.4	$0.24	$0.45	$0.79
Total	93.9	$2.89	$4.79	$8.50

Tax impacts

Impact type	City of Tucson (Sub County General)	Sub County Special Districts	County	State	Federal	Total
Direct	$71,000	$123,600	$88,900	$267,300	$368,300	$919,100
Indirect	$8,100	$14,300	$10,300	$35,000	$94,700	$162,400
Induced	$5,800	$10,000	$7,200	$23,300	$45,900	$92,300
Total	$84,900	$147,900	$106,500	$325,600	$509,000	$1,173,800

C.10.3 Impacts from within City Limits golf courses on City of Tucson

Economic impacts

Impact type	Employment	Labor income ($M)	Value added ($M)	Output ($M)
Direct	76.9	$2.11	$3.48	$5.89
Indirect	8.5	$0.40	$0.63	$1.32
Induced	3.3	$0.15	$0.26	$0.47
Total	88.7	$2.66	$4.38	$7.69

Tax impacts

Impact type	City of Tucson (Sub County General)	Sub County Special Districts	County	State	Federal	Total
Direct	$71,000	$123,600	$88,900	$267,300	$368,300	$919,100
Indirect	$6,600	$11,500	$8,200	$27,200	$69,300	$122,800
Induced	$3,500	$6,100	$4,400	$13,800	$26,400	$54,200
Total	$81,100	$141,100	$101,600	$308,300	$464,100	$1,096,100

C.10.4 Impacts from all courses on the portion of Pima County outside of the City of Tucson

Economic impacts

Impact type	Employment	Labor income ($M)	Value added ($M)	Output ($M)
Direct	373.8	$9.89	$15.77	$27.25
Indirect	19.0	$0.81	$1.34	$3.01
Induced	13.2	$0.60	$1.19	$2.01
Total	406.1	$11.30	$18.30	$32.27

Tax impacts

Impact type	City of Tucson (Sub County General)	Sub County Special Districts	County	State	Federal	Total
Direct	$331,600	$578,400	$416,500	$1,302,900	$2,039,500	$4,668,900
Indirect	$9,800	$17,300	$12,500	$47,600	$152,600	$239,800
Induced	$14,300	$25,000	$18,000	$59,800	$123,100	$240,000
Total	$355,700	$620,700	$446,900	$1,410,300	$2,315,200	$5,148,800

C.10.5 Impacts from within City courses on Pima County outside the City of Tucson

Economic impacts

Impact type	Employment	Labor income ($M)	Value added ($M)	Output ($M)
Indirect	3.1	$0.13	$0.22	$0.49
Induced	2.1	$0.10	$0.19	$0.32
Total	5.2	$0.23	$0.41	$0.81

Tax impacts

Impact type	City of Tucson (Sub County General)	Sub County Special Districts	County	State	Federal	Total
Indirect	$1,600	$2,800	$2,000	$7,800	$25,400	$39,600
Induced	$2,300	$4,000	$2,800	$9,500	$19,600	$38,100
Total	$3,900	$6,800	$4,900	$17,300	$44,900	$77,700

C.10.6 Impacts from golf courses beyond city limits on Pima County outside the City of Tucson

Economic impacts

Impact type	Employment	Labor income ($M)	Value added ($M)	Output ($M)
Direct	373.8	$9.89	$15.77	$27.25
Indirect	15.9	$0.67	$1.12	$2.52
Induced	11.1	$0.51	$1.00	$1.69
Total	400.9	$11.07	$17.89	$31.46

Tax impacts

Impact type	City of Tucson (Sub County General)	Sub County Special Districts	County	State	Federal	Total
Direct	$331,600	$578,400	$416,500	$1,302,900	$2,039,500	$4,668,900
Indirect	$8,200	$14,500	$10,400	$39,800	$127,200	$200,200
Induced	$12,000	$21,000	$15,100	$50,300	$103,500	$201,900
Total	$351,900	$613,900	$442,100	$1,393,000	$2,270,300	$5,071,100

Tables C.8a and C.8b provide a summary of the economic and tax impacts across geographic areas.

