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Developing Criteria and Metrics for Assessing Recycled Water Program Effectiveness

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DEVELOPING CRITERIA AND METRICS FOR ASSESSING RECYCLED WATER PROGRAM EFFECTIVENESS

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ABSTRACT

DEVELOPING CRITERIA AND METRICS FOR ASSESSING

RECYCLED WATER PROGRAM EFFECTIVENESS

by Michelle R. Arias

Many U.S. states are currently experiencing or expect to experience water shortages in the next ten years. Recycling water is one strategy states are pursuing to minimize water shortages. Many states, however, have been unable to reach goals for volume of water recycled, and many regional and municipal programs have been ineffective in meeting production goals. Existing literature focuses primarily on how to implement a program and defines success as the ability to establish a program. After several decades of recycled water use in the United States, there is a lack of accepted metrics that allow for a cross comparison of established programs that might enable states to achieve larger production goals.

This study aimed to identify a common set of metrics that can be used to assess the effectiveness of urban recycled water programs. Proposed metrics were presented to a panel of experts from six major recycled water stakeholder groups in a Delphi Method study.

The survey results showed the panel rated the Recycled Water Portfolio Contribution, Customer Satisfaction, Voter Support, and Community Support metrics as most appropriate. The Recycled Water Program stakeholders agreed most with the Water Supply Program stakeholders and agreed least with the Regulatory Agency stakeholders.

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Problem Statement

Definition of Recycled Water

Recycled water is defined as wastewater treated for beneficial purposes such as irrigation, industrial processes, and toilet flushing (U.S. EPA, 2004). For this research, the source of recycled water is limited to the effluent generated by domestic wastewater treatment facilities (WWTFs).

Recycled Water Program Driver

Cities initially pursued recycling water in order to comply with the requirements of the Clean Water Act which required publicly owned treatment works (POTW) to obtain a permit to discharge any wastewater into navigable waters. More recently, the principle driver for cities to implement recycling programs has shifted from the need to reduce wastewater discharge to the need to increase water supply. In a survey conducted by the U.S. Government Accounting Office in 2003, water managers in 36 states reported either all or parts of their states will experience water shortages in the next 10 years under normal precipitation conditions. When asked what steps each state is taking to prepare for predicted shortfalls, nearly 50 percent reported their state is pursuing development of new water supplies through recycling and reuse of wastewater (U.S. GAO, 2003). Table 1 shows some of the actions states are taking to alleviate water shortages.

Table 1. Actions states are taking to alleviate water shortages

Action	Percentage of surveyed states pursing action
Developing new water supplies through reuse of reclaimed water	48.9%
Developing new water supplies using desalination (seawater or brackish ground water)	19.1%
Using cloud seeding to induce precipitation where it might not occur naturally	17.0%
Source: U.S. GAO (2003)	

Current Status of State Efforts

Three states currently leading the nation in volumes of wastewater recycled are Florida, California, and Arizona (Brandhuber, 2006). There are four ways of reporting or understanding the quantity of recycled water produced or consumed: the volume of recycled water produced, the percentage of the supply portfolio met with recycled water, the percentage of the wastewater flow recycled, and the per capita recycled water use. In all four measurements, Florida is leading the nation. Table 2 shows the production and consumption values for all three states.

Table 2. Current 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[1]	738,739	3.6%	38%	36.79
California[2]	723,845	1.3%	10%	16.06
Arizona[3]	205,400	2.9%	NA	1.33

NA: Not available
[1]FDEP (2010)
[2]CA Recycled Water Task Force (2003)
[3]Calculated from USGS (2005) and ADWR (2011)

Current Status of State Goals

Of the three states, only Florida and California have set state goals for the volume of water recycled. In 2003, Florida set an official statewide goal of recycling 1 billion gallons per day (bgd) by 2010 (EPA, 2004). In 2010, Florida produced 659 million gallons per day (mgd) (FDEP, 2010) and was short of meeting the goal by approximately 34 percent. California has continuously missed meeting all statewide goals set between 1981 and 2000. Figure 1 shows the actual and projected recycled water deliveries in California from 1970-2030.

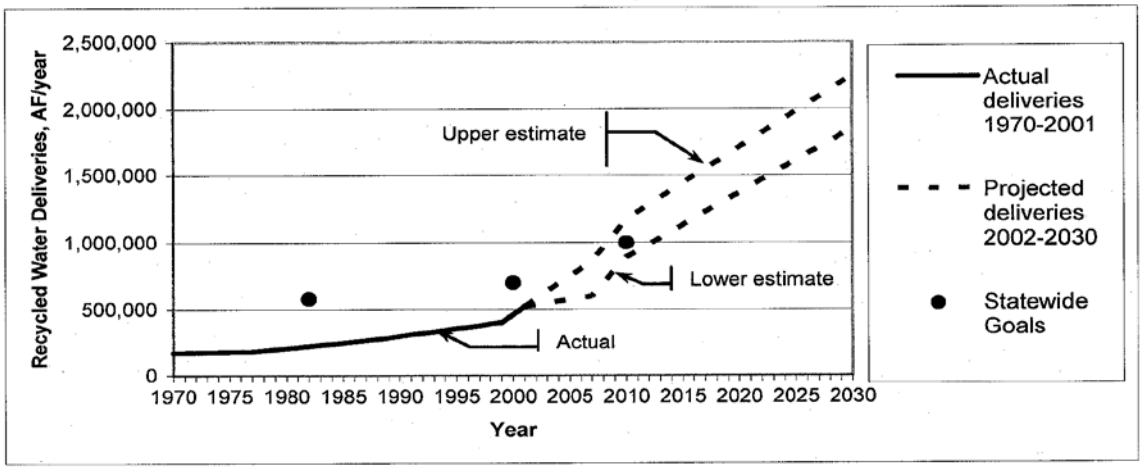


Figure 1. Actual and projected recycled water deliveries in California, 1970-2030. Source: CA Recycled Water Task Force (2003)

Status at the Program Level

Part of the reason why states like California and Florida have had problems reaching production goals is the long lead time needed to establish recycled water programs at the municipal level. Mantovani, Asano, Chang, and Okun surveyed 40 domestic recycled water programs in 2001 and found 22 percent of programs needed eleven to fifteen years to reach full capacity and 33 percent took more than twenty years to reach full capacity (Mantovani et al., 2001). Additionally, some planned projects, like the program in San Diego, California conceived during the 1992 drought, failed to ever be implemented (Po, Kraercher & Nancarrow, 2003).

The impediment cited most frequently in the literature to initiating a recycled water program, is the public's perception of recycled water or more specifically, the public's fear of drinking or bathing with treated wastewater. Research has shown however that the public will support planned municipal and industrial nonpotable reuse (Marks, 2006), such as for landscape irrigation or HVAC cooling towers.

Due to the long planning stage many programs experience and the additional hurdles a program must overcome before ever delivering any recycled water to customers, program success has narrowly been defined as the mere implementation of a program. Previous research has shown however, that programs once implemented have been ineffective in meeting production goals.

Previous Program Evaluations

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 multi-program evaluation in a manner that allows for direct comparison amongst programs. In their current state, evaluations of recycled water programs offer no clarity in determining how programs are managed and where improvements can be made to increase demand and cost recovery.

This gap in the literature calls for an investigation to uncover what evaluative criteria are necessary for established urban recycled water programs to be effective and metrics to measure program's progress toward effectiveness.

The goal of this study is three-fold: 1) identify through expert survey, a common set of evaluative criteria and associated metrics that can be used to assess the effectiveness of urban recycled water programs for municipal and industrial (M&I) users at the regional and municipal level; 2) identify metric values indicative of an effective program; and 3) assess recycled water stakeholder group consensus and understand stakeholder perspectives on program effectiveness.

Significance of Research

Recycled water literature focuses primarily on program implementation. Established programs have been little studied and very few have been evaluated in a meaningful way to allow cross comparison of programs. Thus, this study proposes a universal set of evaluative criteria and associated metrics that can be applied in a program evaluation to help recycled water programs understand areas where the program is performing well and areas where improvement is needed. This study will also help major recycled water stakeholders understand the perspective and role of other stakeholder groups on program effectiveness.

Related Research

Impediments to Recycled Water Adoption

The literature abounds with many impediments to the establishment of a recycled water program, however the two major impediments cited are: public perception (Dolnicar & Hurlimann, 2009; Hartley, 2006; Bridgeman, 2004; Po, et al., 2003; Gibson & Apostolidis, 2001), and economics, specifically the costs of both capital infrastructure and operation and maintenance, and the ability to recover costs (Miller, 2006; CH2MHill, 2004; Cuthbert & Hajnosz, 1999; Asano & Mills, 1990).

Public perception of recycled water. Public perception is the hurdle most cited to water reuse implementation (Dolnicar & Hurlimann, 2009; Hartley, 2006; Bridgeman, 2004; Po et al., 2003; Gibson & Apostolidis, 2001). The "yuck factor" defined as a repugnance to the thought of drinking or using water sourced from treated wastewater is often cited as the reason for the public's rejection of many recycled water project proposals (Po et al., 2003). Research conducted in the 1970s found that the public is supportive of reclaimed water used for nonpotable reuse (Bruvold, 1985).

Economics of recycled water. The second most cited impediment to adoption of recycled water within a community is the capital costs of infrastructure (Asano & Mills, 1990). In addition to the challenge of raising funds for capital infrastructure, most recycled water programs once built have difficulty recovering the full operation and maintenance costs of the program from recycled water user fees (Cuthbert & Hajnosz, 1999; Mantovani et al., 2001; Miller, 2006).

Non-quantified benefits of recycled water. Further complicating the financing of recycled water programs are the many benefits recycled water provides that are difficult to quantify monetarily such as, watershed protection and extension of existing water supplies (Miller, 2006). Because of the difficulty in monetarily quantifying many of the social and environmental benefits of recycling water, economic feasibility is rarely shown (Miller, 2006; Hurlimann & McKay, 2007).

Evaluation of Existing Programs

Due to the large number of planned projects that never came into operation, and the economic hurdles a recycled water program must overcome, for the past twenty years program success has overwhelmingly been defined as simply the establishment of a recycled water program (Hughes, 2009; Hartley, 2006; Ingram, Young, Millan, Chang & Tabucchia, 2006; Marks, 2006; Miller, 2006; CH2MHill, 2004; Anderson, 2003; Higgens, Warnken, Sherman, Teasdale, 2002; Wong & Gleick, 2000; Cuthbert & Hajnosz, 1999; Asano & Mills, 1990; Bruvold, 1988; Crook & Okun, 1987).

Evaluation styles. From a review of available literature, seven papers were found that evaluate existing urban recycled water programs in the U.S. Previous program evaluations exhibited three different styles of evaluation: 1) evaluation of single program with single recommended criterion for evaluation, 2) evaluation of multiple programs with single recommended criterion or limited number of criteria for evaluation, and 3) evaluation of multiple programs with multiple recommended criteria. Each style of program evaluation has different benefits and limitations.

The benefit of the first evaluation style where only one program is evaluated against one recommended criteria is the degree of depth and understanding gained from the program evaluation. The drawback to this style of evaluation is it is difficult to compare or benchmark programs. In the second style of program evaluation where multiple programs are evaluated, it is easier to benchmark programs but the evaluation is limited to understanding only one or two aspects of the program. The third style of evaluation, where multiple programs are evaluated against multiple recommended criteria, offers a broad understanding of several aspects of a program and facilitates a cross comparison or benchmarking of the programs.

One problem, that occurred in several of the previous program evaluations however, is several criteria may have been recommended to be applied in the program evaluation, but not all of the recommended criteria were actually applied to each program in the evaluation. The limitation of not evaluating all programs against all recommended criteria is that it is difficult to cross compare programs. Table 3 shows the evaluation styles and major findings from previous recycled water program evaluations.

Basis of evaluation. In addition to the different styles of program evaluation, previous program evaluations also evaluated programs on different bases of evaluation. The bases of previous evaluations can be organized into four categories: economic, environmental benefits, innovation, and program management. In this section, each of the studies referenced in Table 3 will be discussed at greater length based on the study's basis of evaluation.

Table 3. Previous recycled water program evaluation styles and major findings

Author (Date)	Study	Program Style	No. of Programs Evaluated	No. of Recommended Criteria	No. of Applied Criteria	Findings
Haddad (2002)	Monterey county water recycling project: institutional study	Single program, single recommended criterion	1	1	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	1	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	3	1	South Bay program successfully met program driver to reduce discharge to SF Bay.
Cuthbert & Hajnosz (1999)	Setting reclaimed water rates	Multiple programs, limited recommended criteria	23	2	2	Half of programs base recycled water rates on percentage of potable rate; many programs rely on subsidy to recover costs.
Marks (2006)	Taking the public seriously: the case of potable and non-potable reuse	Multiple programs, limited recommended criteria	8	2	2	One of eight programs reviewed actually implemented IPR component due to extensive public outreach effort.
Wong & Gleick (2001)	Overview to water recycling in California: success stories	Multiple programs, multiple recommended criteria	3	5	3-4	WBMD parcel tax unpopular; Santa Rosa program saved potable water and increased creek flows.
Mantovani et al. (2001)	Management practices for non-potable reuse	Multiple programs, multiple recommended criteria	40	8	2-3	Most programs have not reached capacity; few programs conducted market survey; few programs considered alternative site locations.

Basis of evaluation: economic. The two papers evaluating recycled water programs from an economic basis focused primarily on operation and maintenance (O&M) fee structures. Cuthbert and Hajnosz (1999) evaluated a total of 23 programs against two criteria: how rates were determined and whether the rate could be considered a subsidy. The study found half of surveyed programs based recycled water rates on a

percentage of the potable rate and that many programs rely on a subsidy to recover costs. Cuthbert and Hajnosz (1999) also conducted an in-depth evaluation of Tucson Water Department's price structure to assess whether the distribution of operation and maintenance costs could be considered a subsidy. Even though the rate charged to reclaimed water customers covered only 77 percent of the embedded cost of service, the balance was recovered by an increase in the potable rate. Cuthbert and Hajnosz (1999) concluded that the potable customers were not subsidizing the reclaimed water system, because without recycled water, the city would have exceeded its per capita daily limit and been fined; the cost of which would have been passed onto the potable users.

The West Basin Municipal District (WBMD) and South Bay Water Recycling (SBWR) Programs in California were evaluated by Wong and Gleick (2000). The economic evaluation focused on the distribution of costs to pay for the program and claimed to use equity as a criterion for evaluation. It was explained that the WBMD's debt service is paid for through a parcel tax on district land owners however, no attempt was made to explain the reasoning behind this decision and therefore no clear assessment of equity could be established. The parcel tax was only described as unpopular (Wong & Gleick, 2000). The evaluation did not include a discussion of whether WBMD was able to partially or completely recover operation and maintenance costs or the mechanism of recovery. Similarly, for the evaluation of SBWR only the mechanism for recovering operation and maintenance costs was reported to be accomplished through a 50 percent increase in sewer fees; however, no evaluation of the equity of the fee structure was given.

Basis of evaluation: environmental benefits. Wong and Gleick (2000) also evaluated the recycled water program in Santa Rosa, California. The program was a reported success because of the environmental and farming benefits it provided along with savings of potable ground and surface water. The environmental benefits cited were improved creek flows due to the reduction in pumping from nearby rivers and creeks for agriculture and increased natural habitat in the form of wetlands and a duck pond created from recycled water. The farming benefits included an expanded season due to the conversion of dry-land farming to yearlong irrigation farming and increased farm acreage made possible from the availability of recycled water. However, no effort is made to quantify these benefits in a measurable or comparable way. For example, the increase in acreage devoted to wetlands or farmland is not quantified, increases in stream flow is not numerically reported, and the volume of groundwater savings gained from using recycled water is not included. A summary of the results from the Wong and Gleick study is displayed in Table 4.

Table 4. Summary of results from Wong and Gleick program evaluation (2000)

Program	Criterion				
	Environmental Benefits	**Potable Water Savings**	**Community Economic Benefit**	**Equity of Fees – Debt Service**	**Equity of Fees – O&M**
Santa Rosa	Create wetland habitat	-	Allow farmers to convert to year round farming	-	-
WBMD	Prevent salt water intrusion, reduce wastewater discharge to Santa Monica Bay	25 MCF	-	Unpopular Parcel Tax	"User Pays" Principle
SBWR	-	12.3 MCF	-	-	Wholesaler Rebate, Sewer Rates, Recycled Water Sales

Source: Wong and Gleick (2000)

The Monterey County Water Recycling Project was evaluated by Haddad (2002) on the basis of the environmental benefit the program offered. Haddad's study was an improvement over previous studies because he was able to quantify and support his claim. Haddad reported the program had reduced salt water intrusion by roughly 25 percent preserving existing groundwater sources and farmland (Haddad, 2002).

Basis of evaluation: innovation. Marks (2006) reviewed the public outreach efforts of eight recycled water programs in the United States to evaluate what programs had the most innovative public outreach effort. The criterion Marks (2006) applied in the evaluation was whether or not the program was able to implement an indirect potable reuse scheme based on the program's public outreach effort. Marks (2006) found that of the eight programs proposing indirect potable reuse (IPR) schemes only one program in Orange County, California was able to implement an IPR program. Of the proposals reviewed, Orange County had the most extensive public outreach program where 23 presentations and workshops were held for city council and community groups and informational pamphlets were mailed to 80,000 households. Orange County's success is attributed to its commitment to public outreach. Marks also points out that in each of the eight cases, nonpotable reuse applications historically shown to garner less public resistance, had not yet been fully explored or exhausted within the community when the IPR projects were proposed (Marks, 2006).

Basis of evaluation: program management. In an evaluation of the South Bay Water Recycling Program in San Jose, California, Cusker (2000) suggests programs should be evaluated against initial drivers of the program, customer satisfaction, and

public acceptance of the program (Cusker, 2000). Although three bases of evaluation are suggested, the program was only evaluated against the initial driver to reduce wastewater discharges to the environment, which it was successful in meeting.

Ingram et al. (2006) details the implementation history of the recycled water program in Redwood City, California. The city was motivated to reduce its dependence on imported water from Hetch Hetchy in Yosemite, however, when the public opposed using reclaimed water for school turf irrigation, the city decided to convert schools from natural to synthetic turf (Ingram et al., 2006). The program was ultimately evaluated against its initial driver to reduce dependence on imported supplies; because the program was able to do accomplish its mission, it was viewed as a success despite the fact that recycled water was not part of the solution.

The most comprehensive evaluation of recycled water programs in the United States was conducted by Mantovani et al. (2001) published by the Water Environment Research Foundation and is the best attempt found in the literature to evaluate multiple programs. The study involved a literature review of 200 publications written between 1991 and 2001, a management survey of 65 nonpotable water reuse projects, 40 of which were in the United States, site visits to 12 recycled water programs, and a survey of 20 regulatory agencies.

