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Urban Recycled Water Programs

Identifying Evaluation Metrics and Understanding Key Organizational Relationships

WateReuse Research Foundation

Urban Recycled Water Programs: Identifying Evaluation Metrics and Understanding Key Organizational Relationships

About the WateReuse Research Foundation

The mission of the WateReuse Research Foundation is to conduct and promote applied research on the reclamation, recycling, reuse, and desalination of water. The Foundation's research advances the science of water reuse and supports communities across the United States and abroad in their efforts to create new sources of high-quality water through reclamation, recycling, reuse, and desalination while protecting public health and the environment.

The Foundation sponsors research on all aspects of water reuse, including emerging chemical contaminants, microbiological agents, treatment technologies, salinity management and desalination, public perception and acceptance, economics, and marketing. The Foundation's research informs the public of the safety of reclaimed water and provides water professionals with the tools and knowledge to meet their commitment of increasing reliability and quality.

The Foundation's funding partners include the Bureau of Reclamation, the California State Water Resources Control Board, the California Energy Commission, and the California Department of Water Resources. Funding is also provided by the Foundation's subscribers, water and wastewater agencies, and other interested organizations.

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Acronyms

AC	Academia
ADWR	Arizona Department of Water Resources
AG IRR	agricultural irrigation
BGD	billion gallons per day
BOD	biological oxygen demand
CA DWR	California Department of Water Resources
CBOD	carbonaceous biochemical oxygen demand
CDPH	California Department of Public Health
CEC	contaminant of emerging concern
CUP	consumptive use permit
DPR	direct potable reuse
DWR	Department of Water Resources
EBMUD	East Bay Municipal Utility District
EDC	endocrine-disrupting compound
EI	energy intensity
FC	fecal coliform
FDEP	Florida Department of Environmental Protection
GOLF	golf course irrigation
GR	groundwater recharge
GSP	Groundwater Savings Program
GWRS	Groundwater Replenishment System
IND	industrial applications
IPR	indirect potable reuse
LAND IRR	landscape irrigation
MAD-M	mean absolute deviation from the median
MAF	million acre-feet
mgd	million gallons per day
NGO	nongovernmental organization
NONPOT	nonpotable
NPDES	National Pollutant Discharge Elimination System
NRC	National Research Council
O&M	operations and maintenance
RA	regulatory agency
ROI	return on investment
RW	recycled water
RWC	recycled water customer
RWP	recycled water program
SALT	saltwater intrusion

SAWS	San Antonio Water System
SBWR	South Bay Water Recycling
SCVWD	Santa Clara Valley Water District
SVAWPC	Silicon Valley Advanced Water Purification Center
TDS	total dissolved solids
TMDL	total maximum daily load
TSS	total suspended solids
WBMD	West Basin Municipal District
WSP	water supply program

Foreword

The WateReuse Research Foundation, a nonprofit corporation, sponsors research that advances the science of water reclamation, recycling, reuse, and desalination. The Foundation funds projects that meet the water reuse and desalination research needs of water and wastewater agencies and the public. The goal of the Foundation's research is to ensure that water reuse and desalination projects provide high-quality water, protect public health, and improve the environment.

An Operating Plan guides the Foundation's research program. Under the plan, a research agenda of high-priority topics is maintained. The agenda is developed in cooperation with the water reuse and desalination communities including water professionals, academics, and Foundation subscribers. The Foundation's research focuses on a broad range of water reuse research topics including:

- Defining and addressing emerging contaminants
- Public perceptions of the benefits and risks of water reuse
- Management practices related to indirect potable reuse
- Groundwater recharge and aquifer storage and recovery
- Evaluation and methods for managing salinity and desalination
- Economics and marketing of water reuse

The Operating Plan outlines the role of the Foundation's Research Advisory Committee (RAC), Project Advisory Committees (PACs), and Foundation staff. The RAC sets priorities, recommends projects for funding, and provides advice and recommendations on the Foundation's research agenda and other related efforts. PACs are convened for each project and provide technical review and oversight. The Foundation's RAC and PACs consist of experts in their fields and provide the Foundation with an independent review, which ensures the credibility of the Foundation's research results. The Foundation's Project Managers facilitate the efforts of the RAC and PACs and provide overall management of projects.

This project had three main objectives: to identify, through expert and user opinion, a possible set of common metrics for assessing the performance of urban recycled water programs; to identify what major metrics are used by four case study urban recycled water programs; and to assess the significance of key organizational relationships for program implementation.

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Executive Summary

Water scarcity is becoming an increasingly important issue in most of the contiguous United States. State water managers in most states anticipate shortages by 2013. Increasing the use of recycled water has the potential to significantly address this crisis. Yet despite ambitious state-level goals for increasing its use, recycled water's acknowledged and planned contribution remains limited. In fact, a 2012 National Academy of Sciences report estimates that planned water reuse "accounts for less than one percent of U.S. water use." A review of related research indicates a need for general program-level metrics that provide insight into program performance that could be applicable to cross-program comparison.

The main objectives of this research project were as follows:

- to identify, through expert and user opinion, a possible set of common metrics for assessing the performance of urban recycled water programs, with a focus on nonpotable applications;
- to identify what major metrics are used by four case study urban recycled water programs and how they compare to metrics identified in objective 1; and
- to identify the key organizational relationships that recycled water program managers see as the most influential.

This report is directed at two principal audiences. The first group includes organizations involved in planning for and implementing recycled water programs at the local, regional, and state levels (e.g., recycled water program managers, local water supply managers, regulators, current and potential customers, and regional and state water planning agencies). This research provides them with a set of general metrics that can be used to evaluate and compare urban recycled-water programs. In addition, the investigation provides them with detailed information on how key groups view certain issues (e.g., how recycled water program managers view customer satisfaction). This knowledge can be used to improve interagency cooperation.

The second audience for this report includes the general public and elected officials. The United States has one of the most advanced drinking water systems in the world. However, beyond those who operate or regulate these systems, few people understand how they work or their direct and indirect benefits to communities. With so many states across the country facing impending water shortages, recycled water is becoming an increasingly important part of water supply portfolios. This is why research that helps people understand how recycled water programs work, using measures that can be explained easily to nonexperts, is critical. Educating this broader audience helps set the stage for increased community support of recycled water program expansion.

To meet the first study objective, 29 representatives from six stakeholder groups participated in an online real-time Delphi survey in spring 2011. The stakeholder groups include recycled water programs, water supply organizations, academia, regulatory agencies, nongovernmental organizations, and customers. These groups are a small but important sample of the entire population of organization types involved in recycled water. The majority of participants in this study represented recycled water programs, regulatory agencies, and water supply programs.

The Delphi approach is a systematic, interactive data-gathering technique that was developed in the United States in 1944. This method uses a panel of carefully selected respondents who answer survey questions in two or more rounds. In this study, Delphi panelists rated the appropriateness of 16 possible criteria and associated metrics that might be suitable for measuring program performance.

To "ground truth" the metrics identified in the Delphi portion of the study (and address study objectives 2 and 3), on-site case studies were conducted on four urban recycled water programs. The case studies were South Bay Water Recycling (SBWR) in San Jose, CA; East Bay Municipal Utilities District (EBMUD) in Oakland, CA; Tucson Water in Tucson, AZ; and JEA in Jacksonville, FL. An important part of selecting cases for this study was to examine programs with similar characteristics—for example, service area size. This enhanced the validity of ground truthing metrics identified through the Delphi survey. Consequently, the study team selected similar-sized, well-established programs serving primarily commercial, institutional, industrial, and residential customers. The aim in selecting these cases was that they be representative of programs in their respective states, not necessarily that they be considered "the best of the best."

In response to the study's first objective, the Delphi panel as a whole rated the following metrics as highly appropriate for evaluating program performance. The predominant values selected by the panel for what could constitute good performance for each metric are noted in parentheses:

- recycled water's contribution to the regional water supply portfolio (6 to 10%);
- customer satisfaction (76 to 100%);
- voter support on bonds or other similar ballot items that included a recycled water component (71 to 80%); and
- community support (81 to 90%).

Data from the Delphi panel were also analyzed by individual stakeholder groups (e.g., regulatory agencies) to understand the extent to which groups agreed and disagreed with each other. The study found that panelists in the recycled water program manager group and those in the waste supply program manager group held similar opinions on six metrics. Specifically, both groups rated community support, water quality, voter support, and value-added services as highly appropriate. The ratings of the recycled water program survey participants differed significantly from the responses in the regulator group for 9 out of 16 proposed criteria, reflecting an apparent disparity on what participants in these two groups felt could and should be used to evaluate program performance.

In response to the study's second objective—identifying what major metrics are used by case study programs and how they compare to metrics identified in objective 1—this study finds that case study program managers viewed metrics differently than participants in the Delphi survey, even though the same general areas (e.g., customer and community support) were considered very important. For case study interviewees, a general non-normalized volume metric of recycled water use dominated their perspective. The single most important metric for three of the four case study programs was how much reclaimed water is used per year on an annual average basis, in million gallons per day (mgd). For the Delphi panel as a whole, the contribution of the recycled water program to the regional water picture was the only use-related metric they considered highly appropriate.

Three of the four case study programs had a more qualitative view of customer- and community-related metrics. For these programs, the focus was on personal interaction and lack of customer complaints. This perspective differed from the proposed customer satisfaction metric in the Delphi survey, which was the percentage of satisfied customers. Other secondary goals or metrics identified by case study program managers include water quality (e.g., nitrogen or total dissolved solids (TDS)), potable water offset, and the percentage of the water supply contributed by recycled water.

In response to the study's third objective—assessing the significance of key stakeholder group interactions for program implementation—recycled water program managers identified the following types of organizations as having the most influence on program implementation: regulators, partner agencies, and customers.

The most significant relationship for three of the four recycled water programs was with state or regional regulators. Interaction between recycled water programs and regulators was reported as "frequent" (i.e., several times a month). Interview data suggest that for these programs, the recycled water programs and their regulatory agencies have moved beyond a simple regulator–regulatee relationship. Program managers and regulators interviewed for this project felt that regulators are trying to support increased use of reclaimed water by providing guidance and incentives for future applications. In some cases, regulators are even encouraging reclaimed water use by individual potential customers and getting them connected with key points of contact at the utilities.

The two California case study programs viewed their relationship with partner agencies as extremely important. For these two programs, their ability to produce and distribute reclaimed water depends on being able to utilize multiple treatment plants and distribution networks. Partnering with other agencies brings many obvious economic benefits, such as the ability to share infrastructure and maintenance costs. However, in one case, the goals of the program and its partner agencies are not currently aligned. In this situation, the recycled water program's goal is to increase demand for and use of recycled water. Its partner agencies are more focused on the benefits of using recycled water to meet discharge limits, which were met years ago. This situation has led to program expansion challenges.

Managers of case study recycled water programs also considered customers one of their top three types of stakeholders. For the six customers interviewed for this project, overall satisfaction levels are generally high regardless of whether the use of reclaimed water is mandatory or voluntary or whether the program had customers pay for their own connection infrastructure. For the most part, interviewed customers were satisfied or very satisfied with the programs' water quality, timing, delivery, pressure, and customer service.

Differences in how program managers and customers of nonpotable water perceive customer motivations for using recycled water may have significant relevance for future customer development. Whereas program managers think it is all about cost for the customers, customers interviewed for this project more frequently identified environmental issues as a driver. Customer interviewees felt they had a basic understanding of larger environmental issues in their service area, and this was consistent across customer type and location. Although cost is important, if the customer organization does not already have a commitment to environmental issues and water scarcity concerns, encouraging it to sign up for recycled water may prove challenging. Being "green" may not be the most important factor behind customer decisions, but it may be a necessary condition for hookup.

Interviewees for all case study programs mentioned at least one external policy that encouraged or provided incentives for recycled water use in their service areas. These were primarily grants, revolving loans, and groundwater savings plans. Although supporting policies are certainly helpful, policies or directives that set ambitious goals for reuse, but are unfunded or lack enforcement mechanisms, can present challenges to full implementation of recycled and reclaimed water program goals.

The results of this study provide the basis for an expanded discussion of what form recycled water program-level performance measures might take. The applications and limitations of the methods used to collect study data make the study's results most useful as a baseline for initiating conversation in the reuse industry about what areas of program performance can and should be measured across programs. More specifically, the study's major contribution is identifying *possible* program evaluation criteria rather than determining *definitive* evaluation criteria. Study results also identify areas where enhanced communication between stakeholder groups (e.g., recycled water program managers and customers) could be used to increase future demand and expand applications for recycled water.

Analysis of data from the case study programs suggests that more program management assistance from state and regional water supply agencies to individual recycled water programs could significantly enhance the ability of states to meet long-term recycled water goals. The main recommendation for future research involves conducting a broad industry discussion of identifying program-level metrics that are representative of good performance. Using a modified version of a general metric such as flow ratio could be useful for communicating information on recycled water use to the public and elected officials, who may lack the technical background necessary to fully understand more detailed measures. A second research area with potential involves further investigating differences in perceptions between staff in recycled water programs and their commercial, institutional, and industrial customers.

Chapter 1

Introduction

1.1 Future Water Supply and Recycled Water

Long-term water supply is an issue for most states in the United States. In 2003, results from a national survey of state water managers in 47 states found that 37 anticipated shortages by 2013, with problems being particularly acute in the West. When asked what steps each state is taking to prepare for predicted shortfalls, nearly fifty percent reported their states were pursuing development of new water supplies through recycling and reuse of treated wastewater effluent (U.S. GAO, 2003). More recently, the U.S. EPA reported that from 2003 to 2008, nearly every region in the country experienced water shortages (EPA, 2008). Add to this concerns about population growth and the likely impacts of climate change (NRC, 2012) and a picture starts forming that water from traditional sources is literally in short supply.

Yet despite ambitious regional and state-level goals of increasing recycled water use, its contribution to water supply remains low, even in states that lead the nation in reuse. A 2012 National Research Council (NRC) report estimates that reuse projects account for less than one percent of water used in the United States. Published research and other available literature on what makes for an effective recycled water program often focuses on describing the attributes of successful case studies on a one-by-one basis (e.g., this is why the Factory 21 project is successful) or examining one type of metric (e.g., fee structure). Studies that investigate multiple programs do not tend to focus on standard metrics that can be used to compare programs with one another beyond the basics (e.g., use volume, number of customers, miles of pipeline). One goal of this study was to put forward an initial set of common metrics that could be used to evaluate performance across programs.

Increasing the use of recycled water, along with water conservation and other integrated water management strategies, has the potential to help alleviate pressure on diminishing water supplies. For example, in Santa Clara County, California, recycled water is slated to provide 10% of total supply by 2020. At the state level, the California legislature has adopted goals for recycled water that include providing at least 1.5 million acre-feet (MAF) of recycled water per year by 2020—an objective that involves more than 200 water agencies throughout the state. Arizona and Florida have similar plans. Like California, they face significant future water shortfalls (Martinez and Clark, 2009; WEF and University of AZ, 2007).

Table 1.1 illustrates the current status of recycled water use in California, Arizona, and Florida. These three states represent the nation's most active recycled water programs. The table shows that current combined recycled water production is approximately 1.7 MAF per year, but that recycled water composes only a small fraction of the total supply portfolio. In fact, both California and Florida have experienced difficulty in meeting state goals for recycled water use over the past 10 to 20 years (CA DWR, 2005; FDEP, 2010; U.S. EPA, 2004). For example, in 2010, California fell nearly 300,000 acre-feet short of its goal of recycling 1 MAF of municipal wastewater. At the program level, a review of more than 40 recycled water programs demonstrated that many programs have been unable to reach their distribution goals (Mantovani et al., 2001).

Table 1.1. Production and Consumption of Recycled Water in Florida, California, and Arizona

State	Recycled Water Volume Produced (acre-feet)	Percentage of Supply Portfolio Met with Recycled Water	Percentage of Wastewater Flow Recycled	Per Capita Recycled Water Use (gallons per day)
Florida[a]	738,739	3.6%	38%	36.79
California[b]	723,845	1.3%	10%	16.06
Arizona[c]	205,400	2.9%	NA	1.33

NA = not available.

[a]FDEP (2010).

[b]CA Recycled Water Task Force (2003).

[c]Calculated from Kenney et al, (2009) and ADWR (2010).

In the United States, several different types of organizations play important roles in the development, implementation, and expansion of recycled water programs. The primary organization is the recycled water program itself. It supplies the recycled water and is often part of the regional or municipal wastewater treatment plant. The urban recycled water customers are the industrial, residential, commercial, or institutional recycled water users. The predominant urban application for users in the United States is landscape irrigation. The state regulatory agency sets water quality standards and determines acceptable uses of recycled water. Another key player of increasing importance is the water supply agency, which is responsible for regional potable supply. Two other significant types of organizations are nongovernmental organizations (NGOs) and academics. NGOs can range in size from a small neighborhood association to a national environmental group (e.g., Food and Water Watch). These organizations may take advocacy positions in support of or against recycled water. They can also play an important role in informing and educating the public. The research performed by academics and some consultants provides insight into best practices and issues of specific concern, such as program cost recovery or customer satisfaction. The interaction of these organizations within a given socio-politico-economic and environmental context defines general boundaries within which recycled water programs operate. Other types of organizations, such as the media, local land use planning agencies, and state water planning agencies, can also play important roles.

1.2 Related Research

The focus of previous research on recycled water program implementation and assessment has often highlighted the success of individual programs. More specifically, it examines or describes how programs work. Such research does include multiple programs, but tends not to compare programs to one another using a normalized set of evaluation criteria (e.g., Crook, 2007; Jimenez and Asano, 2008; Metcalf & Eddy, 2007; Ruetten, 2004; U.S. EPA 2004). Because of the large number of planned recycled water projects that never came into operation and the economic hurdles a recycled water program must overcome, for the past 20 years program success has overwhelmingly been defined as the establishment of a recycled water program (Anderson, 2003; Asano and Mills, 1990; Bruvold, 1988; CH2MHill, 2004; Crook and Okun, 1987; Cuthbert and Hajnosz, 1999; Hartley, 2006; Higgens et al., 2002; Ingram et al., 2006; Marks, 2006; Miller, 2006; Wong and Gleick, 2000).

Recycled water can play a major role in meeting future demand and expanding the current supply portfolio across the United States. The following excerpt from the NRC's Committee on Assessment of Water Reuse as an Approach for Meeting Future Water Supply Needs explains just how large this contribution might be:

> Municipal wastewater reuse offers the potential to significantly increase the nation's total available water resources. Approximately 12 billion gallons of municipal wastewater effluent is discharged each day to an ocean or estuary out of the 32 billion gallons per day discharged nationwide. Reusing these coastal discharges would directly augment available water resources (equivalent to 6 percent of the estimated total U.S. water use or 27 percent of public supply). (NRC, 2012)

Of the three states evaluated, Florida and California have established state goals for the use of recycled water. In 2003, Florida set an official statewide goal of recycling 1 billion gallons per day (BGD) by 2010 (U.S. EPA, 2004). In 2011, Florida produced 722 million gallons per day (mgd) (FDEP, 2011) and missed attaining this goal by approximately 28%. California has continuously missed meeting all statewide goals set between 1981 and 2000. Figure 1.1 shows the actual and projected recycled water deliveries in California from 1970 to 2030.

Part of the reason states such as California and Florida have had problems in reaching production goals may be related to the long lead time needed to establish recycled water programs at the municipal level. Mantovani et al. surveyed 40 domestic recycled water programs in 2001 and found that 22% of programs needed 11 to 15 years to reach full capacity and 33% took more than 20 years to reach full capacity (Mantovani et al., 2001).

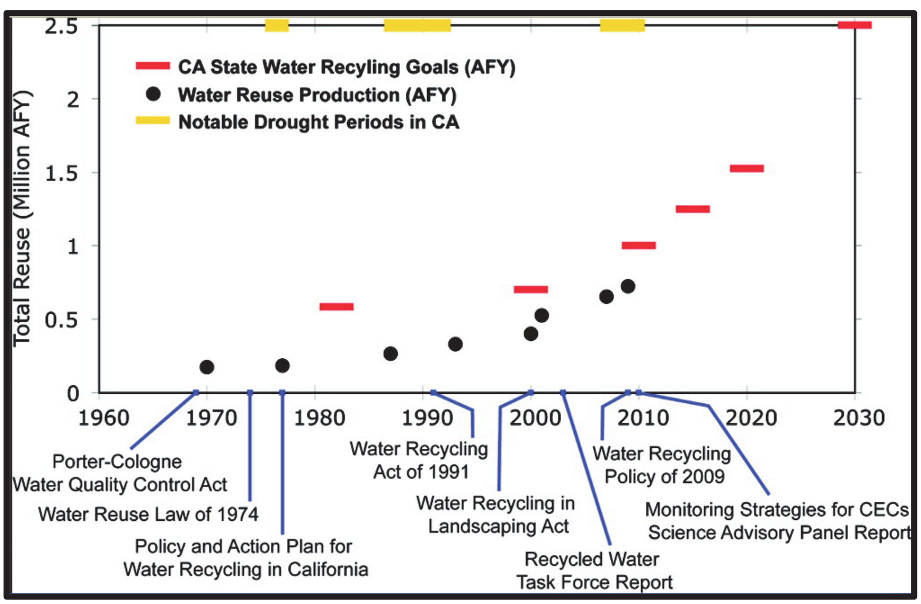

Figure 1.1. Fifty-year timeline of major statewide water recycling goals and production volumes, drought periods, and water recycling policies in California.

Source: Bischel et al., 2012**.**

The historical impediment to initiating a recycled water program cited most frequently in the literature is the public's perception of recycled water or, more specifically, the public's fear of drinking or bathing with treated effluent and negative associations with the words "treated wastewater." More recently, however, public acceptance of uses that have been around for decades indicates high levels of support for conventional applications. Surveys of seven California and Australia communities showed a high level of public acceptance for industrial applications (from 79 to 95%) and irrigation applications (from 47 to 98%, including household gardens) (Marks, 2006). In the same study, support for indirect potable reuse in a different set of communities ranged from 85% acceptance in Dublin, California to 42% in Tampa, Florida.

A 2012 survey of 71 recycled water utilities found that the major hindrance to program implementation is now economic or financial disincentives (cited by 87% of respondents). To a lesser extent, perceptions and social attitudes (cited by 26% of respondents) and who pays for system costs (cited by 20% of respondents) were also identified as barriers (Bischel et al., 2012). To address perceptions and social attitudes, both MacPherson and Slovic (2007) and Marks (2006) emphasize the positive effect that education (e.g., plant tours) and appropriate communication tools (e.g., images and keywords) can have on increasing public acceptance of water reclamation and desalination projects.

Few attempts have been made to evaluate existing or established programs to show where and how demand might be expanded, and none have conducted a multiprogram evaluation in a manner that allows direct comparison among programs. In their current state, evaluations of recycled water programs offer limited direction for determining how programs are managed and where improvements can be made to increase demand and cost recovery. Table 1.2 highlights findings from previous recycled water program evaluations, with Mantovani et al. (2001) conducting the most significant study.

Of recycled water program evaluations reviewed for this report, two studies (Haddad, 2002; Ingram et al., 2006) evaluated a single program against a single criterion. For the Haddad study, it was whether the program produced a significant environmental benefit (i.e., reduction in saltwater intrusion). For Ingram et al., it was whether a proposed project could reduce a city's dependence on Hetch Hetchy water, a surface water source more than 100 miles away. Although both of these studies examined their programs in depth, their use of a single metric makes understanding overall program performance not feasible.

The evaluations by Cuthbert and Hajnosz (1999) and Marks (2006) investigated multiple programs against two criteria. For Cuthbert and Hajnosz, the focus was on the determination of recycled water rates..For Marks, the criterion was whether a proposed indirect potable reuse (IPR) program had enough public support for implementation. Each study thoroughly applied all recommended criteria to every program in the evaluation. However, the evaluations focused on only one aspect of program operations (rates and public outreach), once again making it difficult to understand the programs' overall performance.

Three previous studies (Cusker, 2000; Mantovani et al., 2001; Wong and Gleick, 2000) recommended several criteria for use in program evaluation. However, not all of the recommended criteria were systematically applied to each program in the studies, making it difficult to compare findings across programs. For Cusker, the criteria were whether the program met initial program drivers, customer satisfaction, and public acceptance. In the end, however, her analysis only provided definitive information on whether the initial driver of reducing wastewater discharge to the San Francisco Bay was met. Wong and Gleick put forward several criteria for evaluating program performance: equity of recycled water program cost distribution, potable water savings, and environmental and community benefit.

For the cases they examined, only the potable water savings were described in numerical terms; other benefits appeared substantial based on the authors' description, but were not quantified.

The most comprehensive evaluation of multiple recycled water programs in the United States was conducted by Mantovani et al. (2001) and published by the Water Environment Research Foundation. The study involved a literature review of 200 publications, a management survey of 65 nonpotable water reuse projects (40 in the United States), site visits to 12 recycled-water programs, and a survey of 20 regulatory agencies. Two findings came out of this report that are of particular relevance to the current study. The first is that at the time of the survey, most projects had not met their projected water delivery goals. The second is that more than half of the programs evaluated did not conduct a formal market assessment during the project planning stage (Mantovani et al., 2001).

Differences in evaluation approaches present challenges for assessing overall program performance both within and between programs. For a reclaimed water program manager looking for ways to improve a current program or benchmark performance, these previous evaluations may be of limited value..In sum, this study's review of previous program evaluations demonstrates the need for a more in-depth investigation of general performance criteria.

Table 1.2. Previous Recycled Water Program Evaluations

Author (Date)	Study	Program Style	No. of Programs Evaluated	Type of Reuse*	No. of Criteria Applied	Findings
Haddad (2002)	Monterey county water recycling project: Institutional study	Single program, single recommended criterion	1	AG IRR, SALT	1	Monterey program reduced salt water intrusion by 25%.
Ingram et al. (2006)	From controversy to consensus: The Redwood City recycled water experience	Single program, single recommended criterion	1	LAND IRR	1	Redwood City program successfully met program driver to reduce dependence on imported supply.
Cusker (2000)	A study in infrastructure planning: South Bay Water Recycling program, San Jose, California	Single program, multiple recommended criteria	1	AG IRR, LAND IRR, GOLF, IND, ENERGY	1	South Bay program successfully met program driver to reduce discharge to SF Bay.
Cuthbert and Hajnosz (1999)	Setting reclaimed water rates	Multiple programs, limited recommended criteria	23	AGG IRR, LAND IRR, GOLF, GR, IND	2	Half of programs base recycled water rates on percenta of potable rate; many programs rely on subsidy to reco costs.
Marks (2006)	Taking the public seriously: The case of potable and nonpotable reuse	Multiple programs, limited recommended criteria	8	POTABLE AND NONPOT	2	One of eight programs reviewed actually implemented IPR component due to extensive public outreach effort.
Wong and Gleick (2000)	Overview to water recycling in California: Success stories	Multiple programs, multiple recommended criteria	3	AG IRR, LAND IRR, GOLF, IND, ENERGY	3–4	WBMD parcel tax unpopular; Santa Rosa program saved potable water & increased creek flows.
Mantovani et al. (2001)	Management practices for nonpotable reuse	Multiple programs, multiple recommended criteria	40	AG IRR, LAND IRR, GOLF, IND, ENERGY	2–3	Most programs have not reached capacity; few programs conducted market survey; few programs considered alternative site locations.

*Type of reuse: AG IRR = agricultural irrigation; GOLF = golf course irrigation; GR = groundwater recharge; IND = industrial applications; LAND IRR = landscape irrigation; NONPOT = nonpotable; SALT = prevention of saltwater intrusion.

1.3 Research Objectives

The purpose of this research project was to help answer the question "What might an effective urban recycled water program look like?" To this end, the research team sought to meet the following objectives:

- to identify, through expert and user opinion, a possible set of common metrics for assessing the performance of urban recycled water programs, with a focus on nonpotable applications;
- to identify what major metrics are used by four case studies of urban recycled water programs and how they compare to metrics identified in objective 1; and
- to identify the organizations that recycled water program managers see as the most influential.

1.4 Proposed Program Evaluation Metrics

Tables 1.3 through 1.6 present a set of proposed general performance criteria and possible metrics for urban regional or municipal recycled water programs in operation for 5 years or more. These variables are the basis for questions asked in the Delphi survey described in Chapter 2. They are organized into the following categories:

- water quantity and quality
- application breadth
- customer service and support
- public perception
- cost recovery
- industry trends

The data from which the criteria and metrics were derived come from peer-reviewed and published sources, existing state regulations, state water management agency guidelines, national and professional water organization publications, city environmental performance indices, and data made public by regional and municipal potable or recycled water service providers. Several particularly helpful sources included Cuthbert and Hajnosz's 1999 study of reclaimed water rate setting for cost recovery; the FDEP's 2010 annual reuse report for flow ratio; Larabee et al.'s (2010) study of energy intensity (EI) for the Santa Clara Valley Water District; Mantovani et al.'s 2001 study of recycled water quantity criteria and metrics; and the Silicon Valley Environmental Partnership's 2010 environmental indicators report for portfolio contribution. Other work that influenced the study teams' criteria and metric selection included Hartley (2006); Holliman et al. (2009); Metcalf & Eddy (2007); Rodriguez et al. (2007); Crook (2007); and Yang and Abbaspour (2007).

Table 1.3. Criteria and Metrics for Water Quantity and Quality

Criteria	Description	Proposed Metric
Flow ratio	The reuse flow as a percentage of total wastewater treatment facility flow	$\frac{reuse\ flow\ (mgd)}{total\ wastewater\ treatment\ facility\ flow\ (mgd)}$
Recycled water supply portfolio contribution	The contribution of recycled water to the overall water supply portfolio of in a service area or region	$\frac{recycled\ water\ consumed\ (AFY)}{total\ water\ consumed\ (AFY)}$
Recycled water utilization ratio	A measure of the volume of recycled water actually used versus the volume that could potentially be used	$\frac{recycled\ water\ consumed\ (mgd)}{potential\ recycled\ water\ consumption\ (mgd)}$
Volume growth rate	A measure of increase (or decrease) in recycled water demand	$\frac{recycled\ water\ sold\ (acre-feet\ in\ year\ t)}{recycled\ water\ sold\ (acre-feet\ in\ year\ t-1)}$
Water quality	Degree of regulatory compliance with three water quality parameters that U.S. states commonly monitor: total suspended solids (TSS), biochemical oxygen demand (BOD, CBOD), and fecal coliform (FC)	General test statement: Annual average concentration for a given parameter meets or exceeds state standards for most restrictive permitted use. For each parameter below, a TRUE value for the test statement would be an indicator of good water quality. If [TSS (mg/L)]program ≤ [TSS (mg/l)]state std If [FC (cfu/100 ml)]program ≤ [FC (cfu/100ml)]state std If [BOD (mg/L)]program ≤ [BOD (mg/L)] state std *or* If [CBOD (mg/L)]program ≤ [CBOD (mg/L)] state std

Table 1.4. Criteria and Metrics for Application Breadth and Customer Service and Support

Criteria	Description	Proposed Metric
Product diversification	Metric measures program's strategy to match water quality to water use application	Qualitative metric values describing a range of activity levels A: Program has investigated diversifying product and distributes at least two different qualities of recycled water to meet customer's needs B: Program has investigated diversifying product and has created a plan to produce more than one quality of recycled water within next 3 years C: Program has not investigated diversifying product to match customer needs NA: Program has investigated diversifying product and found limited or no customer need
Recycled water application range	The extent to which a program's water is being used for all possible recycled water applications, expressed as a percentage	$\frac{sum\ of\ all\ actual\ recycled\ water\ applications}{total\ no.\ of\ recycled\ water\ apps.\ permitted\ by\ law}$
Customer satisfaction	A measure of the volume of recycled water actually used versus the volume that could potentially be used	$\frac{no.\ of\ satisfied\ recycled\ water\ customers}{total\ no.\ of\ recycled\ water\ customers}$
Customer complaints	A measure of increase (or decrease) in recycled water demand	$\frac{recycled\ water\ sold\ (acre-feet\ in\ year\ t)}{recycled\ water\ sold\ (acre-feet\ in\ year\ t-1)}$
Value-added services	Noncore services that recycled water programs may offer to aid in recruiting new customers or enhancing the overall experience of a current customer They represent the degree of customer service and support a program provides	No. of the following services recycled water program provides to customers free of charge: • permitting assistance with permitting • landscape consulting • graywater consulting • ROI analysis • assistance with project financing • organizing user group meetings

Table 1.5 Public Perception and Cost Recovery Metrics

Criteria	Description	Proposed Metric
Voter support	Metric measures the level of public support in local elections related to the construction or finance of a recycled water project	$\frac{no.\, voters\ in\ support}{total\ no.\, of\ \ voters}$
Community support	The level of public support for recycled water gathered from a community survey	$\frac{no.\, survey\ respondents\ in\ support}{total\ no.\, of\ \ survey\ respondents}$
Cost recovery	The recycled water program's ability to recover operation and maintenance (O&M) costs	$\frac{average\ annual\ recycled\ water\ sales\ (\$)}{average\ annual\ O\&M\ costs\ (\$)}$

Table 1.6. Criteria and Metrics for Industry Trends

Criteria	Description	Proposed Metric
CEC monitoring and strategy	A program's level of activity for monitoring contaminants of emerging concern (CECs)	Qualitative metric values describing a range of activity levels A: Program monitoring some CECs and has active strategy for future management B: Program monitoring some CECs C: Program not monitoring for CECs, but plans to within next 3 years D: Program not monitoring for CECs, no plans for future monitoring
Energy intensity (EI)	The amount of energy required intensity to produce and distribute a given volume of recycled water	$\frac{sum\ of\ energy\ use\ (kWh)}{volume\ of\ recycled\ water\ produced\ (acre-feet)}$ Sum of energy use is calculated by summing estimated energy use for following phases: supply/storage, conveyance, end use, treatment, and distribution
Indirect potable reuse (IPR) planning and implementation[a]	A program's activity level for planning and implementing IPR.	Qualitative metric values describing a range of activity levels A: Program currently using some form of IPR B: Program has completed plans for IPR project and is in construction phrase C: Program has completed plans for IPR project D: Program considering developing IPR plan within next 3 to 5 years E: Program has no current or future plans to use recycled water for IPR purposes

[a]For this project, IPR was defined as "the blending of advanced treated recycled or reclaimed water into a natural water source (groundwater basin or reservoir) that can be used for drinking (potable) water after further treatment."

1.5 Report Roadmap

The rest of this report is organized along the following lines. Chapter 2 describes the Delphi survey method and the case study research method—the two main techniques used to answer the study's research questions. Chapter 3 presents results that identify, through expert and user opinion, a possible set of 10 metrics for assessing the performance of recycled water programs. Chapter 4 centers on describing the opinions held by Delphi survey participants in the six different stakeholder groups that participated in the study. Chapter 4 also identifies major areas of agreement between recycled water programs and water supply programs and areas of nonalignment between recycled water programs and regulatory agencies. Chapter 5 addresses the study's second objective, identifies major metrics used by four case studies of urban recycled water programs, and explains how they compare with the Delphi survey's proposed metrics. Chapter 6 characterizes the significance of interactions for four case studies of recycled water programs and the organizations they consider their key stakeholders: regulators, partner agencies, and customers. Chapter 7 concludes the study by summarizing the study's main results and implications and identifying important areas for future research.

Chapter 2

Methodology

2.1 Objective 1 Research Method: Delphi Survey

2.1.1 Delphi Method Overview

Because of the wide range of applications and the many different types of organizations involved in recycled water program management, this study utilized an online survey based on the Delphi method to evaluate the metrics presented in Section 1.4. The Delphi technique is characterized as “a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem” (Linstone and Turoff, 1975). The following report sections describe the method, the ways it differs from statistical surveys, and how it was applied to this research project.

The Delphi method is a systematic, interactive forecasting technique, first developed in the United States in 1944. It has been used effectively in thousands of studies to analyze phenomena ranging from high technology to diabetes treatment (Colton & Covert 2007). It relies on a small- to moderate-sized panel of participants who answer questions confidentially in two or more rounds. After each round, a facilitator provides participants with an anonymous summary of results from the previous round, often including detailed comments made by respondents. Delphi panelists are encouraged to review and, if they desire, revise their answers in light of the replies made by other panel members. The process continues after a predefined “stop” criterion is reached, such as consensus or the completion of a given number of rounds (Gordon and Pease, 2006).

The Delphi approach is fundamentally different from a statistical survey of a large population, even though the word “survey” is used to describe both data collection techniques. Consider, for example, a statistical survey conducted by an organization such as Gallup, which measures public opinion. For this type of survey, random individuals from a given population (the sample) are asked questions with the goal of making statistical inferences about the population as a whole.

A Delphi survey is more like a controlled debate.. As described by Gordon (2009) and others (e.g., Gordon and Pease, 2006; Gupta and Clarke, 1996; Hsu and Sandford, 2007), Delphi surveys “do not (and are not intended to) produce statistically significant results.” Instead, they represent the “synthesis of opinion of the particular group, no more, no less.” The results provided by any panel do not predict the response of a larger population or even a different Delphi panel. According to Gordon (2009), the value of the Delphi method “rests with the ideas it generates, both those that evoke consensus and those that do not.” With this method, the arguments for extreme positions are also useful because they identify possible endpoints along the continuum of possible opinions.

