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Sustainability at U.S. Urban Water Utilities: A Framework to Assess Key Attributes

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by

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DEDICATION

This dissertation is dedicated to my family. First, and foremost, to my wife, Lora, for her support, patience, and understanding. I simply could not have completed this without her. It is also dedicated to my children, Alexandria and William, just four and three years old when I started this process, and now growing up quickly. I hope this work in some way leaves a more sustainable world for you and your generation. Finally, this is dedicated to Dr. Paul F. Ries, a retired professor of Physical Geography and Environmental Planning at Elmhurst College and the first Ries to earn a doctorate. I am proud beyond words to be following in your footsteps, Dad.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Urban water utilities in the United States face challenges due to a combination of external drivers. These include urbanization and population growth, which are stressing a system of aging infrastructure. Compliance with increasing regulations is also a challenge in a fiscally-constrained economic environment. A changing climate threatens infrastructure and past assumptions for water supply and quality. Urban utilities provide clean water and sanitation services to over 80% of the country's population and its industrial centers. Therefore, the sustainability of these water utilities are crucial to the country's and the public's well-being.

New operating models are emerging for a "utility of the future." Future utilities will recover resources, reduce their overall environmental impact, partner in the local economy, and deliver watershed-wide benefits to improve quality of life. These are all elements of a sustainable utility, but the sector has not agreed upon an applicable definition of sustainability, which intuitively incorporates an inter-generational approach to utility operations. For the purposes of this research, a sustainable utility is defined as one that will provide its crucial services for current and future generations, protect public and environmental health, and enable economic growth, all while minimizing resource consumption. Previous research provided little guidance on the most important sustainable practices for U.S. urban water utilities or the key attributes of those utilities that enable the shift toward sustainability. Additionally, the practice of sustainability measurement, and the closely-related practice of performance measurement, has not been widely adopted in the U.S. water sector.

This research program addressed the challenge of providing guidance on, and measurement of, sustainability by developing a framework to quickly and quantitatively assess a utility's sustainability and key organizational attributes. A mixed methods approach to this research used qualitative and quantitative methodologies. The approach utilized accepted anthropological methods to assess engineering and business concepts at water utilities. Data originated from semi-structured interviews of an external advisory committee of 12 widely-recognized, progressive, U.S. water utility leaders along with online surveys of water utility professionals.

The analyzed data revealed the most important sustainable practices for sustainable utilities and organizational attributes that enable the shift toward sustainable operations. Practices are actionable, quantitative, and in some cases, unique to the water sector. Attributes are generally qualitative; largely controlled by internal decisions and actions; and influence a utility's ability to operate sustainably. Datasets for sustainable practices and organizational attributes were generated using the techniques of discourse analysis on the semi-structured interview transcripts and freelisting on the online survey results. Top results from each dataset were cross-compared to generate the final, consolidated list of top practices and attributes.

A sustainability index was developed from the top eight sustainable practices, measured via a total of 14 indicators. Indices were tailored to water, wastewater, and combined utilities. The top sustainable practices were: Education and Communication; Financial Management; Green Infrastructure; Habitat/Watershed Protection; Long-term Resource Plan; Resource Recovery; and Water Conservation. These eight practices provided sufficient coverage of the economic, social, environmental, and infrastructure components of the triple bottom line-plus concept used to frame sustainability for this research.

This research also established the top six organizational attributes that enable the shift toward sustainability. These attributes were: Board Support / Political Will; Flexible Staff; Innovative Culture; Leadership; Organizational Commitment; and Staff Training / Development. These six attributes were assessed via a total of seven indicators, with guidance and scaling similar to the practices for ease of use by the end user.

Current sustainability and performance measurement frameworks were analyzed for indicators and measurement approaches that matched the top practices and attributes. Some of the practices and only one of the six attributes matched an existing framework. When there was a match, the existing assessment was used to help with ease of use. In other cases, new indicators, guidance, and scaling (for assessment) were developed. Practices and attributes without a match suggests these aspects of sustainable utilities are relatively new to the sector, or at least, measurement of these practices and attributes is not widespread.