Two primary findings came out of this report that have not been noted or investigated in other published sources. The first is that at the time of the survey, most projects had not met their projected water delivery goals and over half of the programs did not conduct a formal market assessment during the planning stage. Secondly, few

plants considered alternative site locations when choosing to build a reuse facility and either chose to retrofit an existing wastewater facility or locate a new facility near to the existing wastewater treatment plant (Mantovani et al., 2001).

Summary of program evaluations. Of the program evaluations presented, two studies (Haddad, 2002; Ingram et al., 2006) evaluated a single program against a single recommended criterion. While both of these studies were able to investigate each program at great depth, it is difficult to benchmark the programs or understand the program's overall performance.

The evaluations by Cuthbert and Hajnosz (1999) and Marks (2006) investigated multiple programs against two criteria. Each study thoroughly applied all recommended criteria to every program in the evaluation. However, the evaluations are limited due to the narrow focus on only one aspect of the programs, once again making it difficult to understand the program's overall performance.

Three previous studies (Cusker, 2000; Wong & Gleick, 2000; Mantovani et al., 2001) recommended several criteria to be used in a program evaluation, however not all of the recommended criteria were actually applied to each program in the study making it difficult to cross compare or benchmark programs.

These styles of evaluation make it difficult to assess which programs are performing better relative to one another. For a program manager looking for ways to improve their current program or benchmark their own performance, these evaluations offer little advice or help in moving forward. The review of previous program evaluations demonstrates the need for the creation of a universal set of criteria that

evaluates all aspects of a recycled water program's performance or effectiveness and can be applied in a manner that facilitates a cross comparison of programs.

Research Questions

Q_1: What evaluative criteria and associated metrics can be used to assess the effectiveness of recycled water programs at the regional and municipal level?

Q_2: Can recycled water stakeholder groups come to consensus on what evaluative criteria and associated metrics can be used to assess the effectiveness of recycled water programs at the regional and municipal level?

Q_3: What metric values indicate an effective recycled water program?

Q_4: Can recycled water stakeholder groups come to consensus on what metric values indicate an effective recycled water program?

Q_5: How do the perspectives of recycled water stakeholder groups align in terms of what criteria and associated metrics are best to assess the effectiveness of recycled water programs at the regional and municipal level?

Methods

In January 2010 a study team consisting of three graduate students was organized by Dr. Katherine Kao Cushing of San Jose State University to research how recycled water programs could be evaluated with a common set of criteria and metrics. In September 2010, the research team partnered with the City of San Jose and the Santa Clara Valley Water District and received funding from the WateReuse Research Foundation to conduct this research.

From a literature review and through consultation with recycled water industry representatives, fifteen criteria and associated metrics were created to evaluate the effectiveness of regional and municipal recycled water programs. Complete details of the criteria and metric development are included in Appendix A. To validate the developed criteria and metrics, professionals representing six recycled water stakeholder groups were invited to participate in a Delphi Method survey. Participants are predominantly located in Arizona, California, and Florida. These three states were targeted because they lead the nation in recycled water production and use (Bryck, Prasad, Lindley, Davis, & Carpenter, 2008).

The goal of the survey was to ask professional experts from recycled water stakeholder groups to assess the appropriateness of the proposed criteria and metrics, provide feedback for metric improvement, and select values for metrics that would indicate an effective recycled water program. An overview of the Delphi Method, including core assumptions and requirements of the method are described below. Strengths and weaknesses of the method are included in Appendix B. Criteria for

selecting panelists to participate and details of the survey administration follow the description of the method.

Data Collection

Delphi Method overview. For programs where there are no widely established performance measures, metrics and measures must be developed. When developing or testing new metrics, it is important to show validity of the metric (Rossi et al., 2004). Proving the validity of a particular metric is difficult however Rossi et al. (2004) suggest using stakeholder acceptance as one method.

There are many methods available designed to gather stakeholder opinion and judgment. Of these available methods, the Delphi Method was chosen for this study due to its wide use and acceptance, and unique suitability to answer the research questions.

The Delphi Method 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 & Turoff, 1975, p. 3). The method relies on "experts" in the field of study to independently respond to a questionnaire. The researcher then collects and compiles the expert's individual responses, and resubmits the compilation to the individual experts for refinement. Each resubmission to the group is considered a "round." An expert is not required to refine his or her response, but is asked to qualify or give justification for responses that differ greatly from the group's average response. The goal of this process is to guide the panel of experts to reach consensus or agreement. The process continues until either a consensus is reached or a stabilization of results has occurred (Gordon & Pease, 2006).

A typical Delphi study is completed in 2-5 rounds (Linstone & Turoff, 1975). For this study, a stabilization of results occurred rapidly and the process was complete after two rounds. An expanded overview of the Delphi Method is included in Appendix B.

Theoretical assumptions and requirements of the Delphi Method. The core theoretical assumption of the method is that decisions made by groups are generally more valid than those made by individuals. The Delphi Method separates itself from other methods soliciting a group response, such as *Nominal Group Technique,* in that participants do not interact face to face with one another (Murry & Hammons, 1995).

There are three necessary requirements of the Delphi Method. First, the method must ensure anonymity amongst all participants (Murry & Hammons, 1995). Second, participants should be established as experts in the field of study (Linstone & Turoff, 1975; Murry & Hammons, 1995; Gordon & Pease, 2006). Last, the researcher or facilitator must assemble the group's response and submit a summary to the group after each round (Murry & Hammons, 1995).

Expert selection criteria and panel size. When using the Delphi Method in a program evaluation study, such as this study, Delbeq, Van de Ven, and Gustafson (1975) recommend selecting experts who are, "the top management decision makers who will utilize the outcomes of the Delphi study" (Delbecq et al., 1975, p. 85). For this research project, six stakeholder groups were identified: Recycled Water Program, Recycled Water Customer, Regulatory Agency, Water Supply Program, Non-governmental Organization (NGO), and Academia.

Delphi panels usually consist of less than 50 experts (Witkin & Altschuld, 1995), and most studies use between 15 and 20 panelists (Ludwig, 1997). From a review of Delphi studies investigating program effectiveness (Wu, Lin, & Chen, 2007), critical success factors (Okoli & Pawlowski, 2004) and program evaluation criteria (Des Marchais, 1999), the number of experts selected for each Delphi study ranged from six to twenty-three.

For this study, the intention was to have a minimum of two to three experts from each stakeholder group. It was anticipated that the response rate may be low due to the time commitment needed from panelists for multiple rounds. Additionally, because the study involved multiple rounds, there was concern that the attrition rate may also be high in between rounds. Due to these uncertainties, 117 invites were sent by email. Twenty-nine stakeholders (27%) agreed to participate in the survey. There was a loss of one expert from round one, but an addition of one expert in round two, so the attrition rate was in practical terms 0 percent. Table 5 lists the number of experts from each major stakeholder group for each round of the survey and the location of each respondent.

Delphi Method survey administration. The survey was hosted on the internet by the Calibrum Corporation using their product called Surveylet. Calibrum's products have been successfully employed in several environmental policy applications including an analysis of future scenarios for waste management in Hungary and environmental analysis of the agriculture, oil, and tourism industries in Venezuela. The complete Delphi Method survey is included in Appendix C.

Table 5. Number of experts in Delphi Method survey by location

	Number of Experts											
Stakeholder Group	**Arizona**		**California**		**Florida**		**Other U.S.**		**International**		**Total**	
	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**

Each participant for this study was assigned a unique Login ID and password and 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 this research.

Prior to beginning the study, the duration of each round was chosen to be seven days. However due to several participant requests for extensions, round durations were actually 8 to 10 days. Round one opened on March 18 and closed ten days later on March 28, 2011. Round two opened on April 4 and closed eight days later on April 12, 2011. The survey was completed in two rounds. Participants were notified by email when each round would open and close. Reminder emails were sent one day before the closing date to participants who had not yet completed the survey. In round one, six extensions were granted, and in round two, two extensions were granted. Round durations listed above include participant extension periods.

In round one, participants were presented with fifteen evaluative criteria and associated metrics designed to evaluate the effectiveness of recycled water programs at the regional and municipal level. Participants were presented with a brief introduction to the proposed criterion and metric. An example is given in Figure 2.

For each criteria and metric, participants were asked to:

1. Rate how appropriate on a scale of 0 (not at all appropriate) to 10 (extremely appropriate) the presented metric is as a general indicator of recycled water program effectiveness (Survey Question #1) and provide justification for his or her rating (Survey Question #2). An example is shown in Figure 3.
2. From a provided list, choose a value for the metric believed to be considered "good" for a recycled water program in operation for 5 years that has a minimum wastewater treatment plant capacity of 0.1 millions of gallons per day or more (Survey Question #3). An example is shown in Figure 4.
3. If possible, suggest an alternative metric that would better measure the criteria presented. An example is shown in Figure 4.

Participants were not required to answer all questions. In fact, participants were encouraged not to rate any evaluative criteria and associated metrics for topics he or she was unfamiliar. For questions where participants were asked to give a value for an appropriate metric a "do not know" option was given amongst the list of choices.

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.

Figure 2. Example of criterion and metric introduction.

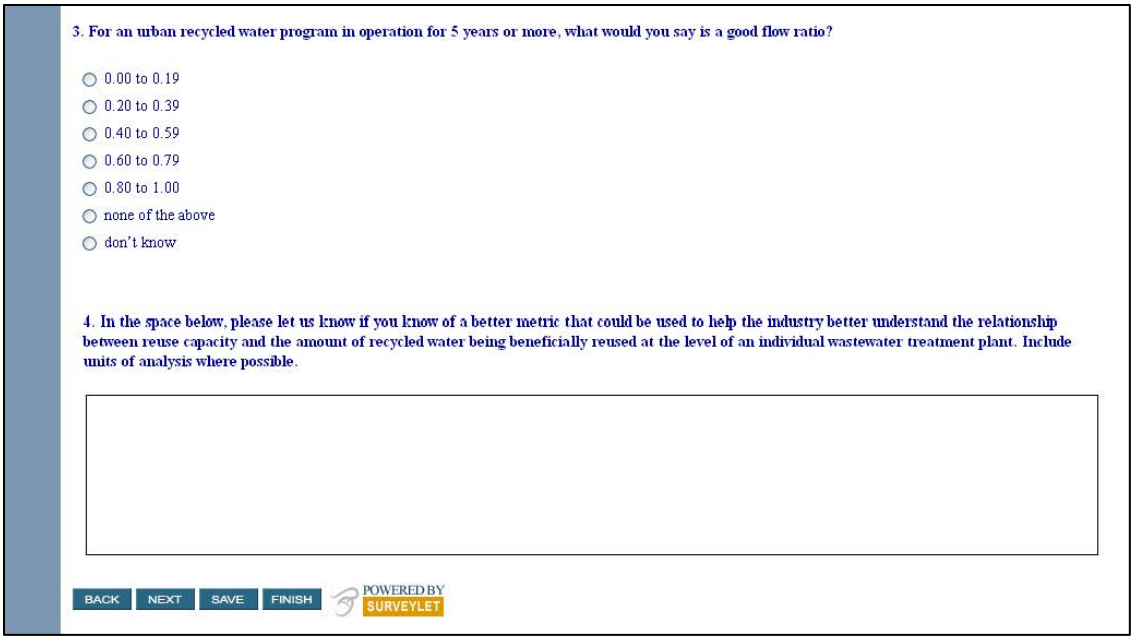
1. Using a scale of 0 to 10 below, please rate how appropriate you think this metric is as a general indicator of recycled water program effectiveness:

Not at all Appropriate — Appropriate — Extremely Appropriate

	0	1	2	3	4	5	6	7	8	9	10
Round 1 Response	○	○	○	○	○	○	○	○	○	○	○

2. Please provide justification for your rating:

Figure 3. Example of Survey Questions #1 and #2.



3. For an urban recycled water program in operation for 5 years or more, what would you say is a good 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
- none of the above
- don't know

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.

BACK NEXT SAVE FINISH POWERED BY SURVEYLET

Figure 4. Example of Survey Questions #3 and #4.

Similarly, if the participant felt the metric was inappropriate, a "none of the above" option was given amongst the list of choices.

The responses from round one were downloaded and imported into a spreadsheet. The Delphi Method requires an anonymous summary of the previous round's results be presented to the panel in subsequent rounds. For round two, the participants were given a quantitative and qualitative confidential summary of the responses from round one. Only the administrator knew the identities of the respondents. In the confidential summary, experts were identified only by stakeholder group and geographic location.

The quantitative summary included three charts for each of the fifteen criteria and metrics. The first two charts showed the distribution of responses for each criterion and metric appropriateness rating (Survey Question #1) and the third chart depicted the distribution of responses for the metric value believed to indicate an effective recycled

water program (survey question #3). For the first chart, the entire panel's ratings were placed into one of three groups that represented their level of appropriateness: high (rating of 7 to 10), medium (rating of 4 to 6), and low (rating of 0 to 3) and the percentage of responses in each category was calculated. The second chart, displayed the median appropriateness rating given by each major stakeholder group. Examples of both charts are included in Figure 5. Lastly, survey respondents saw a chart depicting the percentage of responses for each metric value believed to indicate an effective recycled water program.

A qualitative analysis of the respondent's rating justifications and alternative metric suggestions was also conducted. For each criteria and metric, a representative response for each group of appropriateness rating (high, medium, and low) was selected and directly presented to the panel in round two. Panelists could also view a list of all qualitative responses from round one through a link to another page of the website. Participant names were removed from the list of responses and only the stakeholder group and geographic location of the participant were given.

From the qualitative analysis of panelists' responses, one additional metric, Recycled Water Utilization Ratio, was created and presented to the panel in round two. A new question was also added to clarify the definition of "beneficial reuse." All of the results from round one are discussed later in the Data Results section.

In round two, the panelists were presented with the fifteen initial criteria and metrics, as well as the new criteria and metric, and new question created out of the

responses from round one. Additionally, panelists were given the confidential summary of results from round one.

The goal of the summary is to guide the panel as a whole to agreement or consensus. In round two, participants were asked to review and revise their previous responses in light of the summary provided. Figure 5 through Figure 7 show examples of the survey questions and confidential summary as presented in round two.

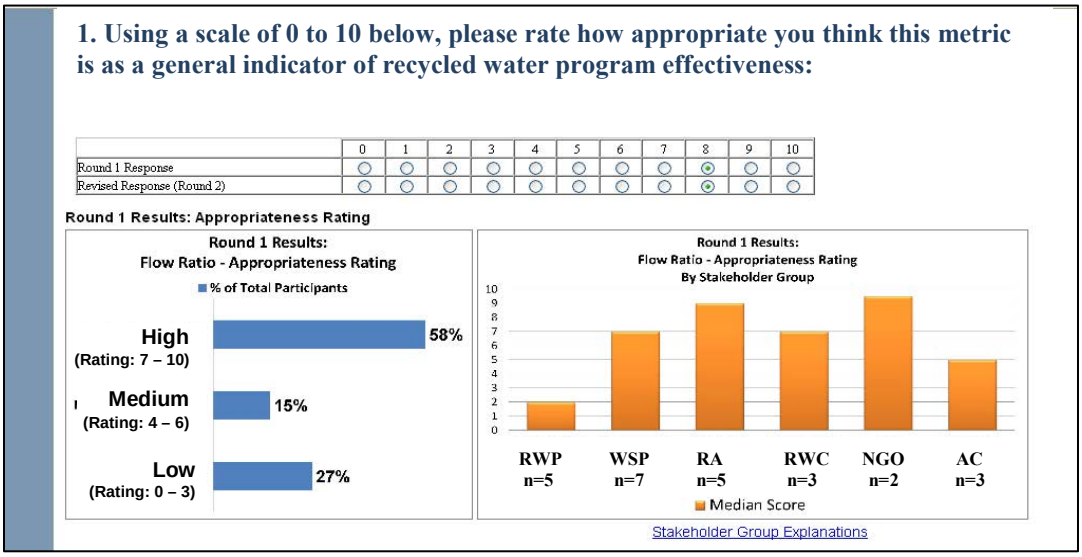


Figure 5. Example of Survey Question #1 and confidential summary as presented in round two.

The results from round two showed that 47 percent of the panelists did not modify any of their responses from round one. Additionally, for each criterion and metric only 12 percent of the panel on average provided a justification for keeping or modifying their previous response. One participant stated their disappointment that criteria and metrics had not been modified based on the results of round one and did not complete round two of the survey.

2. Round 1 justification for your rating:

The amount of reclaimed water produced that is actually reused should be a good measure of the effectiveness of a water reuse program.

Round 1 Results: Representative Responses

High Level of Appropriateness (Rating 7 - 10): "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. Thus, this metric for flow ratio appears to be very appropriate for measuring program effectiveness as long as the potential adverse effects noted above are prevented by utilizing best management practices for utilizing the reclaimed water."

Medium Level of Appropriateness (Rating 4 - 6): "While I appreciate the metric being proposed, it does not test for the ultimate use of the recycled water. Many projects produce "recycled water" but the product water ultimately goes to "environmental enhancement" and not potable water offset..."

Low Level of Appropriateness (Rating 0 - 3): "There are some cities/districts 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."

List of All Responses

If you changed your rating above please explain why below:

Figure 6. Example of Survey Question #2 and confidential summary as presented in round two.

3. For an urban recycled water program in operation for 5 years or more, what would you say is a good flow ratio?

Round 1 Response:	Revised Response (Round 2): Please select one.
○ 0.00 to 0.19	○ 0.00 to 0.19
○ 0.20 to 0.39	○ 0.20 to 0.39
○ 0.40 to 0.59	○ 0.40 to 0.59
○ 0.60 to 0.79	○ 0.60 to 0.79
◉ 0.80 to 1.00	◉ 0.80 to 1.00
○ none of the above	○ none of the above
○ don't know	○ don't know

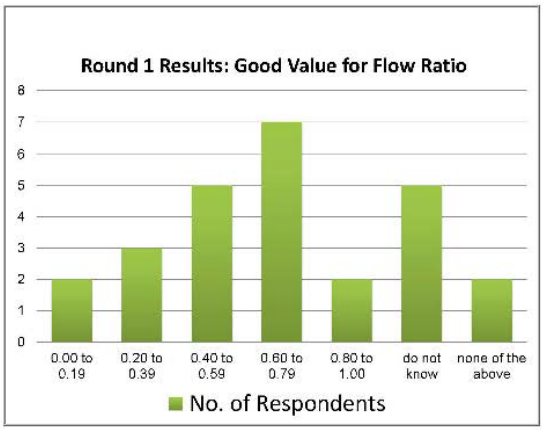


Figure 7. Example of Survey Question #3 as presented in round two.

The Delphi Method dictates that the survey stop once a consensus is reached or the results have stabilized. Based on the fact that nearly half of the participants did not modify their previous responses and on average only 12 percent of participants provided justification or support for either keeping or modifying their responses, the decision was made to end the survey. Measurement of consensus for this survey is discussed in the next section. An expanded discussion of the Delphi Method survey administration is included in Appendix B.