Table C.8a Summary of Economic impacts by Geographical Area

Impact type	Employment	Labor income ($M)	Value added ($M)	Output ($M)
Impacts from outside-of-city-limits courses on entire Pima County service area				
Direct	373.8	$9.89	$15.77	$27.25
Indirect	57.7	$2.60	$4.22	$9.02
Induced	24.6	$1.11	$2.08	$3.64
Total	456.2	$13.60	$22.07	$39.91
Impacts from within-City courses on full Pima County Service Area				
Direct	76.9	$2.11	$3.48	$5.89
Indirect	11.7	$0.53	$0.85	$1.81
Induced	5.4	$0.24	$0.45	$0.79
Total	93.9	$2.89	$4.79	$8.50
Impacts from within City Limits golf courses on City of Tucson				
Direct	76.9	$2.11	$3.48	$5.89
Indirect	8.5	$0.40	$0.63	$1.32
Induced	3.3	$0.15	$0.26	$0.47
Total	88.7	$2.66	$4.38	$7.69
Impacts from all courses on the portion of Pima County outside of the City of Tucson				
Direct	373.8	$9.89	$15.77	$27.25
Indirect	19	$0.81	$1.34	$3.01
Induced	13.2	$0.60	$1.19	$2.01
Total	406.1	$11.30	$18.30	$32.27
Impacts from within City courses on Pima County outside the City of Tucson				
Indirect	3.1	$0.13	$0.22	$0.49
Induced	2.1	$0.10	$0.19	$0.32
Total	5.2	$0.23	$0.41	$0.81
Impacts from golf courses beyond city limits on Pima County outside the City of Tucson				
Direct	373.8	$9.89	$15.77	$27.25
Indirect	15.9	$0.67	$1.12	$2.52
Induced	11.1	$0.51	$1.00	$1.69
Total	400.9	$11.07	$17.89	$31.46

Table C.8b Summary of Tax Impacts by Geographical Area

Impact type	City of Tucson (Sub County General)	Sub County Special Districts	County	State	Federal	Total
Impacts from outside-of-city-limits courses on entire Pima County service area						
Direct	$331,600	$578,400	$416,500	$1,302,900	$2,039,500	$4,668,900
Indirect	$40,300	$70,600	$50,900	$173,000	$463,500	$798,300
Induced	$26,200	$45,700	$32,900	$106,400	$212,500	$423,600
Total	$398,100	$694,700	$500,200	$1,582,300	$2,715,500	$5,890,900
Impacts from within-City courses on full Pima County Service Area						
Direct	$71,000	$123,600	$88,900	$267,300	$368,300	$919,100
Indirect	$8,100	$14,300	$10,300	$35,000	$94,700	$162,400
Induced	$5,800	$10,000	$7,200	$23,300	$45,900	$92,300
Total	$84,900	$147,900	$106,500	$325,600	$509,000	$1,173,800
Impacts from within City Limits golf courses on City of Tucson						
Direct	$71,000	$123,600	$88,900	$267,300	$368,300	$919,100
Indirect	$6,600	$11,500	$8,200	$27,200	$69,300	$122,800
Induced	$3,500	$6,100	$4,400	$13,800	$26,400	$54,200
Total	$81,100	$141,100	$101,600	$308,300	$464,100	$1,096,100
Impacts from all courses on the portion of Pima County outside of the City of Tucson						
Direct	$331,600	$578,400	$416,500	$1,302,900	$2,039,500	$4,668,900
Indirect	$9,800	$17,300	$12,500	$47,600	$152,600	$239,800
Induced	$14,300	$25,000	$18,000	$59,800	$123,100	$240,000
Total	$355,700	$620,700	$446,900	$1,410,300	$2,315,200	$5,148,800
Impacts from within City courses on Pima County outside the City of Tucson						
Indirect	$1,600	$2,800	$2,000	$7,800	$25,400	$39,600
Induced	$2,300	$4,000	$2,800	$9,500	$19,600	$38,100
Total	$3,900	$6,800	$4,900	$17,300	$44,900	$77,700
Impacts from golf courses beyond city limits on Pima County outside the City of Tucson						
Direct	$331,600	$578,400	$416,500	$1,302,900	$2,039,500	$4,668,900
Indirect	$8,200	$14,500	$10,400	$39,800	$127,200	$200,200
Induced	$12,000	$21,000	$15,100	$50,300	$103,500	$201,900
Total	$351,900	$613,900	$442,100	$1,393,000	$2,270,300	$5,071,100