The major benefit of using a Delphi panel to collect data is that the results provide in-depth insight from panelists, as evidenced by the detailed comments in Chapters 3 and 4 of the report. The tradeoff is that when an analysis is conducted, the generalizability of the comments is limited. However, because the panelists are selected for their experience or expertise in the field, their opinions hold significant weight.

Two additional benefits of the Delphi approach are that strong personalities cannot dominate the conversation and that the anonymity of the process makes participants feel freer to express their opinions (Martino, 1993; Martorella, 1991). Finally, the Delphi method is not limited by geographic location—panelists located anywhere in the world can participate (Okoli and Pawlowski, 2004).

There are three requirements of the Delphi method. First, the method must ensure anonymity among all participants (Murray and Hammons, 1995). Second, participants should possess expertise in the field of study (Gordon and Pease, 2006; Linstone and Turoff, 1975; Murray and Hammons, 1995). Last, the researcher or facilitator must assemble the group's responses and submit a summary to the group after each round (Murray and Hammons, 1995).

Delphi panels usually consist of fewer than 50 people (Gordon, 2009; Witkin and Altschuld, 1995), and most studies use between 15 and 20 panelists (Ludwig, 1997). From a review of Delphi studies investigating program effectiveness (Wu et al., 2007), critical success factors (Okoli and Pawlowski, 2004), and program evaluation criteria (Des Marchais, 1999), the number of panelists selected for each Delphi study ranged from 6 to 23.

2.1.2 Delphi Panel Recruitment

Based on the literature review and consultations with professionals working in the recycled water industry, the study team identified six types of organizations to include in the Delphi survey:

- recycled water programs
- water supply programs
- regulatory agencies
- NGOs
- recycled water customers
- academia

This group does not comprise all types of organizations involved with recycled water—doing so would have made the panel too large to produce useful results. Other types of organizations that could be included in future industry surveys are discussed in Chapter 7. Using recommendations made by Hsu and Sandford (2007) for Delphi panelist identification, the research team utilized the following criteria to establish participant qualifications: (1) review of publications in the literature; (2) identification of positional leaders; (3) verification of professionals who have first-hand relationships with the target issue; and (4) recommendations by professionals working in the recycled water field.

In total, 117 invitations were sent by email and 29 professionals (27%) agreed to participate. A group of 29 participants is well within the range of previous Delphi surveys described in Section 2.1.1. The study team's goal was to have a minimum of two or three representatives from each stakeholder group, and this objective was achieved, with stakeholder group size ranging from two to eight. Table 2.1 illustrates the representation of survey participants by stakeholder group and location. Data collection took place during a 2-month period from February to March 2011. Results stabilized after the completion of two rounds.

Table 2.1. Delphi Survey Panelists

	Number of Panelists											
	Arizona		California		Florida		Other U.S.		International		Total	
Stakeholder Group	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**
Recycled water program	2	2	2	2	2	2					6	6
Water supply program	1	1	5	5	2	2					8	8
Regulatory agency		1	2	2	2	2	2	2			6	7
NGO							2	2			2	2
Recycled water customer			1	1	2	2					3	3
Academia	2	2	1						1	1	4	3
Total	5	6	11	10	8	8	4	4	1	1	29	29

Notes: R1 = Round 1; R2 = Round 2.

2.1.3 Delphi Survey Administration

The survey was hosted on the Internet by the Calibrum Corporation using an online Delphi survey product called Surveylet. The company has supported more than 19 Delphi surveys, with several focused on environmental issues. These surveys include an analysis of future scenarios for waste management in Hungary and an environmental analysis of the agriculture, oil, and tourism industries in Venezuela (Calibrum, 2012). Appendix A contains the complete list of Delphi survey questions for this study. Each participant was assigned a unique login ID and password; participants could access the survey from any computer with a connection to the Internet. Before beginning the survey, all participants completed an online agreement to participate in the research and selected a preference for confidentiality in any future publications or presentations resulting from the research.

For each of the proposed evaluation metrics described in Section 1.4, panelists were asked to rank the appropriateness of a proposed metric on a scale of 0 (not at all appropriate) to 10 (completely appropriate). They were also asked to provide input on what a "good" value might be for a program in operation 5 years or more and that had a minimum wastewater treatment plant capacity of 0.1 mgd. For example, Figures 2.1 and 2.2 present the respondent prompts used for the flow ratio metric.

Previous studies indicate that the relationship between the amount of recycled water produced by a program and the amount of recycled water beneficially reused is an important part of understanding overall recycled water program effectiveness.

One metric that can be used to evaluate this relationship is flow ratio, which is defined by the formula below:

$$\frac{\text{Reuse Flow (mgd)}}{\text{Total Wastewater Treatment Facility Flow (mgd)}}$$

Reuse flow is defined as the volume of recycled water recycled for all permitted applications (usually in mgd).

Total wastewater treatment facility flow is defined as the total volume of wastewater treated (usually in mgd).

For example, Florida's Water Reuse Program reports average flow ratios (stratified by Florida Department of Environmental Protection District and Water Management District) that range from 0.12 to 0.90. Their permitted urban recycled water applications include public access area and landscape irrigation; groundwater recharge and indirect potable reuse; toilet flushing; fire protection; and wetlands.

1. Using a scale of 0 to 10 below, please rate how appropriate you think this metric is as a general indicator of recycled water program effectiveness:

0	1	2	3	4	5	6	7	8	9	10
Not at all appropriate					Appropriate					Extremely appropriate

2. Please provide justification for your rating in the space below:

Figure 2.1. Example round 1 metric appropriateness question.

3. For a recycled water program in operation for 5 years or more, what would you say is a good flow ratio (*please check one*)?

	0.00 to 0.19		0.80 to 1.00
	0.20 to 0.39		none of the above
	0.40 to 0.59		don't know
	0.60 to 0.79		

4. In the space below, please let us know if you know of a better metric that could be used to help the industry better understand the relationship between reuse capacity and the amount of recycled water being beneficially reused at the level of an individual wastewater treatment plant. Include units of analysis where possible.

Figure 2.2. Example round 1 metric value question.

In round 2 of the survey, panelists were presented with the 15 initial criteria and metrics, as well as a new criterion and metric and a new question created out of the responses from round 2. In addition, panelists were given the confidential summary of results from round 1.

One purpose of presenting the round 1 summary results was to see if panelists' comments might lead the panel as a whole to greater agreement. In round 2, participants were asked to review and revise as necessary their previous responses in light of the round 1 summary. In the online survey for round 2, respondents saw bar charts showing the distribution of metric appropriateness ratings in two ways, for the panel as a whole and for different stakeholder groups. In addition, respondents saw representative comments from panelists who had assigned the metric high, moderate, and low appropriateness ratings. As they desired, panelists could also click on the screen to view all respondent comments and definitions of the stakeholder group categories. If a respondent changed his or her rating between rounds, there was also a prompt asking for an explanation of the rating change. To illustrate, Figure 2.3 shows the prompt that panelists saw when asked about identifying a "good" value for flow ratio.

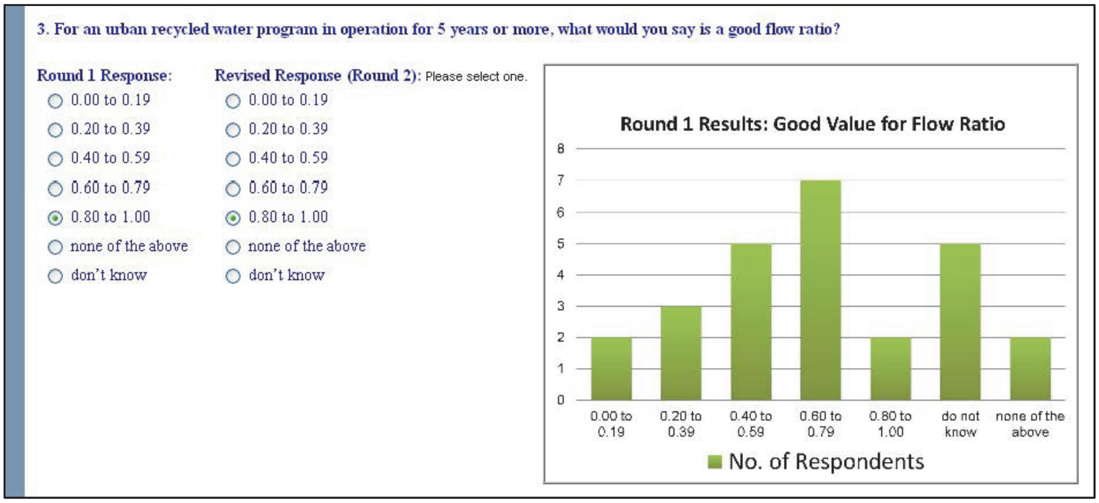

Figure 2.3. Round 2 flow ratio metric value question.

Participants were not required to answer all questions. In fact, participants were encouraged not to rate any criteria or metrics for topics with which they were unfamiliar. For questions where participants were asked to give a value for an appropriate metric, panelists could select a "do not know" option.

The results from round 2 showed that 47% of the panelists did not modify any of their responses from round 1. In addition, for each criterion and metric, only 12% of the panel, on the average, provided a justification for keeping or modifying their previous responses. One participant did not complete round 2 of the survey.

The Delphi method dictates that the survey stop once a consensus is reached or the results have stabilized. Because nearly half of the participants did not modify their previous responses and only 12% of participants provided justification or support for either keeping or modifying their responses, the study team concluded the survey at the end of round 2.

2.1.4 Limitations of the Delphi Method

As mentioned in Section 2.1.2, Delphi surveys are not based on sampling a statistically significant portion of a given population. Therefore, care must be taken not to overgeneralize their results. Data collected using the Delphi method may also be impacted by the response rate of panelists, that is, if panelists in in the first round drop out in subsequent rounds (Hsu and Sandford, 2007). For this survey, out of 29 original participants, one dropped out, but a new participant entered in round 2.

Other limitations of Delphi surveys include the robustness of respondent feedback and subject motivation (Ludwig, 1994), the length of time between survey rounds (Ludwig, 1994), and uneven levels of expertise among panelists (Altschuld and Thomas, 1991). In addition, the 29 respondents who participated in the voluntary survey may have had a particular reason for agreeing to participate in the survey. Consequently, survey results might overemphasize particular aspects of the proposed metrics.

Significant efforts were made to control for these factors in this study. For example, team members responded to invitee emails as promptly as possible and tried to minimize the time between round 1 completion and the onset of round 2. Nevertheless, the applications and limitations of this method make the study's results most useful as a baseline for initiating conversation in the reuse industry about what areas of program performance can and should be measured across programs. More specifically, the study's major contribution is identifying *possible* program evaluation criteria rather than determining *definitive* evaluation criteria.

2.2 Objective 2 Research Method: Case Study

A case study is an in-depth investigation of a complex social phenomenon; in this case, recycled water program implementation. The case study method of this investigation uses the framework developed by the noted sociologist Robert K. Yin (1992). In this sense, the case study is a systematic inquiry, which Yin equates to an "experiment." Multiple case studies are thus viewed as multiple experiments. Where experimental findings consistently concur, they can be used to form the basis of a pattern between and among important variables. For this study, we focused on urban programs in California, Arizona, and Florida—the states most active in water recycling.

Using the recycled water program as the central point of focus for the case study, we conducted semistructured interviews with program managers and key stakeholders, collected supporting documentation at interview sites, and compared this with existing peer-reviewed, popular, and gray literature. Gray literature is information produced by government, academics, business, and industry that is not controlled by commercial publishers. Common types of gray literature include memos, agency reports, and other technical publications. Using multiple types and sources of data enabled the study team to apply principles of "triangulation," which Olsen (2004) aptly defines as the "mixing of data or [data collection] methods so that diverse viewpoints cast light upon a subject." The mixing of data types and methods is helpful in validating the assertions that might arise from analysis.

2.2.1 Case Study Selection

An important part of selecting cases for this study was examining programs with similar characteristics, such as service area size. This enhanced the validity of "groundtruthing" metrics identified through the Delphi survey. Consequently, the study team selected similar-sized, well-established programs serving primarily commercial, institutional, industrial, and residential customers. The aim in selecting these cases was that they be representative of programs in their respective states, not necessarily that they be considered "the best of the best." That said, the following criteria were used to identify and solicit participation from potential case study programs:

- Service area size: major population center (500,000 to 1.5 million)
- Serving primarily "urban" customers (i.e., commercial, institutional, industrial, and residential users)
- Moderate reuse volume (as measured by volume of use in the range of 8 to 15 mgd)
- Willingness to participate
- Representing a range of implementation experience
- In operation for 5 years or more

Potential case study programs were identified during the fall and winter of 2011. Out of 12 programs considered for participation, 4 agreed to participate: the South Bay Water Recycling (SBWR) in San Jose, CA; the East Bay Municipal Utilities District (EBMUD) in

Oakland, CA; Tucson Water in Tucson, AZ; and JEA in Jacksonville, FL. Table 2.2 presents basic information about these programs. Data collection took place in September 2011 and March 2012. Case study visits lasted from a half day to 3 days and included interviews with reclaimed and recycled water program managers, regulators, and customers. In total, the study team conducted 24 interviews lasting from 30 minutes to 4 hours.

Table 2.2. Case Study Programs

	Tucson Water	SBWR	EBMUD	JEA
Location	Tucson, AZ	San Jose, CA	Oakland, CA	Jacksonville, FL
Date est.	1984	1998	1984	1999
Service area	350 mi^2	300 mi^2	330 mi^2	1,615 mi^2
Population	705,000	1.4 million	650,000	1 million
Customers	225,000	620	60	2,365
Miles of pipeline	160 mi	120 mi	88 mi	100 mi

2.2.2 Interview Protocols

To ensure consistency in data collection, semistructured interview forms were used to ask and record answers to questions. Most interviews were also audio-recorded. The basis of the forms centered around two themes: metrics and stakeholder interactions. For example, the form for the program manager was the most complex and contained about 50 questions on the following topics:

- Program context (e.g., history, past and present drivers)
- Use trends and factors affecting those trends
- Major metrics used by case study programs
- Questions on Delphi survey metrics and if data are available for them at the program level
- Who they view as their key stakeholders
- The extent to which they feel those stakeholders understand and share program goals
- Important future partnerships for climate change, IPR, CECs, and EI

The interview form used to interview Recycled Water Program Managers can be found in Appendix B.

2.2.3 Limitations of the Case Study Method

The case study's strength as a research method lies in its ability to provide a rich description of why things happen the way they do for a particular organization. Although case study findings can be generalized to a theoretical proposition, findings cannot be generalized to the entire universe of recycled water programs. In this sense, the project's aims are to expand theories (analytical generalization) and not to enumerate frequencies (statistical generalization) (Yin, 1992).

2.3 Data Analysis

Both quantitative and qualitative analysis techniques were used to attain the study's three main research objectives, with objective 1 containing two sub-objectives. The sections that follow describe the various techniques used to analyze data from the Delphi survey and case studies.

2.3.1 Objective 1: Criteria for Evaluating Program Effectiveness

To be categorized as highly appropriate for evaluating the effectiveness of a recycled water program, data for a proposed metric had to meet two conditions. First, the mean value of the panel's appropriateness rating had to be 7 or higher. Second, panel ratings needed to demonstrate a relatively high level of consensus. The measures and charts provided in the confidential results summary presented to panelists in round 2 also used descriptive statistics.

Descriptive statistics[1] were used to determine mean appropriateness values for the proposed metrics. On the basis of similar studies that used a Likert scale to assess appropriateness (Fitch et al., 2001; Vella et al., 2000), if the Delphi panel assigned a median score of 7 or greater to a criterion, it was categorized as "appropriate."

The mean absolute deviation from the median (MAD-M) was used to compute the level of consensus or agreement among panel members and within major stakeholder groups on the evaluative criteria and associated metrics presented and values indicative of an effective recycled water program. Using this value, respondent agreement levels for each program metric were categorized as high, medium, or low. Agreement levels were calculated for the Delphi panel as a whole and within each major stakeholder group (e.g., regulators). To determine the lower and upper limits for each level of consensus, the difference between the maximum and minimum MAD-M values for each criterion (e.g., flow ratio) were divided into thirds. A MAD-M value of 0.00 would mean the group was in perfect agreement or complete consensus. A MAD-M value in the lowest third of the range means there was less dispersion in the participant's responses and therefore a relatively high level of agreement. Conversely, a higher value for MAD-M indicated a wider dispersion in the data and therefore less agreement. A value in the highest third MAD-M value range indicated a wider dispersion in responses. Consequently, top-third values were considered to represent low agreement for respondents. The upper limit of MAD-M is dependent on the range of the rating scale used and the number of participants; therefore, an absolute value cannot be calculated. One limitation of using this method is that the agreement or consensus levels are relative only to the study or data set from which they are derived, and the values for MAD-M cannot be used comparatively.

On the basis of the analyses described here, each metric was further classified as having a high, moderate, or low level of overall appropriateness. Metrics rated high had a mean panel rating of 7 or higher *and* a high level of consensus. Metrics rated moderate had a mean panel

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[1]Descriptive statistics are used to describe a sample population or set of data, as opposed to making inferences about the data. Examples of descriptive statistics include mean, median, mode, and standard deviation.

rating of 7 or higher *and* a moderate level of consensus. Metrics rated low had a mean panel rating of 7 or higher *and* a low level of consensus. If the panel's median appropriateness rating was less than 7, it received a classification of not appropriate.

2.3.1.1 Sub-objective 1: Metric Values for an Effective Program

In the Delphi survey, participants were given a list of metric values and asked to select the value they thought would be indicative of an effective recycled water program. Before the MAD-M could be calculated, the metric values had to be converted to scalar values. Appendix C contains the list of metric value conversions used for this investigation.

2.3.1.2 Sub-objective 2: Agreement between Stakeholder Groups and Stakeholder Group Positions

Two forms of data analysis were conducted for each stakeholder pair to understand how stakeholder group ratings and opinions aligned. First, median appropriateness ratings between each group of stakeholder group pairs (e.g., regulatory agencies and recycled water programs) were compared to identify metrics for which ratings were within 1 point of one another (on a scale of 0–10). To determine which pairs were least aligned, the median appropriateness ratings between each group of stakeholder group pairs (e.g., regulatory agencies and recycled water programs) were compared to identify metrics for which ratings were 3 or more points apart.

Written comments from Delphi panelists were entered into a spreadsheet and hand-coded to uncover areas of agreement and disagreement, general trends, and the range of opinions. In this report, both major panel themes and stakeholder group perspective themes are reported. Common positions expressed by two or more different stakeholder groups were reported as major panel themes, as described in Chapter 3.

2.3.2 Objective 2: Major Metrics for Case Studies

Using data collected during interviews, which used the protocols described in Section 2.2.2, information on metrics used by each program was recorded and tabulated. Where feasible, values provided by the case study programs were compared with Delphi survey values described in Section 2.3.1.1.

2.3.3 Objective 3: Key Organizational Relationships

Verbal responses to case study interview questions, described in Section 2.2.2, were transcribed and, in most cases, audio-recorded. Using the general inductive approach for analyzing qualitative data described by Thomas (2003), data analysis involved conducting "detailed readings of raw data to derive concepts [and] themes. . . ." As stated by Thomas, "The primary purpose of the inductive approach is to allow research findings to emerge from the frequent, dominant, or significant themes inherent in raw data."

Chapter 3

Objective 1: Criteria for Evaluating Program Effectiveness

This chapter presents the quantitative and qualitative results of the Delphi Method survey for the panel as a whole. It shows panelist ratings and comments for the 10 proposed evaluation metrics they rated appropriate. In addition, this part of the report includes panel results for IPR and EI, because these topics relate to important industry trends. Appendix D summarizes the results for the remaining four proposed evaluation criteria.

For each metric, the median appropriateness rating is reported, along with the panel's level of consensus. Next, themes and representative comments from the qualitative analysis are presented. These provide possible explanations for metric ratings and offer insight into stakeholder group perspectives. Finally, the Delphi panel's responses for the metric value indicative of an effective recycled water program are given. Where data are available, known reference values for metrics from existing programs are compared with the Delphi panel's selection.

3.1 Summary of Panel Ratings: Overall Appropriateness

Out of 16 proposed metrics, the Delphi panel as a whole rated 10 metrics appropriate for evaluating overall recycled water program effectiveness. Table 3.1 summarizes the panel's ratings.

Table 3.1. Metrics Rated Appropriate for Program Evaluation

Metric Name	Metric Category	Consensus Level
Recycled water supply portfolio contribution	Water quality and quantity	High
Customer satisfaction	Customer service and support	High
Voter support	Public perception	High
Community support	Public perception	High
Flow ratio	Water quality and quantity	Moderate
Water quality	Water quality and quantity	Moderate
Recycled water utilization ratio	Water quality and quantity	Moderate
Product diversification	Application breadth	Moderate
Value-added services	Customer service and support	Moderate
CEC monitoring and strategy	Industry trends	Low

Of the 10 metrics rated as appropriate, the following four also had a high level of consensus: recycled water supply portfolio contribution; customer satisfaction; voter support; and community support. The panel had a medium level of consensus for five of the metrics rated appropriate: water quality; recycled water utilization ratio; flow ratio; product diversification; and value-added services. One metric that the panel rated appropriate had a low level of consensus: CEC monitoring and strategy. The following sections provide details on the ratings and comments for each of the metrics in Table 3.1.

3.2 Water Quantity and Quality

3.2.1 Recycled Water Supply Portfolio Contribution

3.2.1.1 Appropriateness Ratings and Consensus Levels

In the Delphi survey, recycled water supply portfolio contribution was defined as the contribution recycled water makes to the overall water supply portfolio for a region, measured as a percentage. It includes use by all sectors (e.g., residential, commercial, agricultural, landscape, irrigation, environmental enhancement, and other uses). The Delphi panel rated it highly appropriate for evaluating recycled water programs (i.e., the metric had a median appropriateness rating of 7 and high level of consensus). The recycled water customer stakeholder group rated this metric the highest, with a median rating of 8. The recycled water program stakeholder group rated this metric the lowest, with a median rating of 5. The median metric ratings for recycled water supply portfolio contribution for the panel and all stakeholder groups are displayed in Table 3.2.

Table 3.2. Recycled Water Portfolio Contribution Metric: Appropriateness Ratings and Consensus Levels

	Number of Panelists		Median Appropriateness Rating		MAD-M Value		Consensus Level	
Stakeholder Group	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**
Entire panel	28	25	7	7	2.11	1.92	High	High
Recycled water program	6	4	6	5	2.83	2.00	Low	Medium
Water supply program	8	7	5.5	6	2.50	2.43	Medium	Medium
Regulatory agency	6	7	7.5	8	1.33	1.14	High	High
Nongovernmental organization	2	2	6.5	6.5	1.50	1.50	Medium	Medium
Recycled water customer	3	3	8	8	1.33	1.00	High	High
Academia	3	2	7	7	1.33	2.00	Medium	Low

The panel displayed a high level of consensus when rating the recycled water supply portfolio contribution metric. As shown in Table 3.2, individual stakeholder groups had varying levels of consensus when rating the metric. The regulatory agency and recycled water customer stakeholder groups had the highest levels of consensus when rating the metric. The academia stakeholder group had the lowest level of consensus.

3.2.1.2 Qualitative Analysis: Major Panel Themes

The predominant reason panelists provided for using portfolio contribution as an evaluation metric was that it "is a very direct measurement of the status of the program and how entrenched recycled water use is relative to other sources." A common theme from panelists more cautious of the metric being used for program evaluation was that the portfolio contribution of individual programs depends on the level of water scarcity in the region. For example, one panelist wrote, "[the metric] is a useful cross-jurisdictional comparison…but it has its limitations that may reflect the particular economic, technical, geographic, and political circumstances of a utility." Another point raised by several panelists is that recycled water may not be the most cost-effective source of water for a region, and therefore it does not make sense for every program to aim to have a large contribution of its total supply portfolio come from recycled water. Major themes from participant comments for the recycled water supply portfolio contribution metric are displayed in Table 3.3.

Table 3.3. Recycled Water Supply Portfolio Contribution Metric: Major Panel Themes

No. of Comments	Theme	Representative Comment
10	Metric is utility-specific.	"This is a useful cross-jurisdictional comparison, but…it has its limitations that may reflect the particular economic, technical, geographic, and political circumstances of a utility…." (Recycled Water Program, FL)
8	Metric is good for measuring recycled water program effectiveness.	"… this metric more closely ties to program effectiveness…. This is a very direct measurement of the status of the program and how entrenched recycled water use is relative to other sources." (Recycled Water Customer, CA)
3	Metric is dependent on water scarcity situation.	"The appropriateness of this metric would depend on the particular water scarcity situation. In a location with higher water scarcity, the recycled water portfolio contribution would be of higher importance than it would be in an area in which scarcity is not as vital…of concern." (Nongovernmental Organization, U.S.)
3	Recycled water may not be most cost-effective source of supply.	"Cities/agencies should complete demand studies prior to determining what recycled water projects to implement… They may determine that it is more cost effective…to develop stormwater and/or implement rainwater and graywater projects." (Water Supply Program, CA)
2	Metric shows how recycled water offsets potable use.	"This metric gives an insightful perspective on the effectiveness of a reuse program as one of the goals of a reuse program should be to offset reliance on natural systems (ground and surface waters) for potable drinking water…." (Regulatory Agency, FL)

3.2.1.3 Individual Stakeholder Group Themes That Differed from Major Panel Themes

In addition to stating that the recycled water portfolio metric was utility-specific, many recycled water program stakeholders also pointed out that the type of use or application of recycled water is more important than the volume of recycled water consumed. A representative comment on this theme is shown in Table 3.4.

Table 3.4. Recycled Water Supply Portfolio Contribution Metric: Individual Stakeholder Group Themes

Stakeholder Group	Theme	Representative Comment
Recycled water program	The type of recycled water use is more important than the volume of recycled water use.	"We are focusing on the volume of reclaimed water used.…We should be focusing more on how beneficially it is being used." (Recycled Water Program, AZ)

3.2.1.4 Metric Value Indicative of Effective Recycled Water Program

Seventy-five percent of the panel responded specifically to the question of what level of contribution to the supply portfolio would be considered "good" for an established recycled water program. Most of the respondents who selected a quantitative value (44%) picked 6–10%. Panelist responses appear to align with current practice in several states. From data available in California (SCVWD, 2008), Arizona (ADWR, 2005), and Texas (SAWS, 2008), recycled water portfolio contributions ranged between 4 and 12% of the total supply. The Delphi panel demonstrated a medium level of consensus on the recycled water portfolio metric value in both survey rounds. Table 3.5 shows the percentage responses for a range of possible metric values.

Table 3.5. Recycled Water Supply Portfolio Contribution Metric: Value Indicative of Effectiveness

	All Values				Exclude "dnk" and "nota"			
	No. of Votes		% of Votes		No. of Votes		% of Votes	
	R1	R2	R1	R2	R1	R2	R1	R2
1 to 5%	1	0	4%	0%	1	0	6%	0%
6 to 10%	7	8	26%	33%	7	8	39%	47%
11 to 20%	6	7	22%	29%	6	7	33%	41%
Greater than 20%	5	3	19%	13%	5	3	28%	18%
None of the above	1	0	4%	0%	—	—	—	—
Do not know	7	6	26%	25%	—	—	—	—
Total	28	25	100%	100%	18	17	100%	100%

Notes: "dnk": = do not know; "nota" = none of the above.

3.2.2 Flow Ratio

For this study, flow ratio was defined as reuse flow (mgd) divided by total wastewater treatment facility flow (mgd). For this study, reuse flow is the volume of recycled water recycled for all permitted applications and total wastewater treatment facility flow is defined as the total volume of wastewater treated by a given facility. This is the major metric used by the state of Florida to measure its level of reclaimed water use (FDEP, 2010).

3.2.2.1 Appropriateness Ratings and Consensus Levels

The Delphi panel as a whole rated the flow ratio metric moderately appropriate for evaluating overall recycled water program effectiveness, with a median appropriateness rating of 7 and a medium level of consensus. The NGO group rated this metric the highest among the six stakeholder groups, with a median rating of 9.5. The recycled water program participants rated this metric the lowest, with a median rating of 3. No stakeholder group displayed a low level of consensus when rating the metric. Table 3.6 shows the appropriateness ratings and consensus levels for the panel as a whole and each stakeholder group.

Table 3.6. Flow Ratio Metric: Appropriateness Rating and Consensus Level

	Number of Panelists		Median Appropriateness Rating		MAD-M Value		Consensus Level	
Stakeholder Group	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**
Entire panel	28	25	7	7	2.38	2.25	Medium	Medium
Recycled water program	6	4	1.5	3	2.00	2.25	Medium	Medium
Water supply program	8	7	7	8	2.25	1.57	Medium	High
Regulatory agency	6	7	8.5	8	1.00	1.43	High	Medium
Nongovernmental organization	2	2	9.5	9.5	0.50	0.50	High	High
Recycled water customer	3	3	7	7	2.33	2.33	Medium	Medium
Academia	3	2	5	6	1.33	1.00	Medium	Medium

3.2.2.2 Qualitative Analysis: Major Panel Themes

Though the Delphi panel rated the flow ratio metric appropriate, the consensus level was medium. A common theme that emerged from panelists' comments is the need to clearly define the specific types of applications included in the calculation of the metric. However, the panel appeared divided on whether environmental enhancement or stream augmentation should be included. For example, the FDEP uses a broad interpretation of beneficial reuse and includes a wide range of applications in its flow ratio calculations. However, individual recycled water program managers interviewed for this project felt that "not all applications should be considered equally" and that an application such as industrial cooling water should be counted differently and given more credit than something such as land disposal. Additional details on panelists' opinions concerning what applications should count as beneficial reuse are presented in Appendix E.

Some panelists were hesitant to rate the metric "appropriate" because they felt that many programs might not be able to recycle a significant volume of effluent because of factors such as climate, permissible applications, and system capacity. Table 3.7 shows the major themes from participant comments for the flow ratio metric.

Table 3.7. Flow Ratio Metric: Major Panel Themes

No. of Comments	Theme	Representative Comment
4	Metric lacks clear definition of reuse.	"A consistent definition of 'beneficial reuse' needs to be established. For example, is discharge of reclaimed water into an adjacent percolation pond considered reuse flow?" (Water Supply Program, FL)
4	Program may not be able to recycle significant volume of wastewater.	"There are some cities…that will never be able to recycle all, or a large portion of their wastewater due to available use, users, climate, system design, etc. I don't believe that this is a major indicator of project efficacy in all cases." (Water Supply Program, CA)
3	Metric is appropriate for evaluating recycled water program effectiveness.	"Although this formula could be more specific, it is appropriate because it's a good overall metric and most utilities would have easy access to this data." (Nongovernmental Organization, U.S.)
3	Metric needs to take into account specific goals of a program.	"FDEP has successfully used flow ratio since 1998 to measure…success of a reuse…program…. Achieving 100% reuse as a goal is dependent on the community needs that must take into account whether the continuation of the forms of discharge are necessary. (e.g., to maintain minimum flows and levels in a lake or stream, etc.)" (Regulatory Agency, FL)
2	Metric does not account for demand.	"This does not account for demand. A program might be 100% efficient, but this could hide the fact that the plant's scale is not big enough to meet the actual demand which is out there." (Academia, International)
2	Metric should incorporate cost-effectiveness of reuse flow.	"A metric based on demand for irrigation or other uses appropriate for recycled water as is cost effective for the service area." (Water Supply Program, CA)

3.2.2.3 Individual Stakeholder Group Themes That Differed from Major Panel Themes

Most of the recycled water program respondents did not think flow ratio was an appropriate evaluation metric because it did not account for factors that limit customer demand. They cited limitations such as the seasonal variation of demand, lack of capital to expand the program, and lack of high-use applications (e.g., groundwater recharge and dual-plumbed buildings), which respondents considered necessary for achieving a high flow ratio. Again, the importance of the type of use rather than the volume of use was stressed by the recycled water program group.

In contrast, panel members in the regulatory agency group emphasized the volume of recycled water produced and consumed as being most important. This difference of quantity of use versus quality of use, or volume versus application, could be a fundamental difference between the regulatory agency and recycled water program stakeholder groups and possibly a basis for why these two stakeholder groups agreed the least when rating metrics. This discrepancy is revisited in Chapter 4.

A member of the academia stakeholder group wrote that the flow ratio metric was too crude and potentially lacked important details. However, this metric is currently used by the state of Florida as its primary statewide measure for evaluating its water reuse efforts. In addition, general metrics such as flow ratio can be a useful way of communicating information on water reuse to the public and decision makers, such as elected officials, who may lack the technical background necessary to fully understand more detailed measures. Comments representing stakeholder group perspectives that differed from those of the panel at large are reported in Table 3.8.

3.2.2.4 Metric Value Indicative of Effective Recycled Water Program

Eighty percent of the panel selected a quantitative value for flow ratio that would be indicative of an effective recycled water program. Twenty percent reported that they did not know and an additional 12% responded "none of the above." Of those who selected a value, the value receiving the highest percentage of votes in round 2 was 0.60 to 0.79 (59%).

Table 3.8. Flow Ratio Metric: Individual Stakeholder Group Themes

Stakeholder Group	Theme	Representative Comment(s)
Recycled water program	Flow Ratio is dependent on climate and application.	"Where irrigation reuse is predominant, these ratios are typically in the 0.5 (50%) range due to the pronounced wet and dry seasons…. If the application is for…cooling water…the actual reuse should be… higher… the meaning of the ratio is related to the particular reuse application… and needs to be interpreted with that understanding." (Recycled Water Program, FL)
Recycled water program	The type of recycled water use is more important than the volume of recycled water use.	"I firmly believe the use of the reclaimed water is more important than the percentage of wastewater being reused. Reclaimed water can be used for some ridiculous purposes such as developing private lakes in water scarce areas…." (Recycled Water Program, AZ)
Regulatory agency	The goal of an effective program is to produce and utilize as much recycled water as possible.	"The goal of an effective water reuse program is to utilize as much treated domestic wastewater as possible for beneficial purposes without causing adverse effects to public health or the environment." (Regulatory Agency, FL)
Regulatory agency	The goal of an effective program is to produce and utilize as much recycled water as possible.	"I agree that a measure of a successful recycling program is one that recycles the most water…" (Regulatory Agency, U.S. EPA)
Academia	Metric is too crude.	"Perhaps something that can capture more than what the current metric does. Perhaps these metrics are too crude and potentially lack important information." (Academia, International)

The state average for flow ratio in Florida is 0.43 (FDEP, 2010). When this actual value is compared to the panel's value of 0.60 to 0.79, it appears that the panel felt that flow ratio values should be higher. This finding is somewhat unexpected given that Florida leads the nation in water reuse. One explanation for this difference may be variability in what individual respondents considered "permitted applications" (i.e., beneficial reuse). Another explanation is that this value may represent a desired level of reuse that could be achieved in the future. In other words, the value identifies a future goal rather than a current situation.

The panel had a low level of consensus concerning the metric value in round 1 and moved toward a higher level of consensus in round 2 (medium level of agreement). Table 3.9 shows the percentage responses for a range of possible metric values.

Table 3.9. Flow Ratio Metric: Value Indicative of Effectiveness

	All Values				Exclude "dnk" and "nota"			
	No. of Votes		% of Votes		No. of Votes		% of Votes	
	R1	R2	R1	R2	R1	R2	R1	R2
0.80 to 1.00	2	2	7%	8%	2	2	11%	12%
0.60 to 0.79	9	10	32%	40%	9	10	50%	59%
0.40 to 0.59	3	3	11%	12%	3	3	17%	18%
0.20 to 0.39	2	1	7%	4%	2	1	11%	6%
0.00 to 0.19	2	1	7%	4%	2	1	11%	6%
None of the above	4	3	14%	12%	-	-	-	-
Do not know	6	5	21%	20%	-	-	-	-
Total	28	25	100%	100%	18	17	100%	100%

Notes: dnk = do not know; nota = none of the above.

3.2.3 Water Quality

For this study, the water quality metric represented the degree of regulatory compliance with three water quality parameters that U.S. states commonly monitor: total suspended solids (TSS), biochemical oxygen demand (BOD) and carbonaceous BOD (CBOD), and fecal coliform (FC). A key excerpt from the test statement presented to the Delphi panelists is shown in Figure 3.1 and the full survey question can be found in Appendix A.

Based on a survey of recycled water quality standards in eight states the following set of metrics provides one way of evaluating water quality for a given program. For each parameter comparison, a TRUE value would be an indicator of good water quality.

Test statement: Annual average total suspended solid (TSS) concentrations for program meets or exceed state standards for most restrictive use.

If $[\text{TSS (mg/L)}]_{\text{program}} \leq [\text{TSS}]_{\text{state std}}$ then above statement is true.

Test statement: Annual average biological oxygen demand/chemical biological oxygen demand meets or exceed state standards for most restrictive use.
If $[\text{BOD or CBOD (mg/L)}]_{\text{program}} \leq [\text{BOD or CBOD (mg/L)}]_{\text{state std}}$ then above statement is true.

Test statement: Annual average fecal coliform concentrations for program meets or exceed state standards for most restrictive use.
If $[\text{FC (cfu/100 ml)}]_{\text{program}} \leq [\text{FC (cfu/100ml)}]_{\text{state std}}$ then above statement is true.