Data Analysis

Both quantitative and qualitative analysis of the data took place to assess what evaluative criteria and associated metrics were most appropriate in a recycled water program evaluation (Research Question #1), stakeholder consensus levels (Research Question #2 and #4), what values for the metrics were indicative of an effective program (Research Question #3), and to understand stakeholder group perspectives and how stakeholder group perspectives aligned (Research Question #5).

Descriptive statistics. Descriptive statistics were used to determine what evaluative criteria and associated metrics can be used to assess the effectiveness of recycled water programs at the regional and municipal level (Research Question #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. Determined from a review of studies also using a Likert scale to assess appropriateness (Vella et al., 2000; Fitch et al., 2001), criteria with a median score of 7 or greater were assessed as appropriate.

To determine what metric values are indicative of an effective recycled water program (Research Question #3), the percentage of panelist votes was calculated and the value with the highest score was reported. The measures and charts provided in the confidential results summary presented to panelists in round two also utilized descriptive statistics.

Consensus measurement. The levels of consensus for the median appropriateness rating, metric classification, and metric value indicative of an effective recycled water program were determined using the mean absolute deviation from the median (MAD-M). Further description of the MAD-M statistic is included below and in Appendix B.

Median appropriateness rating. The mean absolute deviation from the median (MAD-M) was used to compute the level of consensus or agreement amongst panel members and within major stakeholder groups on the evaluative criteria and associated metrics presented (Research Question #2) and values indicative of an effective recycled water program (Research Question #4). Agreement levels for criteria and metrics were categorized into high, medium, and low. The levels of agreement were assessed for the panel as a whole and within each major stakeholder group.

To determine the lower and upper limits for each level of consensus, the difference between the maximum and minimum MAD-M values were divided into thirds. A lower MAD-M value means there is less dispersion in the participants' responses, and therefore more agreement. A MAD-M value of 0.00 would mean the group was in perfect agreement or complete consensus. Conversely, a higher value for MAD-M means

there is wider dispersion in the data, and therefore less agreement. 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 outside of the study.

Metric classification. Based on the level of consensus, the metrics were then classified as primary, secondary, or tertiary for the evaluation of recycled water program effectiveness. Metrics rated appropriate with a high level of consensus were classified as primary for the evaluation of recycled water program effectiveness. If a metric was rated as appropriate, but had a medium or low level of consensus, it was classified respectively as secondary or tertiary. If the metric was rated inappropriate (median rating ≤ 6), regardless of the panel's level of consensus, it received a classification of unsuitable. An expanded discussion of the metric classification is included in Appendix B.

Metric value indicative of an effective recycled water program. In the survey, participants were given a list of metric values and asked to select the value indicative of an effective recycled water program. Before the MAD-M could be calculated, the metric values had to be converted to scalar values. The list of metric value conversions to scalar values is in included in Appendix D.

Coding of qualitative responses. The qualitative responses from panelists were entered into a spreadsheet and hand coded to uncover themes both supportive and critical of the criteria and metrics presented. Both major panel themes and stakeholder group

perspective themes are reported. Themes expressed by at least two or more different stakeholder groups were reported as major panel themes. Stakeholder group perspective themes were those expressed by one or more members of only a single stakeholder group. All qualitative response codes are listed in Appendix D.

Stakeholder group perspective. Several points were included in each stakeholder group perspective summary (Research Question #5). First, the degree of stakeholder unity was determined by the number of metrics rated with a high level of consensus. Second, themes from stakeholder comments were summarized for each group in order to assess the overall stakeholder perspective of the proposed metrics.

Stakeholder alignment. The following two analyses, metric classification and stakeholder group pairing, were performed to uncover where stakeholder group perspectives overlapped and diverged (Research Question #5).

Metrics classifications for each stakeholder group. Using the same logic as before, metrics were classified into primary, secondary, tertiary, and unsuitable for each stakeholder group.

Stakeholder group pairing. An analysis of each stakeholder pair was completed to establish how stakeholder groups aligned. To determine what pairs were most aligned, the total number of primary metrics (median rating ≥ 7 and a high level of consensus) for each stakeholder group was counted. Then, the percent agreement was calculated by dividing the total number of primary metrics each pair had in common by the total number of primary metrics. If the pair had a different total number of primary metrics the larger number was used as the total for the denominator.

Limitations of the Method

Delphi studies are based on group dynamics and not statistical power, therefore due to the small sampling of experts, statistical significance of stakeholder responses cannot be calculated and is not an appropriate measure of the research's validity.

Delphi studies can however have limited representativeness due to the small sampling of experts. The Delphi Method may also "force" consensus when consensus does not really exist. Additionally, because the Delphi Method relies on participants reading and responding to other participants' comments, if participants are not engaged, the method has limited usefulness.

Study Results and Analysis

In this section, the quantitative and qualitative results of the Delphi Method survey are presented. This section is divided into three segments. In the first segment, the results of the panel's responses for specific applications that should be included in the definition of beneficial reuse are reported.

The second segment focuses on criteria and associated metrics for recycled water program evaluation. The segment begins with a summary that answers Research Questions #1 through #4. Following the summary, the results for each individual proposed criterion and metric are presented and analyzed. The evaluative criteria and associated metrics have been organized into the following five categories and are presented in the order below, the number in parenthesis indicates the total number of metrics in the category: Water Quantity & Quality (5), Recycled Water Application Breadth (2), Customer Support (3), Public Perception (2), Cost Recovery (1), and Progressiveness (3). For each metric, the median appropriateness rating for each metric is reported answering Research Question #1 along with the panel's level of consensus answering Research Question #2. Next, themes and representative comments from the qualitative analysis are also presented to provide possible explanation for metric ratings and to understand stakeholder group perspectives answering Research Question #5. Finally, the Delphi panel's responses for the metric value indicative of an effective recycled water program answering Research Question #3 with corresponding level of consensus to answer Research Question #4 are given. Where data is available, known

reference values for metrics from existing programs are compared with the Delphi panel's selection.

In the third segment of the results section, the stakeholder group pairing results are presented and analyzed to answer Research Question #5.

Recycled Water Applications Considered to be Beneficial Reuse

Each panelist was provided with a list of common applications of recycled water and asked to select all applications he or she considered to be a beneficial reuse of recycled water. The results are shown in Table 6. Every panelist thought recycled water should be used for toilet flushing. Most felt applying recycled water to control dust on roads and construction sites was not a beneficial use of recycled water.

Table 6. Percentage of panel votes for applications considered to be 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 & roads)	8%

Evaluative Criteria and Associated Metrics

A complete list of all metrics presented to the panel including metric categories, descriptions, and formulas is included in Table 7.

Table 7. List of metrics presented to expert panel in Delphi Method study

Metric Name	Category	Description	Formula/Descriptor
Water Quality	Quality & Quantity	Three water quality parameters that U.S. states commonly monitor are: total suspended solids (TSS), biochemical oxygen demand (BOD, CBOD), and fecal coliform (FC).	**Test statement:** Annual average total suspended solid (TSS) concentrations for program meets or exceed state standards for most restrictive use. If [TSS (mg/L] $_{program}$ $\leq$ [TSS] $_{state\ std}$ 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 [BOD or CBOD (mg/L)] $_{program}$ $\leq$ [BOD or CBOD (mg/L)] $_{state\ std}$ then above statement is true. **Test statement:** Annual average fecal coliform concentrations for program meets or exceed state standards for most restrictive use. If [FC (cfu/100 ml)] $_{program}$ $\leq$ [FC (cfu/100ml)] $_{state\ std}$ then above statement is true.
Recycled Water Utilization Ratio	Quality & Quantity	Metric measures the volume of recycled water (RW) actually used versus the volume that could potentially be used.	$\frac{\text{RW Actual Use (mgd)}}{\text{RW Potential Use (mgd)}}$
Recycled Water Portfolio Contribution	Quality & Quantity	Metric measures the contribution recycled water makes to the overall water supply portfolio for a region.	$\frac{\text{Recycled Water consumed in given year (ac} - \text{ft)}}{\text{Total water consumed in given year (ac} - \text{ft)}}$
Flow Ratio	Quality & Quantity	Metric measures the volume of wastewater recycled. Reuse Flow is defined as the volume of 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).	$\frac{\text{Recycled Water consumed in given year (ac} - \text{ft)}}{\text{Total water consumed in given year (ac} - \text{ft)}}$

Table 7 continued. List of metrics presented to expert panel in Delphi Method study

Metric Name	Category	Description	Formula/Descriptor
Recycled Water Volume Growth Rate	Quality & Quantity	Metric measures increases (and decreases) in customer demand by comparing the year over year volume of recycled water provided to customers every year for a period of five years of more.	$\frac{\text{Volume of RW sold (current year, ac} - \text{ft)}}{\text{Volume of RW sold (previous year, ac} - \text{ft)}}$
Product Diversification	Application Breadth	Metric measures program's strategy to match water quality to water use application.	A: Program has investigated diversifying product and distributes at least 2 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	Application Breadth	Metric measures the extent to which a program's water can be used for all possible recycled water applications.	$\frac{\text{Sum of all actual RW applications in service area}}{\text{Total no. of possible RW applications in service area}}$
Customer Satisfaction	Customer Support	Metric measures the degree to which recycled water customers are satisfied (or dissatisfied) with the quantity and quality of delivered water.	$\frac{\text{No. of customers satisfied}}{\text{Total no. of customers}}$
Customer Complaints	Customer Support	Metric measures the total number of customer complaints per year.	$\frac{\text{No. of customer complaints}}{\text{year}}$
Value Added Services	Customer Support	Metric measures the degree of customer service and support a program provides. 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.	What three services do you think would be most useful to potential and current recycled water customers? Provide assistance with commercial permit process Provide assistance with residential permit process Provide landscape consultant Provide greywater consultant Provide assistance with ROI analysis Provide assistance with locating financing for customer project Conduct industrial user group annual meeting Other 1 Other 2 Other 3 none of the above

Table 7 continued. List of metrics presented to expert panel in Delphi Method study

Metric Name	Category	Description	Formula/Descriptor
Voter Support	Public Perception	Metric measures the level of public support in local elections related to the construction or finance of a recycled water project.	$\frac{\text{No. of voters in support}}{\text{Total no. of voters}}$ (%)
Community Support	Public Perception	Metric measures the level of public support for recycled water gathered from a community survey.	$\frac{\text{No. of survey respondents in support}}{\text{Total no. of survey respondents}}$ (%)
O&M Cost Recovery Ratio	Cost Recovery	Metric measures a program's ability to recover operation and maintenance (O&M) costs from recycled water sales.	$\frac{\text{Average annual RW sales } (\frac{\$}{yr})}{\text{Average annual O\&M costs } (\frac{\$}{yr})}$
CEC Monitoring & Strategy	Progressiveness	Metric measures a program's strategy for monitoring contaminants of emerging concern (CEC).	A: Program monitoring some CECs and hs 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)	Progressiveness	Metric measures the energy intensity to produce and distribute recycled water per volume.	$\frac{\text{Sum of energy use (kWh)}}{\text{Volume of water produced (ac} - \text{ft)}}$
IPR Planning & Strategy	Progressiveness	Metric measures a program's strategy for planning and implementing an indirect potable reuse (IPR) program.	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

Summary of metric ratings by the panel.

Median appropriateness rating. Of the sixteen total metrics presented to the panel, the Delphi panel as a whole rated ten metrics appropriate for evaluating recycled water program effectiveness; six metrics were rated not appropriate. All metric ratings are reported in Table 8.

Table 8. Summary of Delphi panel's metric ratings

Metric Name	Metric Category	Rating	Consensus Level	Metric Classification
RW Portfolio Contribution	Quality & Quantity	Appropriate	High	Primary
Customer Satisfaction	Customer Support	Appropriate	High	Primary
Voter Support	Public Perception	Appropriate	High	Primary
Community Support	Public Perception	Appropriate	High	Primary
Water Quality	Quality & Quantity	Appropriate	Medium	Secondary
RW Utilization Ratio	Quality & Quantity	Appropriate	Medium	Secondary
Flow Ratio	Quality & Quantity	Appropriate	Medium	Secondary
Product Diversification	Application Breadth	Appropriate	Medium	Secondary
Value-Added Services	Customer Support	Appropriate	Medium	Secondary
CEC Monitoring &Strategy	Progressiveness	Appropriate	Low	Tertiary
Volume Growth Rate	Quality &Quantity	Not Appropriate	Medium	Unsuitable
O&M Cost Recovery Ratio	Cost Recovery	Not Appropriate	Medium	Unsuitable
RW Application Range	Application Breadth	Not Appropriate	Low	Unsuitable
Customer Complaints	Customer Support	Not Appropriate	Low	Unsuitable
Energy Intensity	Progressiveness	Not Appropriate	Low	Unsuitable
IPR Planning & Strategy	Progressiveness	Not Appropriate	Low	Unsuitable

Determination of Evaluation Classification:
Primary: Appropriate + High Consensus Level
Secondary: Appropriate + Medium Consensus Level
Tertiary: Appropriate + Low Consensus Level
Unsuitable: Not Appropriate

Metric rating consensus. The mean absolute deviation from the median (MAD-M) determined the level of consensus for the appropriateness ratings. The upper and lower MAD-M limits for each level of consensus (high, medium, and low) was calculated for both round one and round two. These limits determined the level of consensus for all

metrics for both the entire panel and each individual stakeholder group. All consensus levels are listed in Table 8.

The round 1 upper and lower MAD-M limits for each level of consensus are displayed in Table 9. The round two upper and lower MAD-M limits for each level of consensus are shown in Table 10. The upper and lower MAD-M limits show the overall level of consensus decreased for the entire panel and all stakeholder groups except the Regulatory Agency and Academia stakeholder groups where consensus increased.

Table 9. Appropriateness rating consensus level limits: round one (Calculated from the mean absolute deviation from the median) (MAD-M)

	Consensus Level					
	High		Medium		Low	
Stakeholder Group	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Lower Limit	Upper Limit
Entire Panel	1.68	2.17	2.18	2.66	2.67	3.15
Recycled Water Program	0.75	1.70	1.71	2.65	2.66	3.60
Water Supply Program	1.50	2.12	2.13	2.75	2.76	3.38
Regulatory Agency	0.67	1.55	1.56	2.44	2.45	3.33
Non-governmental Organization	0.50	1.33	1.34	2.17	2.18	3.00
Recycled Water Customer	1.00	1.66	1.67	2.33	2.34	3.00
Academia	0.00	1.16	1.17	2.33	2.34	3.50

Table 10. Appropriateness rating consensus level limits: round two (Calculated from the mean absolute deviation from the median) (MAD-M)

	Consensus Level					
	High		Medium		Low	
Stakeholder Group	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Lower Limit	Upper Limit
Entire Panel	1.42	2.02	2.03	2.64	2.65	3.25
Recycled Water Program	0.67	1.77	1.78	2.89	2.90	4.00
Water Supply Program	1.43	2.14	2.15	2.86	2.87	3.57
Regulatory Agency	0.17	1.11	1.12	2.06	2.07	3.00
Non-governmental Organization	0.00	1.00	1.01	2.00	2.01	3.00
Recycled Water Customer	0.67	1.61	1.62	2.56	2.57	3.50
Academia	0.00	0.83	0.84	1.67	1.68	2.50

Metric classification. Metrics were classified into primary, secondary, tertiary, and unsuitable based on the panel's median metric rating and level of consensus. Of the ten metrics that received an appropriate rating, four had a high level of consensus. These four are classified as primary metrics for the evaluation of recycled water program effectiveness. The primary metrics include: Recycled Water Portfolio Contribution, Customer Satisfaction, Voter Support, and Community Support.

The panel had a medium level of consensus for five of the metrics rated appropriate; these are classified as secondary metrics for the evaluation of recycled water program effectiveness. The secondary metrics include: Water Quality, Recycled Water Utilization Ratio, Flow Ratio, Product Diversification, and Value-Added Services.

Only one metric was rated appropriate with a low level of consensus; this metric is classified as tertiary for the evaluation of recycled water program effectiveness. CEC Monitoring & Strategy was the only metric considered tertiary.

The following metrics were considered unsuitable for program evaluation by the panel: Volume Growth Rate, O&M Cost Recovery Ratio, Recycled Water Application Range, Customer Complaints, Energy Intensity, and IPR Planning & Strategy. All metrics presented to the panel, along with the panel's rating and evaluation classification, are listed in Table 8. The next section provides details on the Delphi panel appropriateness ratings for each metric in the Recycled Water Quality & Quantity category.

Recycled Water Quality & Quantity Metrics.

Category Summary. Of the five metrics presented to the panel in the Recycled

Water Quantity & Quality category, one was classified as primary (Recycled Water Portfolio Contribution), three were secondary (Water Quality, Recycled Water Utilization Ratio, and Flow Ratio), and one was unsuitable (Volume Growth Rate).

Water Quality.

Median appropriateness rating. The panel rated this metric as appropriate (median rating: 8). The Non-governmental Organization stakeholder group rated this metric highest (median rating: 9). The stakeholder group that rated this metric lowest was the Academia stakeholder group. All median metric ratings are displayed in Table 11.

Metric rating consensus. Overall, the panel had a medium level of agreement for the rating of this metric making it a secondary metric for the evaluation of recycled water program effectiveness. The largest jump in consensus for any metric between rounds was within the Recycled Water Program stakeholder group for the Water Quality metric. 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 11.

Table 11. Water Quality metric: median appropriateness rating and consensus level

	Number of Experts		Median Appropriateness Rating		MAD-M Value		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
Non-governmental 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

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 critical themes emerged for this metric. The first is that the metric only measures the ability to meet minimum standards. The second criticism of the metric is that it should include a wider range of parameters. Major themes from participant comments for the Water Quality metric are displayed in Table 12.

Table 12. 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)

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 to understanding the perspective of the two groups. Despite the fact that the Recycled Water Program group rated the metric appropriate, some members expressed that the metric should be based on a national standard to ensure comparison across programs is fair. A representative

comment from the Recycled Water Program group for this viewpoint is shown in Table 13.

Table 13. 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 14	

It was unexpected that the Regulatory Agency group did not rate the Water Quality metric 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 for why the stakeholder group did not rate the metric as appropriate. The Regulatory Agency stakeholder group consisted of seven total 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 experts' 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 14 shows the breakdown of ratings and comments for the water quality metric.

Table 14. Water Quality metric: Regulatory Agency themes

Metric Rating	No. of experts	Agency Representation	Theme	Representative Comment(s)
3	2	State Environmental Protection	Metric parameters are minimum standards.	"While 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..."

Metric value indicative of effective recycled water program. The panel was not given specific values to choose from for the Water Quality metric.

Recycled Water Utilization Ratio. A new criterion, the Recycled Water Utilization Ratio, was created out of panelist's comments for several of the metrics presented in round one. As a result, the Delphi panel only rated this metric in round two. Table 15 shows representative comments that lead to the creation of this metric.