Appendix D
Principles and Guidelines for Setting Rates for Recycled Water: Insights for Tucson Water's Reclaimed Water System

This Appendix addresses key issues pertaining to the rate-setting challenges associated with the Tucson Water Reclaimed Water System, by:

- Articulating the current framework for establishing the cost of service (COS) for the reclaimed water system
- Comparing the historical annual costs to serve, and revenues received from, users of the reclaimed system (both contract and standard customers) to identify the amount and factors contributing to the "subsidy" need for complete cost recovery.
- Evaluating how the size of the subsidy might change if the rate framework were updated to reflect a slightly modified set of principles and approaches.
- Assessing the extent to which the reclaimed water system cross-subsidies align the benefits with the beneficiaries of the reclaimed system.

In addressing these topics, we provide an overview of established guidelines and principles that have emerged regarding rate-setting for recycled water, with a focus on nonpotable reuse (NPR).

D.1 Summary of Findings

Cost of Service-based pricing is a well-established standard practice throughout the water sector for the goods and services provided by water supply and wastewater utilities. However, there are several well documented challenges to applying COS pricing to nonpotable reuse water such as provided by the RWS. Consequently, NPR water typically is priced at rates below the prices charged for potable supplies, which in turn generally results in system revenues recovering less than the full cost of building and operating NPR systems.

Such is the case for Tucson Water's Reclaimed Water System, for which total annualized costs – i.e., annualized capital outlays such as debt service, plus annual operation and maintenance (O&M) costs – amount to $13 million per year (based on the most recently adopted cost-of-service analysis), while revenues from sales of recycled water have ranged from $8 to $11 million in recent years depending on sales volume. The resulting revenue shortfall ($2-5 million per year) between 2017 and 2021 is made up through a "cross-subsidy" derived from charges levied on TW's potable water system customers.

It is common and often economically justified to impose a cross-subsidy to help recover the full COS for nonpotable reuse. The economic justification stems from the concept of "beneficiary pays," reflecting circumstances in which those who receive some of the benefits from a water reuse program may extend beyond those entities that receive (i.e., purchase) the NPR water. More specifically, the beneficiaries may include potable water system customers, to the extent that the NPR program reduces the expense associated with the potable system.

Whether a cross-subsidy is an efficient and equitable solution to covering the full COS for nonpotable reclaimed water systems depends on the specific circumstances in each community. In the case of Tucson's reclaimed system, there is empirical evidence that a reuse surcharge on potable system customers is likely to be economically justified based on benefits received by potable system ratepayers. For example, based on 2019-2020 rates, a typical City of Tucson single family households pays a surcharge of less than $10 per year to support the Reclaimed Water System, whereas those households save an estimated $91 annually on their potable costs due to the RWS reducing demands on the potable system (see Appendix B for details).

D.2 Challenges Posed by Pricing Nonpotable Reuse Water

A significant challenge utilities face in pricing reuse water is developing a suitable balance between (1) Creating and sustaining a market demand for reuse water—by offering attractive, competitive pricing and other incentivizing terms; and (2) Concurrently generating sufficient revenue to cover their costs of producing and delivering reuse water to their customers (Raucher et al., 2019).