The practices and attributes were combined into the final framework, a survey tool, which was pilot tested with three water utilities. The pilot testing demonstrated that the survey was comprehensive, yet at the same time, concise enough that it could be completed in under two hours by a limited number of utility staff. The application of this framework to a representative sample of U.S. urban water utilities can generate data to establish which attributes correlate to sustainable utilities. This will help utilities focus their limited resources on attributes which are shown to enable the shift toward sustainability.

CHAPTER 1: INTRODUCTION

1.1 Purpose of the Research

United States (U.S.) urban water utilities face significant challenges due to a combination of external drivers, including urbanization and population growth, a changing climate, fiscal constraints, increased regulations, and aging infrastructure (2013 Report Card for America's Infrastructure (2016); National Academies of Engineering (NAE) (2008); Ries, Trotz, & Vairavamoorthy, 2016). While many of these external issues are shared with rural utilities and urban water utilities abroad, U.S. urban utilities face unique challenges resulting from increasing regulations and aging infrastructure. A complicating factor is these water services are frequently delivered via a confusing network of overlapping service areas and types of service, such as water supply, wastewater treatment, and stormwater management. Yet these urban water utilities are crucial because they provide clean water and sanitation services to the vast majority of the U.S. population, who reside in cities, and to the industrial centers in these areas. The combination of increasing challenges and infrastructure complexity, coupled with the importance of providing these critical services, necessitates a long-term, sustainable approach to managing these urban water assets that are essential to the enduring health of the country's economy and populace.

New operating models for a sustainable urban water utility are emerging (National Association of Clean Water Agencies (NACWA), Water Environment Federation (WEF), & Water Environment Research Foundation (WERF), 2013), even though the water sector has not agreed upon an operational definition of sustainability (Herrick & Pratt, 2013). For the purposes

of this research, a *sustainable* utility is defined as one that provides its crucial services for current and future generations, protects public and environmental health, and enables economic growth, all while minimizing resource consumption. Moving beyond definitions, researchers have explored the assessment and comparison of sustainable water management. The concept of the "triple bottom line" (TBL), described further in Section 2.3, uses economic, social, and environmental components to assess sustainability using related indicators.

Related to sustainability assessments, some recent studies have evaluated key qualitative attributes of a water utility and its ability to shift to sustainable operations. For example, attributes such as Leadership, governance structure, and technical capacity will influence a utility's ability to operate sustainably. However, a direct linkage between a measurement of sustainability and organizational attributes is not yet established. An understanding of this linkage will help utilities prioritize internal organizational transformation and accelerate the sector's shift to sustainability.

Water management is a complicated process, balancing competing needs and stakeholders, multiple water sources, and treatment options, often in the face of increasingly scarce resources. The concept of Integrated Water Resources Management (IWRM), "a process that promotes the co-ordinated development and management of water, land and related resources in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (Jønch-Clausen, 2004), takes a broad approach to water management. A study by Gallego-Ayala (2013) found that only about 11% of the 353 IWRM papers published in the last decade focused on a city or municipal scale, with the vast majority focused on an entire river basin or country. Downscaling from IWRM, the concept of Sustainable Urban Water Management (SUWM) narrows the scope to water

management in the urban dimension. While SUWM is an aspiration without a strict definition, the concept attempts to maximize benefits when compared to traditional urban water management approaches, often through an adaptive, integrated approach that demonstrates flexibility in infrastructure solutions in addition to inter-organizational coordination (Brown & Farrelly, 2009; Marlow, Moglia, Cook, & Beale, 2013). Also at this scale, the European Innovation Partnership on Water Action Group on "City Blueprints®" established a framework to develop a quantitative, baseline assessment of water management sustainability in a city or region. Data for many of the framework's indicators are from the European Environmental Agency (EEA), and the growing body of work has been European-centric, with 37 of the 45 cities or regions completing the assessment in Europe and only one or two cities participating from each of the other continents. This includes New York City in North America (Koop & van Leeuwen, 2015). Therefore, the limitations of applying this quantitative approach include:

- The unit of interest is the city or region, not specifically the water utility itself;
- Much of the data for the indicators is derived from the EEA and European frameworks, making it difficult for U.S. utilities to easily complete the process and compare results.