Table 15. 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)

Median appropriateness rating. The Delphi panel rated the Recycled Water Utilization Ratio metric appropriate to evaluate recycled water program effectiveness (median rating: 8). The Recycled Water Customer group gave this metric the highest median rating (median rating: 10). The Water Supply Program gave this metric the lowest median rating (median rating: 4). All median appropriateness ratings are listed in Table 16.

Metric rating consensus. The Delphi panel as a whole exhibited a medium level of consensus when rating the Recycled Water Utilization Ratio metric. All stakeholder groups rating this metric appropriate had a high level of consensus. The two groups

rating this metric unsuitable had a medium level of consensus. All consensus level measurements are displayed in Table 16.

Table 16. Recycled Water Utilization Ratio metric: median appropriateness rating and consensus level

	Number of Experts		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
Non-governmental Organization	-	2	-	7	-	0.00	-	high
Recycled Water Customer	-	3	-	10	-	0.67	-	high
Academia	-	1	-	9	-	0.00	-	high

Qualitative analysis: major panel themes. Despite the fact that the metric was created out of multiple panelists' requests, many expressed concern over the metric. Some panelists questioned how the cost-effective potential may be included or calculated. Others were concerned that though there may be a large potential for recycled water, the available supply may be insufficient to fulfill demand. Table 17 shows the major panel themes for the Recycled Water Utilization Ratio metric.

Metric value indicative of effective recycled water program. Despite the panel's opinion that the metric was appropriate, the majority (35%) of the panel did not know what value of the metric would indicate an effective program. Of those panelists who did select a value, the 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 percentage of responses for all metric values is given in Table 18.

Table 17. 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 18. Recycled Water Utilization Ratio metric: value indicative of effectiveness

Value	All values				Exclude "dnk" & "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%	-	0	-	4%	-	0	-	7%	-	low
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%**		

"dnk": do not know, "nota": none of the above

Recycled Water Portfolio Contribution.

Median appropriateness rating. The Delphi panel rated the Recycled Water Portfolio Contribution metric appropriate to evaluate recycled water programs (median rating ≥ 7). The Recycled Water Customer stakeholder group rated this metric the

highest (median rating: 8). The Recycled Water Program stakeholder group rated this metric the lowest (median rating: 5). The median metric rating for Recycled Water Portfolio Contribution for the panel and all stakeholder groups is displayed in Table 19.

Table 19. Recycled Water Portfolio Contribution metric: median appropriateness rating and consensus level

	Number of Experts		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
Non-governmental 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

Metric rating consensus. The panel displayed a high level of consensus when rating the Recycled Water Portfolio Contribution metric. The individual stakeholder groups had varying levels of consensus when rating the metric. The Regulatory Agency and Recycled Water Customer stakeholder groups had the highest level of consensus when rating the metric. The Academia stakeholder group had the lowest level of consensus. The consensus levels for each stakeholder group for rounds one and two are listed in Table 19.

Qualitative analysis: major panel themes. The predominant reason panelists gave in support of the Recycled Water Portfolio Contribution metric is it provides a method to measure the potable water offset of recycled water. A common theme from panelists more critical of the metric is that the Recycled Water Portfolio Contribution will be dependent on the level of water scarcity in the region. Panelists argued that the degree of water scarcity is utility-specific making it an unsuitable metric for comparing programs.

Another point raised by multiple 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 for a large contribution of its total supply portfolio to come from recycled water. Major themes from participant comments for the Recycled Water Portfolio Contribution metric are displayed in Table 20.

Table 20. Recycled Water 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." (Non-governmental 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)

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 of this theme is shown in Table 21.

Table 21. Recycled Water 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 beneficial it is being used." (Recycled Water Program, AZ)

Metric value indicative of effective recycled water program. Twenty-five percent of the panel did not know what metric value indicated an effective recycled water program. Of those that did select a value, most (44%) responded that a recycled water program should contribute 6 to 10% toward the total water supply within the program's service area. The response from the panel appears to align with current practice in several states. From data available in California (SCVWD, 2010), Arizona (ADWR, 2005), and Texas (SAWS, 2008) recycled water portfolio contributions ranged between 4 to 12 percent of the total supply. The Delphi panel came to a medium level of consensus on the Recycled Water Portfolio Contribution metric. Table 22 shows the percent responses for each metric value.

Table 22. Recycled Water Portfolio 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%	1	0	4%	0%	1	0	6%	0%	medium	medium
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%**		

"dnk": do not know, "nota": none of the above

Flow Ratio.

Median appropriateness rating. The Delphi panel as a whole rated the Flow Ratio metric appropriate to measure recycled water program effectiveness (median rating: 7). The Non-governmental Organization stakeholder group rated the metric the highest (median rating: 9.5). The Recycled Water Program rated the metric the lowest (median rating: 3). Table 23 shows the median appropriateness ratings for the entire panel and each stakeholder group.

Metric rating consensus. The Delphi panel showed a medium level of consensus when rating the Flow Ratio metric. No stakeholder group displayed a low level of consensus when rating the metric. The consensus levels for each group are included in Table 23.

Table 23. Flow Ratio metric: median appropriateness rating and consensus level

	Number of Experts		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
Non-governmental 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

Qualitative analysis: major panel themes. Though the Delphi panel rated the Flow Ratio metric appropriate, the metric was classified as secondary, and several themes came out of panelists' comments that were both supportive and critical of the metric. A common point emphasized by Delphi panelists is the need to clearly define the specific

types of applications included in the calculation of the Flow Ratio metric. However, the panel appeared divided on whether environmental enhancement or stream augmentation should be included in the Flow Ratio calculation.

Some panelists were hesitant to rate the metric appropriate due to the belief that many programs may not be able to recycle a significant volume of wastewater due to climate, available applications, and system capacity. Table 24 shows the major themes from participant comments for the Flow Ratio metric.

Table 24. 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.	"While 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." (Non-governmental 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)

Individual stakeholder group themes that differed from major panel themes. Most of the Recycled Water Program stakeholders were critical of the Flow Ratio metric because it did not account for limitations placed on the demand for recycled water. Limitations cited included the seasonal variation of demand, lack of capital to expand the program, and lack of high use applications such as groundwater recharge and dual-plumbed buildings believed to be necessary in order to achieve a high Flow Ratio. Again, the importance of the type of use rather than the volume of use was stressed by Recycled Water Program stakeholders.

In contrast, many Regulatory Agency stakeholders 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 point will be revisited in the analysis of stakeholder alignment.

A member of the Academia stakeholder group expressed that the Flow Ratio metric was too crude, and potentially lacked important details. Representative comments of stakeholder group perspectives that differed from the panel at large are reported in Table 25.

Metric value indicative of effective recycled water program. Of the entire panel, 20 percent did not know what metric value would indicate an effective recycled water program. An additional 12 percent responded "none of the above." Of those who

Table 25. 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)
		"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 potentially lack important information." (Academia, International)

selected a value for the Flow Ratio metric, the value receiving the highest percentage of votes in round two was 0.60 to 0.79 (59%).

The state average for Flow Ratio in Florida is 0.43 (FDEP, 2009). When comparing the panel's response to Florida's average Flow Ratio, it appears that the panel would view Florida's performance as ineffective or that the state is underperforming. This finding is unexpected given the fact that Florida leads the nation in water reuse. The panel had a low level of consensus concerning the metric value in round one and moved towards a higher level of consensus in round two (medium level of agreement). Table 26 shows the percent responses for each metric value.

Table 26. Flow Ratio metric: value indicative of effectiveness

Value	All values				Exclude "dnk" & "nota"				Consensus Level	
	No. of votes		% of votes		No. of votes		% of votes			
	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2
0.80 to 1.00	2	2	7%	8%	2	2	11%	12%	low	medium
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%**		

"dnk": do not know, "nota": none of the above

Recycled Water Volume Growth Rate.

Median appropriateness rating. 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 27 shows the metric ratings for the Delphi panel and all stakeholder groups.

Table 27. Recycled Water Volume Growth Rate metric: median appropriateness rating and consensus level

	Number of Experts		Median Appropriateness 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	medium	medium
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	medium
Regulatory Agency	6	7	6.5	7	1.67	1.71	medium	medium
Non-governmental 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

Metric rating consensus. 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 27.

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 from 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 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 solve 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 recycled water growth rarely follows a smooth growth curve due to the long lead times for construction of infrastructure.

Finally an interesting recommendation made by members in 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 28.

Table 28. 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)

Individual stakeholder group themes that differed from major panel themes. The Non-governmental Organization stakeholders raised a perspective wholly unique and unreferenced by any other stakeholder group in the survey. One panelist questioned how much of recycled water consumption represents demand as opposed to forced supply. The idea that recycled water is a forced supply is a new and interesting perspective that the stakeholder unfortunately did not elaborate. This idea should be further investigated. The stakeholder's comment is displayed in Table 29.

Table 29. Recycled Water Volume Growth metric: individual stakeholder group themes

Stakeholder Group	Theme	Representative Comment
Non-governmental Organization	Metric does not represent demand.	"How much of this metric actually represents demand as opposed to forced supply?" (Non-governmental Organization, U.S.)

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. From 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, Arizona from 1987 to 2006 was 10 percent. For the same time period, the average annual volume growth rate was 7 percent in Phoenix, Arizona (ADWR, 2010). In San Antonio, Texas the average annual volume growth rate was 21 percent between 2001 and 2007 (SAWS, 2008). The percentage of responses for all values is given in Table 30.

Table 30. Recycled Water Volume Growth Rate metric: value indicative of effectiveness

Value	All values				Exclude "dnk" & "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%**		

"dnk": do not know, "nota": none of the above

Application Breadth Metrics.

Product Diversification.

Median appropriateness rating. The Delphi panel rated the Product Diversification metric appropriate to measure recycled water program effectiveness

(median rating: 7). The Recycled Water Customer group rated the metric highest (median rating: 8.5). The Water Supply Program group rated the metric lowest (median rating: 2). The median appropriateness ratings for all stakeholder groups are included in Table 31.

Metric rating consensus. 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. Consensus level measurements are shown in Table 31.

Table 31. Product Diversification metric: median appropriateness rating and consensus level

	Number of Experts		Median Appropriateness Rating		MAD-M Value		Consensus Level	
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
Non-governmental 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

Qualitative analysis: major panel themes. Four themes emerged from panelist comments. Experts supportive of the metric contended it focuses on the customer which is necessary for an effective recycled water program. Other panelists argued a program can still be effective without diversifying product. Panelists also claimed the ability to diversify product would be a function of the program's size and financial resources. Experts argued these two variables are utility-specific which makes the metric difficult to

use as a cross comparison measure of programs. Table 32 shows the major panel themes from participant comments for the Product Diversification metric.

Table 32. 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)

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 questioned if product diversification was the responsibility of the 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 because it offers a way of saving programs money. Representative

comments from the Water Supply Program and Regulatory Agency stakeholders are listed in Table 33.

Table 33. 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 criteria 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)

Metric value indicative of effective recycled water program. A numerical metric for the Product Diversification criterion could not be found in the literature. Instead a nominal lettering system (A: best, C: worst) that included a "not applicable" choice was created to evaluate how or if a recycled water program diversified products. 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 has investigated diversifying product, and has created a plan to produce more than one quality of recycled water within the next 3 years. Because the metric was created by the study team, there are no known reference values to compare with the survey findings. The percentage of responses for all values is given in Table 34.

Table 34. Product Diversification metric: value indicative of effectiveness

Value	All values				Exclude "dnk" & "nota"				Consensus Level	
	No. of votes		% of votes		No. of votes		% of votes			
	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2
NA	2	2	8%	9%	2	2	14%	15%	low	low
D	0	0	0%	0%	0	0	0%	0%		
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%**		

"dnk": do not know, "nota": none of the above

Recycled Water Application Range.

Median appropriateness rating. 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). All metric appropriateness ratings are tabulated in Table 35.

Metric rating consensus. 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. The consensus measurements for the Recycled Water Application Range metric are included in Table 35.

Table 35. Recycled Water Application Range metric: median appropriateness rating and consensus level

Stakeholder Group	Number of Experts		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
Non-governmental 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

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 expressed the degree of market penetration was not related to recycled water program effectiveness. This finding begs 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? This point will be further explored in the Discussion.

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 36.

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 36. 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 recycled water is used is determined by customers and outside the control of the program. Additionally, 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 37.

Table 37. 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)

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%) also responded "none of the above." Of those that 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 38.

Table 38. Recycled Water Application Range metric: value indicative of effectiveness

Value	All values				Exclude "dnk" & "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%**		

"dnk": do not know, "nota": none of the above

Customer Support Metrics.

Customer Satisfaction.

Median appropriateness rating. Of all the metrics presented in any category, the Delphi panel rated the Customer Satisfaction metric highest (median rating: 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 (median rating: 7) but still found this metric appropriate to evaluate the effectiveness of a recycled water program. Table 39 shows the metric ratings for the panel and all stakeholder groups.

Metric rating consensus. The panel as a whole had a high level of consensus when rating this metric. Only two groups (Regulatory Agency and Non-governmental Organization) had a medium level of consensus. All others had a high level of consensus for the metric rating. Consensus level measurements are detailed in Table 39.

Table 39. Customer Satisfaction metric: median appropriateness rating and consensus level

Stakeholder Group	Number of Experts		Median Appropriateness Rating		MAD-M Value		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
Non-governmental 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

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 argued not with the necessity of a program's customers to be satisfied, but cited problems with conducting and analyzing customer satisfaction surveys. Table 40 shows the major themes from participant comments for the Customer Satisfaction metric.

Table 40. 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)

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 41.

Table 41. 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)

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%. The results of customer satisfaction surveys conducted by recycled water programs in the United States are not readily available to the public. The percentage of customers satisfied was not reported in the Australian article from where the metric was adapted. The article only reported that 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 (Hurlimann et al., 2008). The percentage of responses for all values is given in Table 42.

Table 42. Customer Satisfaction metric: value indicative of effectiveness

Value	All values				Exclude "dnk" & "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%	2	2	8%	8%	0	0	0%	0%	high	high
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%**		

"dnk": do not know, "nota": none of the above

Value Added Services.

Median appropriateness rating. The Delphi panel rated the Value Added Services metric appropriate (median rating: 7). The Recycled Water Customer stakeholder group rated this metric highest (median rating: 9). The Academia stakeholder group rated the metric lowest (median rating: 5.5). The median appropriateness rating for all stakeholder groups can be found in Table 43.

Table 43. Value Added Services metric: median appropriateness rating and consensus level

	Number of Experts		Median Appropriateness Rating		MAD-M Value		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
Non-governmental 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

Metric rating consensus. 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 consensus actually decreased (high to medium). All consensus level values are reported in Table 43.

Qualitative analysis: major panel themes. Delphi panelists supportive of the metric argued value added services are helpful for gaining public acceptance and trust. Members of both the Recycled Water Program and Water Supply Program stressed the importance of working closely with the customer because recycled water has a unique set of issues that do not apply to potable water.

Delphi panelists both supportive and critical of the metric expressed value added services are dependent on a program's financial health. For this reason, some panelists argued the metric should be a secondary metric or "extra credit." Other experts felt the need for programs to offer value added services would be greater upon program commencement 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 44.

Individual stakeholder group themes that differed from major panel themes. One member of the Academia stakeholder group thought value added services may encourage unnecessary competition amongst programs which may make programs inefficient. A representative comment from the stakeholder is reported in Table 45.

Table 44. 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." (Non-governmental Organization, U.S.)

Table 45. Value Added Services metric: individual stakeholder group themes

Stakeholder Group	Theme	Representative Comment
Academia	Value added services may encourage unnecessary competition.	"Customer service and support is important up to a point, beyond which it becomes unnecessary and inefficient. I would hate for this metric to instill a competition to provide as many services as possible which may not necessary…" (Academia, International)

Metric value indicative of effective recycled water program. The presentation of this metric was slightly different than 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: provide assistance with commercial permit process (22%), provide landscape consultant (22%), and provide assistance with locating grants or general financing for customer project (13%). Thirteen percent of Delphi panelists recommended alternative services not listed that varied on the themes of public outreach, health and safety, and soil and nutrient management plans. Because a formal survey of recycled water program's value added services has not been conducted, there are no known reference values available to compare with the survey findings. Due to the format of the question (participants were asked to select up to three services), the consensus level could not be measured. The percentage of responses for all values is given in Table 46.

Table 46. Value Added Services metric: value indicative of effectiveness

Value	All values			
	No. of votes		% of votes	
	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%
Greywater 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%**

* Each panelist was asked to vote for up to 3 services.

Customer Complaints.

Median appropriateness rating. While the Delpi panel thought the Customer Satisfaction metric was appropriate, the Delphi panel rated the mirror of the metric, Customer Complaints, unsuitable (median rating: 6). The Non-governmental Organization rated the metric highest (median rating: 9). The Recycled Water Program stakeholder group rated this metric lowest (median rating: 2). The median appropriateness rating for all stakeholder groups is listed in Table 47.

Metric rating consensus. 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 Non-governmental Organization stakeholder group that reached a high level of consensus. Consensus level measurements for the Customer Complaint metric are shown in Table 47.

Table 47. Customer Complaints metric: median appropriateness rating and consensus level

	Number of Experts		Median Appropriateness Rating		MAD-M Value		Consensus Level	
Stakeholder Group	**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
Non-governmental 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

Qualitative analysis: major panel themes. The Delphi panel appeared to rate the Customer Complaint metric low because they disagreed more with the metric formula

rather than the metric's concept. Several experts suggested 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 (Non-governmental Organization, 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 48.

Table 48. 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)

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 49.

Table 49. Customer Complaints metric: value indicative of effectiveness

Value	All values				Exclude "dnk" & "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 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%**		

"dnk": do not know, "nota": none of the above

Public Perception Metrics.

Voter Support.

Median appropriateness rating. The Voter Support metric was also one of the highest rated metrics amongst Delphi panel members (median rating: 8). All stakeholder groups rated this metric appropriate. Table 50 shows the panel's median ratings for the metric.

Metric rating consensus. 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 50 lists the consensus levels for all stakeholder groups for the metric.

Table 50. Voter Support metric: median appropriateness rating and consensus level

Stakeholder Group	Number of Experts		Median Appropriateness Rating		MAD-M Value		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
Non-governmental 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

Qualitative analysis: major panel themes. The major theme to emerge from panelist comments was the connection between the level of public support and a 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 expert thought the Voter Support metric was too blunt because it ignored evaluating specific program efforts to increase public support. Table 51 shows the major panel themes for the Voter Support metric.

Table 51. 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)

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 – 80% of voter support.

From limited information available of known Voter Support metric values, the panel's expectations of an effective program appear to be in alignment with actual program performance. From data reported by the East Valley Tribune in Mesa, Arizona, a $39 million wastewater system revenue bond passed with 74% support from voters in 2010 (Groff, 2010). The percentage of responses for all values is given in Table 52.