The need for market creation (i.e., stimulating and retaining the demand for NPR water) often is a significant challenge, for an assortment of reasons (per Cristiano and Henderson, 2009; AWWA 2017, 2019; Raucher et al., 2019), including:

- The relatively attractive price for potential NPR customers of available substitute and in-place water sources, such as potable supplies and self-supply (e.g., well pumping).
- The up-front retrofit costs many nonpotable reuse customers face in converting to NPR water (including signage and related expenses).
- Initial reluctance to use what may be perceived as a "lower quality" and "used" water.
- Concerns by potential customers over system reliability and water quality.
- Concern by business owners over how their customers may perceive the quality or risk they face from exposure at NPR user facilities (e.g., golf courses).
- The seasonal demand patterns associated with irrigation demands for NPR water.

For many potential NPR customers, potable and other alternative sources of water supply typically already exist, are already the current water source being used, and often are obtained at a relatively modest cost by the customer. In contrast, reuse water generally is relatively costly for the utility to produce and deliver, and often requires end-users to incur retrofit or other additional expenses. There may also be concerns related to reuse water quality (Raucher et al., 2019).

Consequently, reuse water often is sold at less than its full cost (at least in the initial years when a reuse program is starting up). This in turn requires some form of subsidy to cover the gap when rate-driven revenues are less than the program's full costs. These subsidies may be available from third parties (e.g., grants from state or federal agencies), and/or from cross-subsidies from local potable and/or wastewater utility customers.

Such subsidies often are "economically justified" by the avoided costs and other positive externalities (i.e., financial, social, and/or environmental benefits) that arise from prudently tapping reuse water as part of the regional water supply portfolio. For example, reclaimed water yields are typically insensitive to drought or other climate impacts, and reuse water can reduce demands on over-tapped potable supply systems, thereby increasing the overall reliability and reducing the costs of a community's total water supply portfolio.

In the context of Tucson's reclaimed system, state and county requirements instituted 40+ years ago -- including provisions for using sustainable water supplies for turf irrigation under the 1980 State of Arizona *Groundwater Management Act* – created the necessity for golf course developers to tap a renewable source such as recycled water to build new courses and associated resorts. Even with such mandates, securing sufficient and sustained demand for the reclaimed system has required incentivizing terms for securing long-term commitments from potential customers.

D.3 Pricing Nonpotable Reclaimed Water to Create Demand vs. Attaining Full Cost Recovery

Recycled water typically is relatively expensive to produce and deliver, as it requires advanced forms of treatment. And, construction and operation of a separate purple pipe distribution system is required for NPR water, adding considerable up-front and recurring expense. Reuse systems also are typically newer than traditional water source systems, where traditional water sources tapped decades ago were relatively cheaper to acquire, and for which the expense of existing treatment infrastructure and distribution lines has already been depreciated (Cuthbert and Hajnosz, 1999).

Also, potable water pricing often is based on *average costs* across historical supplies (i.e., averaged across all the sources tapped by the potable utility), rather than *marginal costs* of the next water source (Watson, Mitchell, and Fane 2013). As a result of these various factors, the average COS for traditional water sources is often less costly than for NPR (Raucher et al. 2006).

Further, different customer classes for recycled water projects can have distinctly different seasonal water demands and water usage characteristics. This can potentially result in excess recycled water capacity in non-peak months, adding financial strain on a nonpotable recycled water program.

Given these challenges, it is common practice across the United States (and other nations) to sell NPR water at rates that recover revenues less than the full cost of service of producing and distributing high quality, fit-for-purpose product water. Survey results of water reuse utilities confirm that utilities often need to offer incentives to encourage the use of reclaimed water, especially for nonpotable purposes, because of the higher unit cost of most reclaimed water supplies relative to potable supplies, and the need to anticipate upward pressure on water and wastewater rates due to substitution (e.g., American Water Works Association's (AWWA), 2019). Hence, the price charged for reclaimed water is often capped at the potable water price, and frequently the costs recovered are less than the full cost. An AWWA-sponsored survey of reclaimed water rates in 2000 and 2007 showed rates for reclaimed water vary greatly from 20% to 100% of the potable water rate, with a median rate of 80% (Carpenter et al., 2008).