Figure 3.1. Delphi survey excerpt for water quality.

3.2.3.1 Appropriateness Ratings and Consensus Levels

The panel rated this metric as appropriate, with a median panel rating of 8. The NGO group rated this metric highest (with a median rating of 9). The stakeholder group that rated this metric lowest was the academia group. All median metric ratings are displayed in Table 3.10. Overall, the panel had a medium level of agreement for the rating of this metric, making it moderately appropriate for the evaluation of recycled water program effectiveness. The largest jump in consensus for any metric between rounds was within the Recycled Water Program group. All other stakeholder groups were able to come to a medium or high level of agreement on this metric's rating. All consensus level measurements are included in Table 3.10.

Table 3.10. Water Quality Metric: Median Appropriateness Rating and Consensus Level

	Number of Panelists		Median Appropriateness Ratings		MAD-M Values		Consensus Level	
Stakeholder Group	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**
Entire panel	25	24	8	8	2.20	2.08	Medium	Medium
Recycled water program	5	4	8	8	3.00	1.75	Low	High
Water supply program	7	6	9	8.5	2.00	2.00	High	High
Regulatory agency	6	7	7	6	2.00	2.14	Medium	Medium
Nongovernmental organization	2	2	9	9	1.00	1.00	High	High
Recycled water customer	2	2	7.5	8	1.50	2.00	High	Medium
Academia	3	3	6	6	2.00	2.00	Medium	Low

3.2.3.2 Qualitative Analysis: Major Panel Themes

Most panelists felt that the metric was appropriate as a measure of general program effectiveness, and commenters felt that recycled water quality was critical to recycled water program effectiveness. In written comments, two themes emerged for this metric. The first is that the metric only measures the ability to meet minimum standards. The second was that it should include a wider range of parameters. It should be noted that the proposed metrics for water quality presented in the Delphi survey were selected to represent a baseline measure for water quality applicable to all programs, with the purpose of initiating discourse on the larger issue of water quality. Therefore, comments such as those received on standards and parameters were expected and desired. Panelist feedback identifies areas that will need additional discussion and clarification as the industry moves toward more advanced forms of reuse. Major themes from participant comments for the water quality metric are displayed in Table 3.11.

Table 3.11. Water Quality Metric: Major Panel Themes

No. of Comments	Theme	Representative Comment
7	Recycled water quality is critical to recycled water program effectiveness.	"I feel that water quality and adherence to regulated standards is extremely important when evaluating effective reclamation programs." (Academia, AZ)
3	Proposed metric only measures ability to meet minimum standards.	"These are minimum standards. Besides, customers will soon learn the inferior quality of the water is detrimental to the intended use. Finally, the question of safety will kill public acceptance…." (Water Supply Program, CA)
3	The metric should include more parameters.	"It does not include a wide range of parameters. Additionally it trusts that the state guidelines are at an appropriate level— perhaps in some instances that should be questioned." (Academia, International)

3.2.3.3 Individual Stakeholder Group Themes That Differed from Major Panel Themes

The recycled water program and regulatory agency stakeholder groups expressed viewpoints different from major panel themes that are important for understanding the perspectives of the two groups. Despite the fact that the recycled water program group rated the metric appropriate, some members in this group wrote that the metric should be based on a national set of standards to ensure that comparison across programs is fair. A representative comment from the recycled water program group for this viewpoint is shown in Table 3.12.

Table 3.12. Water Quality Metric: Individual Stakeholder Group Themes

Stakeholder Group	Theme	Representative Comment
Recycled water program	Metric should be based on a national water quality standard.	"I would have rated this higher if it was using a national water quality standard instead of a state standard… it seems hypocritical to rate a system higher in a state with lower standards than a system in a state with higher standards." (Recycled Water Program, AZ)
Regulatory agency	See Table 3.13 for details	

It was unexpected that the regulatory agency group did not rate the water quality metric as appropriate. Considering the role this stakeholder group plays in creating and regulating water quality standards for environmental and public health, it was important to uncover a possible explanation. The regulatory agency stakeholder group consisted of seven experts: two members from state public health departments, two members from state environmental protection agencies, one member from a state water resources board, and two members from the U.S. EPA. From the panelists' comments, it can be deduced that the members of the group who rated the metric low disagreed with the details of the metric, not with the concept that water quality is appropriate to determining recycled water program effectiveness. Specifically, stakeholders in the group felt that the metric did not include enough parameters, metric formula units should be changed, or metric wording could be misinterpreted. Table 3.13 shows the breakdown of ratings and comments for the water quality metric.

Table 3.13. Water Quality Metric: Regulatory Agency Themes

Metric Rating	No. of Panelists	Agency Representation	Theme	Representative Comment(s)
3	2	State Environmental Protection	Metric parameters are minimum standards.	"Although fecal coliform monitoring provides partial assurance for protecting public health, in my view TSS and BOD…provide little additional assurance…."
		State Department of Health		"Averaging health based parameters (coliform) is NOT a worthy way of determining an effective recycled water program. Health based parameters should be met at all times…"
6	2	U.S. EPA State	Metric formula should be changed or reworded.	"… the wording might better be something like … meet or be better than…the state standards since 'exceed'…could be interpreted as violating the requirements by exceeding them!"
		State Department of Health		"In my opinion the standards should be based upon monthly averages.…"
9	1	State Water Resources	Use of state standards for metric basis is appropriate.	"As long as the standards are specific to California, this is appropriate—coliform results to indicate adequate control of bacteria, and TSS/CBOD to confirm adequate treatment through the full treatment process."
10	2	State Environmental Protection U.S. EPA		"Florida's high-level disinfection requirements…. were established based on research done by the Department of Health's State Virologist in the 1980's.…Subsequently, there is no evidence of illness associated with use of reclaimed water in Florida.…"

3.2.3.4 Metric Value Indicative of Effective Recycled Water Program

The panel was not given specific values to choose from for the water quality metric.

3.2.4 Recycled Water Utilization Ratio

A new criterion, the recycled water utilization ratio, defined as actual reuse volume (in mgd) divided by potential reuse volume (in mgd), was developed based on panelists' comments on several of the metrics presented in round 1. As a result, the Delphi panel rated only this metric in round 2. Table 3.14 shows representative comments that lead to the creation of this metric.

Table 3.14. Representative Comments Leading to Creation of Recycled Water Utilization Ratio Metric

Total No. Comments	Metric Where Comment Originated	Representative Comment(s)
5	Flow ratio	"If the goal is to determine how well a utility meets the reuse capacity… it might be better to express success with the ratio of actual reuse to potential reuse…." (Recycled Water Program, FL) "I would recommend the criteria be revised to measure the amount of…water… recycled against the amount that could be recycled from the universe of potential users and uses…" (Regulatory Agency, U.S. EPA)
5	Recycled water portfolio contribution	"It is a start by providing general numeric values. IT does NOT provide an assessment of the actual potential as different communities have different recycled water potential…." (Water Supply Program, CA) "A very good metric that could be helped a little with a study of potential for recycled water use…. A metric that uses the potential, specific to an area… would be good." (Water Supply Program, CA)
5	Application range	"Potential studies often ignore the cost, politics, distribution, and regulations and therefore 5 years is a very short period to test. We consider 'potential studies' to be 20 to 30 year time horizons." (Water Supply Program, CA) "Perhaps a better approach would be to ask if a comprehensive user community assessment has been done and if so . . . what percentage of uses can be met with the recycled water would be a better question." (Regulatory Agency, U.S. EPA)

3.2.4.1 Appropriateness Ratings and Consensus Levels

The Delphi panel rated the recycled water utilization ratio metric appropriate for evaluating recycled water program effectiveness, with a median rating of 8. The recycled water customer group gave this metric the highest median rating (10). The water supply program gave this metric the lowest median rating (4). All median appropriateness ratings are listed in Table 3.15. The Delphi panel as a whole exhibited a medium level of consensus when rating the recycled water utilization ratio metric. All stakeholder groups that rated this metric as appropriate had a high level of consensus. All consensus level measurements are displayed in Table 3.15.

Table 3.15. Recycled Water Utilization Ratio Metric: Median Appropriateness Rating and Consensus Level

	Number of Panelists		Median Appropriateness Rating		MAD-M Value		Consensus Level	
Stakeholder Group	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**
Entire panel	—	23	—	8	—	2.17	—	Medium
Recycled water program	—	4	—	5.5	—	2.75	—	Medium
Water supply program	—	7	—	4	—	2.71	—	Medium
Regulatory agency	—	6	—	8	—	0.17	—	High
Nongovernmental organization	—	2	—	7	—	0.00	—	High
Recycled water customer	—	3	—	10	—	0.67	—	High
Academia	—	1	—	9	—	0.00	—	High

3.2.4.2 Qualitative Analysis: Major Panel Themes

Despite the fact that the metric was created out of multiple panelists' requests, many respondents expressed a desire to add details to the proposed metric. Some panelists wondered how the cost effectiveness of a potential application could be included or calculated. Others were concerned that though there may be a large potential demand for recycled water, the available supply may be insufficient to fulfill demand. Table 3.16 shows the major panel themes for the recycled water utilization ratio metric.

3.2.4.3 Metric Value Indicative of Effective Recycled Water Program

Sixty-five percent of the panel selected a quantitative estimate of what value of the metric would indicate an effective program. Of those panelists selecting a value, most (43%) felt that an effective recycled water program should have a utilization ratio of 51 to 75%. Because this metric was created from panelists' comments, reference values are not available to compare with survey findings. The consensus level for this metric was low. Table 3.17 shows the percentage of responses for all metric values. Panelist comments on the metric, presented in Table 3.16, identify possible variables (program target setting, market penetration, cost considerations) that could make the metric more useful for cross-program comparison.

Table 3.16. Recycled Water Utilization Ratio Metric: Major Panel Themes

No. of Comments	Theme	Representative Comment
3	Potential is closely connected with constraints on recycled water utilization.	"[The metric] is too esoteric…. One program's potential is another program's obstacle." (Water Supply Program, FL)
2	Metric is simple to understand.	"This metric provides great information in that it directly examines performance of program compared to target (100%). It is a very simple way to look at how well a program is working." (Recycled Water Customer, CA)
2	Metric measures depth of market penetration not recycled water program effectiveness.	"This metric could have some value in measuring the [market] penetration rate… in a particular area, industry, or other categorical use." (Water Supply Program, FL)
2	Potential may be greater than available supply of recycled water.	"I am somewhat concerned that in some places there may be a high potential for recycled water to be used, but a limited supply of reclaimed water available to service that high potential use demand." (Regulatory Agency, U.S. EPA)
2	Potential should be defined in terms of cost-effectiveness.	"The goal would be to service 100% recycled water to 100% potential. However, cost needs to be factored in as well as energy, etc." (Regulatory Agency, U.S. EPA)

Table 3.17. Recycled Water Utilization Ratio Metric: Value Indicative of Effectiveness

	All Values				Exclude "dnk" and "nota"			
	No. of Votes		% of Votes		No. of Votes		% of Votes	
	R1	R2	R1	R2	R1	R2	R1	R2
0 to 25%	—	0	—	4%	—	0	—	7%
26 to 50%	—	3	—	9%	—	3	—	14%
51 to 75%	—	4	—	26%	—	4	—	43%
76 to 100%	—	5	—	22%	—	5	—	36%
None of the above	—	5	—	4%	—	—	—	—
Do not know	—	7	—	35%	—	—	—	—
Total	0	24	—	100%	0	12	—	100%

Notes" "dnk"= do not know, "nota"= none of the above.

3.3 Application Breadth

3.3.1 Product Diversification

3.3.1.1 Median Appropriateness Ratings and Consensus Levels

This metric describes the extent to which a recycled water program provides different qualities of water. The Delphi panel rated the product diversification metric moderately appropriate for measuring program effectiveness, with a median panel rating of 7. The recycled water customer group rated the metric highest, with a median rating of 8.5. The water supply program group rated the metric lowest, with a median rating of 2. The median appropriateness ratings for all stakeholder groups, along with consensus levels, are included in Table 3.18.

Table 3.18. Product Diversification Metric: Median Appropriateness Rating and Consensus Level

	Number of Panelists		Median Appropriateness Rating		MAD-M Values		Consensus Levels	
Stakeholder Group	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**
Entire panel	25	23	7	7	2.36	2.09	Medium	Medium
Recycled water program	5	4	5	6	2.20	2.75	Medium	Medium
Water supply program	8	7	2	2	2.88	2.29	Low	Medium
Regulatory agency	5	6	7	7	1.00	0.50	High	High
Nongovernmental organization	2	2	6	6	1.00	1.00	High	High
Recycled water customer	2	2	8.5	8.5	1.50	1.50	High	High
Academia	3	2	7	7	0.33	0.00	High	High

The Delphi panel exhibited a medium level of agreement when rating the product diversification metric. Four of the six stakeholder groups maintained a high level of consensus in both rounds when rating the metric.

3.3.1.2 Qualitative Analysis: Major Panel Themes

Four themes emerged from panelist comments. Panelists who gave the metric high appropriateness ratings felt that it focused on meeting customer needs, which is necessary for an effective recycled water program. Other panelists who assigned the metric lower appropriateness ratings felt that a program could be effective without necessarily diversifying its product. Some panelists also commented that the ability to diversify would be a function of the program’s size and financial resources. For these commenters, these two variables were utility-specific, which makes the diversification metric difficult to use for cross-program comparison. Table 3.19 shows the major panel themes from participant comments for the product diversification metric.

Table 3.19. Product Diversification Metric: Major Panel Themes

No. of Comments	Theme	Representative Comment
3	Metric is good because it focuses on the customer.	"In spite of the preferences of the agencies, this takes into consideration the needs of the customer which is the driver for the program." (Water Supply Program, CA)
3	Diversification is not necessary for program effectiveness.	"A program with extensive recycle water demand in one sector can be more effective than a program with many diversifying products." (Water Supply Program, CA)
2	Feasibility of diversification is dependent on size of program.	"For smaller cities it is hard to provide more than one type of water considering treatment, storage and distribution systems." (Recycled Water Program, AZ)
2	Diversification is dependent on local situation.	"I don't see this metric being appropriate for the effectiveness of a program. Each program will make local decisions on whether diversification makes sense." (Water Supply Program, FL)

3.3.1.3 Individual Stakeholder Group Themes That Differed from Major Panel Themes

Members of the water supply program and regulatory agency groups raised issues that differed slightly from major panel themes. One member of the water supply program group wondered whether product diversification was the responsibility of the recycled water program or the customer. The stakeholder pointed out computer chip manufacturers and power plants as examples of industries that have historically provided additional treatment of water on site.

One member of the regulatory agency stakeholder group supported the product diversification metric. He stated that it offered a way of saving recycled water programs money by reducing treatment costs. Representative comments from the water supply program and regulatory agency stakeholders are listed in Table 3.20.

Table 3.20. Product Diversification Metric: Individual Stakeholder Group Themes

Stakeholder Group	Theme	Representative Comment
Water supply program	Further treatment of recycled water may need to take place at customer site.	"On site improvement of quality has proven effective for industries with specific water quality requirements. Computer chip manufacturers and power plants want the quality as high as possible but recognize they need to further treat water delivered from almost any source." (Water Supply Program, AZ)
Regulatory agency	Tailoring recycled water to meet customer need can save money.	"I support this criterion because tailoring recycled water for the use can reduce treatment costs, thereby making the product more economical. . . . Reducing treatment costs and reusing components of the waste stream should be encouraged." (Regulatory Agency, U.S. EPA)

3.3.1.4 Metric Value Indicative of Effective Recycled Water Program

For this study, the Delphi survey used a nominal lettering system to describe a program's level of involvement with product diversification. Survey choices ranged from a program distributing at least two different qualities of water to a program deciding not to investigate if it should diversify. Also included was a "not applicable" choice that could be used to describe a situation where the program had investigated diversification, but found limited or no customer need. When asked to select a "good" value of diversification for an established recycled water program, the response with the highest percentage of votes was "do not know" (39%). Of those that did select a value for the metric, the majority (62%) thought an effective recycled water program should have a letter "B" grade, which meant the program had investigated diversifying product and had created a plan to produce more than one quality of recycled water within the next 3 years. Because the study team developed this metric on its own, there are no known reference values to compare with the survey findings. The percentage of responses for all values is given in Table 3.21. The lack of a clear majority choice and low consensus level for this metric value indicates that the decision of whether or not to diversify is viewed as utility-specific.

Table 3.21. Product Diversification Metric: Value Indicative of Effectiveness

	All Values				Exclude "dnk" and "nota"			
	No. of Votes		% of Votes		No. of Votes		% of Votes	
	R1	R2	R1	R2	R1	R2	R1	R2
NA	2	2	8%	9%	2	2	14%	15%
C	2	0	8%	0%	2	0	14%	0%
B	7	8	28%	35%	7	8	50%	62%
A	3	3	12%	13%	3	3	21%	23%
None of the above	2	1	8%	4%	—	—	—	—
Do not know	9	9	36%	39%	—	—	—	—
Total	25	23	100%	100%	14	13	100%	100%

Notes: "dnk" = do not know; "nota" = none of the above.; refer to Table 1.4 for metric definition

3.4 Customer Service and Support

3.4.1 Customer Satisfaction

3.4.1.1 Median Appropriateness Ratings and Consensus Levels

For this study, customer satisfaction was defined as the percentage of recycled water customers satisfied with the overall quantity and quality of delivered water. For this metric, no distinction was made as to whether the customer was using the recycled water for potable or nonpotable applications. Of all the metrics presented in any category, the Delphi panel rated the customer satisfaction metric the highest, with a median rating of 8.5. Both the recycled water program and recycled water customer stakeholder groups gave this metric a median rating of 10. The academia stakeholder group rated this metric the lowest (7), but still considered it appropriate for evaluating the effectiveness of a recycled water program. Table 3.22 shows the metric ratings and consensus levels for the panel and each stakeholder group.

The panel as a whole had a high level of consensus when rating this metric. Only two groups (regulatory agencies and NGOs) had a medium level of consensus. All other groups demonstrated a high level of consensus.

Table 3.22. Customer Satisfaction Metric: Median Appropriateness Rating and Consensus Level

Stakeholder Group	Number of Panelists		Median Appropriateness Rating		MAD-M Values		Consensus Level	
	R1	R2	R1	R2	R1	R2	R1	R2
Entire panel	25	24	9	8.5	1.68	1.79	High	High
Recycled water program	4	3	10	10	0.75	1.00	High	High
Water supply program	8	7	8	9	2.13	2.00	High	High
Regulatory agency	5	6	9	8.5	1.80	2.17	Medium	Medium
Nongovernmental organization	2	2	8.5	8.5	1.50	1.50	Medium	Medium
Recycled water customer	3	3	9	10	1.00	1.00	High	High
Academia	3	3	7	7	0.33	0.33	High	High

3.4.1.2 Qualitative Analysis: Major Panel Themes

The major theme generated from Delphi panelist comments was that customer satisfaction is crucial to a recycled water program's longevity. Those Delphi panelists critical of the metric did not disagree with the importance of the metric, but cited challenges with conducting and analyzing customer satisfaction survey data. Table 3.23 shows the major themes from participant comments for the customer satisfaction metric.

Table 3.23. Customer Satisfaction Metric: Major Panel Themes

No. of Comments	Theme	Representative Comment
9	Customer satisfaction is crucial to project longevity.	"Customer satisfaction is critical to a project's success. If customers aren't happy with the elements of a project, they can close the project down…." (Water Supply Program, CA)
4	Surveys results can be skewed.	"Customers who are not satisfied turn in their surveys while satisfied customers many times do not." (Regulatory Agency, FL)
3	There are many problems with surveys, such as mood of respondent and statistical measures used to analyze results.	"[Customer Satisfaction Surveys] are influenced by a number of factors that are outside the control of the recycled water program (i.e., respondent had a fight with spouse prior to answering survey, was in an accident, got bad news from the doctor)…" (Water Supply Program, CA)

3.4.1.3 Individual Stakeholder Group Themes That Differed from Major Panel Themes

The academia stakeholders were the only group to suggest specific components of customer satisfaction that should be measured. Examples include cost, value, reliability, and water quality. A representative comment made by the academia stakeholder group is shown in Table 3.24.

Table 3.24. Customer Satisfaction Metric: Individual Stakeholder Group Themes

Stakeholder Group	Theme	Representative Comment
Academia	Several components of customer satisfaction should be measured.	"There can be a wide range of items evaluated to assess satisfaction.… Examples: cost, value, reliability, water quality, environmental ethic, etc." (Academia, AZ)

3.4.1.4 Metric Value Indicative of Effective Recycled Water Program

Only a small percentage of the panel did not know (8%) or did not think (4%) any of the values presented were indicative of an effective recycled water program. Of the remaining panelists, almost all (95%) felt that an effective recycled water program should have a customer satisfaction rate of 76 to 100%, and responses indicated a high level of consensus. The accessibility of customer satisfaction surveys on this topic is limited and often kept confidential. However, a recent survey of residential recycled water users in Arizona found that there was a high level of satisfaction with the use of reclaimed water, with 89% of all respondents being satisfied. Satisfaction included the indication by 90% of respondents that "Having reclaimed water for my landscaping increases the resale value of my home" (Campbell and Scott, 2011). Along similar lines, a 2008 study of the Mawson Lakes residential community in Australia found that, on a scale of 0 (not satisfied) to 10 (very satisfied), residents of the dual-plumbed community reported an average satisfaction rate of 7.51 with their use of recycled water (Hurlimann et al., 2008). Certainly, more data are needed on satisfaction surveys of users for other applications of recycled water (e.g., commercial, industrial, and institutional). The percentage of responses for all values is given in Table 3.25.

Table 3.25. Customer Satisfaction Metric: Value Indicative of Effectiveness

	All Values				Exclude "dnk" and "nota"			
	No. of Votes		% of Votes		No. of Votes		% of Votes	
	R1	R2	R1	R2	R1	R2	R1	R2
0 to 25%	2	2	8%	8%	0	0	0%	0%
26 to 50%	2	2	8%	8%	1	0	4%	0%
51 to 75%	2	2	8%	8%	1	1	4%	5%
76 to 100%	2	2	8%	8%	21	20	91%	95%
None of the above	2	2	8%	8%	—	—	—	—
Do not know	2	2	8%	8%	—	—	—	—
Total	26	24	100%	100%			100%	100%

Notes: "dnk" = do not know; "nota" = none of the above.

3.4.2 Value-Added Services

For this study, value-added services were defined as noncore services that recycled water programs may offer to aid in recruiting new customers or enhancing the overall experience of a current customer, such as assistance with return on investment (ROI) calculations or project funding.

3.4.2.1 Appropriateness Ratings and Consensus Levels

The Delphi panel rated the value-added services metric as moderately appropriate, with a median rating of 7 and a moderate level of panel consensus. The recycled water customer stakeholder group rated this metric highest, with a median rating of 9. The academia stakeholder group rated the metric lowest, with a median rating of 5.5. The median appropriateness ratings for all stakeholder groups can be found in Table 3.26. The Delphi panel as a group exhibited a medium level of consensus when rating the value-added services metric. The level of consensus for individual stakeholder groups ranged from low to high and the level did not change between rounds for any group except the academia stakeholder group, where the level of consensus actually decreased from high to medium.

Table 3.26. Value-Added Services Metric: Median Appropriateness Rating and Consensus Level

	Number of Panelists		Median Appropriateness Rating		MAD-M Values		Consensus Level	
Stakeholder Group	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**
Entire panel	26	24	7	7	2.38	2.25	Medium	Medium
Recycled water program	5	4	9	7.5	1.80	2.00	Medium	Medium
Water supply program	8	7	7	7	3.38	3.43	Low	Low
Regulatory agency	5	6	8	6.5	2.20	2.00	Medium	Medium
Nongovernmental organization	2	2	6	6	1.00	1.00	High	High
Recycled water customer	3	3	9	9	1.00	1.00	High	High
Academia	3	2	5	5.5	1.00	1.50	High	Medium

3.4.2.2 Qualitative Analysis: Major Panel Themes

Delphi panelists who gave the metric a high appropriateness rating felt that value-added services were helpful for gaining public acceptance and trust. Members of both the recycled water program and the water supply program groups stressed the importance of working closely with the customer, because recycled water used for nonpotable applications has its own set of water quality and site compatibility issues.

Comments made by Delphi panelists who gave the metric high and low ratings for appropriateness felt that the ability to provide such services is dependent on the recycled water program's financial health. For this reason, some panelists argued that the metric should be a secondary metric or "extra credit." Others felt that the need for programs to offer value-added services would be greater when the program was first getting started and decrease as the program became more established. Major themes from the qualitative analysis of participant comments for the value-added services metric are displayed in Table 3.27.

Table 3.27. Value-Added Services Metric: Major Panel Themes

No. of Comments	Theme	Representative Comment
6	Value-added services help gain public trust and acceptance.	"Customer service is absolutely critical to a recycled water program. The more… outreach…a city/agency can provide, the better for the customer. …There is also a level of trust that's established with the public." (Water Supply Program, CA)
4	Metric is secondary measure.	"In better economic times, this may be a good measure of a reuse system's… customer service. But money is tight and treatment, reliability, regulatory compliance, safety, and cross connection control activities become more important. This metric, in my opinion, is a nice to have." (Regulatory Agency, FL)
2	There are unique issues associated with recycled water application.	"Use of recycled water has a unique set of issues that are unlike potable water. There are elements of the unknown that the customer may be dealing with as well as water quality issues… and site compatibility elements…. By providing value-added services, the water provider is increasing the buy-in from the customer… minimizing… future concerns." (Water Supply Program, CA)
2	Value-added services are budget dependent.	"We do not have a formal program now because of budget cuts but we did in the past and it was very effective." (Recycled Water Program, AZ)
2	Value-added services are more important when implementing a program.	"One might expect the need for these services to be greatest upon introduction of a reuse program, with need declining as the program is established." (Recycled Water Program, FL)
2	Metric is utility-specific.	"I think this metric is very utility-specific. And, before adding additional services, the utility must determine how to first provide recycled water in the most efficient manner." (Nongovernmental Organization, U.S.)

3.4.2.3 Metric Value Indicative of Effective Recycled Water Program

The presentation of this metric was slightly different from the presentation of the other metrics. Delphi panelists were asked to select the most useful services recycled water programs should provide to potential and existing recycled water customers. The following services received the most votes: assistance with commercial permit process (22%), landscape consulting (22%), and assistance with locating grants or general project financing (13%). Thirteen percent of Delphi panelists recommended additional services that fell into the categories of public outreach, health and safety, and soil and nutrient management plans. Section 5.4.1 describes value-added services provided by the four case study programs reviewed in this study. Because of the format of the question (participants were asked to select up to three services), determining consensus level was not applicable to this variable. The percentage of responses for all values is given in Table 3.28.

Table 3.28. Value-Added Services Metric: Value Indicative of Effectiveness

Value	All Votes No. of Votes R2		% of Votes R2	
	R1	R2	R1	R2
Assistance with commercial permit process	16	15	23%	22%
Assistance with residential permit application process	10	8	14%	12%
Landscape consultant	12	15	17%	22%
Graywater consultant	4	3	6%	4%
Assistance with ROI analysis	5	6	7%	9%
Assistance with locating grants or financing for customer project	8	9	11%	13%
Conduct industrial user group annual meeting	4	3	6%	4%
Other 1	10	7	14%	10%
Other 2	2	2	3%	3%
Total	71	68	100%	100%

Note: Each panelist was asked to select up to three services.

3.5 Public Perception

3.5.1 Voter Support

3.5.1.1 Median Appropriateness Rating

For this study, the voter support metric was defined as the percentage of the voting population that vote “yes” on ballot measures, referenda, or similar initiatives that support the construction, expansion, or financing of recycled water. This metric was also one of the highest-rated metrics amongst Delphi panel members, with a median rating of 8. All stakeholder groups rated this metric as appropriate. Table 3.29 shows the panel’s median ratings and consensus levels for the metric.

The Delphi panel exhibited a high level of consensus for the voter support metric. The agreement level increased from medium to high for the recycled water program and water supply program stakeholder groups. For all other stakeholder groups, the consensus level stayed the same between rounds at either medium or high.

Table 3.29. Voter Support Metric: Median Appropriateness Rating and Consensus Level

Stakeholder Group	Number of Panelists		Median Appropriateness Rating		MAD-M Values		Consensus Level	
	R1	R2	R1	R2	R1	R2	R1	R2
Entire panel	27	23	8	8	1.78	1.42	High	High
Recycled water program	5	3	8	8	2.20	0.67	Medium	High
Water supply program	8	7	8.5	8	2.38	2.14	Medium	High
Regulatory agency	6	7	9	9	0.67	0.57	High	High
Nongovernmental Organization	2	2	7.5	7.5	0.50	0.50	High	High
Recycled water customer	2	2	7.5	8.5	1.50	1.50	High	High
Academia	4	3	6.5	7	2.00	1.67	Medium	Medium

3.5.1.2. Qualitative Analysis: Major Panel Themes

The major theme to emerge from panelist comments was the connection between the level of public support and a recycled water program's education and outreach efforts. Four out of six stakeholder groups (recycled water program, water supply program, regulatory agency, and recycled water customer) confirmed this connection. Only three Delphi panelists rated the metric unsuitable. One participant thought the voter support metric was too blunt because it did not include evaluation of specific program efforts to increase public support. Table 3.30 shows the major panel themes for the voter support metric.

This result does not indicate that the use of recycled water should require voter support in all circumstances. If that was the case, it might imply that all sources of water supply (reservoir, groundwater, transport from other river basins, and the like) require voter support, which is unreasonable. Rather, it simply identifies a big-picture variable that could be illustrative of a program's education and outreach efforts. In addition, data on voting history related to recycled water projects are useful for post hoc assessments.

Table 3.30 Voter Support Metric: Major Panel Themes

No. of Comments	Theme	Representative Comment
6	Voting is linked to education and outreach.	"Community and voter support reflect how well the providers/municipalities have educated the public." (Recycled Water Customer, CA)
3	Voter support metric does not measure program effectiveness.	"I think such a measure is blunt and does not convey detail of why or why not individuals support the program. Additionally, it does not link effectiveness to any community engagement activities—of which effective ones would be critical to a program's effectiveness." (Academia, International)

3.5.1.3 Metric Value Indicative of Effective Recycled Water Program

Twelve percent of the panel either did not know or did not think any of the metric values presented were indicative of an effective recycled water program. Of the remaining participants, most (29%) felt that an effective recycled water program required 71% to 80% voter support. However, responses exhibited a medium level of consensus in round 1 and a low level of consensus in round 2 of the survey.

From limited information available on known voter support metric values, the panel's expectations of an effective program appear to align with actual program performance. For example, from data reported by the *East Valley Tribune* in Mesa, AZ, a $39 million wastewater system revenue bond passed with 74% support from voters in 2010 (Groff, 2010). The percentages of responses for all values are given in Table 3.31.

Table 3.31. Voter Support Metric: Indicative Value of Effectiveness

	All Values				Exclude "dnk" and "nota"			
	No. of Votes		% of Votes		No. of Votes		% of Votes	
	R1	R2	R1	R2	R1	R2	R1	R2
40 to 50%	1	0	4%	0%	1	0	4%	0%
51 to 60%	7	6	25%	25%	7	6	29%	29%
61 to 70%	9	5	32%	21%	9	5	38%	24%
71 to 80%	4	7	14%	29%	4	7	17%	33%
81 to 90%	3	3	11%	13%	3	3	13%	14%
91 to 100%	0	0	0%	0%	0	0	0%	0%
None of the above	1	1	4%	4%	-	-	-	-
Do not know	3	2	11%	8%	-	-	-	-
Total	28	24	100%	100%	24	21	100%	100%

“dnk" = do not know; "nota" = none of the above.

3.5.2 Community Support

3.5.2.1 Appropriateness Ratings and Consensus Levels

For this study, community support was defined as the level of public support for recycled water as gathered from a community survey, measured as the percentage of a surveyed population in a service area that supports use of recycled water for permitted uses. The Delphi panel rated the community support metric as highly appropriate, with a median rating of 8 and a high level of consensus. All stakeholder groups rated this metric as appropriate except the NGO group (median rating: 4.5). All stakeholder median appropriateness ratings and consensus levels are displayed in Table 3.32. The Delphi panel as a group maintained a high level of consensus in both rounds when rating this metric. No stakeholder group exhibited a low level of consensus when rating the metric.

Table 3.32. Community Support Metric: Median Appropriateness Rating and Consensus Level

	Number of Panelists		Median Appropriateness Rating		MAD-M Values		Consensus Level	
Stakeholder Group	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**
Entire panel	27	23	8	8	2.00	1.83	High	High
Recycled water program	5	3	9	9	2.20	1.33	Medium	High
Water supply program	8	7	8	8	1.50	1.43	High	High
Regulatory agency	6	7	9.5	9	1.33	1.71	High	Medium
Nongovernmental organization	2	2	4.5	5.5	0.50	0.50	High	High
Recycled water customer	2	2	7.5	8.5	1.50	1.50	High	High
Academia	4	3	6.5	7	2.00	1.67	Medium	Medium

3.5.2.2 Qualitative Analysis: Major Panel Themes

All stakeholder groups emphasized the idea that community support is critical to program success. Some Delphi panelists were wary of using the metric because they felt it required conducting a public survey, whose outcome was problematic and possibly not accurate. Major themes from the qualitative analysis of participant comments for the community support metric are displayed in Table 3.48.

Table 3.33. Community Support Metric: Major Panel Themes

No. of Comments	Theme	Representative Comment
5	Public acceptance is critical.	"I believe public support is critical because people who don't support the project can either stop the project or delay or increase the cost due to additional studies, overturning board of directors, staging protests, etc." (Regulatory Agency, U.S. EPA)
5	Surveys are problematic.	"Community Surveys could provide a broader picture and a deeper picture of consumer acceptance of the program, but surveys can be manipulated." (Nongovernmental Organization, U.S.)

3.5.2.3 Metric Value Indicative of Effective Recycled Water Program

Eighty-eight percent of panelists selected a quantitative metric value for a "good" level of community support. Twelve percent of the panel chose "do not know" or "none of the above." The remaining responses varied over the range of choices given. The most votes (38%) were cast for a value of 81 to 90% community support; however, the panel's level of consensus on this value was low. The percentages of responses for all values are given in Table 3.34.

Data from several studies of actual community support are in line with the Delphi panel results. For example, a survey in Victor Valley, CA showed that 82% of the community supported recycled water for nonpotable applications (Humphreys, 2006). In addition, a survey of 1,116 residents in Corvallis, OR indicated that the majority (65–89%) of the community was "favorable" or "very favorable" toward using recycled water for most irrigation applications, industrial applications, and a commercial application (car wash) (Dubose, 2009). Survey data reviewed by Marks show a similarly high level of public acceptance for nonpotable applications in seven Californian and Australian communities that included industrial applications (from 79 to 95%) and irrigation applications (from 47 to 98%, including household gardens) (Marks, 2006). Finally, Liu (2006) also found high levels of public support for recycled water use, with 83% of survey respondents in favor of recycled water for nonpotable public uses; 69% for industrial uses; and 39% for nonpotable personal uses (e.g., clothes washing).

Table 3.34. Community Support Metric: Indicative Value of Effectiveness

	All Values				Exclude "dnk" and "nota"			
	No. of Votes		% of Votes		No. of Votes		% of Votes	
	R1	R2	R1	R2	R1	R2	R1	R2
40 to 50%	1	0	4%	0%	1	0	4%	0%
51 to 60%	1	2	4%	8%	1	2	4%	10%
61 to 70%	4	2	14%	8%	4	2	17%	10%
71 to 80%	8	7	29%	29%	8	7	33%	33%
81 to 90%	7	8	25%	33%	7	8	29%	38%
91 to 100%	3	2	11%	8%	3	2	13%	10%
None of the above	1	1	4%	4%	-	-	-	-
Do not know	3	2	11%	8%	-	-	-	-
Total	28	24	100%	100%	24	21	100%	100%

Notes: "dnk" = do not know; "nota" = none of the above.

3.6 Industry Trends

3.6.1 Contaminants of Emerging Concern Monitoring and Planning

For the purposes of this study, contaminants of emerging concern (CECs) were defined as a diverse group of relatively unmonitored and unregulated chemicals found in consumer and industrial products that have been shown to occur at trace levels in wastewater discharges, ambient receiving waters, and drinking water supplies. A key excerpt from the test statement presented to the Delphi panelists is shown in Figure 3.2, and the full survey question can be found in Appendix A.

Water supply agencies have identified contaminants of emerging concern (CECs) as a future set of issues that require resolution before recycled water programs can move to indirect potable reuse (IPR). Outside of this application, there are concerns in the scientific community that CECS, even in small concentrations, can adversely affect aquatic life.

CECs are a diverse group of relatively unmonitored and unregulated chemicals found in consumer and industrial products that have been shown to occur at trace levels in wastewater discharges, ambient receiving waters, and drinking water supplies. CECs include pharmaceuticals, personal care products, and other commercial and industrial compounds.

A 2009 national workshop including more than 50 scientists, regulators, and stakeholders working on this topic estimates that there are more than 100,000 chemicals approved for use in the U.S., but only analytical methods to test for several hundred at concentrations of interest (e.g., parts per trillion).