Table 52. Voter Support metric: indicative value of effectiveness

Value	All values				Exclude "dnk" & "nota"				Consensus Level	
	No. of votes		% of votes		No. of votes		% of votes			
	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2
40 to 50%	1	0	4%	0%	1	0	4%	0%	medium	low
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

Community Support.

Median appropriateness rating. The Delphi panel rated the Community Support metric appropriate (median rating: 8). All stakeholder groups rated this metric appropriate except the Non-governmental Organization stakeholder group (median rating: 4.5). All stakeholder median appropriateness ratings are displayed in Table 53.

Metric rating consensus. 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. All consensus level values are shown in Table 53.

Table 53. Community Support metric: median appropriateness rating and consensus level

	Number of Experts		Median Appropriateness Rating		MAD-M Value		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
Non-governmental 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

Qualitative analysis: major panel themes. All stakeholder groups emphasized community support is critical to program success. Some Delphi panelists objected to the metric because it is determined by a public survey which some panelists view as problematic. Major themes from the qualitative analysis of participant comments for the community support metric are displayed in Table 54.

Individual stakeholder group themes that differed from major panel themes. One member of the Recycled Water Program group questioned the Community Support metric. The member argued measuring the number of voluntary connections would be a better indicator of community support. The Recycled Water Program stakeholder's comment is displayed in Table 55.

Table 54. 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." (Non-governmental Organization, U.S.)

Table 55. Community Support metric: individual stakeholder group themes

Stakeholder Group	Theme	Representative Comment
Recycled Water Program	Metric is not the best measure of community support.	"Both methods rely on proactive customers, those willing to share their viewpoints…A good metric would be number of connections if voluntary." (Recycled Water Program, FL)

Metric value indicative of effective recycled water program. Only 12 percent of the panel chose "do not know" or "none of the above" for the Community Support metric value. The remaining responses varied over the range of choices given however, the most votes (38%) were cast for a value of 81 to 90% community support. The panel's level of consensus was low.

Two surveys reporting the degree of community support for recycled water were located. A survey of residents in Corvallis, Oregon showed that 70 percent of the community supported recycled water (Dubose, 2009). A second survey in Victor Valley, California showed 82 percent of the community supported recycled water (Humphreys, 2006). From these two sources, the panel's expectations for an effective program are

essentially aligned with actual program performance. The percentage of responses for all values is given in Table 56.

Table 56. Community Support metric: indicative value of effectiveness

Value	All values				Exclude "dnk" & "nota"				Consensus Level	
	No. of votes		% of votes		No. of votes		% of votes			
	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2
40 to 50%	1	0	4%	0%	1	0	4%	0%	low	low
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%**		

"dnk": do not know, "nota": none of the above

Cost Recovery Metrics.

O&M Cost Recovery Ratio.

Median appropriateness rating. 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). All stakeholder group ratings for the O&M Cost Recovery Ratio metric are displayed in Table 57.

Metric rating consensus. 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 consensus level measurements are listed in Table 57.

Table 57. O&M Cost Recovery Ratio metric: median appropriateness rating and consensus level

	Number of Experts		Median Appropriateness Rating		MAD-M Value		Consensus Level	
Stakeholder Group	**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
Non-governmental 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

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 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 or fines incurred from violating wastewater discharge regulations. Some experts 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 cost recovery may not be a desired program goal. Instead, avoiding compliance and environmental costs was more important. Other panelists argued it was impossible to compare programs because of differences in accounting practices. Table 58 shows the major themes from participant comments for the O&M Cost Recovery Ratio metric.

Table 58. O&M Cost Recovery Ratio metric: major panel themes

No. of comments	Theme	Representative Comment
5	Metric doesn't 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 doesn't 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)

Individual stakeholder group themes that differed from major panel themes. Several unique stakeholder perspective themes were uncovered from the O&M Cost Recovery Ratio metric comments. First, the Regulatory Agency group was the only group to state cost recovery is necessary for an effective program. Most Regulatory Agency stakeholders did recognize that programs will be unable to cover costs initially, but agreed that over time the program would have to cover costs in order to be sustainable.

Two groups introduced the idea of public acceptance when commenting on the O&M Cost Recovery Ratio metric, but in slightly different ways. The Regulatory Agency argued cost recovery was a function of public acceptance. The Academia group, on the other hand, felt that an effective program was better measured by the level of public acceptance rather than the ability to recover costs.

Finally, a member of the Non-governmental Organization group argued the formula implied the commodification of water which was disconcerting because water belongs to consumers not the program. Representative comments from the above stakeholder groups are displayed in Table 59.

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 to 100% of costs.

Table 59. O&M Cost Recovery Ratio metric: individual stakeholder group themes

Stakeholder Group	Theme	Representative Comment
Regulatory Agency	Cost recovery is linked to public acceptance.	"Being able to recover a high percentage of a water reuse program's O&M costs should be a good measure of the overall effectiveness and local acceptance of the program." (Regulatory Agency, U.S. EPA)
Regulatory Agency	It may take time to recover costs, but cost recovery is important to program effectiveness.	"I believe paying for the annual O&M costs of the reclaimed water should be a basic criteria of success. However, I understand that new programs are less likely to achieve this goal because it takes time to build enough customers to cover costs initially…" (Regulatory Agency, U.S. EPA)
Non-governmental Organization	The O&M Cost Recovery Ratio metric implies the commodification of water.	"…The rubric represented in the example formula raises troubling questions concerning the commodification of water. Even if the water has been recycled, it still belongs to consumers and the 'sale' of such water suggests it is being transferred from those consumers to some other entity." (Non-governmental Organization, U.S.)
Academia	Effectiveness is better measured by public acceptance not cost recovery.	"From a utility perspective this is extremely important however if the way we look at effectiveness is acceptance of recycled water programs then I feel it is less appropriate." (Academia, AZ)

Results from a survey of 109 recycled water programs conducted by the American Water Works Association (AWWA) in 2000 and 2007 show 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, 2008).

The panel's consensus level was low when selecting metric values. The percentage of responses for all values as well as the consensus level is given in Table 60.

Table 60. O&M Cost Recovery Ratio metric: value indicative of effectiveness

Value	All values				Exclude "dnk" & "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%**		

"dnk": do not know, "nota": none of the above

Progressiveness Metrics.

Contaminants of Emerging Concern (CEC) Monitoring and Strategy.

Median appropriateness rating. Overall, the Delphi panel rated the CEC Monitoring and Strategy metric appropriate (median rating: 7). The Non-governmental Organization and Recycled Water Customer stakeholder groups rated the metric highest (median rating: 8.5). The Water Supply Program rated the metric lowest (median rating: 3). All ratings for the CEC Monitoring and Strategy metric are included in Table 61.

Metric rating consensus. The Delphi panel exhibited a low level of consensus for this metric. Consensus levels for individual stakeholder groups varied widely. All consensus level measurements are reported in Table 61.

Table 61. CEC Monitoring and Strategy metric: median appropriateness rating and consensus level

	Number of Experts		Median Appropriateness Rating		MAD-M Value		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
Non-governmental 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

Qualitative analysis: major panel themes. A total of seven themes were generated from panelists' comments on the CEC Monitoring and Strategy metric. The most cited theme was supportive of the metric and claimed that monitoring CECs shows a program is proactive. Stakeholders in nearly every group argued CECs are not well understood. Stakeholders went on to elaborate 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 and added monitoring would add additional costs.

Other stakeholders felt CECs should only be monitored if recycled water was used for certain applications, specifically indirect potable reuse or groundwater recharge.

The panel was divided on whether monitoring CECs would contribute towards increasing or decreasing public acceptance of recycled water.

Still other experts expressed that monitoring CECs would contribute to much needed research on the subject. Finally two experts pointed out that in terms of CECs, recycled water is no different than potable water and should not be held to a higher standard. Major panel themes for the CEC Monitoring & Strategy metric are displayed in Table 62.

Individual stakeholder group themes that differed from major panel themes. While most Regulatory Agency stakeholder comments reflected at least one of the major themes, one Regulatory Agency stakeholder expressed a view in stark contrast to fellow group members and the panel at large. This stakeholder wrote that CECs should not be detected in recycled water. A representative comment is shown in Table 63.

The lack of unified perspective within the Regulatory Agency stakeholder group regarding CECs is perhaps reflective of the larger public's uncertainty with the issue. At an international recycled water stakeholder workshop in 2010, stakeholders raised the question, "Should drinking water agencies be forced to take out micro-constituents from their water supply or should wastewater agencies be forced not to put them into the water supply at all?" (McCarthy, 2010). This point will be revisited in the Discussion.

Metric value indicative of effective recycled water program. The CEC Monitoring & Strategy metric values were organized using a nominal lettering system (A: active management plan, D: no active or future management plan). Twenty-nine percent of respondents answered "do not know" or "none of the above" for the CEC

Table 62. CEC Monitoring & Strategy 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..." (Non-governmental 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)

Table 63. CEC Monitoring & Strategy metric: individual stakeholder group themes

Stakeholder Group	Theme	Representative Comment
Regulatory Agency	CECs should be at non-detect level.	"CECs are extremely important constituents because they can severely impact human health and the health of other living organisms. It is critical that residuals of these substances are at a non-detect level in recycled water." (Regulatory Agency, U.S. EPA)

Monitoring & Strategy metric value. Of those that did select a metric value, most (47%) thought an effective recycled water program should be actively managing CECs (letter grade "A"). There is no publicly available data on how many recycled water programs in the U.S. monitor or plan to monitor contaminants of emerging concern. The level of consensus for the metric value decreased between rounds one and two from medium to low. The percentage of responses for all values is given in Table 64.

Table 64. CEC Monitoring & Strategy metric: value indicative of effectiveness

Value	All values				Exclude "dnk" & "nota"				Consensus Level	
	No. of votes		% of votes		No. of votes		% of votes			
	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2
D	2	2	8%	8%	2	2	12%	12%	medium	low
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%**		

"dnk": do not know, "nota": none of the above

Energy Intensity.

Median appropriateness rating. The Delphi panel rated the Energy Intensity metric unsuitable to measure recycled water program effectiveness. The Recycled Water Program rated the metric highest (median rating: 7.5). The Water Supply Program rated

the metric lowest (median rating: 4). Table 65 shows all stakeholder group median metric ratings.

Table 65. Energy Intensity metric: median appropriateness rating and consensus level

	Number of Experts		Median Appropriateness Rating		MAD-M Value		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
Non-governmental 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

Metric rating consensus. The Delphi panel exhibited a low level of consensus when rating the Energy Intensity metric. Individual stakeholder group consensus levels varied widely from low to high. Consensus level measurements are included in Table 65.

Qualitative analysis: major panel themes. The only supportive theme to emerge from panel comments was that energy intensity is closely related to the cost of water supply. The major reasons given to explain the metric's low appropriateness rating were that energy intensity should be a secondary metric or once again "extra credit" because the goals of the program may outweigh the need to reduce energy intensity. Additionally, experts argued the energy intensity of water sources will be different for every location. Table 66 shows the major themes found from the qualitative analysis of participant comments for the energy intensity metric.

Table 66. 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)

Individual stakeholder group themes that differed from major panel themes. Two individual stakeholder group themes emerged from comments on the Energy Intensity metric. Though the Recycled Water Program as a group rated the Energy Intensity metric appropriate, one member of the group raised a concern that the metric may penalize programs who produce high energy designer water, or in other words, diversify their product.

Regulatory Agency stakeholders pointed out that measuring and reporting the energy intensity of recycled water relative to other sources may increase public support. Representative comments from both the Recycled Water Program and Regulatory Agency stakeholders are shown in Table 67.

Table 67. Energy Intensity metric: individual stakeholder group themes

Stakeholder Group	Theme	Representative Comment
Recycled Water Program	Metric may penalize some programs.	"Energy intensity is generally a consequence of the treatment requirements needed to achieve a given water quality for a given use…so programs that produce high-energy designer waters would rank lower than those producing irrigation water…" (Recycled Water Program, FL)
Regulatory Agency	Metric could increase public acceptance.	"This is appropriate both to get public support for recycling and decision-making support for capital expenditures." (Regulatory Agency, CA)

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

The Delphi panel's response is in alignment with actual known program performance. From the report where the metric was adapted, the Energy Intensity Ratio for recycled water in Santa Clara County, California, is about 50% less than groundwater

(Larabee et al., 2010). No value for how recycled water compared to imported water was given in the report. The percentage of responses for all values is given in Table 68 and Table 69.

Table 68. Energy Intensity metric – compared to groundwater: value indicative of effectiveness

Value	All values				Exclude "dnk" & "nota"				Consensus Level	
	No. of votes		% of votes		No. of votes		% of votes			
	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2
5% to 10% less	3	3	12%	13%	3	3	30%	30%	low	low
11% to 20% less	3	1	12%	4%	3	1	30%	10%		
21% to 30% less	1	2	4%	8%	1	2	10%	20%		
over 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%**		

"dnk": do not know, "nota": none of the above

Table 69. Energy Intensity metric – compared to imported water: indicative value of effectiveness

Value	All values				Exclude "dnk" & "nota"				Consensus Level	
	No. of votes		% of votes		No. of votes		% of votes			
	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2
5% to 10% less	4	3	15%	13%	4	3	29%	25%	low	low
11% to 20% less	0	0	0%	0%	0	0	0%	0%		
21% to 30% less	3	2	12%	8%	3	2	21%	17%		
over 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%**		

"dnk": do not know, "nota": none of the above

Indirect Potable Reuse (IPR) Planning & Strategy.

Median appropriateness rating. The Delphi panel rated the IPR Planning & Strategy metric the second lowest (median rating: 5) of all proposed metrics. Only one stakeholder group, the Non-governmental Organization, rated this metric appropriate to use in a program evaluation. The median ratings for the IPR Planning & Strategy metric are shown in Table 70.

Table 70. IPR Planning & Strategy metric: median appropriateness rating and consensus level

	Number of Experts		Median Appropriateness Rating		MAD-M Value		Consensus Level	
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
Non-governmental 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

Metric rating consensus. The Delphi panel displayed a low level of consensus when rating the IPR Planning & Strategy metric. Individual stakeholder group consensus levels ranged from low to medium. All consensus level measurements are displayed in Table 70.

Qualitative analysis: major panel themes. Some of the themes generated from Delphi panelist's comment were similar to those found for the Energy Intensity 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 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. Major themes from participant comments for the IPR Planning & Strategy metric are displayed in Table 71.

Table 71. IPR Planning & 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 criteria...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)

Individual stakeholder group themes that differed from major panel themes. Only one member from the Regulatory Agency stakeholder group expressed concern over the application of IPR. The stakeholder was from California where there are many successful IPR projects, so this finding was somewhat unexpected. The stakeholder's comment for the IPR Planning & Strategy metric is displayed in Table 72.

Table 72. IPR Planning & Strategy metric: individual stakeholder group themes

Stakeholder Group	Theme	Representative Comment
Regulatory Agency	IPR is too risky.	"The relative risk from contaminating the groundwater aquifer with unknown contaminants makes IPR not a worthwhile endeavor. Traditional uses of recycled water (e.g., irrigation) are favored." (Regulatory Agency, CA)

Metric value indicative of effective recycled water program. Similar to the Product Diversification metric, a nominal letter system was developed for the values of the IPR Planning & Strategy metric. The nominal letter system for this metric was based on a five point scale (A: program utilizing IPR, E: 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 (D: program considering developing IPR plan within 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 & Strategy metric is listed in Table 73.

Table 73. IPR Planning & Strategy metric: value indicative of effectiveness

Value	All values				Exclude "dnk" & "nota"				Consensus Level	
	No. of votes		% of votes		No. of votes		% of votes			
	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2
E	1	0	4%	0%	1	0	7%	0%	low	low
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%	-	-	-	-		
Total	**28**	**25**	**100%**	**100%**	**14**	**13**	**100%**	**100%**		

"dnk": do not know, "nota": none of the above

Stakeholder Alignment

Metric classification by stakeholder group. Metrics were classified into primary, secondary, tertiary, and unsuitable using the same logic as before, only for each individual stakeholder group. The Recycled Water Customer group had the greatest number (10) of primary metrics, while the Recycled Water Program and Academia stakeholder groups had the least number (4) of primary metrics. All metric classifications for each individual stakeholder group are shown in Table 74.

Stakeholder group pairing. The number of primary metrics each stakeholder group pair shared in common is calculated in Table 75. From the number of primary metrics each stakeholder pair shared in common, the percent agreement was calculated and is shown in Table 76. The stakeholder groups who agreed the most (80%) were the Recycled Water Program and Water Supply Program. Following the top pair were the Water Supply Program and Non-governmental Organization pair, who shared 60 percent of primary metrics in common; and the Regulatory Agency and Academia pair who shared 50 percent of primary metrics. The stakeholder group pairs that agreed the least

(20%) were the Water Supply Program and Regulatory Agency pair, Water Supply Program and Academia pair, and Non-governmental Organization and Academia pair.

Table 74. Primary, secondary, tertiary, and unsuitable metrics for evaluating programs by stakeholder group

		Stakeholder Group					
Metric	**Category**	**RWP**	**WSP**	**RA**	**NGO**	**RWC**	**AC**
Water Quality	Quantity & Quality	P	P	U	P	S	U
RW Utilization Ratio	Quantity & Quality	U	U	P	P	P	P
RW Portfolio Contribution	Quantity & Quality	U	U	P	U	P	T
Flow Ratio	Quantity & Quality	U	P	S	P	S	U
Volume Growth Rate	Quantity & Quality	U	U	S	U	P	U
Product Diversification	Application Breadth	U	U	P	U	P	P
RW Application Range	Application Breadth	U	U	T	U	P	U
Customer Satisfaction	Customer Support	P	P	S	S	P	P
Value-Added Services	Customer Support	S	T	U	U	P	U
Customer Complaints	Customer Support	U	U	T	P	T	U
Voter Support	Public Perception	P	P	P	P	P	S
Community Support	Public Perception	P	P	P	U	P	S
O&M Cost Recovery Ratio	Cost Recovery	U	U	T	U	U	U
CEC Monitoring & Strategy	Progressiveness	U	U	T	S	P	P
Energy Intensity	Progressiveness	S	U	U	U	T	U
IPR Planning & Strategy	Progressiveness	U	U	U	T	U	U
	Total Primary metrics (P)	**4**	**5**	**5**	**5**	**10**	**4**
	Total Secondary metrics (S)	**2**	**0**	**3**	**2**	**2**	**2**
	Total Tertiary metrics (T)	**0**	**1**	**4**	**1**	**2**	**1**
	Total Unsuitable metrics (U)	**10**	**10**	**4**	**8**	**2**	**9**

P: primary metric
S: secondary metric
T: tertiary metric
U: unsuitable metric

RWP: Recycled Water Program, WSP: Water Supply Program, RA: Regulatory Agency, NGO: Non-governmental Organization, RWC: Recycled Water Customer, AC: Academia

Table 75. Number of primary metrics shared in common for each stakeholder pair

	Total No. of Primary Metrics Shared in Common					
	Stakeholder Group					
Stakeholder Group	RWP	WSP	RA	NGO	RWC	AC
RWP	-	4	1	2	3	1
WSP	4	-	1	3	3	1
RA	1	1	-	2	4	2
NGO	2	3	2	-	2	1
RWC	3	3	4	2	-	4
AC	1	1	2	1	4	-

RWP: Recycled Water Program, WSP: Water Supply Program, RA: Regulatory Agency, NGO: Non-governmental Organization, RWC: Recycled Water Customer, AC: Academia

Table 76. Stakeholder group pair percent agreement

Stakeholder group pair	Total no. of primary metrics in common	Total no. of primary metrics*	Percent agreement
RWP/WSP	4	5	80%
WSP/NGO	3	5	60%
RA/AC	2	4	50%
RWP/NGO	2	5	40%
RA/RWC	4	10	40%
AC/RWC	4	10	40%
RA/NGO	2	5	40%
NGO/RWC	3	10	30%
RWP/RWC	3	10	30%
WSP/RWC	3	10	30%
RWP/RA	1	4	25%
RWP/AC	1	4	25%
WSP/RA	1	5	20%
WSP/AC	1	5	20%
NGO/AC	1	5	20%

*Total no. of primary metrics taken from Table **74**. The larger total for each pair was used to determine percent agreement.