The inability to fully recover all capital (e.g., debt service) and operation and maintenance expenses through the revenues collected from NPR customers raises a host of issues and concerns. Among these concerns is the need for a "cross-subsidy" from another source (e.g., potable system customers to help cover NPR costs), which in turn raises the economic issues of *equity* (i.e., fairness in terms of who pays versus who benefits) and *efficiency* (putting recycled water to its best and highest uses).

D.4 The Cost of Service for Tucson's Reclaimed Water System

D.4.1 The Role of Cost-Based Pricing in the Water Sector

Cost of service-based pricing is a foundational premise for water sector rate-setting. Water and wastewater utilities typically use a cost-of-service rate setting methodology, based on utility-specific studies reflecting system characteristics, to recover the full cost of providing the utility's service. This is the predominant pricing methodology adopted in the U.S.

A definitive discussion of the COS methodology for water service can be found in the AWWA's M1 service manual, *Manual of Water Supply Practices*. The M1 manual details the multi-step cost allocation process that underlies the COS methodology (AWWA, 2017).

COS-based rate-setting is widely recommended and adopted because:

- COS-based pricing supports the notion that households, businesses, and other customers of water supply and wastewater agencies pay what it costs to deliver the valuable goods and services they receive, while not being gouged by the local utility monopolies providing those services. COS pricing helps set rates so that different customer classes pay their share in a fair and equitable manner.
- Concurrently, COS-based pricing ensures that the utilities—as providers of services essential to the community's public health, welfare, and economic activity—accrue revenues adequate to sustain their enterprises, including full coverage of reasonably incurred capital costs, operation and management expenses, and reserves to provide for periodic replacement and necessary upgrade expenses.

Thus, for standard potable water supply and wastewater utility services, COS-based pricing provides a prudent balance in which the utilities can remain fiscally sustainable in their ability to provide essential services to the communities they serve, while their customers are protected from monopolistic price gouging when purchasing essential water services. COS-based pricing is thus the standard of practice, and it is codified in how investor-owned utilities (IOUs), as well as publicly owned utilities in some states, are economically regulated by state public utility commissions (PUCs). And, COS-based pricing requirements also are extended to many publicly owned water systems through state and local requirements and policies, such as California's Proposition 218 (California Legislative Analyst's Office 1996).

Unfortunately, for water reuse (especially NPR), COS-based pricing typically is not feasible, as creating a market for NPR requires incentivized pricing below the competing potable rate, resulting in a fiscal loss (reuse revenues less than costs) for most NPR programs. As described elsewhere, cross-subsidies from potable water customers often are justified, however, based on benefits accruing to the potable system (e.g., avoided costs).

D.4.2 The Cost of Service for Tucson Water's Reclaimed Water System

Under Tucson Water's cost-of-service framework, annual revenue requirements are allocated among different utility services including potable and reclaimed water services, customer billing, and meter-related services. Potable water costs are further allocated to individual customer classes based on average and peak water usage characteristics.

For the reclaimed water system, the basic rate-setting framework does not differentiate among reclaimed water customers when estimating costs of service; however, rates for some customers (e.g., wheeled water and interruptible service) are determined according to provisions established in negotiated contracts.

Tucson's reclaimed water system has an estimated annual cost of $13 million based on the most recently adopted cost-of-service study and consists of capital and operation and maintenance expenses. Annual revenues from the sale of recycled water in recent years have amounted to about $8 million to $11 million (e.g., Kmiec, 2021). The resulting revenue shortfall of $2 to $5 million per year (i.e., the annual revenue deficit relative to the full COS) is covered through cross-subsidies from potable customers (at a level of $9 to $10 per year for a typical city of Tucson residential potable system customer).

D.5 A "Beneficiary Pays" Approach to Nonpotable Reuse Rate-Setting

A distinction can be made between traditional COS-based cost recovery (which is rarely fully feasible for NPR) and an alternative of applying a COS approach that is blended with a "beneficiary pays" approach that provides sound justification for cross-subsidies (e.g., from potable and/or wastewater system customers) to help cover reuse costs. Such a blended approach is described below.