One metric that has been proposed to evaluate overall effectiveness of recycled water programs is the extent to which CECs are being addressed by the program. There is no specific industrywide metric commonly used to evaluate or measure this criterion. On the basis of the study team's review of existing data on this topic, program activities generally fall into one of following four stages:

(D) Program not monitoring for CECs, no plans for future monitoring
(C) Program not monitoring for CECs, but plans to within next 3 years
(B) Program monitoring some CECs
(A) Program monitoring some CECs and has active strategy for future management

Figure 3.2. Delphi survey excerpt for CECs.

3.6.1.1 Appropriateness Ratings and Consensus Levels

The study's CEC metric measured a program's level of activity for monitoring CECs. Its values ranged from "not monitoring for CECs, and no plans for future monitoring" to "monitoring for some CECs and has active strategy for future management." The Delphi panel rated this metric as appropriate, with a median rating of 7. The NGO and recycled water customer groups rated the metric highest, with a median rating of 8.5. The water supply program group rated the metric lowest, with a median rating of 3. All ratings and consensus levels for the CEC monitoring and planning metric are included in Table 3.35. The Delphi panel exhibited a low level of consensus for this metric. Consensus levels for individual stakeholder groups varied widely.

Table 3.35. CEC Monitoring and Planning Metric: Median Appropriateness Rating and Consensus Level

	Number of Experts		Median Appropriateness Rating		MAD-M Values		Consensus Level	
Stakeholder Group	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**
Entire panel	26	24	7	7	2.92	3.08	Low	Low
Recycled water program	5	4	2	5	3.60	4.00	Low	Low
Water supply program	8	7	4	3	3.00	2.43	Low	Medium
Regulatory agency	6	7	7.5	8	2.67	2.43	Low	Low
Nongovernmental organization	2	2	7.5	8.5	2.50	1.50	Low	Medium
Recycled water customer	2	2	8.5	8.5	1.50	1.50	High	High
Academia	3	2	7	7.5	0.33	0.50	High	High

3.6.1.2 Qualitative Analysis: Major Panel Themes

A total of seven themes were generated from panelists' comments on the CEC monitoring and strategy metric, the most for any proposed metric. The most cited theme was supportive of using the metric for program evaluation, and statements made by respondents indicated that they felt monitoring CECs shows a program is proactive. Stakeholders in nearly every group commented that CECs are not well understood. Specific statements elaborated on the position that there is no agreement on the specific chemicals that should be monitored, the specific analytical methods used, or how results should be interpreted. The recycled water program and water supply program stakeholders especially emphasized these points, adding that CEC monitoring would add to program costs.

Other participants felt that CECs should only be monitored if recycled water was used for certain applications, specifically IPR or groundwater recharge. The panel was divided on whether monitoring CECs would increase or decrease public acceptance of recycled water.

Still other panelists expressed the opinion that monitoring CECs would contribute to much needed research on the subject. Finally, two participants pointed out that in terms of CECs, recycled water is no different from potable water and should not be held to a higher standard. Major panel themes for the CEC monitoring and strategy metric are displayed in Table 3.36.

3.6.1.3 Metric Value Indicative of Effective Recycled Water Program

The CEC monitoring and planning metric values were organized using a nominal lettering system. For example, the letter A was used to describe an active CEC monitoring and management plan. The letter D was used to describe the lack of an active CEC management plan. In the survey, panelists were asked to what would be a good “letter grade” for CEC monitoring and strategy for a recycled water program in operation for 5 years or more.

Table 3.36. CEC Monitoring and Planning Metric: Major Panel Themes

No. of Comments	Theme	Representative Comment
7	Monitoring CECs is proactive.	“While I still think this is largely about a utility being proactive, and not a direct measure of its recycled water program effectiveness, it seems reasonable to me that a utility that isn't even thinking about CECs probably doesn't have an effective recycled water program….” (Nongovernmental Organization, U.S.)
6	CEC are not well understood.	“The problem with monitoring and reporting CEC's (in addition to the considerable cost) is that the lack of standards in combination with the extremely low concentrations and uncertainties about analytical procedures tend to leave a lot of questions and few answers….CEC's are still in the research phase and should not become a monitoring and reporting practice until there is better understanding of the meaning of the data.” (Recycled Water Program, FL)
5	CEC monitoring is dependent on end use.	“If the water is being used primarily for lawn irrigation, I am not sure why the level of CECs would be important. However if the reclaimed water is being used to recharge an aquifer that is… a drinking water source there would probably be a need to monitor CECs.” (Water Supply Program, FL)
5	Monitoring and reporting CECs is critical to public acceptance.	“The public wants to know that they won't have any adverse effects from using recycled water. It is critical to convey to the public that recycled water use is safe. Cities/agencies should provide information to the public with information on what they are doing to address the issue.” (Water Supply Program, CA)
3	Monitoring CECs will contribute to needed research.	“An indicator monitoring approach to CECs is appropriate to satisfy the public that CECs are being controlled, to indicate that CECs are being significantly reduced (or not) based on current treatment, and to provide information on further CEC-related research needs.” (Regulatory Agency, CA).
2	In regard to CEC, recycled water is not different from potable water and should not be held to higher standards.	“If reclaimed water is tested for contaminants that are not being tested in drinking water and surface waters, the big picture can be misconstrued. A recent study conducted by the Southwest Florida Water Management District found that for many CECs reclaimed water was no different than surface or groundwater. Many of these contaminants are now found ubiquitously in the environment….” (Regulatory Agency, FL)
2	Monitoring CECs could lead the public to believe recycled water is unsafe.	“This type of metric requires an educated consumer and generally leads to alarmist conclusions….” (Recycled Water Program, FL)

Sixty-nine percent of the panel selected a metric value for what a “good” program should be doing to address CECs; 29% of respondents selected “do not know” or “none of the above” as their answer to this question. Of those who did select a metric value, most (47%) thought an effective recycled water program should be actively managing CECs (letter grade “A”). There are no publicly available data on how many recycled water programs in the United States currently monitor or plan to monitor CECs. The level of consensus for the metric value decreased between rounds 1 and 2 from medium to low. The percentages of responses for all values are given in Table 3.37.

Table 3.37. CEC Monitoring and Planning Metric: Value Indicative of Effectiveness

	All Values				Exclude "dnk" and "nota"			
	No. of Votes		% of Votes		No. of Votes		% of Votes	
	R1	R2	R1	R2	R1	R2	R1	R2
D	2	2	8%	8%	2	2	12%	12%
C	1	1	4%	4%	1	1	6%	6%
B	6	6	23%	25%	6	6	35%	35%
A	8	8	31%	33%	8	8	47%	47%
None of the above	6	5	23%	21%	—	—	—	—
Do not know	3	2	12%	8%	—	—	—	—
Total	26	24	100%	100%	17	17	100%	100%

Notes: A: monitoring some CECs with active strategy, B: monitoring some CECs, C: not monitoring, but plan to within 3 years, D: not monitoring with no plans for future monitoring.

"dnk" = do not know; "nota" = none of the above.

3.6.2 Indirect Potable Reuse Planning and Strategy

Although IPR and EI did not receive high appropriateness ratings from the Delphi panel as a whole, these topics do represent important industry trends. Therefore, panelists’ ratings and comments for these criteria are presented to provide insight into stakeholder perspectives for these issues.

For the purposes of this study, IPR was defined the blending of advanced treated recycled or reclaimed water into a natural water source (groundwater basin or reservoir) that can be used for drinking (potable) water after further treatment. A key excerpt from the test statement presented to the Delphi panelists is shown in Figure 3.3 and the full survey question can be found in Appendix A.

Indirect potable reuse (IPR) is the blending of advanced treated recycled or reclaimed water into a natural water source (groundwater basin or reservoir) that can be used for drinking (potable) water after further treatment. Applications of IPR include groundwater recharge and reservoir augmentation.

For example, Orange County's Groundwater Replenishment System (GWRS) utilizes microfiltration, reverse osmosis, and ultraviolet light with hydrogen peroxide to treat wastewater. This treated water is then pumped to recharge basins where it naturally filters into the groundwater basin, augmenting drinking water supplies. Other IPR projects have been implemented in Scottsdale, AZ and Upper Occoquan, VA. Advocates of water reuse consider IPR to be a concrete example of recycled water being used for one of its highest possible purposes. On a larger scale, unplanned indirect potable reuse is occurring in virtually every major river system in the United States today.

In contrast, some IPR projects, such as those in San Diego and Dublin/San Ramon, CA, and Tampa, FL have experienced a high degree of public skepticism, lack of support from key decision-makers, or even public opposition. These responses largely stem from concerns that pathogenic organisms may not be adequately removed during treatment processes and negative branding.

There is no specific quantitative measure for evaluating the extent of a program's IPR activities. On the basis of the study team's assessment of available data, the status of U.S. IPR programs generally fall into one of the following stages.

(E) Program has no current or future plans to use recycled water for IPR purposes
(D) Program considering developing IPR plan within next 3 to 5 years
(C) Program has completed plans for IPR project
(B) Program has completed plans for IPR project and is in construction phase
(A) Program currently using some form of IPR

Figure 3.3. Delphi survey excerpt for IPR.

3.6.2.1 Appropriateness Ratings and Consensus Levels

The Delphi panel rated the IPR planning and strategy metric the second lowest of all proposed metrics, with a median appropriateness rating of 5. Only one stakeholder group, the NGOs, rated this metric appropriate to use in a program evaluation. The median appropriateness ratings and consensus levels for the IPR planning and strategy metric are shown in Table 3.38. The Delphi panel displayed a low level of consensus when rating the IPR planning and strategy metric. Individual stakeholder group consensus levels ranged from low to medium. All consensus-level measurements are displayed in Table 3.38.

Table 3.38. IPR Planning and Strategy Metric: Median Appropriateness Rating and Consensus Level

	Number of Panelists		Median Appropriateness Rating		MAD-M Values		Consensus Levels	
Stakeholder Group	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**
Entire panel	26	24	5	5	3.15	3.00	Low	Low
Recycled water program	5	4	5	6.5	3.40	3.00	Low	Low
Water supply program	7	7	4	5	2.71	2.86	Medium	Medium
Regulatory agency	6	7	2.5	6	2.67	3.00	Low	Low
Nongovernmental organization	2	2	7.5	7.5	2.50	2.50	Low	Low
Recycled water customer	2	2	8	6.5	2.00	3.50	Medium	Low
Academia	4	2	4	2	3.50	1.00	Low	Medium

3.6.2.2 Qualitative Analysis: Major Panel Themes

Some of the themes generated from Delphi panelists' comments were similar to those found for the EI metric. Many Delphi panelists felt that the metric should be a secondary metric or "extra credit." Others did not believe the metric measured the effectiveness of a recycled water program. The most interesting question raised from the Delphi panelists' comments is whether or not IPR should be a goal of a recycled water program. Two Delphi panelists wrote that "IPR is the top goal of a recycled water program" and four Delphi panelists wrote that "IPR is not the top goal of a recycled water program." The two Delphi panelists in agreement that IPR is a top goal come from the recycled water program and water supply program stakeholder groups. The Delphi panelists who voiced the opposite view came from the regulatory agency, academia, and also the water supply program stakeholder groups. The member from the water supply program stakeholder group who did not think IPR should be a goal argued that it is more important to meet water supply needs than to have an IPR program. The member from the regulatory agency felt that IPR is just too risky to promote, and the academia group members remarked that a recycled water program with an IPR component may or may not be effective, but that the presence of an IPR component did not, in and of itself, indicate an effective program. Major themes from participant comments for the IPR planning and strategy metric are displayed in Table 3.39.

These results for this metric group were surprising, given the high level of state and federal activity on the IPR front. With changing population demographics and climate change concerns, IPR and even direct potable reuse (DPR) activities going on across the United States have never been more active. Numerous publications and projects illustrate considerable interest at the regional, state, multistate, and federal levels in exploring how DPR and IPR can significantly augment the nation's potable water supply. In fact, in their report on the national potential for municipal wastewater reuse, the National Academy of Sciences does not distinguish between DPR and IPR, using instead the term potable reuse (NRC, 2012).

Other work also illustrates the implementation of small- to large-scale IPR projects, including Rodriguez et al.'s (2009) study, which provides details on 14 demonstration and full-scale IPR projects in the United States and Hong Kong serving populations from 60,000 to 2.3 million people. The paper also mentions 10 other current projects in Arizona, California, Georgia, and Nevada. In addition, there are the Multi-state Salinity Coalition's and Southern California's Salinity Coalition's projects on IPR, which are viewed as a way of addressing salinity in drinking water aquifers (Mosher, 2012) and Schroeder et al.'s (2012) investigation into the potential of DPR and its benefits to public water supplies, agriculture, the environment, and energy conservation. Along the same lines, in 2012, the EPA released a new set of guidelines for water reuse (U.S. EPA, 2012).

However, the results of this study do not refute the assertion that IPR is an important trend for the industry. Nor do they disagree with the position that IPR has the potential to be an important part of future supply portfolios. The question the Delphi survey asked was this: Is the status of a recycled water provider's IPR program an appropriate metric of its overall performance? The Delphi panel as a whole did not consider this criterion to be an appropriate metric. This is different from asking: Is IPR an important part of future water resources management? Or, is it a growing trend in the industry? To both these questions, the answer would be a definite yes. Another confusion might concern the unit of analysis (i.e., the level of organization that is the basis for this study). For this project, the unit of analysis is the recycled water program, not regional or state water supply management.

The Delphi survey results show that opinions on the usefulness of IPR as a program evaluation tool varied significantly among panelists. The panel's comments reflect concerns that they may feel require resolution before moving forward with IPR efforts. Also, some respondents felt that a program could be doing well (i.e., meeting its goals) without necessarily having an IPR component. Several panelists commented that the need for IPR is very location-dependent and that IPR is only one of several ways to augment water supply. Again, these comments return to the recurring question of whether the principal goals of recycled water programs are to use as much recycled water as possible (i.e., maximize volume) or to reuse water for a specific purpose (i.e., try to use recycled water for the best possible application).

Table 3.39. IPR Planning and Strategy Metric: Major Panel Themes

No. of Comments	Theme	Representative Comment
5	IPR is secondary metric.	"I don't believe a judgment of how successful an urban recycled water program is should be based on this criterion…. I would not grade a program lower in success in the absence of it but would highlight it when it occurs." (Regulatory Agency, U.S. EPA)
4	IPR is not top goal of recycled water program.	"The existence of indirect potable use is not the goal, it is how effective the program is at meeting water supply needs." (Water Supply Program, AZ)
4	IPR metric is not a measure of effectiveness.	"This metric is interesting but does not answer the question of program effectiveness. There are too many specific details related to this measurement to make it relevant overall." (Recycled Water Customer, CA)
2	IPR is top goal of recycled water program.	"Indirect potable reuse is by far one of the best uses of reclaimed water if the agency has a good conservation program in place and wisely controls uses of potable water (Recycled Water Program, AZ)

3.6.2.3 Metric Value Indicative of Effective Recycled Water Program

Similarly to the product diversification metric, a nominal lettering system was developed for the values of the IPR planning and strategy metric. The system for this metric was based on a 5-point scale (from A, meaning that a program is using IPR, to E, meaning that the program has no current or future plans to use IPR). Nearly half of the panelists responded "do not know" or "none of the above" for the metric value. Of those that chose a value, most (46%) selected a letter grade of "D" to indicate an effective recycled water program (i.e., the program is considering developing an IPR plan within the next 3 to 5 years). Because there is no established metric to measure how or if recycled water programs are planning for IPR, there are no known reference values available to compare to the study findings. The panel's level of consensus for the metric value was low. The distribution of responses for the IPR planning and strategy metric is listed in Table 3.40.

Table 3.40. IPR Planning and Strategy Metric: Value Indicative of Effectiveness

	All Values				Exclude "dnk" and "nota"			
	No. of Votes		% of Votes		No. of Votes		% of Votes	
	R1	R2	R1	R2	R1	R2	R1	R2
E	1	0	4%	0%	1	0	7%	0%
D	6	6	21%	24%	6	6	43%	46%
C	2	3	7%	12%	2	3	14%	23%
B	2	2	7%	8%	2	2	14%	15%
A	3	2	11%	8%	3	2	21%	15%
None of the above	9	6	32%	24%	-	-	-	-
Do not know	5	6	18%	24%	-	-	-	-

Notes: "dnk" = do not know; "nota" = none of the above; Refer to Table 1.6

3.6.3 Energy Intensity

Energy intensity (EI) is defined as the relative amount of energy (in kWh/AF) required to produce supply from various water sources. It includes estimated energy use for supply/storage, conveyance, end use, treatment, and distribution**.**

3.6.3.1 Appropriateness Ratings and Consensus Levels

The Delphi panel rated the EI metric unsuitable to measure recycled water program effectiveness. The recycled water program group rated the metric highest, with a median rating of 7.5. The water supply program group rated the metric lowest, with a median rating of 4. Table 3.41 shows all stakeholder group median metric ratings and consensus levels. The Delphi panel exhibited a low level of consensus when rating the EI metric. Individual stakeholder group consensus levels varied widely from low to high. Consensus-level measurements are included in 3.59.

Table 3.41. Energy Intensity Metric: Median Appropriateness Rating and Consensus Level

	Number of Panelists		Median Appropriateness Rating		MAD-M Values		Consensus Level	
Stakeholder Group	R1	R2	R1	R2	R1	R2	R1	R2
Entire panel	26	24	7	6	2.58	2.67	Medium	Low
Recycled water program	5	4	9	7.5	1.80	2.00	Medium	Medium
Water supply program	8	7	6	4	3.13	3.57	Low	Low
Regulatory agency	6	7	8	6	3.33	2.86	Low	Low
Nongovernmental organization	2	2	6.5	6.5	0.50	0.50	High	High
Recycled water customer	2	2	7	7	3.00	3.00	Low	Low
Academia	3	2	6	6	1.00	1.00	High	Medium

3.6.3.2 Qualitative Analysis: Major Panel Themes

The only theme to emerge from panel comments was that EI is closely related to the cost of water supply. The major reasons given to explain the metric's low appropriateness rating were that EI should be a secondary metric or once again "extra credit," because other recycled water program goals of the program may be more important than the need to reduce

EI. In addition, panelists felt that the energy intensity of water sources will be different for every location. Table 3.42 shows the major themes that emerged from the qualitative analysis of participant comments for this metric.

Table 3.42. Energy Intensity Metric: Major Panel Themes

No. of Comments	Theme	Representative Comment
4	Energy intensity should be a secondary metric.	"Since this issue is of increasing concern, especially if water is used to create energy, it is important, but…it is not the most important variable." (Academia, AZ)
3	Goal(s) of program may outweigh energy intensity.	"[Metric] can be misleading because there may be a relatively low energy water source, but recycled water would increase water in the ecosystem for threatened… species. In other areas with high ground water tables… using recycled water may use less energy but this use could increase flooding events." (Regulatory Agency, U.S. EPA)
3	Energy intensity is locally specific.	"The energy consumption for different types of reclaimed water applications is largely dependent on the necessary treatment to achieve local and state regulations for that application…." (Regulatory Agency, FL)
3	Energy intensity impacts the cost of recycled water and is therefore an appropriate metric.	"Energy impacts the cost of the recycled water and may contribute to air pollution and expenditure of natural resources. Therefore, it is key to consider energy expenditures when considering sources of water.…" (Regulatory Agency, U.S. EPA)
2	Metric demonstrates one of the benefits of recycled water.	"Good metric. This metric is quantitative and objective when it comes to the benefits of reclaimed water." (Recycled Water Program, AZ)
2	Cost effectiveness of source will outweigh energy intensity of source.	"While I think this is a good metric…for…decision making…I don't see how it is an indicator of effectiveness…. Fresh groundwater in Florida is relatively cheap where available and surface waters are substantially expensive while those relative costs in other parts of the country will be different and/or reversed." (Regulatory Agency, Florida)

3.6.3.3 Metric Value Indicative of Effective Recycled Water Program

For this metric, the EI of recycled water was compared to two sources, groundwater and imported water. Approximately one-third of the panel did not know how the EI of recycled water should compare with the two sources, and approximately 20% responded "none of the above" for both comparisons. Of the remaining half, who selected a metric value, most said the EI of recycled water should be 30% less than the energy intensity of a groundwater or imported water source, but the panel consensus level for this metric value was low.

The Delphi panel's response is in alignment with actual known program performance. From the report where the metric was adapted, the EI ratio for recycled water in Santa Clara County, CA, is about 50% less than for groundwater (Larabee et al., 2010). No value for how recycled water compared to imported water was cited in the report. The percentages of responses for all values are given in Tables 3.43 and 3.44.

Table 3.43. Energy Intensity Metric—Compared to Groundwater: Value Indicating Effectiveness

	All Values				Exclude "dnk" and "nota"			
	No. of Votes		% of Votes		No. of Votes		% of Votes	
	R1	R2	R1	R2	R1	R2	R1	R2
5% to 10% less	3	3	12%	13%	3	3	30%	30%
11% to 20% less	3	1	12%	4%	3	1	30%	10%
21% to 30% less	1	2	4%	8%	1	2	10%	20%
More than 30% less	3	4	12%	17%	3	4	30%	40%
None of the above	5	5	19%	21%	-	-	-	-
Do not know	11	9	42%	38%	-	-	-	-
Total	26	24	100%	100%	10	10	100%	100%

Notes: "dnk" = do not know; "nota" = none of the above.

Table 3.44. Energy Intensity Metric—Compared to Imported Water: Value Indicating Effectiveness

	All Values				Exclude "dnk" and "nota"			
	No. of Votes		% of Votes		No. of Votes		% of Votes	
	R1	R2	R1	R2	R1	R2	R1	R2
5% to 10% less	4	3	15%	13%	4	3	29%	25%
11% to 20% less	0	0	0%	0%	0	0	0%	0%
21% to 30% less	3	2	12%	8%	3	2	21%	17%
More than 30% less	7	7	27%	29%	7	7	50%	58%
None of the above	4	4	15%	17%	-	-	-	-
Do not know	8	8	31%	33%	-	-	-	-
Total	26	24	100%	100%	10	10	100%	100%

Notes: "dnk" = do not know; "nota" = none of the above

Chapter 4

Objective 1: Agreement between Stakeholder Groups and Stakeholder Group Positions

This chapter describes the extent to which recycled water stakeholder groups agreed on the metrics presented in the Delphi survey. First, it presents metric ratings organized by stakeholder group (e.g., NGO, regulatory agency). The second and third parts of the chapter highlight areas of agreement and disagreement between stakeholder groups. The chapter concludes with a section analyzing the ratings and opinions group by group.

4.1 Metric Ratings by Stakeholder Group

Using the metric classification scheme of high, medium, and low levels of appropriateness described in Section 2.3.1 (Data Analysis), Table 4.1 shows how the Delphi panelists rated the 16 proposed program evaluation criteria, organized by stakeholder group. These results illustrate within-group opinions (e.g., how did the regulatory agencies feel about product diversification) as opposed to the panel as a whole. The recycled water customer group had the greatest number of metrics (10) rated highly appropriate. The recycled water program and academia groups had the fewest (4). Table 4.1 shows that three metrics—customer satisfaction, voter support, and community support—were rated highly appropriate by four or more groups.

This result mirrors the results for the Delphi panel as a whole. However, a new metric, recycled water utilization ratio, moves up on the appropriateness scale when the data are analyzed through this lens. Also noteworthy is the downward movement of the portfolio contribution metric on the appropriateness scale. In this scenario, portfolio contribution is rated highly appropriate only by two stakeholder groups. One important factor explaining differences in metric appropriateness ratings is the number of panelists in each stakeholder group. Three groups—the recycled water program, water supply program, and regulatory agency groups—had six to eight participants. Three groups—NGOs, recycled water customer, and academia had two or three participants. Therefore, input from the groups with a larger number of participants is weighted more heavily in Chapter 3, whereas input from all groups is considered more equally in this chapter.

4.2 Areas of Agreement

Members of the recycled water program and water supply program groups agreed that the following four metrics were highly appropriate for program evaluation: water quality, customer satisfaction, voter support, and community support. This set comprised all the metrics rated highly appropriate by the recycled water program group (i.e., 100% overlap). In addition, the water supply program group rated supply portfolio contribution as highly appropriate.

The recycled water program and water supply program groups provided similar appropriateness ratings for six criteria. The median appropriateness ratings were within 1 point of each other for the following metrics: community support metrics (rated 8 and 9); water quality (rated 8 and 8.5); voter support (rated 8 by both); value-added services (rated

7.5 and 7); volume growth rate (5 and 4); portfolio contribution (5 and 6). This relatively high level of agreement indicates that the two stakeholder groups share similar ideas about how recycled water programs might be evaluated. Also, it could mean that the supply and treatment sides of water resources management have become more integrated as supply has become scarcer in many U.S. cities and climate change mitigation issues have loomed larger. If this is indeed the case, it is promising for the future growth of recycled water. Historically in the United States, water supply and recycled water (as part of the wastewater treatment plant) had different missions and goals.

In previous decades, supply agencies were directed to provide potable water, and wastewater treatment plants (and associated reuse programs) were to "dispose of" wastewater. Now that recycle water programs are, in effect, closing the urban water cycle loop by bringing treated wastewater back into the use cycle, these functions find their purposes aligning. This explanation is supported by statements made by interviews at the recycled water case study programs, such as EBMUD, where the recycled water program has recently been reorganized within the utility to report up through the water supply side of the organization (Hu, 2012).

Delphi survey results indicate a greater difference in opinion between participants in the recycled water program group and in the regulatory group. However, a few areas of agreement are worth noting. Participants in both groups identified voter support and community support as highly appropriate for program evaluation. These were also the only two criteria that water supply programs and regulatory agency participants rated as highly appropriate. Respondents from the regulatory agency and recycled water program groups also agreed that the status of a program's IPR activities was not a suitable metric of program performance.

Table 4.1 Appropriateness of Metrics for Program Evaluation by Stakeholder Group

		Stakeholder Group					
Metric	**Category**	**RWP**	**WSP**	**RA**	**NGO**	**RWC**	**AC**
Water quality	Quantity and quality	High	High		High	Mod	
RW utilization ratio	Quantity and quality			High	High	High	High
RW portfolio contribution	Quantity and quality			High		High	Low
Flow ratio	Quantity and quality		High	Mod	High	Mod	
Volume growth rate	Quantity and quality			Mod		High	
Product diversification	Application breadth			High		High	High
RW application range	Application breadth			Low		High	
Customer satisfaction	Customer support	High	High	Mod	Mod	High	High
Value-added services	Customer support	Mod	Low			High	
Customer complaints	Customer support			Low	High	Low	
Voter support	Public perception	High	High	High	High	High	Mod
Community support	Public perception	High	High	High		High	Mod
O&M cost recovery ratio	Cost recovery			Low			
CEC monitoring & strategy	Progressiveness			Low	Mod	High	High
EI	Progressiveness	Mod				Low	
IPR planning & strategy	Progressiveness				Low		
No. highly appropriate metrics		4	5	5	5	10	4
No. moderately appropriate metrics		2	0	3	2	2	2
No. low level of appropriateness		0	1	4	1	2	1

Notes: RW = recycled water; RWP = recycled water program, WSP = water supply program, RA = regulatory agency, NGO = nongovernmental organization, RWC = recycled water customer, AC = academia

4.3 Where Opinions Diverged

The ratings of the recycled water program survey participants differed significantly from the responses in the regulator group for 9 out of 16 proposed criteria, reflecting an apparent disparity on what metrics participants felt could and should be used to evaluate program performance. For example, for the criteria of portfolio contribution, flow ratio, product diversification, application range, CECs, cost recovery, utilization ratio, and customer complaints, the difference in median appropriateness ratings between the two groups is 3 points or more on a 10-point scale. During a field research visit conducted in September 2011 to Tucson, AZ, interview data confirmed that even in this city, which has arguably the most progressive recycled water program in the state, there were still differences in the perceived extent to which the recycled water program managers felt that state regulators understood and shared similar goals for recycled water (Dotson, 2011). This discrepancy likely reflects the traditional differences between wastewater treatment plans (as regulated entities) and regulatory agencies (as the organizations that monitor and set limits on their operations). On a positive note, however, the differences pinpoint areas around which further communication can be designed to promote shared understanding and goal setting.

Participant comments about the primacy of the volume of recycled water used versus the applications for which it was being used emerged as the strongest difference among stakeholder groups, particularly between recycled water program managers and regulators. These differences were elaborated in many of the comments made by recycled water program managers about the need for program metrics to incorporate the specific context of individual programs (e.g., climate, seasonality, sources of water supply, customer base) and not to use too broad a measure, such as flow ratio, that does not distinguish between different applications of recycled water. The report presents more details on the relationship between these two groups in Chapter 6.

Another area of notable controversy was CECs. In response to questions on this criterion, a total of seven themes were identified from 31 panelist comments. This topic generated the most respondent comments of any criterion. The Delphi panel as a whole exhibited a low level of consensus for this metric and consensus levels within individual stakeholder groups (e.g., regulators) varied widely. The most cited theme (present in seven comments) was supportive of the metric and claimed that monitoring CECs shows a program is proactive. Six commenters representing nearly every stakeholder group argued that CECs are not well understood and several felt that it was inappropriate to monitor for CECs at this time, because none of them are currently regulated at the federal level.

4.4 Stakeholder Group Positions

The following discussion draws on Delphi panel comments to help explain the positions of respondents in each stakeholder group and identify common themes.

4.4.1. Recycled Water Program

The recycled water program panelists held a wide range of opinions on most metrics. Many comments made in by this group focused on *how* recycled water is used (i.e., its specific application). Others comments highlighted the degree to which recycled water is able to stretch potable supplies and contribute to a community's water needs.

Stakeholders appeared to rate most of the proposed metrics using the same question: whether or not the proposed metric was within or outside the program's control. This was evident from the number and type of stakeholder references to limits on demand. From this group's perspective, areas their programs are able to control include recycled water quality, EI, customer service, and public and consumer education. In these areas, where the stakeholders feel they have control, group members agree it is appropriate to be evaluated.

For quantity-based metrics, members pointed out several factors affecting demand for recycled water. From this particular respondent group's perspective, the program itself is only able to control a few factors influencing the volume of recycled water consumed. The four factors that recycled water program stakeholders repeatedly mentioned as affecting demand are climate, production capacity, the type and number of applications available, and the economy. A complete list of factors limiting demand identified by all Delphi survey participants is shown in Table 4.2.

Table 4.2 Factors Limiting Recycled Water Demand

	Number of Comments by Stakeholder Group						
Factors Limiting Growth or Demand	**RWP**	**WSP**	**RA**	**NGO**	**RWC**	**AC**	**Total**
Cost effectiveness	2	9	2				13
Climate	5	2	4		1	1	13
Application	3	7					10
Capacity/limited supply	4	1	2			1	8
Economy	3	3			1	1	7
Customer	2	4					6
Water scarcity		5		1			5
Acceptance	1		4				5
Regulations	2	2					4
Infrastructure		3					3
Conservation	2	1					3
Urban growth	1	1					2
Water rates	1	1					2
Total	26	39	12	1	2	3	83

It is interesting to note that of the factors influencing the volume of recycled water consumed, public acceptance and inconsistency in regulatory standards were seldom mentioned by recycled water program group participants. This finding differs from much of the existing literature on recycled water programs, which emphasizes public acceptance as the key to successful programs. This is not to say that recycled water program stakeholders did not view public support as important. This group gave a median rating of 8 to both community and voter support. The fact that this group of respondents did not list public acceptance directly as a growth-limiting factor may be due to the panel's experience with existing programs. Public acceptance is of primary importance before and during the early stages of use. As the receiving community becomes more used to the idea of recycled water for conventional applications, the emphasis on public acceptance may not be as necessary, unless novel applications are being considered.

The recycled water program panelists did not rate either of the application breadth metrics appropriate for overall program evaluation. The production diversification metric was closer (median rating: 6) to being rated appropriate than the recycled water application range metric (median rating: 4.5). Panelists explained in their comments that the basis for the application range metric (the number of applications for which recycled water is used) is primarily determined by the customer, not by them. Product diversification, on the other hand, is an approach that allows the program to have more of a say in determining what quality of water is needed for a specific customer need. One interpretation of these comments is that recycled water program respondents felt that they have control over the degree of product diversification and not the range of applications for which recycled water is used. This subtle but distinct difference could explain the difference in the group's ratings of these two metrics.

The O&M cost recovery ratio metric was the only metric not rated through the lens of program control. For the O&M cost recovery ratio metric, recycled water program stakeholder comments fell into two categories. One set of comments wanted more details included in the metric formula: for example, capital investments and avoided costs. The other set of comments questioned if the metric could be calculated in such a way as to allow for a fair and equal comparison of programs. Because the water situation of every program is unique, costs to produce recycled water will likewise vary. The difficulty of quantifying the social and environmental benefits of recycled water also adds to the complexity of determining the appropriateness of this metric.

Taken together, the ratings and comments from this group indicate a desire for evaluation metrics that can be normalized or adapted to the unique circumstances of individual programs. Respondents do not want programs to be held accountable for metrics they perceive as being out of their control. The challenge will be to balance the specificity of the metric with its usefulness as a general indicator of performance.

4.4.2 Water Supply Program

The water supply program group was the third most unified of all stakeholder groups. Only two metrics had a low level of consensus; all other metrics had a medium or high level of within-group consensus. When commenting on metrics, water supply program participants appeared to focus on two issues.

The first was the metric's ability to reflect the quantity of potable water offset by recycled water. Despite this focus, however, the water supply program stakeholders rated only one quantity-based metric, flow ratio, appropriate for the evaluation of recycled water program effectiveness.

Second, similarly to comments of the recycled water program stakeholders, the water supply program panelists' comments focused on whether the main factors affecting a metric's value or a program's performance were within or outside the program's control. Somewhat unexpectedly, water supply program stakeholders raised the point much more often than recycled water program stakeholders. The specific factors affecting demand for recycled water were also slightly different from those of recycled water program respondents.

For water supply program respondents, the top factors affecting recycled water demand were cost effectiveness, the number and types of applications available, and the degree of water scarcity in a region. Other factors mentioned that influenced demand included climate, customer need, production capacity, the economy, conservation, urban growth, and water rates. Similarly to the recycled water program stakeholders, regulations were seldom mentioned and public perception or acceptance was never referenced as factors limiting recycled water demand.

4.4.3 Regulatory Agency

As a group, regulatory agency participants demonstrated the widest spectrum of ratings and opinions. However, setting consensus levels aside, the group rated the second largest number of metrics appropriate (12), more than any other group. Their comments emphasized the need for programs to produce and use as much recycled water as possible.

Although water quality concerns are important to the group, the quantity of water recycled, as well as cost recovery, may be equally important. This was the only stakeholder group to rate the O&M cost recovery ratio metric appropriate. In the comments for several metrics, cost or revenue was repeatedly mentioned. In addition, multiple regulatory agency stakeholders stressed that only volumes of recycled water actually sold, not given away, should be included in the calculation of quantity-based metrics. This orientation supports the idea that recycled water should be thought of as a resource and priced accordingly. Respondents mentioned factors that could limit maximizing the use of recycled water use several times. However, comments were general in nature (e.g., “conditions outside a program’s control”).

4.4.4 Recycled Water Customer

Out of all the stakeholder groups, the recycled water customer respondents rated 10 metrics as highly appropriate. Their ratings were also the most unified. The other stakeholder groups rated about half that many as highly appropriate. One interpretation of this result could be that the more measures showing how effective a recycled water program is, the more comfortable the customer may be with the program’s overall service and reliability.

Few comments made by recycled water customer respondents focused on factors inhibiting demand. In fact, respondent comments demonstrated an optimistic view of the industry’s current level of growth and emphasized that overall growth in recycled water use is very dynamic.

From the recycled water customer perspective, recycled water programs must be proactive in educating the public and potential customers about the benefits and safety of using recycled water. The group also emphasized that programs need to provide incentives to potential customers and cater to the needs of current customers.

The only two metrics the group rated unsuitable for the evaluation of recycled water program effectiveness were the O&M cost recovery ratio and the IPR planning and strategy metrics. Members seemed to disagree more on the details for both metrics rather than on the concepts behind them. For both metrics, stakeholders felt that there were too many variables affecting cost recovery or too many details affecting IPR to make the proposed metrics appropriate for rating recycled water program effectiveness.

The generally positive nature of comments made by this group of stakeholders and the lack of negative comments provide support for the argument that the recycled water customers participating in this survey were satisfied with their recycled water service.

4.4.5 Nongovernmental Organization

The NGO respondents were the second most unified group. The small group size (2) likely contributed to the high level of consensus.

The group members mentioned water scarcity as a factor influencing recycled water demand, but the general subject was not a primary focus of their comments. In this sense, their comments differed from those of the recycled water program and water supply program participants.

NGO respondents raised two ideas that were unique among all respondent comments. The first was the idea that water sent to the wastewater treatment plant might be considered to have an economic value, even before treatment. The second comment stated that recycled water was a type of “forced” supply. In this sense, the respondent is probably referring to the de facto use of treated wastewater to augment drinking water supplies. This phenomenon is mentioned as being “common in many of the nation’s water systems” in the recent National Research Council report on water reuse (NRC, 2012).