RWP: Recycled Water Program, WSP: Water Supply Program, RA: Regulatory Agency, NGO: Non-governmental Organization, RWC: Recycled Water Customer, AC: Academia

Summary of Stakeholder Alignment. As is shown in Table 74, Figure 8, and Figure 9, individual stakeholder groups agree little on what metrics are appropriate for evaluating program effectiveness. Figure 8 shows only primary metrics for each stakeholder group. As is evident in Figure 8, no single metric was primary to every

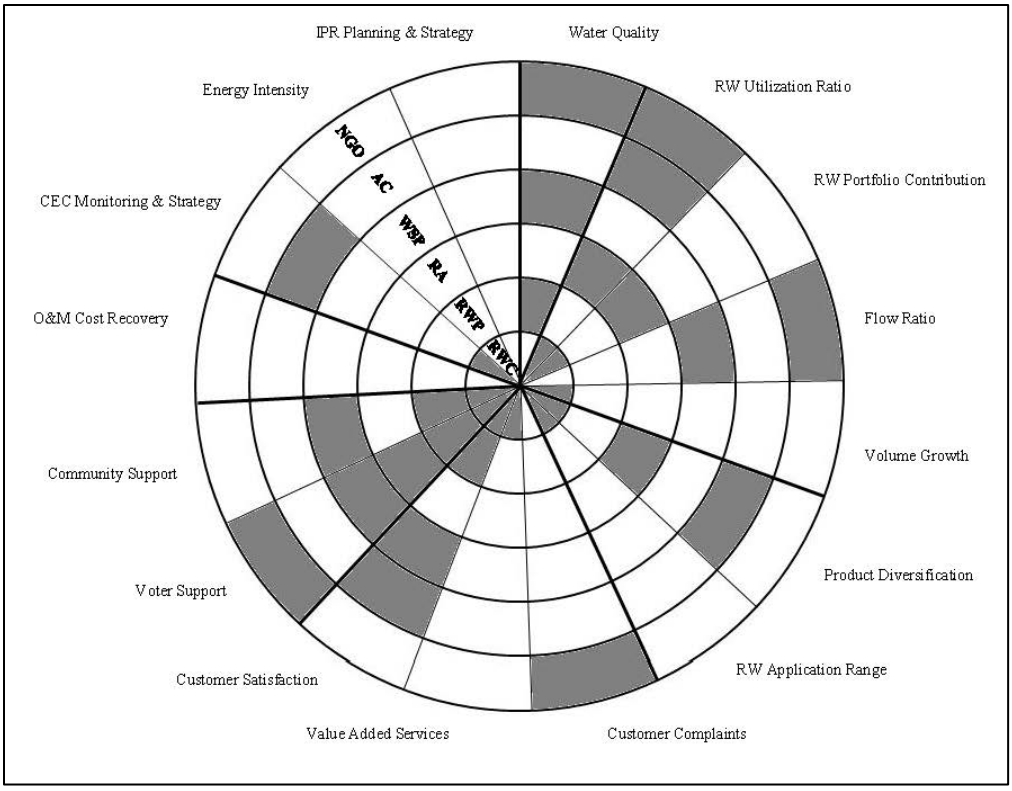


Figure 8. Stakeholder group alignment - primary metrics only
Metrics in gray are primary.

stakeholder group. The only metric that was close to being primary for every stakeholder group was Voter Support. This finding has implications for how the results of a program evaluation using the metrics proposed in this study might be received. Given that few stakeholder groups agree on the appropriateness of the proposed metrics, it is likely that the validity of any conclusions made from a program evaluation using these metrics would be questioned by one or more stakeholder groups. The lack of unity amongst stakeholder groups would also likely make creating a plan for programs to meet production goals and reach design capacity in the near future difficult.

Figure 9 shows that if stakeholder group consensus levels are ignored, and all metrics rated appropriate by the individual stakeholder groups are included, the outlook

improves a little. If consensus level is ignored at least some members from each stakeholder group would consider the program evaluation results for the Voter Support and Customer Satisfaction metrics valid.

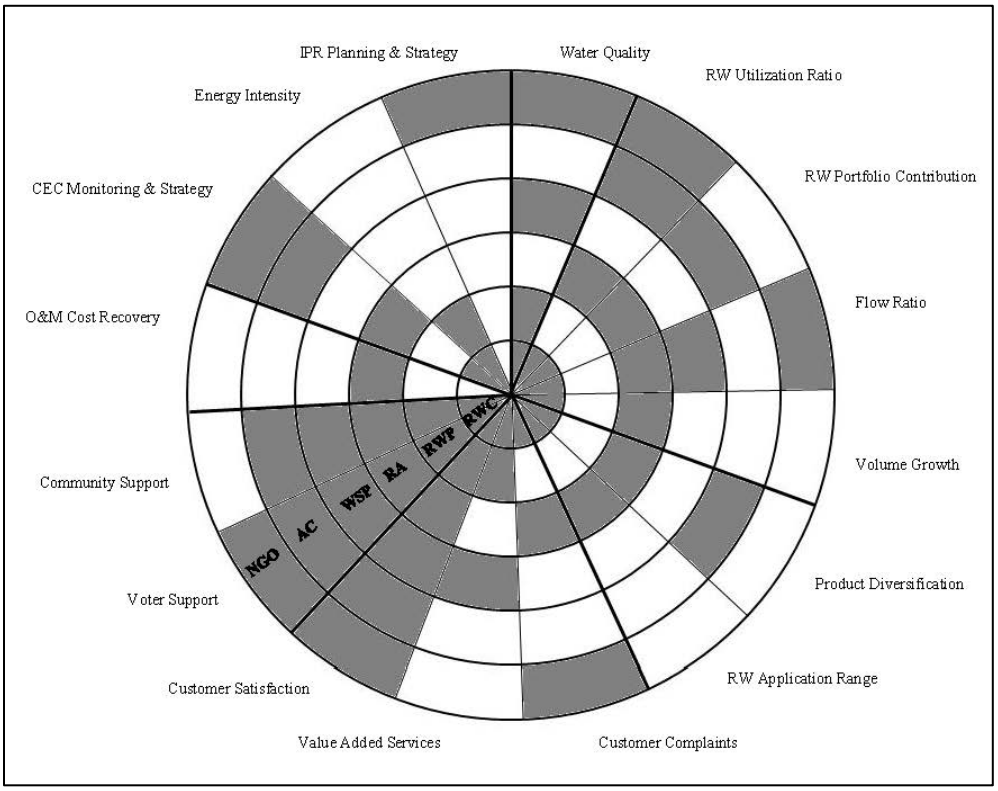


Figure 9. Stakeholder group alignment - primary, secondary, and tertiary metrics
Metrics in gray are primary, secondary or tertiary. White areas represent unsuitable metrics for each stakeholder group.

Stakeholder Group Perspectives

In order to further explain areas of stakeholder group agreement and disagreement, themes from metric rating comments are reviewed below for each stakeholder group.

Recycled Water Program. As a group, the Recycled Water Program stakeholders appear divided over most metrics. Some stakeholders are focused on *how* recycled water is used, for example, how beneficial is the use or application. Others are

focused on *whether* recycled water is able to stretch potable supplies and contribute to a community's water needs, regardless of the application.

Stakeholders did appear however to rate most of the proposed metrics through the same lens. Stakeholders focused on whether the main factors affecting a metric's value or program's performance were within or outside the program's control. This was evident from the number and type of stakeholder references to limits on demand. From the Recycled Water Program stakeholder perspective, areas the recycled water program is able to control include recycled water quality, energy intensity, 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 the recycled water program stakeholder perspective, there are few factors influencing the volume of recycled water consumed that the program is able to control. The four factors recycled water program stakeholders repeatedly mentioned affecting demand are climate, production capacity, the type and number of applications available, and the economy. A complete list of factors referenced by Recycled Water Program stakeholders limiting demand is shown in Table 77.

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 members. This is an unexpected finding that diverges from the majority of literature. This is not to say that Recycled Water Program stakeholders did not view public support as important. Metrics in the Public

Perception category were rated second and third highest by the group. Recycled Water Program stakeholders feel public support is critical to program success, but did not list it directly when explaining factors controlling or inhibiting demand.

Table 77. Stakeholder references to factors limiting growth or demand

	Number of References						
	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
customer	2	4					6
economy	3	3			1	1	7
water scarcity		5		1			5
acceptance	1		4				5
infrastructure		3					3
conservation	2	1					3
regulations	2	2					4
urban growth	1	1					2
water rate	1	1					2
capital		1					1
energy			1				1
geography	1						1
reliability	1						1
politics	1						1
program credibility			1				1
technical	1						1
tourism			1				1
Total	**30**	**40**	**15**	**1**	**2**	**3**	**90**

The Recycled Water Program stakeholders did not rate either of the Application Breadth metrics appropriate to use in a program evaluation. The Production Diversification metric was closer (median rating: 6) to being rated appropriate than Recycled Water Application Range metric (median rating: 4.5). Stakeholders explained the basis for the Recycled Water Application Range metric (the number of applications recycled water is used) is primarily determined by the customer. Product diversification,

on the other hand, is an approach that allows the program to work closely with the customer, tailoring water quality based on a specific customer need. It can be inferred that the difference between the Product Diversification and Recycled Water Application Range metrics is the perception of control. Recycled Water Program stakeholders perceive to 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 is likely the reason explaining the difference in the group's rating of the two metrics.

In regard to regulatory standards, it could be inferred from stakeholder comments that some stakeholders might invite or possibly welcome regulation of water quality standards, including CECs, at the national level.

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 stakeholders could be divided into two camps. In one camp, members disagreed with details left out of the metric formula, for example capital investments and avoided costs. In the other camp, members questioned if the metric could be calculated in a way to allow for a fair and equal cross comparison of programs.

If metrics could somehow be normalized or adapted for circumstances the Recycled Water Program stakeholders view they have little or no control, many may reconsider the appropriateness of some metrics presently rated unsuitable for the evaluation of recycled water program effectiveness.

Water Supply Program. The Water Supply Program Stakeholder 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 consensus. When rating the metrics, Water Supply Program stakeholders appeared to focus on two issues.

The first is 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 appropriate for the evaluation of recycled water program effectiveness.

Second, similar to the Recycled Water Program stakeholders, the Water Supply Program stakeholders also focused on whether the main factors affecting a metric's value or 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 of recycled water were also slightly different from those of Recycled Water Program stakeholders.

For Water Supply Program stakeholders the top factors affecting recycled water demand are cost effectiveness, the number and types of applications available, and the degree of water scarcity in a region. Other factors influencing demand also mentioned include climate, customer need, production capacity, the economy, conservation, urban growth, and water rates. Also like the Recycled Water Program stakeholders, regulations were seldom mentioned and public perception or acceptance was never referenced when listing factors influencing demand. Table 77 shows the number and types of factors Water Supply Program stakeholders referenced limiting demand or growth for recycled water.

Regulatory Agency. As a group, the Regulatory Agency stakeholder group was the least united. The lack of group cohesion meant few metrics were primary for evaluating recycled water program effectiveness. However, setting consensus levels aside, the group rated the second largest number of metrics appropriate. Only four of the sixteen proposed were rated unsuitable. More than any other group, the Regulatory Agency group emphasized the need for programs to produce and use as much recycled water as possible. This emphasis was very different from the Recycled Water Program group which emphasized how recycled water is used, or how beneficial the use is to the community.

While safety concerns are important to the group, it appears that the quantity of water recycled as well as cost recovery might be equally as 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. For example, the Value Added Services metric was rated unsuitable partly because it is believed programs do not have room in budgets for these types of services. Additionally, multiple Regulatory Agency stakeholders stressed only volumes of recycled water actually sold, not given away, should be included in the calculation of quantity based metrics.

Limitations on maximizing recycled water use were moderately mentioned, and when mentioned were referenced more generally as simply "conditions outside a program's control." Stakeholder comments indicated however, that several metrics either indirectly measured the level of public support for the program or would help boost public support for the program. From these comments it is possible to infer that from the

Regulatory Agency stakeholder perspective the primary limitation on maximizing recycled water use is public perception and support. Table 77 lists the number and types of factors Regulatory Agency stakeholders referenced limiting demand or growth of recycled water.

Further evidence of the Regulatory Agency's lack of cohesion is found in comments on the CEC Monitoring & Strategy metric. From participant comments, federal and state levels of government appear disconnected regarding whose responsibility it is to monitor CECs. From panelist remarks, it can be inferred that state agencies are looking for federal guidance or regulation of CECs. Alternatively, the federal agency is expecting the treatment process to remove all CECs. The question of who is responsible for the monitoring and regulation of CECs will likely have to be resolved within the Regulatory Agency stakeholder group before the industry and other stakeholder groups will be able to make any progress regarding CECs.

Recycled Water Customer. The Recycled Water Customer stakeholder group rated the most metrics appropriate of any stakeholder group and was the most unified. Of the sixteen proposed metrics, the Recycled Water Customer group rated ten metrics primary, two as secondary, two as tertiary, and two as unsuitable for a program evaluation. In some regard, it may make sense that the Recycled Water Customer stakeholders rated the most metrics appropriate. As customers of recycled water programs, the more measures available to show how effective the program is, the more comfortable the customer may be with the program's service and reliability overall.

Recycled Water Customer stakeholders focused little on factors inhibiting demand. In fact, members demonstrated a somewhat optimistic view of the industry's current level of growth and emphasized growth is overall very dynamic.

From the Recycled Water Customer perspective, programs must be proactive in both educating the public and potential customers about the benefits and safety of using recycled water. The group also emphasized 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 & Strategy metrics. Members seemed to disagree on details in both of the metrics rather than the concepts behind the metrics. For both metrics, stakeholders felt there were too many variables affecting cost recovery or too many details affecting IPR to make the metrics appropriate for rating recycled water program effectiveness.

From the general attitude exhibited by stakeholders and lack of negative comments, it can be inferred that the recycled water customers participating in this survey are satisfied with their recycled water service.

Non-governmental Organization. The Non-governmental Organization stakeholders were the second most unified group. The small group size likely contributed to the high level of consensus witnessed within the group.

The group members did not mention any specific factors besides water scarcity that influence the consumption or demand for recycled water. Two ideas raised only by the Non-governmental stakeholders were the commodification of water and recycled

water as a "forced" rather than alternative supply. From one stakeholder's point of view, even though water may be recycled by a municipality, the water "still belongs to consumers" and the sale of such water suggest it is being transferred from those consumers to some other entity." The idea that recycled water is a "forced" supply is a new and interesting perspective that the stakeholder unfortunately did not elaborate. This idea should be further investigated to see if this is a reason why the Non-governmental Organizations have traditionally not engaged much with recycled water issues.

Academia. The Academia stakeholder group was divided over most metrics. Academia stakeholders emphasized the need for programs to contribute towards meeting the water needs of a region in the most efficient and environmentally sustainable way as possible. From the Academia perspective, if a recycled water program can reduce the pressure put on potable systems and not take water away from environmental purposes such as stream or wetland augmentation, then the recycled water program should be supported.

The Academia stakeholder group rated seven of the sixteen metrics appropriate. Criticisms of proposed metrics appeared to focus less on factors limiting demand for recycled water, and more on the metric's inability to explain why a program scored poorly or well on a metric. Additionally, 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. Three metrics in particular, Flow Ratio, Public Support, and Voter Support, were criticized for being too "crude" or "blunt." The Public Perception based metrics

were rated appropriate, but stakeholders pointed out that the metrics did not link specific recycled water program activities to specific metric values (e.g., extent of outreach efforts).

Few factors limiting demand or growth of recycled water were mentioned except, the degree of water scarcity in a region or climate. On the contrary, one stakeholder stated limitations on recycled water use are not demand based but rather supply based and noted plants may not have the capacity to fulfill existing demand. Over half of Academia stakeholders explicitly stated that effectiveness is defined by a program's ability to increase the portion of the water budget met with recycled water and increase public acceptance of recycled water.

From stakeholder comments, it can be inferred that the primary hurdle recycled water programs need to overcome is public acceptance. This finding is very aligned with the literature and is not unexpected considering Academia stakeholders likely contribute most to existing literature on recycled water.

Summary of major differences amongst stakeholder groups. At the most basic level it appears the Recycled Water Program and Water Supply Program groups are most focused on factors limiting demand. Additionally, most of the factors cited are perceived to be outside the program's control. Both stakeholder groups also feel it is the responsibility of regulators to provide guidance for managing CECs.

The Regulatory Agency stakeholders are concerned with a recycled water program's ability to not only maximize production and use of recycled water, but also

recover costs. The group is divided on whether CECs should be managed at the state or federal level.

The Academia stakeholder group is focused most on how metrics can describe or connect a program's actions to performance. The Non-governmental Organization group voiced opposition to implications of the commodification of water and appears unsure of the role recycled water should play in a community's portfolio. The Recycled Water Customer stands somewhat alone and is optimistic of the industry's performance.

Discussion

The Discussion is divided into four parts. In the first section the results of the survey will be reported as they pertain to metric ratings (Research Questions #1 and 2) and stakeholder alignment (Research Question #5). In the second section, a discussion of the major findings from the survey will be discussed and where relevant major findings will be compared with previous research. If possible, recommendations for steps forward or future research for each of the major findings will be made as well. In the third section, for metrics where known reference values are available, recycled water program performance is compared with panelists' expectations for an effective recycled water program (Research Question #3 and 4). In the last section, recommendations for the next phase of the research project are made.