D.5.1 Reclaimed Water System Benefits and Beneficiaries: Cross-Subsidies May be Justified (but Not Always Allowed)

The reuse pricing challenge is complicated because many of the ultimate beneficiaries of a reuse program extend well beyond those who directly use and pay for reuse water through reuse rates (Raucher et al. 2006). The fact that benefits are widely disbursed creates a potential disconnect between those customers who obtain and pay directly for recycled water and those who ultimately benefit from the reuse program.

Communities typically invest in water reuse because it provides important and widespread benefits, such as offsetting the need to develop or expand other water supply options that would be very expensive, unsustainable, unreliable, and/or environmentally harmful. When other potable water supply options are unavailable or less desirable, a water reuse program may avoid periodic water shortages and their associated adverse consequences across the community. In such cases, the entire water-using community benefits from a reuse program because it provides a less expensive and more reliable overall water supply for all, even if only a small portion of that community directly receives reuse water.

Under such circumstances, aligning who pays with those who benefit entails "subsidizing" reuse pricing with revenues collected from the broader water supply rate base. These cross-subsidies often are economically justified based on the principle of having beneficiaries pay for their share of value-added or avoided costs. However, applying such cross-subsidies may be difficult to justify, and may even be illegal in some communities and institutional settings. This is especially relevant for public systems in California, which are subject to the strict application of cost-of-service pricing, and prohibitions on (or key limitations for) cross-subsidies under Proposition 218.

D.5.2 Third-Party Subsidies Help, but Are Limited

In some cases, subsidies for reuse projects may be available from third parties, such as the federal Bureau of Reclamation (e.g., Title XVI), or various state agencies (e.g., California's Proposition 50, Proposition 84, and Proposition 1 grants). These grants, cost-shares, and local resource development subsidies are intended to help systems bear the costs of water reuse projects by helping to compensate utilities for some of the "external benefits" that reuse generates (i.e., benefits beyond those who directly receive and pay for the product water). These outside subsidies help moderate COS pricing, but the available funding is limited and unlikely to expand significantly in the current economic climate.

In short, the concept "beneficiary pays" may be fundamentally consistent with traditional COS-based rate-setting based on the circumstances under which more than the reuse system customers who are beneficiaries and, thus, receive the "service". However, beneficiary pays approaches may not be applicable in all circumstances when setting recycled water rates, because even when beneficiaries are identified there may be no convenient mechanism available to charge them. In the face of this challenge, some agencies have adopted non-economic strategies like mandatory reuse policies to reduce the discount required for creating a market for recycled water.

On the other hand, an important ruling by the California Public Utilities Commission (CPUC, the economic regulator for investor-owned water utilities in the state) recognizes that traditional COS-based pricing is unsustainable to support many water reuse projects. CPUC has thus implemented a policy that recognizes that cross-subsidies from potable system (and/or wastewater system) customers is justified and allowed in its rate case determinations (CPUC 2014).

Methods are available to allocate costs under a COS methodology that is blended with a beneficiary pays concept. One such method is the Separable Costs-Remaining Benefits (SCRB) method. The SCRB method is suited to allocating costs across users and purposes for the project in a manner that aligns with beneficiary pays. Costs are distributed among project purposes by identifying separable costs for each user or participant (the "private" costs that can be directly associated with that user) and then determining joint costs by subtracting separable costs from total project costs. The method then allocates joint costs or joint savings in proportion to each user's share of the remaining public benefits (De Souza et al., 2011).

D.5.3 Reuse Pricing Practices Across the U.S.

A recent AWWA-sponsored study developed a survey, conducted interviews, and reported on patterns in the cost allocation and pricing for reuse water service in the United States. The objective was to illustrate practices and to draw out lessons and opportunities, based on the practices of a sample of water utilities drawn from across the country. They found that utility efforts at water reuse cost allocation and pricing are highly varied and disconnected (AWWA 2019).