4.4.6 Academia

The academia stakeholder group was divided over most metrics. Comments made by Delphi survey participants in this group emphasized the need for programs to contribute to meeting the water needs of a region in the most efficient and environmentally sustainable way possible. From the academia perspective, if a recycled water program can reduce the pressure on potable demand and not take water away from environmental purposes (e.g., stream or wetland augmentation), then the application should be supported.

The academia stakeholder group rated 7 of the 16 metrics as appropriate. Panelist comments focused less on factors limiting demand for recycled water, and more on the desire to enhance the explanatory power of a particular metric. In addition, the academia stakeholders tended to examine specific details and the basis of a metric more closely than other stakeholder groups. For example, the water quality metric was questioned because it relied on existing state standards. Panelists felt that three metrics in particular, flow ratio, public support, and voter support, might be too crude as presented and that they would benefit from additional details. For example, one respondent pointed out the need for metrics to link specific recycled water program activities to specific metric values (e.g., extent of outreach efforts community support for a specific application).

Few factors limiting demand or growth of recycled water were mentioned except the degree of regional water scarcity. On the contrary, one stakeholder felt that limitations on recycled water use are not demand-based but supply-based. This respondent also noted that plants may not have the capacity to fulfill existing demand. Two of the three participants in the academia group explicitly stated that program effectiveness is defined by two criteria: (1) the program’s ability to increase the portion of the “water budget” met with recycled water, and (2) increased public acceptance of recycled water.

Chapter 5

Objective 2: Major Metrics for Case Studies

The study's second objective was to identify what major metrics were used by four case study urban recycled water programs and how they might be used to evaluate program performance. To understand which metrics the programs used and why, it is helpful first to understand the programs' origins and how program managers view future demand for recycled water.

5.1 Initial Drivers, Future Demand, and Major Metrics

Table 5.1 presents the initial drivers and self-reported major metrics used by the case study programs. Two programs, Tucson Water and EBMUD, began providing water to external customers in the mid-1980s. The other two programs, SBWR and JEA, began in the late 1990s. Although the driving factor behind both Tucson Water and EBMUD was and continues to be the augmentation of potable water supply, the driving factors behind SBWR and JEA have changed. Initially, the impetus for initiating SBWR's and JEA's programs was discharge-related. For SBWR it was a 120 mgd effluent discharge cap for the main treatment facility; for JEA, it was nitrogen reduction. For both SBWR and JEA, these discharge goals were met years ago. SBWR personnel interviewed for the project felt that the additional goal of augmenting potable water supply to its "driver" list occurred in the mid-2000s. For JEA, the main factor driving its current reclaimed water program is the need to meet promised delivery goals outlined in its consumptive use permit (CUP) conditions (Chansler, 2012; Hankin, 2012; Mann, 2012; Porter, 2012; Steinbrecher, 2012). According to Karl Hankin, a Planning Director for JEA, this issue became a strong driving force in its reclaimed water program around 2008, when negotiations began for a new 20-year permit.

Table 5.1 Program Drivers and Major Metrics

	Tucson Water	SBWR	EBMUD	JEA
Initial driver	1984 Reduce ground-water pumping and augment potable supply	1998 Meet NPDES discharge limit of 120 mgd to San Francisco Bay	1984 Augment potable supply	1999 Nitrogen total maximum daily load for St. Johns River
Current and/or additional driver	Same	Augment potable supply	Same	Meet CUP Conditions
Most important program goals	To use 100% of our effluent allocation (no specific year given)	Reuse 40 mgd by 2022	Reuse 20 mgd by 2040	Increase reclaimed water use to 32 mgd by 2020 in order to withdraw 142 mgd of water from the Floridan Aquifer
2011 status	40%	8.1 mgd	7.7 mgd	13.5 mgd
Other significant measures of program activity	Addition of new customers Volume of reclaimed water used annually Positive community and media comments Lack of customer complaints	No. of Customers Miles of pipeline Cost recovery	No. of Customers Level of funding assistance from state, federal, and other external sources	Potable water offset Nitrogen discharge Number of line repairs per year Response time and length of time for major outages Percentage of time a ticket referral is cleared within 8 hrs

Sources: Anaheim, 2012; Dotson, 2011; Hankin, 2012; Hu 2012; Ong, 2012; Porter, 2012; Steere, 2012.

On the basis of program manager feedback, the single major metric for three of the four case study programs was use-based (i.e., mgd recycled or reclaimed water used per year on an annual average basis) (Hankin, 2012; Hu, 2012; Ong, 2012; Porter, 2012). Secondary goals or metrics include water quality (e.g., for N or TDS), potable water offset (mgd), contribution to water supply, and customer-related indicators. Interviewees also identified other metrics they kept track of, but reported that they were not really setting goals based on them (e.g., number of customers). These are listed in Table 5.1 as other "other significant measures of program activity."

Table 5.1 also presents information on each case study program's long-term distribution goal and 2011 status. The current progress of programs toward their future distribution goals is between 20 and 42%. Given the current gap between the goals and their 2011 status, the attainment of these goals appears ambitious. Service area demand will need to increase dramatically in the coming decades if these goals are to be meet.

As part of the study, recycled water program managers were asked the following question: In the past 5 years, has per capita recycled water use been increasing, been decreasing, or stayed about the same? Table 5.2 summarizes the answers to this question. For three of the four programs, managers report that use has been increasing. For one program, SBWR, use has been decreasing, largely because of a dramatic drop-off of economic activity following the economic crisis of late 2008 and other factors explained in Chapter 6 of the report. As Ong (2012) put it:

> The recent economic downturn has reduced the need of local gas power plants to generate electricity, thus resulting in a large reduction in demand for recycled water for cooling. Out of 620 connections, about two-thirds of our demand, about 9 mgd, is from a dozen cooling towers.

Table 5.2 Current and Predicted Use Trends

	Tucson Water	SBWR	EBMUD	JEA
Reported current use trend	Increasing	Decreasing	Increasing	Increasing
	Total calendar year consumption (mgd): 14.0 (08) 15.2 (09) 13.7 (10) 13.9 (11)	Total calendar year consumption (mgd): 10.52 (08) 9.85 (09) 8.61 (10) 8.17 (11)	Total calendar year consumption (mgd): 5.3 (10) 7.7 (11)	Total calendar year consumption (mgd): 10.37 (08) 11.27 (09) 11.72 (10) 13.75 (11)
Predicted use trend	Increasing	Unclear with present situation; potential for increase if right conditions present themselves	Increasing	Should be increasing, but amount dependent on economy and development

Economic conditions will continue to figure prominently in recycled water demand for SBWR in the coming years (Ong, 2012). Similarly, interviewees at JEA felt that the ability to meet use targets for reclaimed water in their area would depend largely on improving economic conditions (Hankin, 2012; Porter, 2012).

When asked about their outlook for future reclaimed or recycled use in their region, program managers for Tucson Water and EBMUD felt strongly that use would increase. For these two organizations, interviewees felt that increased demand would come from the retrofitting of existing potable water customers. Tucson Water predicted that about half of the new demand would come from new development and half would be existing development that converts, with a focus on parks and schools. For SBWR and JEA interviewees, future demand seemed less clear and more dependent on a number of factors outside program control.

For example, one of the main factors that could support a dramatic increase in recycled water demand for the SBWR service area is its institutional arrangement with the SCVWD, the principal water supply agency for Santa Clara County. SCVWD plans on doubling the percentage of countywide supply that comes from recycled water by 2025 (John, 2012). From 2008 to 2010, the SCVWD and the city negotiated an institutional arrangement for the two agencies to meet their mutual goals of reliable water supply, recycled water infrastructure expansion, and enhancement of recycled water quality to expand the types of uses.

In March 2010, the water district executed two important agreements with the city, an agreement for recycled water production and integration and a ground lease agreement that includes constructing an advanced treatment recycled water facility, the Silicon Valley Advanced Water Purification Center (SVAWPC). These agreements have fundamentally changed the water district's recycled water role with the city and support the idea that recycled water is indeed being seen as a valuable tool for augmenting supply. The SCVWD will own and operate the SVAWPC.

5.2 Comparison with Delphi Metrics

Recall from Chapter 3 that Delphi survey participants identified four metrics as highly appropriate. These were supply portfolio contribution, customer satisfaction, voter support, and community support. In contrast, as shown in Table 5.1, the importance of a more direct volume metric—mgd of recycled water consumed—dominates the program managers' perspective. Program managers view customer-related metrics in a customer-specific and qualitative way. For example, several program managers interviewed for this study stated that their focus was on minimizing recycled water customer complaints and maximizing the number of customers rather than an overall percentage of satisfied customers (Beaver, 2012; Hankin, 2012; Hu, 2012; Ong, 2012). Table 5.3 presents Delphi survey data for "good" values of the primary metrics and what, if any, data were available for the case study programs. In most cases, it was an "apples to oranges" comparison. For example, even though case study program managers considered customer feedback important, with the exception of SBWR, most did not measure it the same way as the proposed Delphi metric. During interviews for all the case study programs, respondent comments described how customer concerns were typically dealt with on a case-by-case basis, both for getting customers set up initially and later for ongoing use issues (e.g., salinity management). They viewed community support in a similar way. For example, program staff characterized their programs' levels of community support by describing interpersonal interactions and questions they receive at public meetings, lectures, talks, and other outreach activities (Hankin, 2012; Hu, 2012; Ong, 2012; Steere, 2012).

The first row of Table 5.3 shows that the Delphi panel considered portfolio contribution to be an appropriate metric for program evaluation. In fact, for Tucson Water, the portfolio contribution metric used to be the overarching numeric goal of the program. The goal was that effluent for nonpotable reuse would be 8% of the total water demand through the year 2050 (Dotson, 2011). However, Tucson Water interviewees for this project felt that, as their program developed, this metric was not the best indicator of program performance. And although it was an important metric for a number of years, a different metric, described next by Dotson, is considered more useful for program planning and evaluation purposes.

Table 5.3 Comparison of Highly Appropriate Metrics with Case Study Program Data

Metric	Tucson Water	SBWR	EBMUD	JEA
Portfolio contribution “good” = 6–10%	8–10%	4.3%	3.6%	2.6%
According to program managers, portfolio contribution not viewed as a major metric by which they measure performance				
Customer satisfaction “good” = 76–100%	Not tracked at RW program level	Tracked at biannually	Not tracked at RW program level	Not tracked at RW program level
Most customer concerns dealt with on a case-by-case basis.				
Community support “good” = 81–90% supports some RW application	Not tracked at RW program level	Not tracked at RW program level; University study indicates 83% in support	Not tracked at RW program level	Not tracked at RW program level
Program staff “measure” community support by reception and questions they receive at public meetings, lectures, talks, and other outreach activities.				
Voter support “good” = 71–80%	Only track pass/fail of related ballot measures	Not tracked at RW program level	Not tracked at RW program level	Not tracked at RW program level
For program managers, voters and community members probably viewed as being one and the same.				

> In the 1990s Tucson Water had the idea that reclaimed water would be a certain percentage of all use and we picked that percentage to be 8%, based on looking at historical data. Recently we realized this was not a good way to go because the total water use picture is changing. Overall per capita water usage of potable water has radically decreased in a way no one could expect. Recycled Water use is "colored" by the weather and it is very difficult to predict when and if customers are going to connect to the reclaimed water system. Therefore, in the upcoming Tucson Recycled Water Master Plan, a different overall metric—volume growth rate over a 5-year period—will be used.…Tucson is an irrigation-dependent reclaimed water system, so there is no way to account for changes in precipitation. It is like "being a farmer who is dependent on the weather." Now we look more at volume growth, instead of doing an annual projection. In the draft of our upcoming Recycled Water Master Plan we are making projections based on 5-year blocks because 1 year is too small to make projections for….Some years we may get a lot of new customers, some years, we may get none. Also some years may be wetter or drier. So in a 5-year period we figure we will get one big customer, say of 400 acre feet a year, and some smaller customers, say 100 to 200 acre feet a year. The 5-year horizon is what is being proposed in the new Recycled Water Master Plan. Portfolio contribution is a good number to have in retrospect but we've determined that using portfolio contribution as a target is not a good way to go. (Dotson, 2011)

A similar statement about the year-to-year fluctuation in recycled water consumption and weather was made by the program manager at EBMUD.

> It's interesting, just looking at the [use] numbers from year to year, even though we are retrofitting more customer sites and bringing more people online, there will be years where it [the annual use figure] looks like use is tapering off. It is so weather-dependent. Last year we had rain into June. When you have rain, customers are not irrigating, so the weather really affects use. Use at the Chevron refinery cooling tower project is very weather dependent, too. Customers coming online don't immediately result in a corresponding ramp up in use because of this weather dependency. (Hu, 2012)

5.3 Quantity and Quality Metrics

This section presents case study program managers' perspectives on the proposed Delphi metrics for quantity and quality.

5.3.1 Flow Ratio

As defined by the FDEP, flow ratio is reuse flow (in mgd) divided by total wastewater treatment facility flow (in mgd). This metric was categorized as moderately appropriate by the Delphi panel. Nevertheless, its use as the major metric by FDEP and its potential use in other states make interviewee comments on this topic meaningful.

Because major wastewater treatment facilities in the state are required to report these figures, JEA readily provided a value of 0.20 for this variable. Other case study programs did not report using a similar variable to measure program operations. For SBWR, over the past 5 years, flow ratio has ranged between 0 and 20%, with annual average ranging from 9.5 to 7.6%. Although calculable with data that program staff is able to access, it is not seen as a major performance metric by the program (Ong, 2012). Neither EBMUD nor Tucson Water measured recycled water use in this way. As shown by the following comments, managers for these programs felt that the variable would need to include additional parameters to appropriately represent program activity. Says Dotson (2011):

> To be useful [in Arizona] the flow ratio metric would have to include an explanation of how "stored" recycled water and recycled water credits are included in the…calculation. Flow Ratio works for systems that are trying to go to "zero wastewater discharge," but for counties or utilities that have other drivers or motivations for using recycled water, flow ratio won't really work or may not be easy or even possible to calculate.

A similar comment was made by program managers at EBMUD, who stated,

> If we were to look at this [metric] it wouldn't look very good for some individual plants and it wouldn't explain the overall picture [of recycled water use]. This metric is useful when there is one big plant and they are recycling out of that facility, but we don't have an easy way to do that ratio for EBMUD. It's more of a regional, system-wide program…a bubble. We have five wastewater treatment that comprise an interactive system and use varies depending on points of discharge….We look at it [recycled water] more as an issue of water supply [rather than discharge]. It's hard for us [to calculate something like flow ratio] because we don't own the other wastewater treatment plants—only our own. (Hu, 2012)

5.3.2 Water Quality

In interviews with program managers, none reported having any major problems with maintaining water quality (i.e., providing water that meets or exceeds existing levels for particular contaminants). Regulatory issues brought up during discussions with program managers dealt more with consistency and pressure of flow and infrequent spills. For the most part, program managers view water quality as providing a quality of water that fits current and future customers' specific needs. Available water quality data for SBWR, Tucson Water, and JEA are presented in Appendix F. The main water quality measurement parameters identified by interviewees included turbidity, coliform, NDMA (including precursors), salt, CBOD, and *E.coli.*

5.4 Application Breadth and Customer Service and Support

5.4.1 Recycled Water Utilization Ratio

Recycled water utilization ratio is defined as the volume of recycled water used divided by the volume that could potentially be used. Although all programs have conducted and continue to conduct assessments of future customers, program managers from the four case study programs do not track this specific metric. Interviewees from Tucson Water found previous market assessments to be inaccurate (i.e., the customers that they thought were going to hook up were not the ones that actually did). EBMUD tracks it on a project level, if required by funding agency, but interviewees did not report using it for their own planning or program management purposes.

5.4.2 Product Diversification

Two of the four case study programs (Tucson Water and SBWR) currently provide one level of water quality (“Unrestricted use” for SBWR, “A” level for Tucson Water). EBMUD and JEA provide two qualities of water to users. For EBMUD, secondary treated water is delivered to several golf courses for restricted access applications. Tertiary treated water is provided to all other users. Similarly, JEA provides two qualities of water—one type for nonpublic access and another for public access. In the near future, SBWR and the SCVWD will be providing a second quality of recycled water with much lower salinity concentration through the SVAWPC project described in Section 5.1. Further details on how the project will work are provided in Figure 5.1.

In March 2010, the District and the City signed a 40-year agreement to build the SVAWPC and to increase the use of recycled water in the county. The SVAWPC will be constructed on a five-acre parcel adjacent to the San Jose/Santa Clara Water Pollution Control Plant. The SVAWPC facility will be a state-of-the-art water treatment facility that will use three advanced water treatment technologies to produce highly purified water. The SVAWPC will have the treatment capacity for 10-million-gallon per day (mgd) microfiltration,
8-mgd reverse osmosis, and 10-mgd ultraviolet light disinfection. The highly purified water from the SVAWPC will be blended with tertiary-treated recycled water from the San Jose/Santa Clara Water Pollution Control Plant and distributed by SBWR. This enhanced blend of water will help industrial users reduce operating costs, and it can be used on a wider variety of landscapes because of a much lower level of salinity. As a result, it is expected that more customers will tap into the recycled water system.

Figure 5.1. Investment in product diversification.

Another major decision about future product diversification looms large for both Tucson Water and SBWR—whether or not reclaimed water will eventually be used for IPR. Both programs are in the process of seriously considering this application as a future supply augmentation option. The SCVWD has recently completed a feasibility study to evaluate the expanded use of advanced treated recycled water for IPR as a key component of its current and future water supply portfolio. The goal of this study is to evaluate how advanced treated recycled water can be expanded, integrated, and optimized in the water supply portfolio. This study found that IPR is feasible, and the Water Supply Infrastructure Master Plan recommended a water supply strategy that includes an IPR component (John, 2012). Similarly, IPR applications are being considered in the 2012 Recycled Water Master Plan being developed by Tucson Water (Scott et al., 2012). IPR is discussed in further detail in Section 5.6, which focuses on IPR, EI, and CECs.

5.4.3 Value-Added Services

Before value-added services and customer satisfaction for the case study programs are discussed in detail, it is useful to first understand who is generally expected to pay for the cost of hooking up a user to the recycled or reclaimed water system and whether or not recycled water rates are discounted. Of the four programs, Tucson Water and JEA use a "customer pays" approach to hookup. For EBMUD and SBWR, the hookups for the majority of customers are paid for by the utility itself, either through grants or through the utilities' own funds. For new development, customers may be asked to pay the cost of connecting to the system, as was the case for Chevron's RARE water project. EBMUD and SBWR use a rule-of-thumb metric for determining if assisting a potential customer for hookup is worth it. For SBWR they use $737/AF (Ong, 2012); for EBMUD, they use $1,000 to 2,000/AF (Hu, 2012). For SBWR and EBMUD, customers pay 20% to 50% less for recycled water. In Tucson, reclaimed rates vary depending on use, but are generally less for big volume water users. For JEA, rates for potable and reclaimed water are the same.

For the purposes of this project, value-added services were defined as non-core recycled water services that may aid in recruiting new customers or enhancing the overall experience of a current customer. In the Delphi survey, this metric category was rated "appropriate" and had a medium level of consensus. Table 5.4 provides a summary of what program managers view as the main value-added services offered by their programs. All programs currently or previously provided financial assistance to customers to help fund infrastructure costs. Three of the four programs generally provided three or four additional services, with the most common service offered being permit assistance. This service can come either in the form of the program "holding" the permit for the users, as is the case for Tucson Water and EBMUD, or by providing users with assistance obtaining the necessary use permits from local and state authorities. Both Tucson Water and SBWR provide customers with assistance in conducting ROI analyses. In both these programs, the rate for recycled water is considerably less than that for potable. For EBMUD, because the utility generally pays for hookup costs, and the cost for recycled water is discounted, ROI is not really applicable to the program. For JEA, because reclaimed water is priced at the same rate schedule as potable, it actually costs the user more to use than potable; thus ROI is also not applicable to their program, but for the opposite reason.

Table 5.4. Main Value-Added Services

Service	TW	SBWR	EBMUD	JEA
Recycled water project funding	●	●	●	●
Permit assistance	●	●	●	
ROI calculations	●	●	NA	NA
Pre-use site evaluation		●	●	
Ongoing site evaluation	●			
Graywater support and funding	●		●	
Other			●	

Managers for two programs identified a specific service as being the most useful for their customers. For EBMUD, it was their preuse Site Evaluation Program. Says Hu (2012):

> Through this program, we have a horticultural consultant under contract, and she performs a horticultural site evaluation before the site is switched over to recycled water. So the customer knows and EBMUD knows if there any problems, what are the heads up that we should know about and provide to the customers, what are the BMPs that we want to recommend to the customer, what are special things they need to do to mitigate problems on site. So for the customer it's a huge value added because at least for San Ramon, it also included a soil test. When you get those results back, it's terrific…it tells you all about the soil quality, various things you need to do to improve your soil quality, what you need to add, etc. the benefit to EBMUD is that we know what's going on with that site. A lot of times the sites already have some problems even on potable water so it's good to document that and let them know hey these are issues that you have to work on and then with recycled water, what [additional things] you need to be doing. If horticulturalist observes that potential customer has plants that are salt sensitive, that's in her report.

In contrast, Tucson Water interviewees felt that carrying the permit for all its recycled water customers brought the biggest benefit. As they put it, "we decided to do this to take the burden off the customer" (Dotson, 2011).

5.4.4 Customer Satisfaction

For SBWR, biannual customer surveys are one of several important performance measures that have been reported to the San Jose city manager since 1997. Results from a 2006 survey indicated that the majority of responding customers were satisfied or very satisfied overall with reclaimed water (City of San Jose Environmental Services Department, 2006). However, the SBWR program manager interviewed for this project viewed customer satisfaction in a more personal way. The other three recycled water program managers in case study programs did not report regularly conducting formal surveys of customer satisfaction with recycled water. As one interviewee put it, "if the customer is unhappy with the water, we hear about it." Staff and management for the other three case study programs echoed this sentiment in their own statements. JEA and EBMUD, which have combined water and power divisions, do conduct general customer satisfaction surveys, but interviewees were not aware of details related to any recent customer satisfaction surveys that had focused on reclaimed water (Beaver, 2012; Hu, 2012; Ong, 2012; Steere, 2012). Tucson Water interviewees recalled a University of Arizona survey of the topic conducted by Campbell and Scott but could not recall when the survey was conducted or specific survey findings. Upon further investigation, the research team verified that a recent customer survey had indeed been conducted involving 149 residential users (Campbell and Scott, 2011). Similarly, EBMUD program managers recalled some questions on a general EBMUD customer survey that took place several years earlier. They recalled that respondents' support for recycled water applications was associated with providing information about the nature and use of recycled water. When more information about recycled water was provided, respondent support for recycled water use increased (Hu, 2012; Steere, 2012). Program managers from JEA reported that they did not conduct surveys of user satisfaction (Beaver, 2012; Hankin, 2012).

Simply put, the percentage of customers satisfied with overall water quality and service does not appear to factor directly into program operations. However, this does not mean that customers are not important to programs. It just means that, perhaps, on an operational level, programs do not measure or manage customer satisfaction that way. During interviews, program managers repeatedly emphasized their desire to develop and maintain good relationships with users. This view is supported by interviews conducted with six customers, most of whom praised program staff for their dedication to their projects. Topics that were specifically mentioned included permitting, financing, technical support, and ongoing maintenance.

For the six nonresidential customers interviewed for this project, overall satisfaction levels were generally high, averaging 8.7 on a scale of 1 to 10. The majority of customers were satisfied or very satisfied with the program's water quality, timing, delivery, pressure, and customer service.

Tucson Water is the only case study program that is currently providing water to residential users. Although no residential users were interviewed for this study, available research indicates a generally high level of satisfaction with this particular program for this user group.

For example, a survey of 149 residential recycled water users in Tucson was conducted by researchers at the University of Arizona in 2009. The study's authors reported that 89% of all respondents reported being satisfied. Moreover, satisfaction "included the indication by 90% of respondents that 'Having reclaimed water for my landscaping increases the resale value of my home'" (Campbell and Scott, 2011). According to the authors,

> Many respondents also indicated that the use of reclaimed water for residential irrigation should be expanded and some expressed surprise that it is used so little. Said one key informant: "I didn't realize it was that unique [to have reclaimed water]. I assumed it was widely used around town. It is amazing so little is used."

5.4.5 Customer Issues

For two of the customers interviewed, water quality and associated plant or tree die-off continue to be problematic areas, even after several years of use. Also mentioned in customer interviews was the idea that users were not aware of all the ramifications associated with using recycled water for their particular applications (whether industrial or irrigation), so "tweaking" was required in the field. The reported level of assistance for troubleshooting varied from "very responsive" to "having to figure things out on our own." Specific program staff members in Tucson Water, SBWR, and JEA were called out by name as doing a good to excellent job of providing customer service and helping resolve technical challenges. For SBWR, the three customers interviewed reported being quite satisfied with water pricing, giving it 9 out of 10 possible points. However, for Tucson Water, satisfaction with pricing ranged from 7 to 2 on a 10-point scale. This rating level can be attributed to recent rate increases for reclaimed water, which one customer said is "sometimes more expensive than potable."

5.5 Community and Voter Support

As described in the previous section, program managers did not view variables associated with community and voter support in a strictly numerical way. Recall in the Delphi survey that the proposed measure of community support was the percentage of the population in a service area that was generally supportive of recycled or reclaimed water applications. The proposed measure for voter support was the percentage of the relevant voting population that voted in favor of a bond or other type of legislation that contained a reclaimed or recycled water component.
Figure 5.2 provides details on two measures of community support that pertain to the case study programs. Practically speaking, however, these criteria are not actively tracked or followed at the program level.

Only program managers at Tucson Water reported tracking voter information, and even then only at a "big picture" level (e.g., if a bond passes or fails). For SBWR, data on community support of reclaimed or recycled water for various applications was conducted on behalf of the Guadalupe River Park and Gardens by a university graduate student (Liu, 2006), and not initiated by the SBWR itself.

In 2000, Tucson, voters approved a $32 million bond for its reclaimed water system. In 2005 a similar bond for $28.2 million also passed. A 2009 survey of 253 randomly selected Tucson residents indicated a generally high acceptance rate for common outdoor applications (e.g., 95% in favor of use for fire hydrants and irrigation of nonedible crops, 88% for golf courses, 89% for landscape irrigation); with 79% in favor of using recycled water for toilet flushing, but generally less than 50% of respondents in favor of recycled use for other indoor applications (e.g., laundry, cooking)

For San Jose, Liu (2006) conducted a survey of 1,031 San Jose residents in 2005. Eighty-three percent of respondents strongly supported public uses of recycled water (e.g., public access irrigation on turf, fountains, and for toilet flushing); only 3% were opposed to any kind of recycled water application.

Figure 5.2. Community and voter support.

Sources: Liu, 2006; Scott & Campbell, 2009.

Instead, program managers view community and voter support in terms of outreach efforts and face-to-face interactions between program staff and community members at public meetings, tours, conferences, and similar events. All four programs have robust and active outreach efforts, as evidenced by videos, customer brochures, publications, meeting minutes, and staff participation in local, state, and national conferences. Tucson Water has, perhaps, the most active outreach program because of their large number of residential customers. Figure 5.3 lists some more noteworthy examples of program support and outreach efforts.

In Silicon Valley, South Bay Water Recycling is a founding member of EcoCloud, a consortium of government agencies, industry, academia, and the NGO community that apply the principles of industrial ecology to the San Francisco Bay area. One of the first focus areas of EcoCloud was recycled water.

Tucson Water has instituted an inspection program for current residential reclaimed water users staffed by five cross connection control specialists to ensure its proper application. It also provides an annual newsletter to its reclaimed water users.

EBMUD has a dedicated staff person, who focuses primarily on community outreach and customer relations for reclaimed water. One of her responsibilities is to work with the community beginning at the planning phase of a project to get the word out early and obtain community input "before we even start designing and constructing a project" (Hu, 2012).

JEA staff regularly present on the status of the organization's reclaimed water program and plans for future development. Of recent note is Director Karl Hankin's presentation on water supply and reclaimed water at the City of Jacksonville's sustainability conference in August 2011.

Figure 5.3. Customer support and community outreach efforts.

When asked about public perceptions of reclaimed or recycled water, program managers responded that health concerns about water quality very rarely come up in their interactions with the public. Managers for all four programs feel that the public is very supportive of recycled and reclaimed water use. The following quotations illustrate the nature of public comments and community inquiries recently received by recycled water program staff and a state regulator in Arizona.

> We have supportive customers and the public. They all know about it [recycled water]…. It's pretty well established. . . nothing new in this area anymore. We get a lot of phone calls from people asking, "Can we get it [for our home]?" (Hu, 2012).

> Whenever I talk at public meeting, I've never gotten negative feedback like "Ooh, that's disgusting." They [residents] will usually catch me at

> the end of the meeting and say, "I live at such and such an address and I'd like to use reclaimed water." Or sometimes [at these meetings] somebody will raise their hand and say "Why don't we just treat it a little more and connect it to the drinking water system?" (Hankin, 2012).
>
> [For residential applications] there is less controversy about recycled water in Arizona than other states because it has been going on for so long…. Some people may not even know they are using recycled water in some of the bigger systems. (Graf, 2012)

On the other hand, the use of reclaimed water for snowmaking in Tucson has been the subject of recent controversy. Two recent lawsuits filed in federal court questioned the safety of using reclaimed water for snowmaking at the Snowbowl ski resort in Flagstaff, AZ. Some NGOs cited concerns over possible ingestion of snow as a potential health hazard. Although the courts upheld the safety of reclaimed water, a position also supported by most academics in the community, there has been a substantial amount of negative press.[2] Numerous protests and dozens of arrests occurred in 2011 over the use of reclaimed water associated with the resort's planned expansion (*Arizona Daily Sun*, 2011).

5.6 Contaminants of Emerging Concern, Indirect Potable Reuse, and Energy Intensity

In this section, we present program manager feedback on metrics concerning several issues salient to future applications of reclaimed and recycled water: CECs, IPR, and EI. All program managers are aware of and in the process of responding to at least one of these issues, with Tucson Water being the most active in CECs and SBWR having the most developed concept of EI. Table 5.5 presents a summary of program activities in these areas. The degree to which case study programs are actively involved in these issues depends largely on the security and source of future potable supply options and the cost of reclaimed or recycled water relative to other sources.

[2] It should be noted, however, that the issues surrounding Snowbowl's reclaimed water use expand well beyond simply the water itself. The resort and local Hopi and Navajo Native American tribes have been battling over the resort's operation and planned expansion since the 1960s. The tribes consider the land on which the resort is built (San Francisco Peaks) to be sacred and believe that the operation and expansion of the resort impedes their religious rights under the Indian Religious Freedom Act of 1978.

Table 5.5. Program Activity and Perspectives on EI, IPR, and CECs

	Tucson Water	SBWR	EBMUD	JEA
EI	Not tracking "not a primary goal of our recycled water program" "In the future, EI may be used to sell the idea of 'climate independent' sources of water vs. 'climate dependent' sources."	Has assisted with the Santa Clara Valley Water District's two studies on EI. Average EI ratios for water used by the SCVWD range from 0 (for water conservation) to 694 kWh/AF (for recycled water) to 1,695 kWh/AF (for imported water). The EI ratio for recycled water is 18% less than for local surface water, and about 50% less than groundwater.	Not tracking Organizational focus is on climate change, or "climate footprint" relative to long-term water supply. Because system is gravity-fed, recycled water would "not compare favorably" to the area's current source of supply.	Not tracking "We have not done this type of analysis."
IPR	Considering for future use	Considering for future use	Not considering for future use	Not considering for future use
CECs	Monitoring some	Not monitoring, but plan to in next 3 years	Not monitoring with no plans for near future monitoring	Not monitoring with no plans for near future monitoring

5.6.1 Contaminants of Emerging Concern and Indirect Potable Reuse

Two case study programs, SBWR and Tucson Water, either have some CEC monitoring taking place or are anticipating monitoring in the near future. Tucson Water has the most developed program. They have been monitoring CECs since 2002. Currently a contract lab annually monitors 96 endocrine-disrupting compounds (EDCs) on their behalf. Monitoring results are presented to the mayor and city council in an annual memorandum. In addition, Tucson Water is collaborating with the University of Arizona Tucson, AWWA, USGS, and the WateReuse Research Foundation on several CEC-focused projects (Dotson, 2012). Examples of compounds that have been monitored include those noted in Table 5.6. A full list of all 96 EDCs studied in 2012 can be found in Appendix G.

Table 5.6. Examples of EDCs Monitored by Tucson Water

Compound	Use
Acetaminophen	Analgesic
Amoxicillin	Antibiotic
BPA	Plasticizer
Caffeine	Stimulant
DEET	Insect repellent
Estradiol	Birth control
Ibuprofen	Analgesic
Lidocaine	Anesthetic
Naproxen	Analgesic
4-Nonylphenol	Detergent metabolite
Propyphenazone	Analgesic
Progesterone	Hormone
Testosterone	Hormone
Triclosan	Anti-bacterial

Source: MWH, 2012.

Despite rising public concern about the potential impact of these compounds on human health and the environment, one interviewee felt that federal regulation of CECs, specifically EDCs of concern, may be years, even decades away. This position is based on the fact that the EPA's most recent contaminant candidate list (issued in 2008) hardly contained any chemicals of current EDC concern (Graf, 2012).

The SBWR program manager thought that his program or SCVWD will be monitoring some CECs within the next 3 years (Ong, 2012). An excerpt from an interview with a senior civil engineer for the SCVWD corroborates this position.

> We are not directly initiating any particular CEC monitoring program but are following developments at the state and federal level. We will also be developing a water quality monitoring plan for the SVAWPC that will include measurement of CECs. We have also monitored CECs in the past as part of other studies, such as a stream flow augmentation with recycled water study. (John, 2012)

According to interviewees at JEA and EBMUD, CECs are more of a concern if a planned recycled or reclaimed water application includes IPR. Because neither utility plans to use IPR in the next 20 to 30 years because of its high cost, they are not currently monitoring for CECs and do not plan to in the near future.

Because SBWR and Tucson Water are both considering IPR for future use (Dotson, 2011; Johns, 2012; Ong, 2012), this could explain why those programs are either currently monitoring or planning to monitor CECs. EBMUD and JEA view their major sources of potable supply (the Floridan Aquifer for JEA and the Molukulme River for EBMUD) as providing the majority of their future drinking water, so they are not considering IPR (or any associated CEC monitoring programs) (Hankin, 2012; Hu, 2012; Porter, 2012; Steere, 2012).

5.6.2 Energy Intensity and Climate Change

For the purposes of this study, EI is defined as the sum of energy used to produce a given quantity of water (e.g., in kWh/acre-foot). It includes energy use for supply, storage, conveyance, end use, treatment, and distribution.

Of the four case study programs, only SBWR, indirectly via its relationship with the SCVWD, has been involved in conducting an in-depth analysis of the energy (and the associated costs) used for its different sources of water supply. In fact, the wholesale water supply agency, SCVWD, has conducted an internal analysis twice, with its most recent effort taking place in 2010. The other program managers think of the issue more broadly, in the context of larger efforts that fall under organization-wide sustainability, climate change, or energy conservation efforts.

In the 2010 SCVWD study, *Watts to Water*, the EI of recycled water was estimated at 649 kW/AF compared to 1,695 kWh/AF for imported water. Figure 5.4 provides further details on why measuring EI makes sense in the context of the water supply scenario for Santa Clara County, CA.

The primary goal of SCVWD's recycled water program is to use water more efficiently; however, ancillary benefits include energy savings and the resultant air quality benefits. The latter arise because California's water supply chain, or the route water follows as it is pumped and/or conveyed from its source, treated to drinking water standards, distributed, used, and treated to wastewater standards is energy-intensive. More specifically, water-related energy consumption in the state represents approximately 15–20% of all energy consumed in California because of the high elevations and long distances over which water must be pumped and conveyed. Thus, a reduction in flow through the water supply chain brought about by an alternative supply source, such as recycled water, can decrease energy use as long as the alternative water source is less energy intensive.

Water provided to Santa Clara county is approximately 50% imported water and 50% local sources or groundwater. The combined energy costs of sourcing the water, treating the water, and distributing the water mean that supplying a typical acre-foot of water to a generic consumer in Santa Clara county uses approximately 760 kWh. The incremental energy cost of delivering recycled water is assumed to consist only of distribution energy because an energetically similar level of treatment is required before wastewater can be released into the Bay. Since FY 98–99, the water provided through the recycled water program has saved approximately 84 million kWh and 20,000 tonnes of carbon dioxide.

Figure 5.4. Recycled water and energy in Santa Clara county.

Sources: John, 2012; Larabee et al., 2010**.**

For EBMUD and Tucson Water, reclaimed water is considered more in the context of climate change or "climate independence" as opposed to EI. Managers for both programs felt that if they were to analyze recycled or reclaimed water using an EI framework, it would not come out favorably relative to their existing (and less expensive) main source of potable water. Neither program directly calculates the carbon footprint of reclaimed or recycled water. The following statements made by program managers at Tucson Water and EBMUD help illustrate the programs' positions on this topic.