Summary of Metric Ratings and Stakeholder Alignment

The results of the survey showed every stakeholder group rated the customer satisfaction and voter support metrics appropriate. Overall, the Delphi panel rated ten of the sixteen proposed metrics appropriate to evaluate recycled water program effectiveness.

The pairs of stakeholders most aligned with one another are the Recycled Water Program and Water Supply Program, Water Supply Program and Non-governmental Organization, and the Regulatory Agency and Academia. The Recycled Water Customer stakeholder group stands alone due to rating most metrics appropriate.

Major Findings as They Relate to Previous Research

Survey findings viewed within the institutional theory of water managers. A theoretical framework was not sought at the outset of this study due to the exploratory nature of the research. However, after collection and analysis of the data, some survey findings may support previous research conducted on the institutional norms of water management organizations. Institutions are defined as the norms and values created through group consensus that carry a strong sense of sanction for violation (Lach, Ingram, & Rayner, 2005). Lach et al. (2005) found that innovation was prevented or incremental at best of three water organizations in the Pacific Northwest, in Southern California, and in the Washington D.C. metropolitan area. The lack of innovation was explained by three phenomena. First, water managers in the study all understood water supplies to be highly unpredictable. Second, water managers in the study perceived the water systems they managed as being "highly sensitive to local conditions" (Lach et al., 2005). Third, managers at all three organizations described the same hierarchy of values: reliability, quality, and cost of water management (Lach et al., 2005). This hierarchy is based on the number of complaints each value receives. In other words, interruptions in service (unreliability) receive more complaints than changes in water quality, and changes in water quality receive more complaints than increases in fee structures. This hierarchy of values led Lach et al. to conclude that success for water managers in the three study sites means "not being noticed" (Lach et al., 2005).

Similarities exist in all findings of the Lach et al. study and this study. First, the view that recycled water demand and use are highly unpredictable resonates with the

major theme expressed by the Recycled Water Program and Water Supply Program stakeholders that many of the factors limiting demand or growth of recycled water are outside the program's control. Methods for how programs might deal with uncontrollable factors are discussed later in this chapter.

Second, the view of water systems as "highly sensitive to local conditions" expressed by water managers in the previous study was also shared by participants in this study. One theme repeated for five of the sixteen proposed metrics in this study was "the metric is utility or location specific." Lach et al. (2005) explained this understanding by water managers resulted in the expectation and acceptance that their staffs would need years to become familiar with a water system's characteristics and through time would develop "craft skills" to manage the system. Some panelists in the Water Supply Program stakeholders' group expressed similar sentiments in regard to the length of time it may take a program to recruit customers and get the program off the ground. One panelist wrote, "There is no better ratio [RW Utilization Ratio]; it just takes time to secure customers and construct infrastructure to deliver."

Third, depending on how reliability is defined, the results of this study may or may not concur with the hierarchy of values outlined in the Lach et al. study. If reliability is defined as customer service, then the results of this study appear to support the previous study. Both the Recycled Water Program and Water Supply Program groups rated the Customer Service metric the highest of any metric followed by the Water Quality metric. If on the other hand, reliability is defined as quantity, then the values

expressed by the Recycled Water Program and Water Supply Program managers in this study may be reversed from those of Lach et al.

In relation to cost, Lach et al. found that water rates for users in the three water basins studied were in many places lower than the cost of service. This phenomenon is supported by previous studies of recycled water rates as well as the findings of this study. The O&M Cost Recovery Ratio metric was rated lowest of any metric by the panel and was the second lowest rated metric by the Recycled Water Program stakeholders. The primary criticism of the metric was that avoided costs, such as the development of new and more expensive potable supplies or fees and fines associated with discharge compliance were not included. When viewed in the context of the study from Lach et al., this theme may imply that the motivation to keep costs down is more a function of keeping customer rates down rather than completely recovering costs.

Need for new framework to understand hurdles experienced by established programs. As noted in the problem statement, previous research focuses almost exclusively on how to establish a recycled water program. Studies investigating programs post implementation have shown programs ineffective in either meeting production goals or recovering costs (Mantovani et al., 2001). The major obstacle cited in the literature is public acceptance of recycled water (Dolnicar & Hurlimann, 2009; Hartley, 2006; Bridgeman, 2004; Po, Kaercher & Nancarrow, 2003; Gibson & Apostolidis, 2001). The fact that both the Recycled Water Program and Water Supply Program groups in this study rarely if ever mentioned public acceptance as a factor limiting demand stands in stark contrast to existing literature. The very fact that

stakeholders in these two groups referenced many other factors that influence demand for recycled water including climate, the economy, cost effectiveness, the degree of water scarcity, and the number and types of applications customers choose to utilize recycled water is significant. This finding shows a gap between the literature and reality concerning the hurdles a program must overcome to increase recycled water use. It is not to say that one is incorrect. Instead this study confirms the need for additional study and research of programs in a post implementation stage. It is clear from the survey findings, the hurdles a program faces are different in different stages of program development.

A proposed framework for defining program stages, how recycled water is viewed by the community, and what metrics may be relevant at each stage of development is displayed in Figure 10. In the diagram below, the program stages are categorized into establish and expand. On the horizontal axis is the progression of how recycled water is viewed. In the problem statement, two principle drivers for creating a recycled water program were referenced.

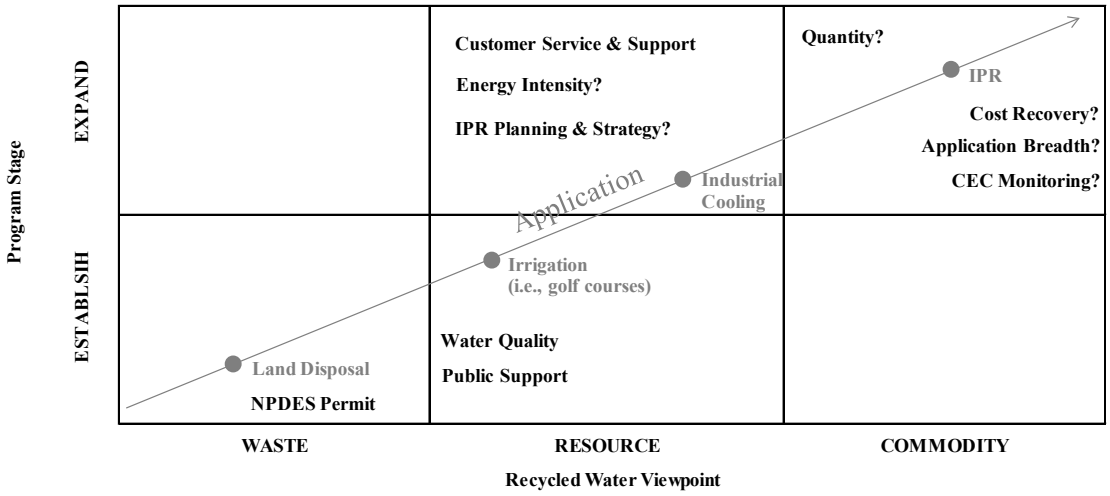


Figure 10. Proposed framework for recycled water program development

Initially recycled water programs were created to reduce the volume of wastewater discharged to nearby waterways in order to comply with the requirements for a NPDES permit under the Clean Water Act. Over time, the driver to create or expand a recycled water program has moved from the need to reduce wastewater discharge to increase the water supply available to a community to meet growing needs. In the future, recycled water may even be viewed as a commodity. As the view of recycled water evolves, it is proposed that there is a change in the types of applications for which recycled water is used as is shown along the gray arrow moving from the lower left corner to the upper right corner of the diagram. As the applications of recycled water change or evolve there is likely a change in the types of metrics that are relevant or appropriate to use in evaluating a program's effectiveness. This figure is only a proposed model, but is an initial proposal towards finding a new framework for understanding what hurdles programs face at different stages of development and what corresponding metrics are relevant to use in a program evaluation based on the program's current stage of development.

The fact that stakeholders, in particular those from the Recycled Water Program and Water Supply Program, view many of the factors limiting demand as outside the control of a program is also significant. Many other industries are subject to pressure from factors perceived outside the control of the industry. Other industries have likely investigated ways of dealing with these uncontrollable factors. An investigation into strategies used by other industries to ease or overcome uncontrollable or exogenous factors may be helpful for recycled water programs to increase demand.

Method for easing effects of uncontrollable factors. One strategy used by other industries to ease the effects of exogenous factors is the use of marketing techniques. Dolnicar & Saunders (2005) reviewed marketing-related research efforts in the area of recycled water going back to the early 1970s. The researchers concluded that many of the criticisms made of recycled water marketing-related research in the 1970s still hold true today (Dolnicar & Saunders, 2005). It is interesting to note that in the present survey of recycled water stakeholders, only one-third of respondents mentioned marketing in relation to recycled water program effectiveness. For example, when commenting on the Recycled Water Application Range metric, four panelists responded that the metric measured the depth of market penetration but not recycled water program effectiveness. This point made by respondents raises two important questions. First, is the ability to penetrate the market for recycled water a necessary characteristic of an effective program? Second, if it is not the responsibility of recycled water programs to market recycled water, then whose responsibility is it?

In a study conducted of forty programs in the U.S., Mantovani et al. (2001) found that more than half of surveyed projects had not completed a formal market assessment either during or after the program planning stage. The City of Palo Alto, CA, on the other hand, did conduct a market assessment prior to implementing their program in 1992. In 2006, the city reassessed the market for recycled water and found the initial assessment had overestimated the demand for recycled water by 58 percent. The overestimation was attributed to excessive irrigation demands used in the 1992

assessment (RMC, 2006). A better understanding of how programs estimate the market and demand for recycled water is needed.

A strategy is needed for CEC monitoring. The survey responses also indicate that the industry would benefit from a CEC monitoring strategy. Recycled Water Program stakeholders are reluctant to monitor CECs in light of the lack of standards, analytical procedures, additional cost, and uncertainty about the message CEC monitoring might send to the public regarding the safety of recycled water. The Regulatory Agency stakeholders rated the CEC Monitoring & Strategy metric appropriate but had a low level of consensus meaning the group was very divided. State regulators appeared to invite guidance and even regulation of CECs from the federal government. In contrast, the expectation of federal government representatives in this study was that CECs should be at non-detect levels in recycled water. In other words, federal regulators expected technology to ensure the water is free of any CECs. It is clear progress will not be made on the issue of CECs without further dialogue and agreement between the Regulatory Agency and Recycled Water Program stakeholders. It is recommended that the U.S. EPA initiate a conversation amongst state regulators, recycled water programs, and water supply programs to craft a monitoring protocol for both potable and recycled water.

Comparison of Recycled Water Program Performance and Panelist Expectations

Of the seven metrics for which there are known reference values, stakeholders' expectations of recycled water performance is aligned with actual program performance for four metrics (Recycled Water Portfolio Contribution, Voter Support, Community

Support, and Energy Intensity). For two of the remaining metrics (Flow Ratio and O&M Cost Recovery Ratio), the panel's selection would imply programs are under performing. In contrast, known reference values show that programs in most cases are exceeding panel expectations in terms of Volume Growth.

Only Florida's statewide average for Volume Growth is in alignment with panelist expectations. This finding is somewhat unexpected given the fact that Florida leads the nation in the production and use of recycled water. A likely explanation for this phenomenon is that Florida's volume growth rate was calculated from production values after 1997. By 1998, Florida was already recycling 31 percent of the total wastewater flow (FDEP, 2010). This finding would imply that growth rates are larger during the early development of the program and taper as the program ages. The panel's response for metric values indicative of an effective program are compared to program reference values in Table 78.

Table 78. Metric values indicative of effective program: comparison of panel response and program reference values

Metric	Majority Response	Majority Value Response	Program Reference Value	Consensus Level	Alignment: Majority Value Response to Reference Value
Water Quality	na	na	na	na	-
RW Utilization Ratio	do not know	51 - 75%	na	medium	-
RW Portfolio Contribution	6 - 10 %	6 - 10 %	4-12%	medium	aligned
Flow Ratio	0.60 - 0.79	0.60 - 0.79	0.43[2]	medium	not aligned
RW Volume Growth	tie: do not know and 1 - 5%	1 - 5%	Florida: 2.6%[3] Phoenix, AZ: 7% [4] Tucson, AZ: 10%[5] San Antonio, TX: 21%[6]	low	not aligned
Product Diversification	do not know	B	na	low	-
RW Application Range	do not know	76 - 100%	na	low	-
Customer Satisfaction	76 - 100%	76 - 100%	na	high	-
Value Added Services	commercial permit, landscape consultant, finance assistance	commercial permit, landscape consultant, finance assistance	na	na	-
Customer Complaints	0 - 5	0 - 5	na	high	-
Voter Support	71 - 80%	71 - 80%	Mesa, AZ: 74%[7]	low	aligned
Community Support	81 - 90%	81 - 90%	Corvales, OR: 70%[8] Victor Valley, CA: 84%[9]	low	aligned
O&M Cost Recovery Ratio	do not know	0.80 - 1.00	2000 AWWA: unknown or <0.25[10] 2007 AWWA: 50% <0.5[10]	medium	not aligned
CEC Monitoring & Strategy	A	A	na	low	-
Energy Intensity (GW)	do not know	RW < 30% GW	SCVWD: RW < 50% GW[11]	low	aligned
Energy Intensity (IW)	do not know	RW < 30% IW	na	low	-
IPR Planning & Strategy	tie: do not know, none of the above, and D	D	na	low	-

na: not available, RW: recycled water

Sources: [1]Arizona Water Atlas (ADEQ, 2005), SAWS Stat Book (SAWS, 2008), (SCVWD, 2010)
[2]Florida state average Flow Ratio (FDEP, 2010)
[3]Calculated from Annual Reuse Inventory (FDEP, 2010)
[4]Calculated from Phoenix AMA Summary Budget (ADWR, 2010)
[5]Calculated from Tucson AMA Summary Budget (ADWR, 2010)
[6]Calculated from SAWS Stat Book (SAWS, 2008)
[7](Groff, 2010)
[8](Dubose, 2009)
[9](Humphreys, 2006)
[10](AWWA, 2008)
[11](Larabee et al., 2010)

Case Study Recommendations

This survey is the first part of a two part research project aiming to understand the influence of stakeholder group roles on the effectiveness of urban recycled water program effectiveness. In phase two, the metrics rated appropriate by panel members will be used to evaluate twelve recycled water programs in Arizona, California, and Florida. Below are recommendations for improving metrics rated unsuitable by panel members.

Six metrics were rated unsuitable by the panel. For most metrics, suggestions from panelists can be incorporated. Metric changes are first described and then summarized at the end of the section in Table 79.

The formula for the Customer Complaints metric should be modified to measure the total number of complaints as a percentage of the total number of customers instead as an absolute number.

The Volume Growth metric should be normalized for perceived exogenous factors (e.g., climate, economy). The simplest method to normalize for these types of factors would be to compare recycled water performance to the potable system's performance. The rationale for the comparison is that the potable system would be subject to the same uncontrollable factors if measured in the same time period. Similarly, the Application Range metric should also be normalized for uncontrollable factors. However, comparing the recycled water program to the potable system will likely not solve this problem and would only serve to make the results less meaningful. Instead, if the program has conducted a market assessment or re-assessment, results of the market surveys should be substituted for the Application Range metric.

Table 79. Modified metrics

Metric Name	Existing Metric Formula	Modified Metric Formula
Customer Complaints	$\frac{\text{No. of customers complaints}}{\text{Year}}$	$\frac{\text{No. of customers complaints}}{\text{Total no. of customers}}$ (%)
Recycled Water Volume Growth Rate	$\frac{\text{Volume of RW sold (current year, ac} - \text{ft)}}{\text{Volume of RW sold (previous year, ac} - \text{ft)}}$	$\frac{\frac{\text{Volume of RW sold (current year, ac} - \text{ft)}}{\text{Volume of RW sold (previous year, ac} - \text{ft)}}}{\frac{\text{Volume of Potable sold (current year, ac} - \text{ft)}}{\text{Volume of Potable sold (previous year, ac} - \text{ft)}}}$
Recycled Water Application Range	$\frac{\text{Sum of all actual RW applications in service area}}{\text{Total no. of possible RW applications in service area}}$	Market Assessment
Energy Intensity	$\frac{\text{Sum of energy use (kWh)}}{\text{Volume of water produced (ac} - \text{ft)}}$	Secondary metric, Measure against "next available source"
IPR Planning & Strategy	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	Secondary metric
O&M Cost Recovery Ratio	$\frac{\text{Average annual RW sales } (\frac{\$}{yr})}{\text{Average annual O\&M costs } (\frac{\$}{yr})}$	Create uniform accounting template
Potable Water Offset	-	$Offset = 100\ x\ \frac{Qa}{Qb}$ Volume usage for the offset purpose before (*Qb*) and after (*Qa*) the change was made[1]
Source: [1](Palenchar, Friedman, & Heaney, 2009)		

Though rated unsuitable, the Energy Intensity metric should still be measured only as a secondary metric, and perhaps measured against the "next available source" instead of only groundwater and imported water sources. The IPR Planning & Strategy metric should likewise also be measured as a secondary metric.

Instead of measuring the O&M Cost Recovery Ratio metric, research efforts should be applied towards collecting information on accounting processes and contribute towards making a uniform template. This template could be used in the future by programs to measure and compare cost recovery of programs.

In addition to the modifications made to proposed metrics, the program evaluation should include an additional new metric that measures the potable water offset of recycled water. Several panelists referenced using this measure when evaluating existing programs. This fact will facilitate easy collection of relevant data and will provide information of value to recycled water stakeholders.

Conclusion

As water shortages become increasingly more common, more cities will turn to recycling water. Many existing programs are failing to meet production goals and recover costs. The literature focuses primarily on program establishment and not how existing programs can become more effective. This study proposed a universal set of evaluative criteria and associated metrics to use in a program evaluation of established programs. Based on study findings, the hope for developing a program evaluation all stakeholder groups would be able to agree is valid will be challenging. The results of the survey show that stakeholder groups hold diverse opinions on most metrics. The pairs of stakeholders most aligned with one another are the Recycled Water Program and Water Supply Program, Water Supply Program and Non-governmental Organization, and the Regulatory Agency and Academia. The Recycled Water Customer stakeholder group stands alone due to rating most metrics appropriate.

Additionally, this study found that the impediments an established program faces are different than those a program experiences when it is first starting out. More research is needed on how established programs can ease or overcome exogenous factors and expand demand for recycled water.

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Appendix A. Criteria and Metric Development for Program Evaluation

Criteria and metrics to evaluate recycled water program effectiveness were borrowed, adapted, and created from literature specific to recycled water and through consultation with recycled water industry representatives. Final metrics presented in the Delphi Method survey were vetted with the WateReuse Research Foundation. Criteria and metrics were extracted or adapted from existing literature on potable and recycled water use from traditional peer-reviewed and published sources, existing state regulations, state water management agency guidelines, national and professional water organization publications, city environmental performance indices, and publicly available data from water providers at the regional and municipal levels, as well as performance metrics for industries unrelated to water.