The authors discovered a wide diversity of approaches to pricing and cost recovery for reuse water programs. Their primary conclusion was that a "one size fits all" approach does not apply, and that:

> A fully informed approach to reuse pricing must focus on utility-specific policies and objectives, not on specific [cost] allocation processes, and be fully responsive to the unique conditions facing each reuse utility. It is not that cost of service principles do not apply, or that revenue adequacy, financial stability, or any other fundamental principle of utility management is irrelevant, it is rather that successful reuse programs are especially sensitive to local conditions, and that these conditions require the use of very different cost allocation and pricing strategies from locale to locale… (AWWA, 2019).

D.5.4 The City of Tucson - Pima County Context

Selling reclaimed water at a discount (i.e., at a rate less than the full COS) implies that its users (e.g., golf courses) are being subsidized by other parties, typically the customers of the local potable and/or wastewater systems (as is the case in Tucson). The use of "cross-subsidies" often are well justified by the benefits the various parties receive from the reclaimed water system, including avoiding the expense of expanding the potable system to meet nonpotable demands. The main body of this TM explores the extent to which the benefits and the associated beneficiaries compare to the Reclaimed Water System's costs and the allocation of those costs.

The Tucson reclaimed system provides a range of valuable benefits to the residents, businesses, and other entities in the region. The Reclaimed Water System: (1) facilitated regional population and economic growth, (2) reduces demands on the potable water supply system (thereby providing significant cost savings for potable system customers), (3) contributes to stored groundwater reserves while (4) reducing groundwater depletion and subsidence, (5) restores native riparian habitat, and (6) supports green spaces that enhance the quality of life for the residents of and visitors to the City of Tucson and the broader region.

As described elsewhere in this TM, one way to explore the beneficiaries pay approach entails applying a Triple Bottom Line (TBL) approach to fully identify, describe, and – to the extent feasible and credible – quantify and monetize all the benefits and costs associated with a water reuse option. A key distinction is made here between a ***financial*** analysis (focused on *revenues* and costs), and an ***economic*** analysis (focused on *benefits* and costs). By understanding the full range of benefits, a reuse project can be properly evaluated relative to its anticipated costs. And, by understanding the full range of benefits, the beneficiary pays approach can be more readily developed to generate the fiscal revenues required to pay for reuse programs generating positive net benefits.

D.6 Local Circumstances Amend a "One-Size-Fits-All" Reuse Rate-Setting Approach

Regardless of the rationale or availability of cross-subsidies, the presence of a gap between reuse program costs and the revenues generated by NPR sales often creates a fiscal challenge that may be difficult for a utility to sustain over the long term. The valid economic rationale that community-wide benefits may well outweigh reuse water program costs is not always sufficient for addressing concerns aired by those focusing on the financial accounting ledger and observing that costs exceed revenues. In a sector that is predominantly governed by cost-of-service principles, water reuse programs may thus stand out as a fiscal challenge.

For Tucson Water and its challenge for Reclaimed Water System rate setting, the cross-subsidies from potable customers may be justified in terms of cost savings realized by potable customers, and in light of the need to build demand for the reclaimed system by attracting and holding NPR customers as the system was initially developed and became well established. The reclaimed system's success has also generated significant benefits to the city and county's regional economy as well as other important benefits enjoyed by city and county residents alike.

As the reclaimed system continues to evolve in terms of the type of customers served (e.g., standard and special service customers) and the system's relationship to the potable water system (e.g., providing water for potable system aquifers through SHARP and Heritage projects), a fresh examination of the rate setting framework and assumptions may be warranted to further refine overall reclaimed system cost estimates, and the varying costs for serving different customer types within the reclaimed system.

For example, golf course and associated resort owners realize considerable benefits by having reuse water, as those golf courses and resorts might not exist or be as attractive and successful but for access to the reclaimed system for turf and landscape irrigation. A more comprehensive cost-of-service framework that considers the different levels of service provided by the reclaimed system may be desirable to better evaluate intra-class subsidies between standard reclaimed customers (like golf courses) and special rate customers

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