> At the moment, recycled water is not the most cost effective source, and it may never be….When the Tucson recycled water program was created in the 1980s energy intensity wasn't an issue….In the future, [the concept of] energy intensity may be used to sell the idea of "climate

> independent" sources of water vs. "climate dependent" sources. CAP water is climate dependent, whereas reclaimed water is part of a groundwater replenishment scheme that is climate independent. (Dotson, 2011; Kmiec, 2011; Titus, 2011)
>
> We don't compare recycled water to surface [for energy intensity] because it wouldn't come out favorably. Our water supply comes from Mokelumne River, mostly by gravity flow. (Hu, 2012)

The following excerpt from an article written by EBMUD staff illustrates how recycled water fits into the organization's overall climate change strategy.

> In 2008, EBMUD incorporated climate change into its Strategic Plan, and has developed and implemented a climate change monitoring and response plan to inform future water supply, water quality, and infrastructure planning. EBMUD is evaluating numerous water supply portfolios with components including conservation, water recycling, groundwater banking, interbasin transfers, desalination, and surface water storage. Among other criteria, each portfolio is being evaluated for its carbon footprint. The portfolios being evaluated include one with a low carbon footprint and another that is diversified in order to adapt to future changes, including climate change. (Wallis et al., 2008)

On a program management basis, EBMUD recycled water program managers view 20 mgd by 2020 as their main program objective and do not see themselves as directly involved in climate change activities within EBMUD. At the present time, reclaimed water does not appear to factor significantly into JEA's climate change planning or monitoring efforts (JEA, 2011).

Chapter 6

Objective 3: Understanding Key Stakeholder Interactions

This chapter presents highlights from interviews with program managers, regulators, and customers that help explain the interaction between recycled and reclaimed water programs and key stakeholders. It also discusses complementary policies that have helped support recycled water adoption for the case study programs.

6.1 Who Program Managers View as Key Stakeholders

Generally, program managers identified the following three types of organizations as their main stakeholders: regulators, partner agencies, and customers. As one program manager put it, "It's a three legged stool, the [water] district, the customer and us" (Hankin, 2012).

6.2 Regulators

The most significant relationship for three of the four programs was with regulators. The following quotation from a recycled water program manager at JEA helps explain his organization's relationship with the St. Johns River Water Management District:

> Definitely our most significant organizational relationship is with the Water Management District. They are really involved. For example, in the past, they recommended that we put in bigger pipes. They've also helped get us [JEA] obtain funding for reclaimed water infrastructure in the past. They're the ones who, when they have a customer who is using wells, tries to get them off the wells and switched to using reclaimed. The District gets us talking to the customers. . . . Right now, we're working with them on trying to get the Queen's Harbor golf course hooked up (Hankin, 2012).

Two of the three reclaimed water program managers who identified their regulatory agencies as being key stakeholders felt that their regulators had a "good to very good" understanding of their program goals and objectives and that their regulatory agencies were generally supportive of recycled water use. Says a recycled manager at SBWR:

> Our regulator [the Regional Water Quality Control Board] has a very complete level of understanding about of the goals and priorities of SBWR's recycled water program….They are aligned with several program goals and supportive of recycled water use. (Ong, 2012).

A similar sentiment was shared by the recycled water program manager at JEA, who also felt that the water district understands how future economic conditions might limit the volume of reclaimed water consumed:

> The [water management] district would like us to do more reclaimed, but they understand our limitations. In [our consumptive use] permit conditions, they put that each year, our total reclaimed number would go up and reach 68 mgd by 2031, but there's an economic feasibility condition. They've got it built in as a permit condition. So in 2015, we have to go back and explain in front of the District Board what we've done under our permit conditions. If we are not at this level, we're going to have to have very specific reasons why. Their level of understanding about our reclaimed water goals is generally good. We can only go with what's in our permit. They would like us to use a lot less water from the aquifer and have a bigger reclaimed water program. But we've just gone through four years in a row of rate increases. It's tough to do. (Hankin, 2012)

On the other hand, the reclaimed program managers for Tucson Water felt that the Arizona Department of Environmental Quality's understanding of their goals was low at first, but that it improved over time. The following comment made by one of those program managers illustrates this evolving relationship:

> [The Arizona] DEQ had a low level of understanding about our reclaimed water program and objectives, but it's improving. They understand how a [recycled water] program works. A recent Blue Ribbon Panel has opened their eyes as to the issues and challenges a reclaimed water provider has. Now DEQ is a lot more open-minded when dealing with utilities and encouraging recycled water use. Before their role was more of just a regulator. Generally, DEQ is behind or supports reclaimed water programs, but at a high level. (Dotson, 2011)

Interviews were conducted with the local regulatory agencies for two of the case study programs. Both regulatory agency representatives viewed the focus of their relationship as permit management and negotiations and described inter-organizational communication as frequent to occasional (i.e., several times a month to several times per year). The following interview excerpts provides perspective on how the JEA regulator viewed her relationship with program staff. The regulators for JEA and Tucson Water felt that they had a good to very good understanding of recycled water program goals and that they were supporting the programs to the best of their ability. This position is illustrated by the following quotation from an interview with a hydrologist at the St. Johns River Water Management District:

> Speaking only for myself, I'd say we're working towards a much more productive partnership. I have a great rapport with JEA project staff. They could provide more incentives [to customers]. I have a good understanding of the goals and priorities of program's reclaimed water program. I understand that they are a utility that has a job to do. They have revenue to make and customers to supply. I think I understand their business model, but I wish they could be more proactive with [potable water] offset projects [that might be more costly in the long run]. For example, instead of having to go to desal [sic], trying to be more forward-thinking. (Silvers, 2012)
>
> I think that we share some of [the program's] goals. . . . we've worked very hard together and we've [the District] provided them with a lot of cost share funding. I think there have really been two mechanisms to really drive JEA's [reclaimed water efforts]. The first was their TMDL wastewater discharge

> into the river. I think that helped get the program going and now the aquifer offsets are helping to accelerate it. I think we're working hard, it's just very difficult times right now. I think the program wants to accomplish a lot more reuse. (Silvers, 2012)

In addition to permit management, the Arizona DEQ's interactions with Tucson's recycled water program include enforcement actions, program development, stakeholder groups, interpretation of AZ DEQ rules, and identification of research gaps. Closely intertwined with the reclaimed water permit process is the state's Aquifer Protection Program, which controls discharges for all wastewater treatment plants in the state (Graf, 2011). When asked to describe the relationship between AZ DEQ and Tucson Water, the local regulator said that it was "terrific" and "feedback oriented." He felt that AZ DEQ had a very complete understanding of the goals and priorities of Tucson's recycled water program and he felt that AZ DEQ is aligned with most or all of Tucson Water's reclaimed water program goals (Graf, 2011).

6.3 Partner Agencies

Two case study programs, EBMUD and SBWR, listed their partner agencies as being one of the top three in importance. EBMUD felt their three partner agencies (West County Wastewater District, the city of San Leandro's water pollution control plant, and the Dublin–San Ramon Services District) understood and were aligned with their own program goals. In their system, EBMUD controls only a portion of the recycled water infrastructure, so it relies heavily on interagency coordination to meet its program goals.

However, the situation for SBWR is currently different. SBWR works under a Joint Powers Authority that involves eight members (called tributary agencies) and includes the cities and sanitation districts for San Jose, Santa Clara, Milpitas, Los Gatos, Cupertino, and Campbell. The SBWR program manager interviewed for this project felt that these organizations had a "very complete understanding" of the goals and priorities of SBWR's recycled water program.

Currently, SBWR and its tributary agencies have different goals. According to a SBWR recycled water program manager, "At one time, SBWR and the Tributary Agencies shared the same priorities [for discharge control and supply augmentation], but now they don't." The following interview excerpt clarifies this point:

> Right now, there is are two conflicting goals: meeting the discharge cap of 120 mgd discharged to the San Francisco Bay and supply condition…. These goals are on opposite sides of the spectrum, meaning that they are at odds with each other…they [SBWR and Tributary Agencies] have two opposing goals…. It would be nice if we had an effluent flow that's reaching our cap plus we have a drought where we need more recycled water. Then the goals will converge again. But now conditions are on the opposite side of the spectrum, so the goals…are not aligned. (Ong 2012)

In other words, SBWR discharges were so far under the flow cap because of the 2008 recession and the associated decrease in manufacturing that there was no longer any pressure on the Joint Powers Authority to reduce flow. Also, because the region was not in a drought, there was no increased customer demand for recycled water.

However, this condition should change in the near future with the development of projects such as the new Apple complex in Cupertino, CA. One of the additional challenges SBWR faces is that its funding source is tied to discharge fees, so the benefits of use are not monetized in a way that comes back to the program. In another quotation, the program manager illustrates how the cost bearers and the beneficiaries of the program are not in line:

> The funding source for recycled water comes from the sewage fee…. Because the sewage treatment plant has met its flow cap, there is no need to divert more [effluent flow]. The sewage fee is our [SBWR's] funding source. Now, that recycled water is a also a water supply issue, [the city of] San Jose wants the District to step up and put money into the recycled water program, because now recycled water is a [water] supply resource.

This conflict illustrates the transitional state that SBWR finds itself in. Its original mandate was effluent reduction, but its revenue stream is based on the volume of wastewater treated by the plant. Even though recycled water contributes to the overall Silicon Valley water supply, this contribution is not reflected in apportionment of program costs on the supply side. The situation for EBMUD is different because the utility provides both water and wastewater services under the same organizational umbrella, so funding schemes can be more flexible.

Even though the current relationship with tributary agencies may be one of conflict, a significant future partner for SBWR is the SCVWD, which has made a 40-year commitment to the shared provision of recycled water to its service area. As mentioned in Chapter 5, the SCVWD will run the SVAWPC, and water from this plant will be blended with treated effluent from SBWR facilities. The agreement between these two organizations includes provisions for cost and revenue sharing. In addition, the SCVWD has seven staff members in its own recycled water unit, and it is seeking to expand in the future (John, 2012).

The following excerpt from an interview with a senior engineer at the SCVWD clarifies the nature of this relationship.

> Since 2010 our programs have been tightly integrated [with SBWR]. We collaborate on recycled water outreach, including the development of a strategic outreach plan and we are collaborating on the development of a long-term recycled water strategic plan…. We have been interacting and meeting with SBWR staff on a regular basis for over 10 years and during the past 3 years we have met even more frequently than in the past. The District's Board and the San Jose City Council have twice-yearly meetings where recycled water issues are discussed from a policy level. (John, 2012)

6.4 Customers

Two case study programs, SBWR and EBMUD, identified their customers as being among the three most important organizations to their programs. Both program managers felt that the main incentive for recycled water use for their customers (i.e., end users) was economic:

> Their [the customers'] main concern is the bottom line—less expensive water . . . it's really the [economic] bottom line. Customers have "some understanding" of one or two major program issues, but not in depth. When we go to the [potential] customer and say, "Hey, you can use recycled water

> and it will reflect well on your bottom line," immediately you get their attention…. The next thing we say is "Do you know recycled water costs 50% less [than potable]?" Once you get their attention, then the interest is there. (Ong, 2012)

> For customers, recycled water aligns with their bottom line…. We'll get the water, we won't get cut back during a drought, we're getting it at a lower rate, also when the drought hits we are not going to have to pay those drought surcharges and penalties that we would have on potable. Those are the things that they [the customers] really care about. (Hu, 2012)

In line with program manager opinions on what mattered to end users, of the six customers interviewed for the project, three identified cost or price savings as a primary motivating factor underlying their decision to hook up. This incentive is described by two current industrial customers of SBWR and one customer of Tucson Water in the following quotations:

> Cost was one of the incentives from the get go….Let's be clear—there was a big enticement there. It was certainly something that helped drive the discussion [about whether to go forward with the project or not] …I ran a basic ROI and found that we had essentially a 1 year payback period so it was very attractive financially. (Charpentier, 2012)

> The cost benefit to the company is huge. We don't pay for water we don't use, we don't pay the sewer tax. We received 40 to 80 thousand dollars in rebates from the city of Santa Clara. (Bryan, 2012)

> Reclaimed water pricing was very attractive in the beginning. When we first began using it, Tucson Water subsidized a portion of the reclaimed water price, I think 50%. (Murietta, 2011)

However, all the customers interviewed (six out of six) cited environmental or sustainability concerns as a primary, or, in one case, the most important reason that they decided to hook up. Variations of the phrase "it was the right thing to do" came up in every interview. The following customer statements further illustrate how environmental concerns at both the organizational and the individual level factored into decision-making:

> Recycling water is supportive of sustainability principles and it sends the right message to students that the school is in support of a sustainable lifestyle. (Cook, 2011—this interviewee cited that this was the main reason his organization decided to use reclaimed water)

> We're very environmentally sensitive…. It's the [San Francisco] Bay Area; environmental issues are near and dear. We're trying to be good stewards…. It seemed like this was the way of the future, of using water responsibly. (Charpentier, 2012)

> We wanted to do the right thing. (Bagley, 2012; Hubbuch, 2012)

> At that time, the University was beginning to look more at sustainability issues. There was a campus-wide movement going on to think about these

> things. This [reclaimed water project] was one of many green initiatives on campus. (Hubbuch, 2012)
>
> It's a personal thing. I grew up a coastal California kid, so I've always been an environmentalist. (Bryan, 2012)

Two of the six customers interviewed for the project identified government mandates or pressure as the main reason behind their hookup. This is described by the following quotations from customers in Florida and California:

> It was mandated [by the SJRWMD] that we were going to have to use recycled water. The SJRWMD is the organization that regulates our water consumption on campus. We have a CUP that is issued by the District. That specifies the uses of all types of waters [including reclaimed]…. We didn't resist it. I can tell you there was no financial incentive for us to do it. The source of water before that point was large deep [groundwater] wells that we had on campus. We abandoned free water and now we're paying for irrigation water. (Hale, 2012)
>
> Primarily, we were kind of pressured by the city to do it. (Bagley, 2012)

The differences in how program managers and customers perceive customer motivations may have significant relevance to future customer development. The implications of this finding are discussed further in Chapter 7.

6.5 Supporting Policies

All program managers mentioned at least one external policy that encouraged or provided incentives for recycled water use in their service areas. These were primarily grants, revolving loans, or groundwater savings plans. Although supporting policies are certainly helpful, policies or directives that are unfunded or lack enforcement mechanisms can present challenges to full implementation of recycled and reclaimed water program goals.

6.5.1 Groundwater Savings

For Tucson Water, the main policy mentioned was the AZ DWR's Groundwater Savings Program (GSP). Interviewees felt it was "an important program driving a lot of golf courses to sign on [to reclaimed water]" (Dotson, 2011). Recall that half of Tucson Water's use by volume comes from this customer group. This program was also cited by the AZ DEQ interviewee as a positive feature of the state's reclaimed water system. In this program, reclaimed water users receive groundwater recharge credits (Graf, 2011). The following excerpt from Megdal and Shipman (2010) explains in more detail how the program works:

> Sometimes called indirect recharge or in-lieu recharge, the GSP allows storing entities [e.g., Tucson Water] to accrue groundwater storage credits when irrigators use surface water or effluent (in this case, reclaimed water) in place of groundwater…. Through the GSP, these entities are able to provide CAP water to irrigators at a cheaper rate than what irrigators would pay directly, and by subsidizing the delivery of CAP water to the irrigator, they earn storage credits as compensation for the groundwater saved through the transaction.

Tucson Water program managers also mentioned the Reclaimed Water Master Plan, due to be released in 2012, as an important policy. This document will direct long-term infrastructure projects for the next several decades.

For JEA, conditions of their CUP allow for a similar type of reclaimed water-groundwater exchange from the Floridan Aquifer. Under the permit, JEA's 2022–2031annual groundwater allocations will increase on a 1:2 basis, for if they "make reclaimed water available through a point of connection to permitted Floridan Aquifer users… and contract …with them to supply it to replace groundwater use" (SJRWMD, 2011). This means that for every additional gallon of reclaimed water used beyond permit specifications, JEA has access to an additional half gallon allocation of groundwater, up to 43.76 mgd by 2030.

Along similar lines, the CA DPH is developing regulations for using recycled water to replenish groundwater basins. This will clarify rules for a practice that is already occurring in the southern part of the state. The rationale for this program lies in Section 13562 of the State Water Code. In November 2011, California Department of Public Health issued draft regulations to this effect.[3] Although this program was not mentioned directly by our two California case study program managers, this regulation will factor significantly in the future activity of any reuse program considering potable reuse applications with a recharge component.

A key partner in the future use of recycled water for SBWR, the SCVWD is tracking developments in technology, policy, and regulations as they relate to groundwater recharge. Current California state law requires that final regulations for IPR through groundwater recharge be developed by 2013. A draft version of the groundwater recharge regulations has been released by the California Department of Public Health. To pursue potable reuse, SCVWD will need to review all aspects, including regulations, appropriate treatment technologies, water quality, public health protection, and public acceptance (John, 2012).

6.5.2 Funding and Cost Share Programs

All case study programs mentioned at least one cost-share or grant program as being an important part of their operations. For two of the four programs (EBMUD and SBWR), a significant portion of customer hookup costs was paid for by grant funds or by the utilities themselves, with the recycled water program playing a major role in securing those funds. These kinds of programs (e.g., for supporting cooling tower retrofitting) were mentioned repeatedly by program managers in both organizations as playing a very important role in keeping their programs going. For both these programs, the hookup cost is paid for by the utility.

Grant and cost share programs were also mentioned by program mangers at Tucson Water and JEA, but they did not figure as prominently. For these two programs, the majority of hookup costs are paid for by the users themselves. Of note for Tucson Water is the cost share partnership they have with the Tucson Unified School District. This program has been used to connect schools since 1998 (Dotson and Crockett, n.d.). In this partnership, Tucson Water pays for the reclaimed water meters and advances the school district funds to renovate existing turf irrigation systems at schools. Reclaimed water costs approximately 40% less

[3] Follow this link for the November 21, 2011 draft regulations and other related materials: http://www.cdph.ca.gov/healthinfo/environhealth/water/pages/waterrecycling.aspx

than potable water, so the school district is able to repay the city for the improvements to their irrigation systems from the savings accrued by converting to reclaimed water.

JEA interviewees cited a St. Johns River Water Management District cost-share program that provided JEA with up to 50% of the infrastructure cost for new hookups through the district's Water Protection and Sustainability Program. Unfortunately, this funding source is no longer viable, but up until 2010 it funded approximately $15 million worth of projects.

6.6 Support Policies Needing Enhancement

Although supporting policies or goals are certainly helpful, policies or directives that are unfunded or lack enforcement mechanisms can present challenges to full implementation of recycled and reclaimed water programs. Interviewees for two of the four programs, JEA and SBWR, mentioned two such policies. Conceptually, both are strongly supportive of increasing reclaimed and use. However, actually implementing these policies and making their objectives a reality has proven more difficult, particularly in the context of a post-2008 economy.

In May 2006, the City of Jacksonville passed an ordinance strongly encouraging the use of reclaimed water. This ordinance was mentioned by several JEA interviewees as having the potential to increase demand in the service area. However, it was also described as lacking enforcement resources. Currently the ordinance is "not doing much" to encourage new customer hookups or retrofits (Hankin, 2012). As currently written, the ordinance does not include enforcement. So although JEA can install new infrastructure and retrofit older neighborhoods, it cannot mandate organizations to hook up to reclaimed water lines. In fact, up until 2007, the city itself was one of the most infrequent users of reclaimed water for irrigation (Sharkey, 2007). Both JEA and the city of Jacksonville recognize the limitations of the current ordinance and want to modify the ordinance in the future (Hankin, 2012; Seibold, 2012).

In 2007, the city of San Jose adopted its Green Vision, a 15-year plan for economic growth, environmental sustainability, and an enhanced quality of life for its community. The vision is "operationalized" with 10 quantitative goals, and Goal 6 is to "recycle or beneficially reuse 100% of our wastewater." To achieve this goal, SBWR assembled a number of potential project portfolios that would enable the city to meet this goal. Although it has been useful for planning purposes, the Green Vision (for Goal 6) is "an unfunded mandate" (Ong, 2012). The chief issue is that the goal is not tied to a specific source of funding. This lack of stability explains, in part, why a major cooling tower retrofit project that came out of the Green Vision planning process for the 2012 fiscal year was not approved.

Chapter 7

Main Study Findings and Their Implications

The sections that follow summarize the main findings for each research objective and discuss their implications.

7.1 Program Evaluation Metrics

The study's first objective was to identify metrics that could be used to evaluate program performance. In response to this query, the Delphi panel agreed that keeping customers happy, enjoying strong public support, and contributing to a region's overall water supply were appropriate measures of overall program effectiveness.

7.1.1 Customer Satisfaction

Even though the panel ranked customer satisfaction highly appropriate for evaluating overall program performance, only one of the recycled water programs in the case studies regularly conducted formal surveys of customer satisfaction focused specifically on recycled water. Customer interviews indicate a high level of satisfaction, but three of the four case study programs do not appear to monitor this in a systematic way. Obtaining data on customer satisfaction on a regular basis may provide a valuable way for recycled programs both to increase current volumes of use and to expand the range of recycled water applications used at customer sites. In addition, enlisting the help of satisfied customers can be a useful tool for recruiting new customers.

Differences in how program managers and customers perceive customer motivations for using recycled water may have significant relevance to future customer development. Although program managers interviewed for this study think it is all about cost for the customers, customers interviewed for this project more frequently identified environmental issues as a driver. Customers felt they had a basic understanding of larger environmental issues in their service areas (e.g., why saving potable water is important in the San Francisco Bay area), and this is consistent across customer type and location. Although cost is important, if the customer organization does not already have a commitment to environmental issues and water scarcity concerns, selling it on recycled water may prove challenging. Being "green" may not be the most important factor behind customer decisions, but it may be a necessary condition for hookup. Given the modest number of customers and recycled water program managers interviewed for this study, the results are not widely generalizable. However, the apparent distinction between program manager and customer perceptions merits further investigation. An interesting question for future research in this area would be whether customers are more likely to connect if utilities market to them on environmental grounds.

Delphi panelists who provided a numerical value for what might represent a "good" value for customer satisfaction selected a range of 76 to 100% of customers being satisfied or very satisfied. This percentage range is consistent with a previous study of user satisfaction for residents of a dual-plumbed community in Tucson, AZ (Campbell & Scott, 2011), where 89% of residents reported being satisfied with recycled water. However, more work is needed to develop and implement customer satisfaction surveys for CII customers, who are often the largest users of urban recycled water programs. Along these lines, a related area of research is being explored in WateReuse Research Foundation Project WRRF-12-03, "Analysis of Technical and Organizational Issues in the Development and Implementation of Industrial Reuse Projects." The focus of this study is on understanding the differences in perceptions between recycled water programs and their industrial customers.

7.1.2 Community and Voter Support

The Delphi panel also ranked community and voter support as highly appropriate for evaluating overall program performance. A large body of research identifies public perception as the most important factor in the establishment of water reuse programs (Bridgeman, 2004; Dolnicar and Hurlimann, 2009; Gibson and Apostolidis, 2001; Hartley, 2006; Po et al., 2003). This research supports the idea that community and voter support continue to be important for established programs as well.

The suggested values of what would constitute a "good" value for these metrics were high (81–80% for community support, 71–80% for voter support), suggesting that panelists felt that well-performing programs enjoyed support from the vast majority of their communities and voters. However, the consensus level was low. This means that panelists considered the criteria important for measuring program performance, but that they were not in agreement about what specific value would constitute a "good" level of performance. Although program managers in case studies were aware of these metrics, they did not consider them central to program operations or planning.

7.1.3 Contribution to Regional Supply

Responses to the Delphi survey indicate that the ability of a local recycled program to contribute to *regional* water supply can be an appropriate way to gauge overall performance. For example, communities such as Tucson, AZ and Santa Clara County, CA have set future goals for the percentage of total demand that will be met by recycled water of 8% and 7%, respectively (Dotson, 2011; SCVWD 2012). Although the panel as a whole rated this metric high, the response from recycled program managers was quite different. They rated this metric much lower on the appropriateness scale and their detailed comments suggest a hesitancy to use a metric that measures variables that are not solely within their control. Panelists in this group felt that the proposed metric needed to take into consideration variable service area demand, as well as local climatic, economic, and political conditions. Variability in demand because of seasonality and other factors is also cited as a major barrier to full program implementation for nonpotable recycled water systems by Bickford and Neller (2013) in their report to the WateReuse Research Foundation.

One recommendation stemming from this finding is that state and regional water supply agencies provide more program management assistance to individual recycled water programs. This support will help better align regional level goals (i.e., contribution to service area water supply portfolio) to individual program output. As recycled water becomes more of a supply resource and is managed less like a waste product, financing and organizational relationships need to reflect this change. This suggestion echoes much earlier findings of Wong and Gleick (2000), who found that key barriers to program implementation are "institutional barriers that separate water supply and wastewater functions." As described by

Raucher (2007), one approach to improved integration would be to incorporate recycled water more directly into state integrated resource planning processes. Similarly, the study supports the WateReuse Research Foundation report findings of Scott et al. (2011) that call for the "regionalization" of reclaimed water planning.

Delphi panelists in recycled water programs and water supply programs demonstrated a high level of agreement on metric ratings, further reinforcing the idea that these two organization types are moving closer together. One interpretation of this result is that recycled water program managers and water supply program managers tend to see eye to eye on potential program metrics. Data from case study interviews also provide several examples of more integrated project planning and program operations, such as the Advanced Treatment Facility (a collaboration between the SCVWD and SBWR) and the reorganization of EBMUD's recycled water group into the organization's water supply branch.

A suggested direction for future research would involve expanding the Delphi survey to a broader array of stakeholders (e.g., local land use planning agencies and state water planning agencies) or expanding the measurement of a single metric (e.g., developing an industry working group to come up with a broadly applicable customer satisfaction survey). Delphi panel findings apply only to one particular panel, so care should be taken not to overgeneralize this study's conclusions. To get a more complete picture of what program evaluation metrics should be used, a more comprehensive survey of the industry is needed. Input could be gathered at annual meetings of professional associations such as the WateReuse Research Foundation and the International Desalination Association.

7.2 Case Study Program Metrics

Recall that study objective number two was to identify major metrics used by case study programs. For the four programs examined in this project, the most important metric for performance was use-based (mgd of water used on an annual average basis). Indeed, this is the major metric used to describe most recycled water programs—size. However, also using normalized metrics that reflect characteristics such as application breadth and volume of use relative to treatment capacity could provide valuable information for program management and planning. One recommendation of this study is to convene a task force within the WateReuse Research Association or a similar organization to determine whether a modified version of flow ratio, a widely used and important metric for Florida (FDEP, 2010), would be useful. If some variant of a flow ratio could be modified to take into account the following kinds of variables identified by this study's participants, its utility as a measure of program performance could be greatly enhanced:

- Potable water offset
- Groundwater replenishment
- Differing values based on "quality" of the application (e.g., should IPR be valued higher than landscape irrigation?)
- Year-to-year fluctuations in demand (for both potable and reclaimed water)
- Precipitation patterns
- Regional, as opposed to plant-by-plant, generation and usage

7.3 Key Organizational Relationships

Study objective three focused on understanding key relationships and their effect on recycled water program implementation. For this project, case study program managers identified the following three types of organizations as having the most influence: regulators, partner agencies, and customers. Interview data for the programs indicates that there is strong regulatory support for appropriate applications of recycled water. In addition, the relationship between programs and their associated regulatory agencies is maturing and becoming more cooperative.

For the two California case study programs, cooperation with partner agencies was cited by interviewees as crucial for funding hookups and extending infrastructure within their service areas. For SBWR, having program priorities that differ from their partner agencies' priorities has created challenges to program expansion. The findings of this study are consistent with the work of Rosenblum (2012), who emphasized the importance of stronger interagency partnerships for attaining regional and state recycled water goals.

Case study program managers recognize the crucial role customers play in program implementation. From the recycled water program managers' perspective, community and customer support for conventional nonpotable applications (e.g., landscape irrigation) is high. All program managers felt that their current goals for water quality have moved beyond meeting state standards and center more on providing a quality of water that meets customer needs. Customer satisfaction was important to case study programs but was not measured in a systematic or regular way by three of the four programs. On the basis of feedback from six customers interviewed for this project, overall satisfaction with recycled water service was high.

Our case study interview data indicated that public and CII customer acceptance for nonpotable applications was high and that the major impediment to program implementation for two of the case study programs was cost. These findings are consistent with the work of Bischel et al. (2012), who found that the most frequently cited hindrance to implementation in 71 Northern California recycled water programs was "economic and financial disincentives," with "perception and social attitudes" being cited by about one-fourth of survey respondents. For two of the case study programs we examined in depth, JEA and SBWR, program managers reported that the economic downturn of fall 2008 had a significant impact on reduced demand on the customer end, as well as a reduction in federal and state funding available for financing retrofits and new construction. Bischel et al. (2012) also found that another significant implementation barrier was "Who pays for system cost?" In all four case study programs, system cost is often heavily subsidized by the recycled water program, either through the utility itself or with state or federal grant money.

Cost was not brought up as an implementation issue by program managers at Tucson Water or EBMUD. For Tucson Water, one explanation for why money may not be so much of an issue is the use of innovative funding agreements, such as the one it has with the Tucson Unified Water District (one of its major customers). In this partnership, the utility pays for the meters and advances the district funds for the renovation of turn irrigation systems. The District then repays the loan through savings accrued through the conversion to recycled water, which costs 40% less than potable (Dotson and Crockett, n.d.). For EBMUD, the wastewater treatment and water supply functions fall under a single organizational entity, which may allow more flexibility in the funding of recycled water projects.

In sum, this study identifies a set of criteria and associated metrics that could be used to evaluate urban recycled water program performance. It also provides detailed comments from representatives of several stakeholder groups that help explain why certain metrics may or may not be appropriate. The rich description points out potential areas of agreement and disagreement between and among recycled water program managers, water supply program managers, regulators, NGOs, customers, and academia. The case study portion of the project describes the major metrics used by four case study urban recycled water programs. Interview data from these programs provides a unique snapshot of the dynamic and evolving relationship between recycled water programs and their regulators, partner programs, and customers. Taken together, these results can be used to improve coordination between organizations involved in recycled water from the local to the state level. They also provide direction on specific types of projects that could help improve the ability of local programs to reach their full potential.

The metrics and criteria developed in this report can be understood by the general public and elected officials, an important set of stakeholders who often lack detailed knowledge of urban water systems. Even though the United States has one of the most advanced drinking water systems in the world, beyond those who operate or regulate these systems, few people understand how they work or their direct and indirect benefits to communities. With so many states across the country facing impending water shortages, recycled water is becoming an increasingly important part of water supply portfolios. This is why research that helps people understand how recycled water programs work using measures that can be easily explained to nonexperts is critical. Educating this broader audience helps set the stage for increased community support of recycled water program expansion.

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Appendix A

Delphi Survey Questions

Proposed Criterion: Water Quality

One criterion that has been proposed in previous studies to evaluate overall effectiveness of recycled water programs is water quality, which is defined as the extent to which recycled water meets applicable state regulatory standards. There are no national-level recycled water standards. Rather, there are state-specific standards, which vary by the purpose (or application) of the water use. Local recycled water programs also typically monitor other parameters (e.g., mercury, nitrates).

Three water quality parameters that U.S. states commonly monitor are fecal coliform (FC), total suspended solids (TSS), and biochemical oxygen demand (BOD, CBOD).

Based on a survey of recycled water quality standards in eight states, the following set of metrics provides one way of evaluating water quality for a given program. For each parameter comparison, a TRUE value would be an indicator of good water quality.

Test statement: Annual average total suspended solid (TSS) concentrations for program meets or exceed state standards for most restrictive use.

If $\textbf{[TSS (mg/L)]}_{\text{program}} \leq \textbf{[TSS (mg/L)]}_{\text{state std}}$

Then the above statement is **TRUE**

Test statement: Annual average biological oxygen demand/chemical biological oxygen demand meets or exceed state standards for most restrictive use.

If $\textbf{[BOD or CBOD (mg/L)]}_{\text{program}} \leq \textbf{[BOD or CBOD (mg/L)]}_{\text{state std}}$

Then the above statement is **TRUE**

Test statement: Annual average fecal coliform concentrations for program meets or exceed state standards for most restrictive use (e.g., unrestricted access irrigation). Note that two different types of measurements apply to this water quality parameter, based on practices currently used in several U.S. states.

If $\textbf{[FC (cfu/100 ml)]}_{\text{program}} \leq \textbf{[FC (cfu/100 ml)]}_{\text{state std}}$

Then the above statement is **TRUE**

If $\textbf{(\% of days no fecal coliforms detected)}_{\text{program}} \geq \textbf{(\% of days no fecal coliforms detected)}_{\text{state std}}$ (e.g., 75%)

Then the above statement is **TRUE**

For example, in Florida, the most restricted uses are processed food crop irrigation, restricted recreational impoundments, unrestricted access irrigation, toilet flushing, and industrial cooling water. For these applications, the fecal coliform standard is that on 75% of the monitoring days there are zero fecal coliforms detected AND that the number of bacteria present in the sample cannot exceed 25 per 100 ml of water; the TSS standard is 5 mg/L and the CBOD standard is 20 mg/L.

A water utility in southern Florida, reported the following average annual water quality measures for 2010:

Fecal Coliform: 0.86 cfu/100 ml; percent of days with no detectable FC: 89%
TSS: 0.9 mg/L
CBOD: 2.6 mg/L

For this southern Florida Utility:

The fecal coliform water quality standard would be evaluated as:

$$[89\% \text{ days no detectable FC}]_{\text{UTILITY}} > [75\% \text{ days no detectable}]_{\text{FL Std}} = \text{TRUE}$$

The TSS water quality standard would be evaluated as shown below:

$$[0.9 \text{ mg/L}]_{\text{UTILITY}} < [5.0 \text{ mg/L}]_{\text{FL Std}} = \text{TRUE}$$

And the CBOD water quality standard would be evaluated as follows.

$$[2.6 \text{ mg/L}]_{\text{UTILITY}} < [20.0 \text{ mg/L}]_{\text{FL Std}} = \text{TRUE}$$

Using a scale of 0 to 10 below, please rate how appropriate you think this metric is as a general indicator of recycled water program effectiveness:

0	1	2	3	4	5	6	7	8	9	10
Not at all appropriate					Appropriate					Extremely appropriate

Please provide justification for your rating in the space below:

In the space below, please let us know if you know of a better metric that could be used to help the industry better understand the importance of water quality.

Proposed Criterion: Recycled Water Potential

The concept of recycled water potential recurred consistently in the panel's responses for several proposed criteria. A brief literature review was conducted to find other research on the concept. Based on a paper from Yang and Abbaspour (2007) on the analysis of wastewater reuse potential in Beijing, the following metrics were developed. All of the metrics were based on the first metric below and adapted for two major recycled water applications.

$$\text{Recycled Water Utilization Ratio} = \frac{\text{Recycled Water Potential Use (mgd)}}{\text{Recycled Water Actual Use (mgd)}} \ (\%)$$

$$\text{Recycled Water Utilization Ratio}_{(\text{Irrigation})} = \frac{\text{Area suitable for RW x Irrigation Requirement } (\frac{\text{vol}}{\text{area}})}{\text{Actual Vol of Recycled Water used to irrigate suitable area}}$$

$$\text{Recycled Water Utilization Ratio}_{(\text{Power Plant})} = \frac{\text{C x E x K}}{\text{Actual Vol of Recycled Water used in power plant(s)}}$$

Where C: generating capacity of thermal power plants (million KWh (or equivalent); E: water consumption of unit generating capacity of thermal power plants (vol/kWh) or eqv.; K: ratio of circulating cooling water and ash-rinsing water to total water withdrawal of thermal power plants (%).

For example, if a total of 100 irrigated acres of parks exist within a program's service area, and only 50 acres is irrigated with recycled water, the recycled water utilization ratio for the service area would be 50%.

Using a scale of 0 to 10 below, please rate how appropriate you think this metric is as a general indicator of recycled water program effectiveness:

0	1	2	3	4	5	6	7	8	9	10
Not at all appropriate					Appropriate					Extremely appropriate

Please provide justification for your rating in the space below:

For a recycled water program in operation for 5 years or more, what would you say is a good basic recycled water utilization ratio (*please check one*)?

	0 to 25%		76 to 100%
	26 to 50%		none of the above
	51 to 75%		don't know

In the space below, please let us know if you know of a better metric that could better capture the concept of recycled water potential. Include units of analysis where possible.

Proposed Criterion: Recycled Water Portfolio Contribution

Another criterion that has been proposed in previous studies to evaluate overall effectiveness of recycled water programs is the contribution recycled water makes to the overall water supply portfolio for a region. One way of measuring this contribution is defined by the formula below:

$$\textbf{Recycled Water Portfolio Contribution} = \frac{\textbf{Recycled water consumed in given year } (ac-ft)}{\textbf{Total water consumed in given year } (ac-ft)} \ (\%)$$

For example, in 2007, 5% of the total water supplied from the Santa Clara Valley Water District in California came from recycled water. Similarly for 2007, 4% of the total water supplied from the San Antonio Water System in Texas came from recycled water. In 2008, approximately 12% of the total water supplied from Tucson Water in Arizona came from recycled water.

Using a scale of 0 to 10 below, please rate how appropriate you think this metric is as a general indicator of recycled water program effectiveness:

0	1	2	3	4	5	6	7	8	9	10
Not at all appropriate					Appropriate					Extremely appropriate

Please provide justification for your rating in the space below:

For a recycled water program in operation for 5 years or more, what would you say is a good value for the recycled water portfolio contribution (*please check one*)?