The following six areas were chosen to evaluate recycled water program effectiveness for this study: Recycled Water Quality & Quantity, Recycled Water Application Breadth, Customer Support, Public Perception, Cost Recovery, and Progressiveness. The specific sources where metrics originated are detailed in the pages that follow.

Recycled Water Quality & Quantity

A technical memorandum prepared for the U.S. Bureau of Reclamation states for recycled water to be of maximum benefit, the recycled water must meet the needs of the end user in terms of quality, quantity, and timing (CH2MHill, 2004). One metric was created to measure a program's recycled water quality, and four metrics (Recycled Water Portfolio Contribution, Flow Ratio, Recycled Water Volume Growth Rate, and Recycled

Water Utilization Ratio) were created to measure the quantity of recycled water produced and consumed in a community.

Water Quality. There are no federal standards for recycled water quality. Each state determines the water quality standards for recycled water application. This fact made creating a metric for water quality that could be applied universally to programs in different states challenging. The final metric created focused on three water quality parameters commonly monitored in most states: fecal coliform (FC), total suspended solids (TSS), and biochemical oxygen demand (BOD, CBOD). For each program, the average annual measurement for each parameter is compared to the state standards. The program would receive a "passing" grade if the average annual measurements met or surpassed the state standard.

Recycled Water Portfolio Contribution. Recycled Water Portfolio Contribution is a common metric used by water supply agencies when reporting where water supplies are sourced (SAWS, 2008; Tucson Water, 2008; SVEP, 2010).

Flow Ratio. The Flow Ratio metric was taken from the Florida Department of Environmental Protection (FDEP) Annual Reuse Inventory (FDEP, 2010). Since 1998, the state of Florida has required recycled water programs report the Flow Ratio annually to FDEP. FDEP reports each county's Flow Ratio in its annual reuse inventory made available online each year.

Recycled Water Volume Growth Rate. The Recycled Water Volume Growth Rate metric was adapted from general metrics commonly used to assess growth in an

industry or company (Clark & Morgan, 2001). The metric has not typically been used in the recycled water industry.

Recycled Water Utilization Ratio. This metric was created out of comments from the Delphi Panel in round one. The metric was only presented to the panel for review in round two.

Recycled Water Application Breadth

In 1958, The United Nations Social and Economic Council announced a policy that declared, "No higher water quality, unless there is a surplus of it, should be used for a purpose that can tolerate a lower grade" (Okun, 1996). This concept of matching water quality to water application has been adopted into the plans and policies of the California Department of Water Resources (CA Code 13550), the Arizona Department of Water Resources (BRPWS, 2010), and the Florida Department of Environmental Protection (FDEP, 2010). To measure how programs incorporate the concept of matching water quality to end use, two metrics were developed: Product Diversification and Application Range.

Product Diversification. In order to meet the specific needs of end users, the recycled water supply may need to be tailored to match water treatment levels to users' applications (CH2MHill, 2004). For example, the Irvine Ranch Water District and West Basin Municipal Water Districts have treated the recycled water supply to meet the needs of carpet dyeing manufacturers and refinery customers (CH2MHill, 2004). There is no specific industry-wide metric commonly used to evaluate or measure this criterion. The

following nominal lettering system was created to understand how or if programs are diversifying product:

(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 three years

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

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

Recycled Water Application Range. The metric was adapted from a formula published in an article by Yang and Abbaspour (2007) where the potential for wastewater reuse in Beijing was analyzed. A list of applications suited to the quality of recycled water produced was created. Based on the water demand for each application Yang and Abbaspour determined the potential volume of recycled water that could be consumed in a community.

For this study, a metric was proposed to measure the percentage of actual recycled water applications utilized in a community of the total possible recycled water applications permissible in a community.

Customer Support

The need for recycled water programs to understand customer satisfaction and provide support has been noted in the literature (Hurlimann & McKay, 2008). Three metrics (Customer Satisfaction, Customer Complaints, and Value Added Services) were

developed to measure a program's ability to provide support to customers and the customer's rate of satisfaction with program service.

Customer Satisfaction. The Customer Satisfaction metric was adapted from an article published by Hurlimann et al. (2008) where the customer satisfaction rate of residents living in a community dual-plumbed for recycled water in Australia was assessed.

Customer Complaints. The Customer Complaints metric was adapted from general metrics commonly used to assess customer satisfaction in an industry or company (Mitki, Shani & Meiri, 1997).

Value Added Services. Value added services are defined as non-core services a company or program may offer to aid in recruiting new customers or enhance the overall experience of current customers (Gulati & Kletter, 2005). A list of recycled water value added services was compiled from internet sources and discussions with recycled water providers in the San Francisco Bay Area.

Public Perception

As noted earlier, public perception and acceptance is cited as the number one hurdle programs must overcome. To measure the degree of public support for a program two metrics were developed, Voter Support and Community Support.

Voter Support. The Voter Support metric was developed from available data for local elections in which bonds for recycled water projects were proposed to the public (Groff, 2010; St. Pete Beach, 2011).

Community Support. The Community Support metric was developed from available surveys conducted in Corvallis, Oregon (Dubose, 2009) and Victor Valley, California (Humphreys, 2006) of public support for local recycled water programs and projects.

Cost Recovery

Several studies have investigated a program's ability to recover costs. The studies often report conflicting levels of cost recovery, however most show recycled water programs rarely recover full operation and maintenance costs from recycled water user fees. From a survey conducted in 1997 of 23 recycled water producers in 5 states, most utilities reported recovering 75 percent of operating costs from recycled water fees (Cuthbert & Hajnosz, 1999). In a study only two years later conducted by Mantovani et al. (2001), only 9 percent admitted to fully recovering their total costs from recycled water rates in a study by. In the 2007 study conducted by the American Water Works Association (AWWA), 75 percent of programs did not fully recover operating costs from recycled water rates and 38 percent recovered less than 25 percent of operating costs.

O&M Cost Recovery Ratio. The O&M Cost Recovery Ratio metric was adapted from the Cuthbert and Hajnosz (1999) and AWWA (2007) studies.

Progressiveness

The following three metrics were developed to capture how programs incorporate progressive issues into their programs: CEC Monitoring & Strategy, Energy Intensity, and IPR Planning & Strategy. Each is briefly described below.

CEC Monitoring & Strategy. Contaminants of emerging concern (CEC) is a specific water quality issue that has gained wider attention recently, especially in discussions of indirect potable reuse. As analytical techniques improved, chemicals previously undetected in water bodies began to be measured and are generally referred to as "CECs." Examples of CECs include: persistent organic pollutants such as flame retardants and plastics, endocrine disrupting compounds found in many pesticides, and most recently pharmaceuticals and personal care products. The majority of these compounds have no regulatory standard.

In the late 1990s the Orange County Water District (OCWD) and an independent scientific advisory panel attempted to conduct a case-control study in the Santa Ana River watershed to evaluate the health risks associated with exposure to CECs. The study was ultimately found not feasible due to limitations in the ability to assess historical exposures. Instead of additional epidemiological studies, the panel recommended programs focus on monitoring to verify the effectiveness of the treatment processes to reduce known chemical contaminants (Rodriguez, Van Buynder, Lugg, Blair, Devine, Cook, & Weinstein, 2009).

An approach for analyzing and assessing the hazard significance of unregulated chemicals in both potable and recycled water has been outlined in a report from the U.S. Geological Survey (USGS) published in 2003 (Toccolino et al.,2003). Based on the USGS report, Rodriguez, Cook, Van Buynder, Devine, & Weinstein, (2007) recommend a three-tiered approach for recycled water programs to monitor contaminants of emerging concern based on available toxicity information. Currently, there are no state guidelines

to monitor CECs. Likewise, there is no established metric to measure how or if recycled water programs are monitoring CECs. For this study, a metric was developed and based on the following nominal lettering system:

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

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

(B) Program monitoring some CECs

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

Energy Intensity. Due to increased awareness of the water-energy nexus in recent years, some programs are measuring the energy intensity of recycled water compared to other sources as a method to quantify one of the benefits of recycled water. Depending on where water is sourced, recycled water may require less energy to produce than traditional potable sources. The Energy Intensity metric was adapted from a report by the Santa Clara Valley Water District (Larabee, Ashktorab, & Darlow, 2010) in which the energy intensity of recycled water is compared to other sources of water.

IPR Planning & Strategy. Marks (2006) found that few programs have been able to implement indirect potable reuse projects (IPR). There is no established metric to measure how or if recycled water programs are planning for IPR. The IPR Planning & Strategy metric was adapted by a report written for the WateReuse Research Foundation in 2004 (Ruetten, 2004). For this study, a metric was developed and based on the following nominal lettering system:

(E) Program has no current or future plans to use recycled water for IPR purposes

(D) Program considering developing IPR plan within the 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

Appendix B. Expanded Overview and History of the Delphi Method

In 1959, the RAND Corporation developed The Delphi Method as an efficient and useful means for collecting and integrating expert judgments. The first RAND study published in1964 investigated the method's ability to forecast military priorities (Murry & Hammons, 1995), and since then the method has been utilized to collect expert assessments of policy, decision making, forecasting and planning practices in subjects ranging from education and business (Gordon & Pease, 2006), health care, information technology, real estate, social science, engineering and the environment (Gupta & Clarke, 1996).

Strengths and Weaknesses of the Method

The Delphi Method has become increasingly popular in graduate level studies because it is a flexible technique well suited to explore new theories and concepts, especially in fields where there is limited or incomplete research about a well-documented problem (Gupta & Clarke, 2006; Skulmoski, Hartman, & Krahn, 2007) and can be relatively inexpensive to administer (Masser & Foley, 1987). Additionally, if designed properly the Delphi Method can illuminate interrelated and multidimensional variables characteristic of complex problems (Gupta & Clarke, 1996). A Delphi study should not be employed to validate highly developed ideas because panelists are seldom able to contribute towards "highly elaborated initial concepts" (Linstone & Turoff, 1975).

Because participants due not meet face to face, the Delphi Method's most notable advantage over other group methods is the elimination of group bias and group think, or possible dominance of the group by a single individual (Martino, 1983; Martorella, 1991;

Somers, Baker, & Isbel, 1984). By preventing these disadvantages common to other group methods, data collection becomes more efficient and valid (Murry & Hammons, 1995). Delphi studies are not limited by geographic considerations also characteristic of other group methods because participants do not meet collectively in one location and can participate through postal mail or the internet (Okoli & Pawlowski, 2004).

Furthermore, the method allows for considerable flexibility in regard to question design. Because expert judgments are collected in a series of rounds it is suitable for both quantitative and qualitative studies and can begin very broad and become more narrow as rounds progress. A researcher might decide a broad approach is appropriate for the first round of questions because the study matter is highly controversial or little studied. In this case, open-ended questions would be submitted to the group. As the number of responses begins to narrow or stabilize in subsequent rounds, the researcher might then start to focus the study by asking experts to begin ranking the importance of responses within a provided framework or suggest mechanisms for the prioritization of responses. Conversely, if a problem with corresponding solutions is well documented in the literature, a researcher might begin the first round by listing the solutions and asking participants to prioritize or rank the solutions based on how appropriate or feasible they are to the problem at hand. For this study, the second approach was utilized and panelists were presented with a structured questionnaire for round one.

The primary criticism of the Delphi Method is the length of time studies can take to reach consensus among the group. Classically, researchers and experts communicated by paper sent through postal mail and a four-round study typically would take three to six

months to complete (Gordon & Pease, 2006). For this study, an internet based Delphi was utilized and the complete survey was completed in three weeks.

The second common criticism of the method is the lack or rigor and standards for selecting experts (Okoli & Pawlowski, 2004; Gupta & Clarke, 2006; Hsu & Sandford, 2007). To address this criticism, a review of Delphi Method studies used predominantly in program evaluations was conducted and recommendations from these studies were followed.

Delphi Method Survey Administration

To address the primary criticism of Delphi studies, in September, 2004, the Defense Advanced Research Projects Agency (DARPA) initiated a request for proposals to improve the speed and efficiency of collecting judgments in a Delphi study. From this request, an internet based Delphi Method was developed. The group of experts is referred to a secure website where each expert logs in with a unique Login ID and password to answer survey questions (Gordon & Pease, 2006).

An internet-based Delphi study can be administered synchronously, where all participants are online at the same time, or asynchronously, where each expert can answer at any time within a given time period, for example one week or one month. This study employed the asynchronous version.

Description of MAD-M Statistic

The MAD-M is a nonparametric statistic that measures the dispersion of a data set, or in this study, the dispersion of participant responses. Data generated from Likert

scales is generally not normally distributed. The MAD-M is recommended for data sets not normally distributed (Vella et al., 2000; Fitch et al., 2001). The formula for

$$\text{MAD-M} = \frac{Sum\ |X - median|}{n}.$$

Metric Classification

The metric classifications were assigned as a method of understanding how the metric might be received, valued, and interpreted by recycled water stakeholders if used in an actual program evaluation. The assumption is that metrics classified as primary will be well received by most recycled water stakeholders and the program evaluation results will be viewed as useful to the recycled water industry. The results of program performance from metrics rated as secondary and tertiary could receive less acceptance by both programs under evaluation and professionals reviewing and interpreting the evaluation results.

Appendix C. Delphi Method Survey: Proposed Criteria and Metrics

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). TSS, BOD, CBOD Defined

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.

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

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.

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

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.

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

Then the above statement is **TRUE**

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

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.

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

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:

3. 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%.

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:

3. 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

4. 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.

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:

3. 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

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 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.

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:

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.

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 five 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:

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

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:

3. 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

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 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

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:

3. 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

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 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:

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

* 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) x 100 = 33%; i.e., the theoretical program's recycled water is used for only 33% of the total allowable applications.

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:

3. 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

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 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

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:

3-1. 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

3-2. 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

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 customer satisfaction. Include units of analysis where possible.

Proposed Criterion: Customer 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.

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:

3. 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 greywater 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, non-edible crops; public toilets; cooling; industrial processes; and fire hydrant supply. A 2006 public survey conducted in Victor Valley, CA 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:

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

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:

3-1. 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

3-2. 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

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 public support.

Proposed Criterion: Operation & 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:

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

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 and 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.

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:

3. 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		

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 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

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:

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

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

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 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.

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:

3-1. 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

3-2. 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

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 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, AZ and Upper Occaquan, 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

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:

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

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

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 how programs are dealing with IPR.

Definition: Beneficial Reuse

From Round One'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.

1. 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

2. 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 D. Scalar Conversion 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.
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.

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.
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.

	Rates							
	Lowest Performance Value				**Highest 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

Appendix E. Coding of Qualitative Responses

Metric: Water Quality

No. of Comments	Theme
7	Recycled water quality is critical to recycled water program effectiveness.
3	Proposed metric measures ability to meet minimum standards, not recycled water program effectiveness.
3	The metric should include more parameters.

Metric: RW Utilization Ratio

No. of Comments	Theme
10	Metric is utility specific.
8	Metric is good for measuring recycled water program effectiveness.
3	Metric is dependent on water scarcity situation.
3	Recycled water may not be most cost effective source of supply.
2	Metric shows how recycled water offsets potable use.

Metric: RW Portfolio Contribution

No. of Comments	Theme
10	Metric is utility specific.
3	Metric is dependent on water scarcity situation.
3	Recycled water may not be most cost effective source of supply.
2	Metric shows how recycled water offsets potable use.

Metric: Flow Ratio

No. of Comments	Theme
4	Lack of clear definition of reuse.
4	Program may not be able to recycle significant volume of wastewater.
3	Metric is appropriate for evaluating recycled water program effectiveness.
3	Metric needs to take into account specific goals of a program.
2	Metric does not account for demand.
2	Metric should incorporate cost effectiveness of reuse flow.

Metric: Volume Growth

No. of Comments	Theme
8	Metric should be normalized to variations caused from weather, economy, and conservation.
2	Metric doesn't account for long lead time needed for capital infrastructure.
2	Metric should only include recycled water sold.

Metric: Product Diversification

No. of Comments	Theme
3	Metric is good because it focuses on the customer.
3	Diversification is not necessary for program effectiveness.
2	Feasibility of diversification is dependent on size of program.
2	Diversification is dependent on local situation.

Metric: RW Application Range

No. of Comments	Theme
4	Metric measures market penetration not recycled water program effectiveness.
4	Program can be effective and serve few applications.
4	It may not be cost effective to provide recycled water for a wide range of applications.
2	Range of applications is dependent on infrastructure.
2	Range of applications is location specific.

Metric: Customer Satisfaction

No. of Comments	Theme
9	Customer satisfaction is crucial to project longevity.
4	Surveys results can be skewed.
3	There are many problems with surveys, such as mood of respondent, statistical measures used to analyze results.

Metric: Customer Complaints

No. of Comments	Theme
3	Complaints should be normalized to total number of customers.
2	Complaints are a function of individuals.
2	The type of complaint is more important than the number of complaints.

Metric: Value Added Services

No. of Comments	Theme
6	Value Added Services helps gain public trust and acceptance.
4	Metric is secondary measure.
2	There are unique issues associated with recycled water application.
2	Value Added services are budget dependent.
2	Value Added services are more important when implementing a program.
2	Metric is utility specific.

Metric: Voter Support

No. of Comments	Theme
6	Voting is linked to education and outreach.
3	Voting metric does not measure program effectiveness.

Metric: Community Support

No. of Comments	Theme
5	Surveys are problematic.
5	Public acceptance is critical.

Metric: O&M Cost Recovery Ratio

No. of Comments	Theme
5	Metric doesn't include avoided costs - potable supply & discharge.
5	Metric doesn't include avoided costs - environmental.
4	Metric is difficult to measure.

Metric: CEC Monitoring & Strategy

No. of Comments	Theme
7	Monitoring CECs is proactive.
6	CEC are not well understood.
5	CEC monitoring is dependent on end use.
5	Monitoring and reporting CECs is critical to public acceptance.
3	Monitoring CECs will contribute to needed research.
2	In regard to CEC, RW is not different from potable water and should not be held to higher standards.
2	Monitoring CECs could lead the public to believe recycled water is unsafe.

Metric: Energy Intensity

No. of Comments	Theme
4	Energy Intensity should be a secondary metric.
3	Goal(s) of program may outweigh Energy Intensity.
3	Energy Intensity is locally specific.
3	Energy Intensity impacts the cost of recycled water and is therefore an appropriate metric.
2	Metric demonstrates one of the benefits of recycled water.
2	Cost effectiveness of source will outweigh Energy Intensity of source.

Metric: IPR Planning & Strategy

No. of Comments	Theme
5	IPR is secondary metric.
4	IPR is not top goal of recycled water program.
4	IPR metric is not a measure of effectiveness.
2	IPR is top goal of recycled water program.