	1 to 5%		> 20%
	6 to 10%		none of the above
	11 to 20%		don't know

In the space below, please let us know if you know of a better metric that could be used to help the industry better understand the importance of recycled water's contribution to the overall supply portfolio for a municipality. Include units of analysis where possible.

Proposed Criterion: Reuse Efficacy

Previous studies indicate that the relationship between the amount of recycled water produced by a program and the amount of recycled water beneficially reused is an important part of understanding overall recycled water program effectiveness.

One metric that can be used to evaluate this relationship is flow ratio, which is defined by the formula below:

$$\textbf{Flow Ratio} = \frac{\textbf{Reuse Flow (mgd)}}{\textbf{Total Wastewater Treatment Facility Flow (mgd)}}$$

Reuse Flow is defined as the volume of recycled water recycled for all permitted applications (usually in mgd).

Total Wastewater Treatment Facility Flow is defined as the total volume of wastewater treated (usually in mgd).

For example, Florida's Water Reuse Program reports average flow ratios (stratified by Florida Department of Environmental Protection District and Water Management District) that range from 0.12 to 0.90. Their permitted urban recycled water applications include public access area and landscape irrigation; groundwater recharge and indirect potable reuse; toilet flushing; fire protection; and wetlands.

Using a scale of 0 to 10 below, please rate how appropriate you think this metric is as a general indicator of recycled water program effectiveness:

0	1	2	3	4	5	6	7	8	9	10
Not at all appropriate					Appropriate					Extremely appropriate

Please provide justification for your rating in the space below:

For a recycled water program in operation for 5 years or more, what would you say is a good flow ratio (*please check one*)?

	0.00 to 0.19		0.80 to 1.00
	0.20 to 0.39		none of the above
	0.40 to 0.59		don’t know
	0.60 to 0.79		

In the space below, please let us know if you know of a better metric that could be used to help the industry better understand the relationship between reuse capacity and the amount of recycled water being beneficially reused at the level of an individual wastewater treatment plant. Include units of analysis where possible.

Proposed Criterion: Demand Growth

Another criterion cited in the literature as an indicator of an effective recycled water program is increasing customer demand, or demand growth. One way of measuring increases (and decreases) in customer demand involves comparing the volume of recycled water provided to customers every year for a period of 5 years of more and looking for general trends.

There is no specific industry-wide metric commonly used to assess this criterion. One metric adapted from the business world that could be used to measure demand growth is volume growth rate, which is defined by the formula below:

$$\textbf{Volume Growth Rate} = \frac{\textbf{Volume of Recycled Water Sold (current year, ac} - \textbf{ft)}}{\textbf{Volume of Recycled Water Sold (previous year, ac} - \textbf{ft)}}$$

Using a scale of 0 to 10 below, please rate how appropriate you think this metric is as a general indicator of recycled water program effectiveness:

0	1	2	3	4	5	6	7	8	9	10
Not at all appropriate					Appropriate					Extremely appropriate

Please provide justification for your rating in the space below:

For an urban recycled water program in operation for 5 years or more, what would you say is a good average annual recycled water volume growth rate (*please check one*)?

	1 to 5%
	6 to 10%
	11 to 15%
	16 to 20%
	none of the above
	don’t know

In the space below, please let us know if you know of a better metric that could be used to help the industry better understand the relationship between marketing and volume growth rate. Include units of analysis where possible.

Proposed Criterion: Product Diversification

Matching water quality to water use application has been a strategy emphasized by the California Department of Water Resources, the Arizona Blue Ribbon Panel on Water Sustainability, and the Florida Department of Environmental Protection.

One metric that has been proposed in previous studies to evaluate overall effectiveness of recycled water programs is product diversification, where a program produces several qualities of recycled water to match different end uses.

For example, the West Basin Municipal Water District in Los Angeles County provides five types of recycled water, sometimes referenced as "boutique water," from four treatment plants. The different water qualities are distributed to a petroleum refinery, seawater barrier groundwater injection project, and to irrigation users throughout the district.

There is no specific quantitative measure for the metric. Rather, it would be evaluated based on interviews and document review provided by the utility. Based on the study team's assessment, programs would be given one of four ratings:

(C) Program has not investigated diversifying product to match customer needs

(B) Program has investigated diversifying product, and has created a plan to produce more than one quality of recycled water within next 3 years

(A) Program has investigated diversifying product and distributes at least 2 different qualities of recycled water to meet customer's needs

(NA) Program has investigated diversifying product and found limited or no customer need

Using a scale of 0 to 10 below, please rate how appropriate you think this metric is as a general indicator of recycled water program effectiveness:

0	1	2	3	4	5	6	7	8	9	10
Not at all appropriate					Appropriate					Extremely appropriate

Please provide justification for your rating in the space below:

For a recycled water program in operation for 5 years or more, what would you say is a good "letter grade" for product diversification (*please check one*)?

	A		NA
	B		none of the above
	C		don't know

In the space below, please let us know if you know of a better metric that could be used to help the industry better understand the importance of product diversification. Include units of analysis where possible.

Proposed Criterion: Application Breadth

One criterion that has been proposed in previous studies to evaluate overall effectiveness of a recycled water program is the extent to which a program's water can be used for all possible recycled water applications. One way of measuring this would be to determine the program's application range, which we define using the formula below:

$$\text{Recycled Water Application Range} = \frac{\textit{Sum of all actual applications of recycled water in given service area*}}{\textit{Total no. of possible applications in a given service area}}\ (\%)$$

* examples of types of application: irrigation (all), impoundments, cooling, toilet flushing, fire-fighting, commercial laundries, commercial car washes, concrete mixing, and street cleaning.

For example, the recycled water produced by a theoretical program in California is used for irrigation of golf courses only (sum of all actual applications = 1).

However, within both the state and the program's service area the following applications are allowable: irrigation, cooling, and street cleaning (total no. of possible applications = 3).

For this theoretical program, the Recycled Water Application Range would be: (1/3) × 100 = 33%; i.e., the theoretical program's recycled water is used for only 33% of the total allowable applications.

Using a scale of 0 to 10 below, please rate how appropriate you think this metric is as a general indicator of recycled water program effectiveness:

0	1	2	3	4	5	6	7	8	9	10
Not at all appropriate					Appropriate					Extremely appropriate

Please provide justification for your rating in the space below:

For a recycled water program in operation for 5 years or more, what would you say is a good value for the recycled water application range (*please check one*)?

	0 to 25%		76 to 100%
	26 to 50%		none of the above
	51 to 75%		don't know

In the space below, please let us know if you know of a better metric that could be used to help the industry better understand how well a program is doing at providing water for the broadest range of allowable applications. Include units of analysis where possible.

Proposed Criterion: Customer Satisfaction

The degree to which recycled water customers are satisfied (or dissatisfied) with the quantity and quality of delivered water is another important program characteristic. Customer Satisfaction has been reported for residential use of recycled water in places like Australia and Singapore.

For example, on a scale of 0 (not satisfied) to 10 (very satisfied), residents of a dual plumbed community at Mawson Lakes in Australia, reported an average satisfaction rate of 7.51 with use of recycled water.

The satisfaction level of industrial or commercial users of recycled water has not been reported in any published source. However, numerous interviews conducted during the preliminary research phase of this project indicate that customer satisfaction is an important, if not critical part, of an effective program.

Customer Satisfaction can be quantified in several ways. Two possible metrics for this criterion (for individual user groups*) are presented below:

$$\textbf{Customer Satisfaction} = \frac{\textbf{No. of customers satisfied}}{\textbf{Total no. of customers}} \ (\%)$$

$$\textbf{Customer Complaints} = \frac{\textbf{No. of customer complaints}}{\textbf{Year}}$$

*user groups will include irrigation (all), cooling, toilet flushing, fire fighting, commercial laundries, commercial car washes, concrete mixing, and street cleaning.

Using a scale of 0 to 10 below, please rate how appropriate you think this metric is as a general indicator of recycled water program effectiveness:

0	1	2	3	4	5	6	7	8	9	10
Not at all appropriate					Appropriate					Extremely appropriate

Please provide justification for your rating in the space below:

For an urban recycled water program in operation for 5 years or more, what would you say is a good level of customer satisfaction (i.e., the percentage of responding customer that are satisfied or very satisfied with water quantity, quality, and support)?

	0 to 25%
	26 to 50%
	51 to 75%
	76 to 100%
	none of the above
	don’t know

For an urban recycled water program in operation for 5 years or more, what would you say is an acceptable number of customer complaints in a year?

	0 to 5
	6 to 10
	11 to 15
	> 15
	none of the above
	don't know

In the space below, please let us know if you know of a better metric that could be used to help the industry better understand customer satisfaction. Include units of analysis where possible.

Proposed Criterion: Customer Service and Support

One criterion that has been proposed in previous studies to evaluate overall effectiveness of recycled water programs is the provision of customer service and support. This can be evaluated by identifying the number and type of value-added customer service programs offered. Value-added services are defined as non-core services that recycled water programs may offer to aid in recruiting new customers or enhancing the overall experience of a current customer.

For example, South Bay Water Recycling provides free consulting services to new customers to help them complete their cooling tower permit application process. East Bay Municipal Utility District provides complementary horticulturist services to potential new recycled water customers for site evaluations.

Using a scale of 0 to 10 below, please rate how appropriate you think this metric is as a general indicator of recycled water program effectiveness:

0	1	2	3	4	5	6	7	8	9	10
Not at all appropriate					Appropriate					Extremely appropriate

Please provide justification for your rating in the space below:

For a recycled water program in operation for 5 years or more, what would you say is a good value for the recycled water application range (*please check one*)?

	Provide assistance with commercial permit application process
	Provide assistance with residential permit application process
	Provide landscape consultant
	Provide graywater consultant
	Provide assistance with ROI analysis
	Provide assistance with locating grants or general financing for customer project
	Conduct industrial user group annual meeting
	Other 1 - please give us the name and a brief description of the service:
	Other 2 - please give us the name and a brief description of the service:
	Other 3 - please give us the name and a brief description of the service:
	Don’t know

Proposed Criterion: Public Support

One criterion that has been proposed in previous studies to evaluate overall effectiveness of recycled water programs is public support. Public support and public perception of recycled water are the most studied and written about aspects of recycled water.

The following examples provide some basic context for identifying potential metrics of public support and public perception related to recycled water.

In a 2009 public opinion survey conducted in Corvallis, Oregon, more than 70% of respondents favored the use of recycled water for irrigation of business and park landscapes, golf courses, nonedible crops; public toilets; cooling; industrial processes; and fire hydrant supply. A 2006 public survey conducted in Victor Valley, California found that 84% of surveyed residents would favor similar uses of recycled water in their community.

One way to measure the percentage of a surveyed population in a service area that support use of recycled water for permitted uses is with the formula below:

$$\text{Community Support} = \frac{\text{No. of survey respondents in support}}{\text{Total No. of survey respondents}} \ (\%)$$

Another measure of public support for recycled water is majority support in local elections related to the construction or finance of a recycled water project. For example, the residents of St. Pete Beach, Florida, approved a ballot initiative in 1992 to both finance and construct a recycled water program. In 2010, a $39 million wastewater system revenue bond passed with 74% support from voters in Mesa, Arizona. Funds from the bond will be used to replace aging distribution lines and improve reclaimed water facilities.

One way to measure the percentage of voting population in a service area that support ballot measures or initiatives focused on the construction, expansion, or finance of recycled water programs is with the formula below:

$$\text{Voter Support} = \frac{\text{No. of voters in support}}{\text{Total No. of voters}} \ (\%)$$

Using a scale of 0 to 10 below, please rate how appropriate you think this metric is as a general indicator of recycled water program effectiveness:

0	1	2	3	4	5	6	7	8	9	10
Not at all appropriate					Appropriate					Extremely appropriate

Please provide justification for your rating in the space below:

For an urban recycled water program in operation for 5 years or more, what would you say is a good value for the percentage of survey respondents who supports the use of recycled water (Community Support)?

	40 to 50%		81 to 90%
	51 to 60%		91 to 100%
	61 to 70%		none of the above
	71 to 80%		don't know

For an urban recycled water program in operation for 5 years or more, what would you say is a good value for the percentage of voters who vote "yes" on ballot measures that support the construction, expansion, or finance of recycled water programs (Voter Support)?

	40 to 50%		81 to 90%
	51 to 60%		91 to 100%
	61 to 70%		none of the above
	71 to 80%		don't know

In the space below, please let us know if you know of a better metric that could be used to help the industry better understand public support.

Proposed Criterion: Operation and Maintenance Cost Recovery

One criterion that has been proposed in previous studies to evaluate overall effectiveness of recycled water programs is the extent to which a program is able to recover its operations and maintenance (O&M) costs. A metric that can be used to assess this type of cost recovery is defined by the formula below:

$$\textit{O\&M Cost Recovey Ratio} = \frac{\textit{Average annual recycled water sales } (\frac{\$}{yr})}{\textit{Average annual O\&M costs } (\frac{\$}{yr})}$$

For example, based on a survey of 23 utilities in the states of Arizona, California, Florida, Hawaii, and Texas, recovery ratios ranged from less than a third to 100%

The AWWA conducted a survey of approximately 100 utilities in 2000 & 2007. In 2000, two-thirds of respondents either did not track cost recovery or recovered less than 25% of annual operations costs from recycled water rates. In 2007, more utilities tracked cost recovery, however one-third recovered less than 25% of annual operation costs from recycled water rates.

Using a scale of 0 to 10 below, please rate how appropriate you think this metric is as a general indicator of recycled water program effectiveness:

0	1	2	3	4	5	6	7	8	9	10
Not at all appropriate					Appropriate					Extremely appropriate

Please provide justification for your rating in the space below:

For a recycled water program in operation for 5 years or more, what would you say is a good operations and maintenance cost recovery ratio (*please check one*)?

	0.00 to 0.19		0.80 to 1.00
	0.20 to 0.39		none of the above
	0.40 to 0.59		don’t know
	0.60 to 0.79		

In the space below, please let us know if you know of a better metric that could be used to help the industry better understand how well a program is recovering its costs. Include units of analysis where possible.

Proposed Criterion: Contaminants of Emerging Concern

Water supply agencies have identified contaminants of emerging concern (CECs) as a future set of issues that require resolution before recycled water programs can move to indirect potable reuse (IPR). Outside of this application, there are concerns in the scientific community that CECS, even in small concentrations, can adversely affect aquatic life.

CECs are a diverse group of relatively unmonitored and unregulated chemicals found in consumer and industrial products that have been shown to occur at trace levels in wastewater discharges, ambient receiving waters, and drinking water supplies. CECs include pharmaceuticals, personal care products, and other commercial and industrial compounds.

A 2009 national workshop including over 50 scientists, regulators, and stakeholders working on this topic estimates that there are over 100,000 chemicals approved for use in the U.S., but only analytical methods to test for several hundred at concentrations of interest (e.g., parts per trillion).

One metric that has been proposed to evaluate overall effectiveness of recycled water programs is the extent to which CECs are being addressed by the program. There is no specific industry-wide metric commonly used to evaluate or measure this criterion. Based on the study team's review of existing data on this topic, program activities generally fall into one of following four stages:

(D) Program not monitoring for CECs, no plans for future monitoring

(C) Program not monitoring for CECs, but plans to within next 3 years

(B) Program monitoring some CECs

(A) Program monitoring some CECs and has active strategy for future management

Using a scale of 0 to 10 below, please rate how appropriate you think this metric is as a general indicator of recycled water program effectiveness:

0	1	2	3	4	5	6	7	8	9	10
Not at all appropriate					Appropriate					Extremely appropriate

Please provide justification for your rating in the space below:

For a recycled water program in operation for 5 years or more, what would you say is a good "letter grade" for CEC monitoring and strategy (*please check one*)?

	A		D
	B		none of the above
	C		don't know

In the space below, please let us know if you know of a better metric that could be used to help the industry better understand the importance of product diversification. Include units of analysis where possible.

Proposed Criterion: Energy Intensity

One criterion that has been proposed in previous studies to evaluate overall effectiveness of recycled water programs is the energy intensity of recycled water compared to other sources of water supply. Energy intensity is defined as the relative amount of energy (in kWh/AF) required to produce supply from various water sources.*

$$\textbf{Energy Intensity} = \frac{\textbf{Sum of Energy Use (kWh)}}{\textbf{Amount of Recycled Water Used (acre} - \textbf{ft)}}$$

* This value is calculated by summing estimated energy use for following five phases: supply/storage, conveyance, end use, treatment, and distribution.

For example, average energy intensity ratios for water used by the Santa Clara Valley Water District in Northern California range from 0 (for water conservation) to 694 kWh/AF (for recycled water) to 1,695 kWh/AF (for imported water). The energy intensity ratio for recycled water is 18% less than for local surface water, and about 50% less than groundwater.

Using a scale of 0 to 10 below, please rate how appropriate you think this metric is as a general indicator of recycled water program effectiveness:

0	1	2	3	4	5	6	7	8	9	10
Not at all appropriate					Appropriate					Extremely appropriate

Please provide justification for your rating in the space below:

For an urban recycled water program in operation for 5 years or more, what would you say is a good value for the energy intensity for recycled water (RW) relative to groundwater (GW)?

	Energy intensity of RW is 5% to 10% less than energy intensity for GW
	Energy intensity of RW is 11% to 20% less than energy intensity for GW
	Energy intensity of RW is 21% to 30% less than energy intensity for GW
	Energy intensity of RW is over 30% less than energy intensity for GW
	None of the above
	Don’t know

For an urban recycled water program in operation for 5 years or more, what would you say is a good value for the energy intensity for recycled water (RW) relative to imported water (IW)?

	Energy intensity of RW is 5% to 10% less than energy intensity for IW
	Energy intensity of RW is 11% to 20% less than energy intensity for IW
	Energy intensity of RW is 21% to 30% less than energy intensity for IW
	Energy intensity of RW is over 30% less than energy intensity for IW
	None of the above
	Don’t know

In the space below, please let us know if you know of a better metric that could be used to help the industry better understand customer satisfaction. Include units of analysis where possible.

Proposed Criterion: Indirect Potable Reuse (IPR)

Indirect potable reuse (IPR) is the blending of advanced treated recycled or reclaimed water into a natural water source (groundwater basin or reservoir) that can be used for drinking (potable) water after further treatment. Applications of IPR include groundwater recharge and reservoir augmentation.

For example, Orange County's Groundwater Replenishment System (GWRS) utilizes microfiltration, reverse osmosis and ultraviolet light with hydrogen peroxide to treat wastewater. This treated water is then pumped to recharge basins where it naturally filters into the groundwater basin, augmenting drinking water supplies. Other IPR projects have been implemented in Scottsdale, Arizona and Upper Occoquan, Virginia. Advocates of water reuse consider IPR to be a concrete example of recycled water being used for one of its highest possible purposes. On a larger scale, unplanned indirect potable reuse is occurring in virtually every major river system in the United States today.

In contrast, some IPR projects, such as those in San Diego and Dublin/San Ramon, California, and Tampa, Florida have experienced a high degree of public skepticism, lack of support from key decision-makers, or even public opposition. These responses largely stem from concerns that pathogenic organisms may not be adequately removed during treatment processes and negative branding.

There is no specific quantitative measure for evaluating the extent of a program's IPR activities. Based on the study team's assessment of available data, the status of U.S. IPR programs generally fall into one of the following stages.

(E) Program has no current or future plans to use recycled water for IPR purposes
(D) Program considering developing IPR plan within next 3 to 5 years
(C) Program has completed plans for IPR project
(B) Program has completed plans for IPR project and is in construction phase
(A) Program currently using some form of IPR

Using a scale of 0 to 10 below, please rate how appropriate you think this metric is as a general indicator of recycled water program effectiveness:

0	1	2	3	4	5	6	7	8	9	10
Not at all appropriate					Appropriate					Extremely appropriate

Please provide justification for your rating in the space below:

For a recycled water program in operation for 5 years or more, what would you say is a good "letter grade" for IPR planning and strategy (*please check one*)?

	A		E
	B		none of the above
	C		don't know
	D		

In the space below, please let us know if you know of a better metric that could be used to help the industry better understand how programs are dealing with IPR.

Definition: Beneficial Reuse

From Round 1's responses, we learned there is a wide range of definitions of beneficial reuse. Listed below are several urban applications of recycled water. Please check all that you consider beneficial reuses of recycled water in an urban area.

Beneficial Reuse Applications: Please select all that apply.

	residential turf irrigation
	commercial turf irrigation
	open space irrigation
	golf course irrigation
	commercial car washes
	dust control (construction & roads)
	fire protection
	concrete mixing
	cooling
	snowmaking
	groundwater recharge
	toilet flushing
	decorative fountains
	decorative lakes
	recreational lakes
	wetland restoration
	salt water barrier

In the space below, please list any additional applications or uses of recycled water you consider beneficial that were not included in the list above.

Appendix B

Example Case Study Interview Form

WateReuse Research Foundation Project: Understanding the Influence of Stakeholder Groups on Urban Recycled Water Programs (Recycled Water Program Manager)

Name:	Date Interview Scheduled:
Title:	Interview Location:
Organization:	Contact Information:
Interview Date:	Interview Time:
Interviewer Name:	Transcribed:

Introduction

This research is being conducted by a team of researchers at San Jose State University Department of Environmental Studies in collaboration with South Bay Water Recycling and the Santa Clara Valley Water District. This research project is divided into two stages and has the following three objectives: (1) to identify through expert analysis a common set of evaluative criteria and metrics that can be applied to assess effectiveness of urban recycled water programs at the regional and municipal level, (2) evaluate the effectiveness of twelve case study urban recycled water programs in California, Florida, and Arizona, and (3) assess the significance of stakeholder group roles on recycled water program effectiveness. California, Florida, and Arizona have been chosen as study locations because these three states lead the nation in recycled water use. This effort is funded by the WateReuse Research Foundation.

In the first stage of data collection, evaluative criteria and metrics were developed. These interviews contribute toward fulfilling the last two objectives of the project.

Your input will be used to provide an explanation and deeper understanding of the interactions between key stakeholder groups and the implementation of urban recycled water programs. The information you volunteer will be used to help state and local government officials and managers of recycled water programs design policies and practices to better facilitate the use of recycled water. The answers you provide may be published or presented to the public. As described in informed consent form, at your request, your identity and responses will be kept confidential in any publication or presentation associated with this work.

Background

1. Could you please provide me with some perspective on the history of recycled water use in your service area, the original program goals and the extent to which you feel those *goals* have been achieved to date? Are there two or three goals that are currently driving program activities? *[please try to get key dates in chronology]*

2. In the past 5 years, has per capita recycled water use been increasing, decreasing, or stayed about the same? [ask for annual RW use figures if available, in addition to treatment capacity]. In your opinion, what factors do you feel are most closely associated with increases or decreases in demand for recycled water in _______________ (interviewee's service area)?

Metric Questions

3. Overall, what measures or goals does the program set to evaluate its performance? For example, some utilities conduct an annual customer survey, others measure the volume of recycled water provided to customers divided by the recycled water treatment capacity of the facility, others measure the volume of recycled water put to 'beneficial use'. What would you say would be the three to five most important metrics used by your program? *[MOST IMPORTANT QUESTION]*

This next set of questions is designed to collect data on the metrics associated with the evaluative criteria identified by the Delphi survey and related literature as possible metrics for understanding program performance. Through the collection of this data across multiple programs, we can begin to see where areas of commonality might suggest a shared set of informative metrics for programs across the U.S. The first group of questions focuses on recycled water quantity and quality. Subsequent question groups ask about recycled water customers, community support, and emerging issues.

Recycled Water Portfolio Contribution= $\frac{Recycled\ water\ consumed\ in\ given\ year\ (ac-ft)}{Total\ water\ consumed\ in\ given\ year\ (ac-ft)}$ (%)

1.1 One metric that has been proposed in previous studies to evaluate overall effectiveness of recycled water programs is the percentage contribution recycled water makes to the overall water supply portfolio for a region, defined by the formula below:

Recycled Water Portfolio Contribution =

[For example, in 2007, 4.3% of the total water supplied from the Santa Clara Valley Water District in California came from recycled water (SCVWD, 2010). Similarly for 2007, 4.0% of the total water supplied from the San Antonio Water System in Texas came from recycled water (SAWS, 2008). In 2006, 10.6% of the total water supplied from Tucson Water in Arizona came from recycled water (Tucson Water, 2008).]

1.2 Does your facility keep track of data that would allow you to calculate the recycled water portfolio contribution or some type of similar data?

NO ↓ YES→ 1.2.1 Can you tell us what the recycled water portfolio contribution for your program has been over the past 5 calendar years? (Down arrow indicates proceed to following question)

1.3 Has your organization or local government set a goal in the past or near future (0-10 years) for the recycled water portfolio contribution?

NO ↓ YES→ 1.3.1 Has the organization been able to meet past goals or is on track to meet future recycled water portfolio contribution goals? (Down arrow indicates proceed to following question)

1.3.2 Can you elaborate on why your organization was or was not able to meet past goals and is or is not on track to meet future goals?

Flow Ratio

2.1 One metric that has been proposed in previous studies to evaluate overall effectiveness of recycled water programs is flow ratio, which is defined by the formula below:

$$\frac{Reuse\ Flow\ (mgd)}{Total\ Wastewater\ Treatment\ Facility\ Flow\ (mgd)}$$

For example, average flow ratios in Florida (stratified by Florida Department of Environmental Protection District and Water Management District) range from 0.12 to 0.90.

Does your facility keep track of data that would allow you to calculate this number?

NO ↓ YES→ 2.1.2 Can you tell us what the flow ratio for your program has been for the past 5 calendar years or provide us with necessary data for us to calculate it? (Down arrow indicates proceed to following question)

Recycled Water Utilization Ratio

3.1 One metric identified by the Delphi study as an appropriate evaluator of the overall effectiveness of recycled water programs is recycled water utilization ratio. This metric measures the volume of recycled water actually used versus the volume that could potentially be used.

3.2 Does your program track recycled water utilization ratio?

NO ↓ YES→ 6.2.1 Can you provide us with your program's reports or summaries on recycled water utilization ratio for the past 5 calendar years? (Down arrow indicates proceed to following question)

Product Diversification

4.1 Matching water quality to water use application has been a strategy emphasized by the California Department of Water Resources, the Arizona Blue Ribbon Panel on Water Sustainability, and the Florida Department of Environmental Protection.

One metric that has been proposed in previous studies to evaluate overall effectiveness of recycled water programs is product diversification, where a program produces several qualities of recycled water to match different end uses.

For example, The West Basin Municipal Water District in Los Angeles County provides five types of recycled water, sometimes referenced as "boutique water," from four treatment plants. The different water qualities are distributed to a petroleum refinery, seawater barrier groundwater injection project, and to irrigation users throughout the district.

4.2 Does your facility offer different or specialized types of recycled water?

NO ↓ YES→ 8.2.1 How many different types of recycled water do you offer? (Down arrow indicates proceed to following question)

4.3. Have you investigated offering different types of recycled water or plan to in the near future?

Water Quality

5.1 One metric that has been proposed in previous studies to evaluate overall effectiveness of recycled water programs is water quality. There are no nationwide standards for recycled water quality parameters. Each state has created its own standards by application type. Three quality parameters each state monitor are: fecal coliform, total suspended solids (TSS), and biochemical oxygen demand (BOD, CBOD).

There is no specific quantitative measure for the metric. The study team has developed the following metric to measure and compare the water quality nationwide for producers of recycled water.

Water Quality (Fecal Coliform) = Volume of recycled water that exceeds state fecal coliform standards for most restrictive use / Total volume of recycled water produced (%)

Water Quality (TSS) = Volume of recycled water that exceeds state TSS standards for most restrictive use / Total volume of recycled water produced (%)

Water Quality (BOD, CBOD) = Volume of recycled water that exceeds state BOD or CBOD standards for most restrictive use / Total volume of recycled water produced (%)

5.2 How does your program track and monitor water quality?

Customer Satisfaction

6.1 One metric that has been proposed in previous studies to evaluate the overall effectiveness of recycled water programs is customer satisfaction.

6.2 Does your program assess customer satisfaction?

NO ↓ YES→ 6.2.1 Can you provide us with any program's reports or summaries on customer satisfaction rates conducted in the past 5 years? (Down arrow indicates proceed to following question)

Value-Added Services

7.1 One metric that has been proposed in previous studies to evaluate overall effectiveness of recycled water programs is the provision of Value-Added Customer Service. Value added services are defined as non-core services recycled water services that may aid in recruiting new customers or enhancing the overall experience of a current customer.

7.2 Does your program provide any of these or other value-added services (check appropriate box below)?

( ) Provide assistance with commercial permit application process
( ) Provide assistance with residential permit application process
( ) Provide landscape consultant
( ) Provide graywater consultant
( ) Provide assistance with ROI analysis
( ) Provide assistance with locating grants or general financing for customer project
( ) Other:____

____Total

7.3 Of the services offered, are there any that are particularly popular with customers?

Voter Support

8.1 One metric identified by the Delphi study as an appropriate evaluator of the overall effectiveness of recycled water programs is voter support.

8.2 Does your program track voter support?

NO ↓ YES→ 8.2.1 Can you tell us about recent ballot measures or bonds and their outcomes related to recycled water use, programs or infrastructure that have affected your program? (Down arrow indicates proceed to following question)

Community Support

9.1 One metric identified by the Delphi study as an appropriate evaluator of the overall effectiveness of recycled water programs is community support.

9.2 Does your program track community support of recycled water?

NO ↓ YES→ 9.2.1 Can you provide us with your program's reports or summaries on community support for the past 5 calendar years?

9.3 Does your program document efforts to increase community support?

CEC Monitoring and Strategy

10.1 Water supply agencies and the public have identified contaminants of emerging concern (CECs) as a future set of issues that require resolution before recycled water programs can move to indirect potable reuse (IPR). Outside of this application, there are concerns in the scientific community that CECS, even in small concentrations, can adversely affect aquatic life.

10.2 Considering regulatory environment, community and voter support, demand, climate, and other factors, what do you think are the main factors driving CEC strategies for your organization's recycled or reclaimed water program?

10.3 Which of the following statements best describes the state of CEC monitoring and evaluation for your program? (check appropriate choice below)

( ) Program not monitoring for CECs, no plans for future monitoring
( ) Program not monitoring for CECs, but plans to within next 3 years
( ) Program monitoring some CECs
( ) Program monitoring some CECs and has active strategy for future Management

O&M Cost Recovery Ratio

11.1 One metric that has been proposed in previous studies to evaluate overall effectiveness of recycled water programs is O&M cost recovery ratio, which is defined by the formula below:

$$\frac{Average\ annual\ recycled\ water\ fee\ revenue\ (\$)}{Average\ annual\ operation\ an\ maintenance\ expenditures\ (\$)}$$

For example, based on a survey of 23 utilities in the states of Arizona, California, Florida, Hawaii, and Texas, recovery ratios ranged from less than a third to 100%. Additionally, the AWWA conducted a survey of approximately 100 utilities in 2000 & 2007. In 2000, two-thirds of respondents either did not track cost recovery or recovered less than 25% of annual operations costs from recycled water rates In 2007, more utilities tracked cost recovery, however one-third recovered less than 25% of annual operation costs from recycled water rates (AWWA, 2008).

11.2 How does your program track recycled water program cost recovery or other important financial aspects of the program?

11.3 Does your facility keep track of data that would allow you to calculate a specific number for cost recovery?

NO ↓ YES→ 11.3.1 Can you tell us what the current O&M cost recovery ratio is for your program? (Down arrow indicates proceed to following question)

11.3.2 What are the programs sources of revenue?

11.3.3 Which expenses are considered under operations and maintenance?

Energy Intensity

12.1 One metric that has been proposed in previous studies to evaluate overall effectiveness of recycled water programs is energy intensity ratio, which is defined by the formula below:

$$\frac{Sum\ of\ Energy\ Use*\ \ (kWh)}{Amount\ of\ Recycled\ Water\ Used\ (acre-foot)}$$

* based on addition of energy uses for following five phases: supply/conveyance, end use, treatment, distribution, and treatment.

For example, average energy intensity ratios for water used by the Santa Clara Valley Water District in Northern California range from 0 (for water conservation) to 694 kWh/AF (for recycled water) to 1,695 kWh/AF (for imported water).]

12.1 Is reducing energy intensity presently a primary goal of your program? Do you think it will be in the future?

12.2 Does your facility keep track of data that would allow you to calculate energy intensity?

NO ↓ YES→ 12.2.1 Can you tell us what the energy intensity is of recycled water produced for the past 5 calendar years? (Down arrow indicates proceed to following question)

NO ↓ YES→ 15.2.1.1 How does the energy intensity of recycled water compare and rank with other supply sources for your service area? (Down arrow indicates proceed to following question)

Stakeholder Collaboration and Engagement

This second set of questions is intended to collect data about the nature of the relationship between urban recycled water programs and other organizations that impact their operations and planning.

13. Which of the following types of organizations currently play important roles in the provision of recycled water to your service area? (circle the top 3)

Other recycled water programs or contributing agencies

Wholesale water supply agencies

State, regional, or local regulators

Customers

Federal regulators (e.g., EPA)

Other federal agencies (e.g., Bureau of Reclamation)

Non-governmental organizations (e.g., environmental groups, community groups)

Academics

Public officials (e.g., the Mayor's Office, local congressmen)

The local press and media

Other

14. For those organization identified as playing an important role in the previous question, please describe the nature of your program's interaction with them.

Organization type 1

Organization type II

Organization type III

15. How would you describe the frequency of your interaction with staff involved in the organization types identified above? For example, would you say your level of interaction is . (circle most appropriate response)

(For Organization Type I) ___________________________

Very frequent (e.g., communicate on a daily or weekly basis)

Frequent (e.g., communicate several times per month)

Occasional (e.g. communicate several times per year)

Infrequent (e.g. communicate once or twice per year)

Very infrequent (e.g., less than once per year)

(For Organization Type II) ___________________________

Very frequent (e.g., communicate on a daily or weekly basis)

Frequent (e.g., communicate several times per month)

Occasional (e.g. communicate several times per year)

Infrequent (e.g. communicate once or twice per year)

Very infrequent (e.g., less than once per year)

(For Organization Type III) _________________________________

Very frequent (e.g., communicate on a daily or weekly basis)

Frequent (e.g., communicate several times per month)

Occasional (e.g. communicate several times per year)

Infrequent (e.g. communicate once or twice per year)

Very infrequent (e.g., less than once per year)

[Put additional comments here]

16. Can you please tell me two or three adjectives that could be used to describe the nature of the relationship between your organization and the "important" organizations you identified in the previous question?

(For Organization Type I) __________________________

____

____

(For Organization Type II) ____________________________

____

____

(For Organization Type III) ____________________________

____

____

17. To what extent do you feel these organizations *understand* the goals and priorities of your recycled water program? (*circle appropriate interviewee response*)

(For Organization Type I)

Very complete understanding

Good understanding of major issues

Some understanding of one or two issues, but not in depth

Little to no understanding

(For Organization Type II)

Very complete understanding

Good understanding of major issues

Some understanding of one or two issues, but not in depth

Little to no understanding

Very complete understanding

(For Organization Type III)

Very complete understanding

Good understanding of major issues

Some understanding of one or two issues, but not in depth

Little to no understanding

Very complete understanding

Why do you say that? [please elaborate on your assessment]

18. To what extent do you feel these organizations *share* the goals and priorities of your recycled water program? (*circle most appropriate response*)

(For Organization Type I)

Aligned with most to all of the recycled water program's major goals

Aligned with several program goals

Aligned with one or two program goals

No alignment

Organization has goals that conflict with one or more recycled water program goals

Don't know

(For Organization Type II)

Aligned with most to all of the recycled water program's major goals

Aligned with several program goals

Aligned with one or two program goals

No alignment

Organization has goals that conflict with one or more recycled water program goals

Don't know

(For Organization Type III)

Aligned with most to all of the recycled water program's major goals

Aligned with several program goals

Aligned with one or two program goals

No alignment

Can you please elaborate on the choice you made above (e.g., which program goals are shared or in conflict?

This final set of questions concerns issues important future issues facing water reuse programs.

19. Considering climate change, which partnerships (between your organization and the following groups) will be most critical to formulating successful long-term strategies? (*pick up to three*)

Other recycled water programs

Local water supply program

State, regional, or local regulatory agencies

Other local, state, and federal government (city council, Congress, etc.)

Non-governmental organizations

Recycled water customers

Academics (research institutes, etc.)

Other non-utility water retailers

Other recycled water programs or contributing agencies

Other federal agencies

Customers

Federal regulators (e.g., EPA)

Other federal agencies (e.g., Bureau of Reclamation)

Non-governmental organizations (e.g., environmental groups, community groups)

Academics

Public officials (e.g., the Mayor's Office, local congressmen)

20. Considering contaminants of emerging concern, which partnerships (between your organization and the following groups) will be most critical to formulating successful long-term strategies? (*rank as many as you wish, but please pick at least the top three*)

Other recycled water programs

Local water supply program

State, regional, or local regulatory agencies

Other local, state, and federal government (city council, Congress, etc.)

Non-governmental organizations

Recycled water customers

Academics (research institutes, etc.)

Other non-utility water retailers

Other recycled water programs or contributing agencies

Other federal agencies

Customers

Federal regulators (e.g., EPA)

Other federal agencies (e.g., Bureau of Reclamation)

Non-governmental organizations (e.g., environmental groups, community groups)

Academics

Public officials (e.g., the Mayor's Office, local congressmen)

21. Considering indirect potable reuse, which partnerships (between your organization and the following groups) will be most critical to formulating successful long-term strategies? (*rank as many as you wish, but please pick at least the top three*)

Other recycled water programs

Local water supply program

State, regional, or local regulatory agencies

Other local, state, and federal government (city council, Congress, etc.)

Non-governmental organizations

Recycled water customers

Academics (research institutes, etc.)

Other non-utility water retailers

Other recycled water programs or contributing agencies

Other federal agencies

Customers

Federal regulators (e.g., EPA)

Other federal agencies (e.g., Bureau of Reclamation)

Non-governmental organizations (e.g., environmental groups, community groups)

Academics

Public officials (e.g., the Mayor's Office, local congressmen)

22. Considering energy intensity, which partnerships (between your organization and the following groups) will be most critical to formulating successful long-term strategies? (Rank as many as you wish, but please pick at least the top three.)

Other recycled water programs

Local water supply program

State, regional, or local regulatory agencies

Other local, state, and federal government (city council, Congress, etc.)

Non-governmental organizations

Recycled water customers

Academics (research institutes, etc.)

Other non-utility water retailers

Other recycled water programs or contributing agencies

Other federal agencies

Customers

Federal regulators (e.g., EPA)

Other federal agencies (e.g., Bureau of Reclamation)

Non-governmental organizations (e.g., environmental groups, community groups)

Academics

Public officials (e.g., the Mayor's Office, local congressmen)

Appendix C

Scalar Conversions of Metric Values

Explanation: The values for each metric are in the horizontal row right of the metric and organized from lowest to highest performance level. The metric values for each metric correspond to the numerical rate value listed in the top of the metric value column. The numerical rates were used in the MAD-M calculation to determine stakeholder level of consensus.

For example, for Flow Ratio, a metric value of "0.40 to 0.59" would be converted to a rate of 3. For Voter Support, a metric value of "91 to 100%" was converted to a rate of 6.The rate conversions of "none of the above" and "do not know" were not used in the MAD-M calculation. They were converted to negative numbers only so that they were easily excluded in the spreadsheet calculation of MAD-M. The MAD-M was calculated using only positive numbers. A response of "none of the above" (nota) was converted to a rate of -2. A response of "do not know" (dnk) was converted to a rate of -1.

	Lowest Scalar Performance Value				**Highest Scalar Performance Value**			
	1	**2**	**3**	**4**	**5**	**6**	**-2**	**-1**
Metric	**Metric Value**							
Flow Ratio	0.00 to 0.19	0.20 to 0.39	0.40 to 0.59	0.60 to 0.79	0.80 to 1.00		nota	dnk
RW Portfolio Contribution	1 to 5%	6 to 10%	11 to 20%	>20%			nota	dnk
RW Application Range	0 to 25%	26 to 50%	51 to 75%	76 to 100%			nota	dnk
RW Utilization Ratio	0 to 25%	26 to 50%	51 to 75%	76 to 100%			nota	dnk
Water Quality								
Volume Growth Rate	1 to 5%	6 to 10%	11 to 15%	16 to 20%			nota	dnk
O&M Cost Recovery Ratio	0.00 to 0.19	0.20 to 0.39	0.40 to 0.59	0.60 to 0.79	0.80 to 1.00		nota	dnk
Customer Satisfaction	0 to 25%	26 to 50%	51 to 75%	76 to 100%			nota	dnk
Customer Complaints	>15	10 to 15	5 to 10	0 to 5			nota	dnk
Value-Added Services								
Product Diversification	NA	D	C	B	A		nota	dnk
Voter Support	40 to 50%	51 to 60%	61 to 70%	71 to 80%	81 to 90%	91 to 100%	nota	dnk
Community Support	40 to 50%	51 to 60%	61 to 70%	71 to 80%	81 to 90%	91 to 100%	nota	dnk
IPR Planning & Strategy	E	D	C	B	A		nota	dnk
CEC Monitoring & Strategy	D	C	B	A			nota	dnk
Energy Intensity – GW	5 to 10%	11 to 20%	21 to 30%	over 30%			nota	dnk
Energy Intensity - IW	5 to 10%	11 to 20%	21 to 30%	over 30%			nota	dnk

Notes: “dnk" = do not know;, "nota" = none of the above.

Appendix D

Additional Delphi Panel Survey Results

D.1. Recycled Water Volume Growth Rate

For the purposes of this study, volume growth rate was defined as the volume of recycled water sold in a given year (in AF) divided by the volume of recycled water sold in the previous year over a period of 5 years or more. It provides a way of assessing general trends in demand over time.

D.1.1. Appropriateness Ratings and Consensus Levels

The Delphi panel overall did not find this metric appropriate (median rating 5.5). Two stakeholder groups did, however, find this metric appropriate (regulatory agency and recycled water customer). Table D.1. shows the metric ratings for the Delphi panel and all stakeholder groups. The Delphi panel as a whole exhibited a medium level of consensus when rating the Volume Growth metric. Most stakeholder groups showed a low or medium level of consensus. Two exceptions were the academia stakeholder group, which displayed a perfect level of consensus (MAD-M: 0) in both rounds and the recycled water customer stakeholder group, which showed a high level of consensus as well. Each stakeholder group's level of consensus is listed in Table D.**1**.

Table D.1. Recycled Water Volume Growth Rate Metric: Median Appropriateness Rating and Consensus Level

	Number of Panelists		Median Appropriatenes s Rating		MAD-M Value		Consensus Level	
Stakeholder Group	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**	**R1**	**R2**
Entire panel	28	25	5	5	2.29	2.32	Mediu m	Mediu m
Recycled water program	6	4	5	5	1.17	1.25	High	High
Water supply program	8	7	5	4	2.88	2.29	Low	Mediu m
Regulatory agency	6	7	6.5	7	1.67	1.71	Mediu m	Mediu m
Nongovernmental organization	2	2	4	4	3.00	3.00	Low	Low
Recycled water customer	3	3	10	10	1.67	1.67	High	High
Academia	3	2	3	3	0.00	0.00	High	High

D.1.2. Qualitative Analysis: Major Panel Themes

The overwhelming reason given by Delphi panelists for rating the metric unsuitable was that the metric was not normalized to account for volume variations caused by weather, the economy, and conservation efforts. This point was especially emphasized by members of the recycled water program and water supply program stakeholder groups.

Perhaps the most logical way to normalize the metric for these factors perceived outside the control of a recycled water program would be to compare the volume growth of recycled water to that of potable water. Potable water growth is likely influenced by variations in the weather, the economy, and conservation efforts. A comparison of the two growth rates would possibly resolve the major complaint panelists had with this metric.

Other Delphi panelists noted the long lead time required for capital infrastructure to produce and deliver recycled water. Delphi panelists argued that recycled water growth rarely follows a smooth growth curve because of these lead times.

Finally, an interesting recommendation made by members of both the regulatory agency and academia stakeholder groups to improve the metric was to include only recycled water that is sold in the metric calculation. Major themes from the qualitative analysis of participant comments for the recycled water volume growth rate metric are displayed in Table D.2.

Table D.2. Recycled Water Volume Growth Rate metric: major panel themes

No. of Comments	Theme	Representative Comment
8	Metric should be normalized to variations caused from weather, economy, and conservation.	"Year over year demand may reflect weather conditions more than anything else. . . . This does not explicitly reflect factors such as customer or population growth, weather, promotion or conservation, economic downturns or upturns, reuse water production capacity, and so on." (Recycled Water Program, FL)
2	Metric doesn't account for long lead time needed for capital infrastructure.	"Sales cycles for customer commitment and capital construction is not always a smooth, year to year process . . . the year to year change may be minimal followed by an exceptionally large increase in the next year." (Water Supply Program, CA)
2	Metric should only include recycled water sold.	"Demand for recycled water is a positive indicator that the program is successful. However this criteria by itself may be misleading because the program may be selling the recycled water or giving it away at the expense of covering the expenses of developing and delivering it." (Regulatory Agency, U.S. EPA)

D.1.3. Metric Value Indicative of Effective Recycled Water Program

Nearly half of all participants responded "do not know" or "none of the above" when asked to choose a value for the recycled water volume growth rate metric. Of the panelists who did select a value, most (43%) thought an effective recycled water program should have a growth rate of 1 to 5% per year.

Known values for the recycled water volume growth rate metric in three different cities show that programs are outperforming panel expectations. The average annual volume growth rate for Tucson, AZ from 1987 to 2006 was 10%. For the same time period, the average annual volume growth rate was 7% in Phoenix, AZ (ADWR, 2010). In San Antonio, Texas the average annual volume growth rate was 21% between 2001 and 2007 (SAWS, 2008). The percentage of responses for all values is given in Table D.3.

Table D.3. Recycled Water Volume Growth Rate Metric: Value Indicative of Effectiveness

Value	All values				Exclude "dnk" and "nota"				Consensus Level	
	No. of votes		% of votes		No. of votes		% of votes			
	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2
1 to 5%	7	6	26%	25%	7	6	50%	43%	Low	Low
6 to 10%	3	4	11%	17%	3	4	21%	29%		
11 to 15%	3	3	11%	13%	3	3	21%	21%		
16 to 20%	1	1	4%	4%	1	1	7%	7%		
None of the above	5	4	19%	17%	-	-	-	-		
Do not know	8	6	30%	25%	-	-	-	-		
Total	27	24	100%	100%	14	14	100%	100%		

Notes: "dnk" = do not know; "nota" = none of the above.

D.2. Recycled Water Application Range

For this study, application range was defined as the extent to which a program's water can be used for all possible recycled water applications. One way of measuring this involves dividing the sum of all actual applications of recycled water in a given service area by the total number of possible applications in that service area to arrive at a percentage.

D.2.1. Appropriateness Ratings and Consensus Levels

The Delphi panel as a whole rated the recycled water application range metric appropriate to evaluate recycled water programs (median rating: 5.5). The regulatory agency stakeholder group rated this metric the highest (median rating: 9). The water supply program stakeholder group rated this metric lowest (median rating: 2). The panel as a whole displayed a low level of agreement in both rounds when rating the recycled water application range metric. All stakeholder groups showed a low to medium level of consensus except the recycled water customer stakeholder group, which displayed a high level of consensus. All metric appropriateness ratings and consensus levels are shown in Table D.4.

Table D.4. Recycled Water Application Range Metric: Median Appropriateness Rating & Consensus Levels

Stakeholder Group	Number of Panelists		Median Appropriateness Rating		MAD-M Value		Consensus Level	
	R1	R2	R1	R2	R1	R2	R1	R2
Entire panel	26	24	5.5	5.5	3.08	3.25	Low	Low
Recycled water program	5	4	3	4.5	3.20	3.25	Low	Low
Water supply program	8	7	5	2	3.13	2.71	Low	Medium
Regulatory agency	5	6	9	9	2.80	2.33	Low	Low
Nongovernmental organization	2	2	5	5	3.00	3.00	Low	Low
Recycled water customer	3	3	6	7	1.33	1.33	High	High
Academia	3	2	4	2.5	1.67	2.50	Medium	Low

D.2.2. Qualitative Analysis: Major Panel Themes

Many Delphi panelists interpreted the recycled water application range metric as a method of measuring the depth of recycled water market penetration. Several Delphi panelists, however, stated that the degree of market penetration was not related to recycled water program effectiveness. This finding raises the question, if penetrating the market for recycled water is not a function of an effective recycled water program, then whose responsibility is it to penetrate the market?

Other panelists felt that a program could still be effective while serving a small number of applications and questioned the cost-effectiveness of serving a large number of applications. Major themes from participant comments for the recycled water application range metric are displayed in Table D.5.

D.2.3. Individual Stakeholder Group Themes That Differed from Major Panel Themes

Some of the major differences among the three major recycled water stakeholder groups (recycled water program, regulatory agency, and recycled water customer) were uncovered in comments about the recycled water application metric.

Table D.5. Recycled Water Application Range Metric: Major Panel Themes

No. of Comments	Theme	Representative Comment
4	Metric measures market penetration, not recycled water program effectiveness.	"This is more of a market evaluation metric, not effectiveness. You can have an effective program while serving a low proportion of possible applications in service area." (Recycled Water Program, CA)
4	Program can be effective and serve few applications.	"A reclaimed water program could be highly effective if 100% of the reclaimed water produced is used in one application. . . . The fact that other possible applications aren't used doesn't diminish the effectiveness of the program." (Water Supply Program, FL)
4	It may not be cost-effective to provide recycled water for a wide range of applications.	"Water supply planners have to determine the cost/benefit of a project. . . . For example, if a city/agency serves a predominately residential area, then it may make sense to produce recycled water that solely meets irrigation standards." (Water Supply Program, CA)
2	Range of applications is dependent on infrastructure.	"My concern is infrastructure impediment to getting the recycled water to appropriate uses and the difficulty in getting existing users to convert to recycled water." (Water Supply Program, AZ)
2	Range of applications is location-specific.	"A program should . . . allow many different types of potential uses. However the metric might not be that diagnostic because the actual number of possible uses may be location specific (for example, for many WWTPs located at the lower end of communities, irrigation reuse may be the only feasible option)." (Regulatory Agency, AZ)

One member of the recycled water customer stakeholder group felt that measuring the depth of market penetration was connected to recycled water program effectiveness. This comment stands in stark opposition to the comments made by a large number of panelists who separated marketing from recycled water program effectiveness.

The recycled water program commenters tended to give the criterion a low appropriateness rating because, in their opinion, the number of applications for recycled water is determined by customers and outside the control of the program. In addition, recycled water program stakeholders thought the metric ignored measuring how beneficial the types of applications are to the community.

In contrast, some regulatory agency stakeholders thought the volume of water recycled is more important than the number of applications. Representative comments for the three major stakeholder groups are displayed in Table D.6.

Table D.6. Recycled Water Application Range Metric: Individual Stakeholder Group Themes

Stakeholder Group	Theme	Representative Comment
Recycled water customer	Metric measures market penetration, important to recycled water program effectiveness.	"This metric shows the depth of market penetration and is very useful. . . . Usefulness of the water supply is an important factor in its success." (Recycled Water Customer, CA)
Recycled water program	Number of applications is customer based.	"I don't particularly see the value of this metric. Customers for whatever use application they may have are typically taken on a first come/ first served basis, so this is not something that utilities necessarily control. . . ." (Recycled Water Program, FL)
Recycled water program	The type of recycled water use is more important than the volume of recycled water use.	"The formula disregards the volume of reclaimed water used for highly beneficial application (community economic benefit). The water belongs to the water provider . . . they should target the use of the water toward what provides the greatest benefit for the community, not artificial lakes, golf courses, turf, etc." (Recycled Water Program, AZ)
Regulatory agency	The volume of water recycled is more important than the number of applications for which it is used.	"Not an effective parameter; the number of uses and the amount of recycled water used as it relates to total water usage is much more important . . . get the lowest hanging fruit first is probably more important than using the recycled supply in multiple ways." (Regulatory Agency, CA)

D.2.4. Metric Value Indicative of Effective Recycled Water Program

The majority (29%) of the Delphi panel did not know what value for the recycled water application range metric would indicate an effective recycled water program. Many (21%) responded "none of the above." Of those who did choose a value for the metric, the value with the highest response (42%) was 76 to 100%. Because this metric was adapted from a model used to analyze the potential for water reuse in Beijing, China, there are no known reference values to compare with the survey findings. The response breakdown is shown in Table D.7.

Table D.7. Recycled Water Application Range Metric: Value Indicative of Effectiveness

Value	All values				Exclude "dnk" and "nota"				Consensus Level	
	No. of Votes		% of Votes		No. of Votes		% of Votes			
	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2
0 to 25%	1	0	4%	0%	1	0	7%	0%	Low	low
26 to 50%	4	3	15%	13%	4	3	29%	25%		
51 to 75%	3	4	12%	17%	3	4	21%	33%		
76 to 100%	6	5	23%	21%	6	5	43%	42%		
None of the above	6	5	23%	21%	-	-	-	-		
Do not know	6	7	23%	29%	-	-	-	-		
Total	26	24	100%	100%	14	12	100%	100%		

Notes: "dnk" = do not know; "nota" = none of the above.

3. Customer Complaints

This variable provides information on the degree to which recycled water customers are satisfied (or dissatisfied) with the quantity and quality of delivered water. It is measured by the number of customer complaints per year.

3.1. Appropriateness Ratings and Consensus Levels

Although the Delphi panel thought the customer satisfaction metric was appropriate, the Delphi panel rated the mirror of the metric, customer complaints, unsuitable (median rating: 6). The NGO stakeholder group rated the metric highest (median rating: 9). The recycled water program stakeholder group rated it lowest (median rating: 2). The Delphi panel showed one of the lowest levels of consensus when rating the customer complaints metric. Most stakeholder groups displayed either a low or medium level of consensus, with the only exception the NGO stakeholder group, which reached a high level of consensus. Appropriateness ratings and consensus level measurements for the customer complaint metric are shown in Table D.8.

Table D.8. Customer Complaints Metric: Median Appropriateness Rating and Consensus Level

Stakeholder Group	Number of Panelists		Median Appropriateness Rating		MAD-M Value		Consensus Level	
	R1	R2	R1	R2	R1	R2	R1	R2
Entire panel	25	24	7	6	3.04	3.21	Low	Low
Recycled water program	4	3	1.5	2	2.75	3.00	Low	Low
Water supply program	8	7	6.5	4	2.50	2.71	Medium	Medium
Regulatory agency	5	6	8	7.5	3.00	2.83	Low	Low
Nongovernmental organization	2	2	9	9	1.00	1.00	High	High
Recycled water customer	3	3	7	7	2.67	3.00	Low	Low
Academia	3	3	4	4	1.33	1.33	Medium	Medium

D.3.1. Qualitative Analysis: Major Panel Themes

The Delphi panel appeared to rate the customer complaint metric low more because they disagreed with the metric formula than because they rejected the metric's concept. Several participants suggested that the metric be normalized to the number of customers in the program and reported as a percentage instead of an absolute number.

Some Delphi panelists argued that the nature of the customer complaint is more important than the number of complaints received by a program. Of those stakeholder groups that did rate the metric appropriate (NGO, regulatory agency, and recycled water customer), the common theme was that customers are more apt to complain about unsatisfactory service than compliment a program for a job well done. Major themes from participant comments for the customer complaints metric are displayed in Table D.9.

Table D.9. Customer Complaints Metric: Major Panel Themes

No. of Comments	Theme	Representative Comment
3	Complaints should be normalized to total number of customers.	"Logging the number of complaints per year, in isolation from the total number of customers, strikes me as a less useful measure. . . ." (Recycled Water Program, FL)
2	Complaints are a function of individuals.	"Many people are hesitant to complain based on personal preference, cultural views, etc." (Recycled Water Customer, CA)
2	The type of complaint is more important than the number of complaints.	"The nature of the complaints not just the number would be important as well." (Regulatory Agency, U.S. EPA)

D.3.2. Metric Value Indicative of Effective Recycled Water Program

Unlike the customer satisfaction metric, the majority of Delphi panelists either did not know (38%), or did not think (17%) any of the values presented for the customer complaint metric indicated an effective recycled water program. Of those that did select a value, respondents overwhelmingly (95%) chose 0 to 5 customer complaints per year as a value indicative of an effective recycled water program. As a result, the level of consensus for the metric value was high. There are no known metric values to reference. The percentage of responses for all values is given in Table D.10.

Table D.10. Customer Complaints Metric: Value Indicative of Effectiveness

Value	All Values No. of Votes		% of Votes		Exclude "dnk" and "nota" No. of Votes		% of Votes		Consensus Level	
	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2
0 to 5	9	10	36%	42%	9	10	75%	91%	High	High
5 to 10	1	0	4%	0%	1	0	8%	0%		
10 to 15	2	1	8%	4%	2	1	17%	9%		
More than 15	0	0	0%	0%	0	0	0%	0%		
None of the above	5	4	20%	17%	—	—	—	—		
Do not know	8	9	32%	38%	—	—	—	—		
Total	26	24	100%	100%	12	11	100%	100%		

Notes: "dnk" = do not know; "nota" = none of the above.

D.4. Operations and Maintenance Cost Recovery

One criterion that has been proposed in previous studies to evaluate the overall effectiveness of recycled water programs is the extent to which a program is able to recover its operations and maintenance (O&M) costs. For this study, panelists were asked to evaluate the metric of average annual recycled water sales divided by average annual O&M costs.

D.4.1. Appropriateness Ratings and Consensus Levels

The Delphi panel rated this metric lowest of all the proposed metrics (median rating: 4.5). The only stakeholder group that rated this metric appropriate was the regulatory agency stakeholder group (median rating: 7). The recycled water program stakeholder group gave this metric the lowest median rating (median rating: 2.5).

The Delphi panel reached a medium level of consensus when rating this metric. The level of consensus stayed the same for most stakeholder groups between rounds. All stakeholder group appropriateness ratings and consensus levels for the O&M cost recovery ratio metric are displayed in Table D.11.

Table D.11. O&M Cost Recovery Ratio Metric: Median Appropriateness Rating and Consensus Level

Stakeholder Group	Number of Panelists		Median Appropriateness Rating		MAD-M Value		Consensus Level	
	R1	R2	R1	R2	R1	R2	R1	R2
Entire panel	26	24	5	4.5	2.62	2.63	Medium	Medium
Recycled water program	5	4	3	2.5	2.60	2.75	Medium	Medium
Water supply program	8	7	4.5	4	2.75	2.29	Medium	Medium
Regulatory agency	5	6	6	7	2.20	2.33	Medium	Low
Nongovernmental organization	2	2	5	4	3.00	2.00	Low	Medium
Recycled water customer	3	3	4	4	2.33	3.33	Medium	Medium
Academia	3	2	5	3.5	1.00	1.50	High	Medium

D.4.2. Qualitative Analysis: Major Panel Themes

The O&M cost recovery ratio metric was rated the lowest (median rating: 4.5) of any metric presented to the panel. Only one group, the regulatory agency group, rated the metric as appropriate. The major theme generated from panelists critical of the metric was that the metric does not account for avoided costs. Avoided costs include the cost of developing an alternative potable supply and fines incurred by violating wastewater discharge regulations. Some survey participants also pointed out that the environmental costs and benefits of recycled water, such as reduced carbon emissions, were also not included in the metric calculation.

Several panelists argued that cost recovery may not be a desired program goal. Instead, avoiding compliance and environmental costs may be more important. Other panelists argued that it was impossible to compare programs because of differences in accounting practices. Table D.12 shows the major themes from participant comments for the O&M cost recovery ratio metric.

Table D.12. O&M Cost Recovery Ratio Metric: Major Panel Themes

No. of Comments	Theme	Representative Comment
5	Metric does not include avoided costs—potable supply and discharge.	"Many do not seek full cost recovery because the recycled water prevents or delays the cost of acquisition of other, more expensive water sources. . . ." (Water Supply Program, AZ)
5	Metric does not include avoided costs—environmental.	"I think this is an important criterion. . . . However, the [metric] does not explicitly include a measure . . . of the environmental costs such as impact of carbon emissions etc. . . ." (Academia, International)
4	Metric is difficult to measure.	"There is no way, short of capturing this type of data using a uniform cost and revenue template, that you will avoid an apples to oranges comparison. Reclaimed water systems typically operate as a sub-account on water and sewer bills, so the costs and revenues are really blended with other utility costs and revenues." (Recycled Water Program, FL)

D.4.3. Metric Value Indicative of Effective Recycled Water Program

Most respondents either did not know the value (46%) or thought none of the values (8%) presented for O&M cost recovery ratio indicated an effective recycled water program. Of the panelists that did select a value, most indicated (64%) that an effective recycled water program should recover between 80 and 100% of costs.

Results from a survey of 109 recycled water programs conducted by the American Water Works Association (AWWA) in 2000 and 2007 show that panelists' expectations are not aligned with actual program performance. The AWWA reported that approximately two-thirds of surveyed programs either did not track cost recovery or recovered less than 25% of costs. In 2007, almost all programs were tracking costs, but still one-third recovered less than 25% of costs (AWWA, 2009).

The panel's consensus level was low when they were selecting metric values. The percentage of responses for all values, as well as the consensus level, is given in Table D.13.

Table D.13. O&M Cost Recovery Ratio Metric: Value Indicative Of Effectiveness

Value	All Values				Exclude "dnk" and "nota"				Consensus Level	
	No. of Votes		% of Votes		No. of Votes		% of Votes			
	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2
0.00 to 0.19	1	0	4%	0%	1	0	7%	0%	Low	Low
0.20 to 0.39	3	1	12%	4%	3	1	20%	9%		
0.40 to 0.59	2	1	8%	4%	2	1	13%	9%		
0.60 to 0.79	3	2	12%	8%	3	2	20%	18%		
0.80 to 1.00	6	7	23%	29%	6	7	40%	64%		
None of the above	3	2	12%	8%	-	-	-	-		
Do not know	8	11	31%	46%	-	-	-	-		
Total	26	24	100%	100%			100%	100%		

Notes: "dnk" = do not know; "nota" = none of the above.

Appendix E

Delphi Panel Opinions on Beneficial Water Reuse

As part of the Delphi survey, each participant was provided with a list of common applications of recycled water and asked to select all applications he or she considered to be beneficial reuses of recycled water. The results are shown in Table E.1. Every panelist thought recycled water should be used for toilet flushing and over 90% of the panel considered various forms of irrigation, cooling, and groundwater recharge to be beneficial reuse. Only 8% of participants selected dust control for roads and construction sites as a beneficial use of recycled water.

Table E.3. Delphi Panel Opinions on Beneficial Reuse

Application	Panel Votes (%)
Toilet flushing	100%
Commercial turf irrigation	96%
Golf course irrigation	96%
Cooling	96%
Wetland restoration	96%
Residential turf irrigation	92%
Groundwater recharge	92%
Open space irrigation	88%
Fire protection	88%
Concrete mixing	88%
Salt water barrier	88%
Commercial car washes	83%
Decorative lakes	79%
Decorative fountains	71%
Recreational lakes	67%
Snowmaking	63%
Dust control (construction and roads)	8%

Appendix F

Recycled and Reclaimed Water Quality

F.1. For Tucson Water

Parameter	2010 [1]
Inorganic Constituents	
Alkalinity (as $CaCO_3$)	217 mg/l
Arsenic	0.0049 mg/l
Boron	0.25 mg/l
Cadmium [2]	< 0.004 mg/l
Calcium	83.5 mg/l
Chloride	139 mg/l
Copper [2]	< 0.02 mg/l
Hardness (as $CaCO_3$)	270 mg/l
Magnesium	15 mg/l
Phosphate (as P)	1.22 mg/l
Sodium	142 mg/l
Sulfate	158 mg/l
Nitrogen Forms	
Ammonia Nitrogen	7 mg/l
Nitrate (as N)	5.1 mg/l
Nitrite (as N)	0.76 mg/l
Organic Nitrogen (Calculated)	3.00 mg/l
Total (Calculated)	15.96 mg/l
Reuse Permit	
Turbidity	1.66 NTU
E. Coli [2]	Negative
pH	7.48 S.U.
Other	
Total Dissolved Solids	736.6 mg/l
Electrical Conductivity	1214 μS/cm
Residual Sodium Carbonate	-1.06 meq/l
Sodium Adsorption Ratio (SAR)	3.75 meq/l

Water Quality Abbreviations
$CaCO_3$ — calcium carbonate
mg/l — milligrams per liter
meq/l — milliequivalents per liter
μS/cm — microSeimens/centimeter
N — nitrogen
NTU — nephelometric turbidity units
P — phosphorus
S.U. — standard unit

[1] Annual Average. Source: Tucson Water's Water Quality Laboratory.

[2] Average is less than the detection limit

Source: Tucson Water website. Available online: http://cms3.tucsonaz.gov/water/recl_wq

F.2. For JEA

Variable	Reg. Limit	Avg. May ’12	Range	No. Noncompliance instances
TSS	5 mg/l	1.2	1-1.8	0/31
CBOD	60 mg/l	11	2-202	4/24
E Coli	25U/100ml	2	2-2	0/31

Source: JEA Reclaimed Water Quality Report for May 2012.

Recycled Water Quality Information for the San Jose/Santa Clara Water Pollution Control Plant
2012

Water Quality Parameter	Yearly Average	Standard Deviation	Minimum Level	Maximum Level	Jan-Feb Average	Mar-Apr Average	May-Jun Average	Jul-Aug Average	Sep-Oct Average	Nov-Dec Average	Sample Frequency
General Parameters											
Alkalinity (Total as CaCO3), mg/L	150	6.4	127	163	145	156					Weekly
Ammonia (as Nitrogen), mg/L	<0.6	NA	<0.1	3.1	0.8	<0.4					Daily
Bicarbonate (HCO3), mg/L	150	6.4	127	163	145	156					Weekly
Biological Oxygen Demand, mg/L	3.0	0	2.0	5.0	3.0	3.0					3/Weekly
Conductivity, umhos/cm	1,170	28.0	1,090	1,230	1,150	1,190					Weekly
Hardness (as CaCO3), mg/L	230	10.6	214	250	223	238					Weekly
Nitrate (as Nitrogen), mg/L	10.6	3.1	8.1	13.3	8.4	12.8					Monthly
Nitrite (as Nitrogen), mg/L	0.45	0.43	0.1	1.4	0.77	0.16					Weekly
Permeability SAR [calculated]	4.0	0.4	3.6	4.5	3.8	4.3					Monthly
pH (units)	7.5	0.1	7.2	7.7	7.4	7.5					Daily
Temperature, degrees Fahrenheit	67.2	1.1	60.8	72.1	66.4	68.0					Daily
Total Coliform Count, CFU/100ml	<1.0	NA	<1.0	21.0	<1.0	<2.0					Daily
Total Dissolved Solids, mg/L	697	11.0	626	738	690	706					Weekly
Total Fats, Oils & Grease, mg/L	<5.0	NA	<5.0	<5.0	<5.0	<5.0					Quarterly
Total Suspended Solids, mg/L	1.0	0	1.0	2.0	1.0	1.0					3/Week
Turbidity, NTU	0.9	0.1	0.5	1.7	0.9	1.0					Daily
Chemical Parameters											
Arsenic (As), ug/L	0.9	0.2	0.7	1.2	0.7	1.0					Monthly
Boron (B), ug/L	410	28.3	380	440	430	390					Monthly
Cadmium (Cd), ug/L	<0.1	NA	<0.1	<0.1	<0.1	<0.1					Monthly
Calcium (Ca), ug/L	46,500	354	42,900	50,600	46,800	46,300					Monthly
Chloride (Cl), ug/L	176,000	21,200	157,000	195,000	161,000	191,000					Monthly
Total Chromium (Cr), ug/L	0.5	0.1	0.4	0.6	0.4	0.5					Monthly
Copper (Cu), ug/L	4.0	0.7	3.2	6.2	4.7	3.7					Monthly
Iron (Fe), ug/L	105	14.1	90.0	130	115	95.0					Monthly
Lead (Pb), ug/L	0.5	0.1	0.3	0.9	0.4	0.5					Monthly
Magnesium (Mg), ug/L	26,500	495	24,600	29,100	26,200	26,900					Monthly
Mercury (Hg), ug/L	0.0017	0.0004	0.0012	0.0028	0.0015	0.0020					Monthly
Nickel (Ni), ug/L	6.2	0.9	5.1	7.2	5.3	6.6					Monthly
Phosphate (PO4), ug/L	1,360	700	750	2,260	860	1,860					Monthly
Potassium (K), ug/L	14,500	707	14,000	15,000	14,000	15,000					Monthly
Silicon (Si), ug/L	9,890	163	9,310	10,700	10,000	9,770					Monthly
Silver (Ag), ug/L	<0.1	NA	<0.1	<0.1	<0.1	<0.1					Monthly
Sodium (Na), ug/L	139,000	12,700	129,000	150,000	130,000	148,000					Monthly
Sulfate (SO4), ug/L	90,400	6,720	84,300	97,900	85,700	95,200					Monthly
Zinc (Zn), ug/L	25.4	1.6	20.6	30.3	23.9	26.1					Monthly
Other											
Dissolved Oxygen, mg/L	7.2	0.1	6.5	8.0	7.1	7.2					Daily
Ortho Phosphate, mg/L	1.1	0.4	0.8	1.6	0.9	1.4					Monthly

NA = Not Available
MPN = Most Probable Number
SAR = [Na+] /sqrt(([Ca++]+[Mg++])/2)

NTU = Nephelometric Turbidity Units (measure of the suspended material in water)
mg/L = Milligrams per Liter (parts per million)
µg/L = Micrograms per Liter (parts per billion)

Appendix G

Endocrine-Disrupting Compounds Evaluated for Tucson Water in 2012

#120480, Amendment One (1) **Attachment A** **Revised Price Pages Page 10 of 12**

Revised Price Page - D

Endocrine Disrupting Compounds/Pharmaceuticals Table of Analytes

PARAMETER	RDL	PARAMETER	RDL	PARAMETER	RDL
1,7-Dimethylxanthine	5 ng/L	Ethylparaben	20 ng/L	Sucralose	100 ng/L
2,4-D	5 ng/L	Flumequine	10 ng/L	Sulfachloropyridazine	5 ng/L
4-Nonylphenol- (Semi-Quant)	100 ng/L	Fluoxetine	10 ng/L	Sulfadiazine	5 ng/L
4-Tert-Octylphenol	50 ng/L	Gemfibrozil	5 ng/L	Sulfadimethoxine	5 ng/L
Dilantin	20 ng/L	Ibuprofen	15 ng/L	Sulfamerazine	5 ng/L
Acesulfame-K	20 ng/L	Iohexal	10 ng/L	Sulfamethazine	5 ng/L
Acetaminophen	5 ng/L	Iopromide	5 ng/L	Sulfamethizole	5 ng/L
Albuterol	5 ng/L	Isobutylparaben	5 ng/L	Sulfamethoxazole	5 ng/L
Amoxicillin (semi-quant.)	20 ng/L	Isoproturon	100 ng/L	Sulfathiazole	5 ng/L
Andorostenedione	5 ng/L	Linuron	5 ng/L	TCEP	5 ng/L
Atenolol	5 ng/L	Ketoprofen	5 ng/L	TCPP	5 ng/L
Atrazine	5 ng/L	Ketorolac	5 ng/L	TDCPP	100 ng/L
Azithromycin	20 ng/L	Lidocaine	5 ng/L	Testosterone	5 ng/L
Bendroflumethiazide	5 ng/L	Lincomycin	10 ng/L	Theobromine	5 ng/L
Bezafibrate	5 ng/L	Linuron	5 ng/L	Theophylline	10 ng/L
Bis Phenol A (BPA)	10 ng/L	Lopressor	20 ng/L	Triclosan	10 ng/L
Bromacil	5 ng/L	Meclofenamic Acid	5 ng/L	Trimethoprim	5 ng/L
Butalbital	5 ng/L	Meprobamate	10 ng/L	Warfarin	5 ng/L
Butylparaben	5 ng/L	Metazachlor	5 ng/L		
Caffeine	5 ng/L	Methylparaben	20 ng/L		
Carbadox	5 ng/L	Naproxen	10 ng/L		
Carbamazepine	5 ng/L	Nifedipine	20 ng/L		
Carisoprodol	5 ng/L	Norethisterone	5 ng/L		
Chloramphenicol	10 ng/L	Oxolinic Acid	5 ng/L		
Chloridazon	5 ng/L	Pentoxifylline	5 ng/L		
Chlorotoluron	5 ng/L	Perfluoro Butanoic Acid- PFBA	10 ng/L		
Cimetidine	5 ng/L	Perfluoro Octanesulfonic Acid-PFOS	5 ng/L		
Clofibric Acid	5 ng/L	Perfluoro octanoic acid-PFOA	5 ng/L		
Cotinine	10 ng/L	Perfluoro-1-butanesulfonic acid	5 ng/L		
Cyanazine	5 ng/L	Perfluoro-1-hexanesulfonic acid	5 ng/L		
DACT	5 ng/L	Perfluoro-n-decanoic acid	5 ng/L		
DEA	5 ng/L	Perfluoro-n-heptanoic acid	5 ng/L		
DEET	2 ng/L	Perfluoro-n-hexanoic acid	5 ng/L		
Dehydronifedipine	5 ng/L	Perfluoro-n-nonanoic acid	5 ng/L		
DIA	5 ng/L	Perfluoropentanoic acid	5 ng/L		
Diazepam	5 ng/L	Phenazone	5 ng/L		
Diclofenac	5 ng/L	Primidone	5 ng/L		
Diuron	5 ng/L	Progesterone	5 ng/L		
Erythromycin	10 ng/L	Propazine	5 ng/L		
Estradiol	5 ng/L	Propylparaben	5 ng/L		
Estrone	5 ng/L	Quinoline	5 ng/L		
Ethinyl Estradiol-17 Alpha	5 ng/L	Simazine	5 ng/L		

Note: Labs performing the EDC/pharmaceutical analysis must meet the above stated reporting detection limits for all compounds listed.




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