The study of organizational theory is well-established and has evolved for almost a century. In the 1960s, the concept of an open system model for organizations gained favor with researchers following early applications in open systems in the natural world (Scott, 2004; von Bertalanffy, 1950). This open systems theory, applied to organizations, acknowledged that organizations are influenced by the environments in which they operate. This contrasts with earlier theories about closed systems, or self-contained organizations which are independent and limit exchange with their environment (Mele, Pels, & Polese, 2010).

Organizational change theories have been studied for several decades (Armenakis & Bedeian, 1999). However, these theories have not been widely applied in the study of water utilities. Brown (2008) noted the lack of contemporary research on non-technical aspects of water organizations. Only recently, work sponsored by the Water Research Foundation and the Water Environment Research Foundation is beginning to highlight the qualitative, organizational attributes of sustainable water utilities and institutions (Herrick, et al., 2013; Mukheibir, Howe, & Gallet 2014).

This dissertation presents a framework to assess and prioritize key organizational attributes that drive sustainability for U.S. urban water utilities. It builds upon previous work to develop an indicator-based approach to assess sustainability, specifically for U.S. urban water utilities. It also establishes a set of representative organizational attributes that can be efficiently assessed. While open systems theory acknowledges external influences on an organization, this research focuses on organizational attributes that can be controlled internally, as opposed to external forces that are beyond a utility's control. For the purposes of this research, attributes are generally qualitative; largely controlled by internal decisions and actions; and influence a utility's ability to operate sustainably. Finally, three water utilities pilot tested the framework and a method to correlate a utility's sustainability rating to its organizational attributes was proposed. It is anticipated that subsequent research applying this framework to a large number of utilities will produce results to prioritize activities and accelerate the transition towards SUWM.

1.2 Research Questions

Researchers have compiled a significant body of work on sustainable water management, but much of the research has focused outside of the U.S. Additionally, the scope of study is often at the country, region, or city scale. There is a need to downscale sustainability studies to the

utility scale in the U.S. context. The development of a sustainability index comprised of several components which are made up of multiple indicators will facilitate an urban water utility sustainability assessment.

The success or failure of an organization's transition to sustainability is influenced by its organizational attributes. A 2013 report by Herrick et al. evaluated internal and external factors that can influence organizational change in water utilities. Otherwise, very little research has been done specifically examining the organizational attributes of water utilities that have transformed to a more sustainable operation. Therefore, this research addressed the following five questions to develop a framework to assess key attributes driving sustainability for U.S. urban water utilities.

1. What are the components of a sustainable urban water utility in the U.S.?
2. What sustainability indicators make up those components of a sustainable urban water utility?
3. What organizational attributes are affiliated with a sustainable utility?
4. How can a water utility's organizational attributes be measured, quantifying gradations of a qualitative attribute?
5. What methodologies and approaches can link quantitative variables (sustainability index and indicators) to qualitative variables (organizational attributes) in the context of U.S. urban water utilities?

1.3 Research Structure

This research program answers the above research questions via three interconnected Work Packages as shown in Figure 1.1. After establishing the foundation for this research in a literature review, two Work Packages, Work Package 1 and Work Package 2, proceeded in

parallel and shared the methods of semi-structured interviews and online surveys for qualitative data gathering and subsequent quantitative analysis. Work Package 1 focused on sustainable practices, or quantifiable actions taken by a utility. It addressed research questions one and two. Work Package 2 addressed research questions three and four. It focused on utility attributes, which are generally qualitative, largely internal, and influence a utility's ability to operate sustainably. The top practices and attributes from these two Work Packages were combined in Work Package 3, which addressed research question five. It assigned indicators to the practices and attributes, and developed a survey that was pilot tested. Feedback from that pilot test informed the final framework resulting from this research, which can be used to measure and compare U.S. urban water utilities and correlate their ratings to their internal attributes. This framework will ultimately help utilities prioritize their efforts to be more sustainable.

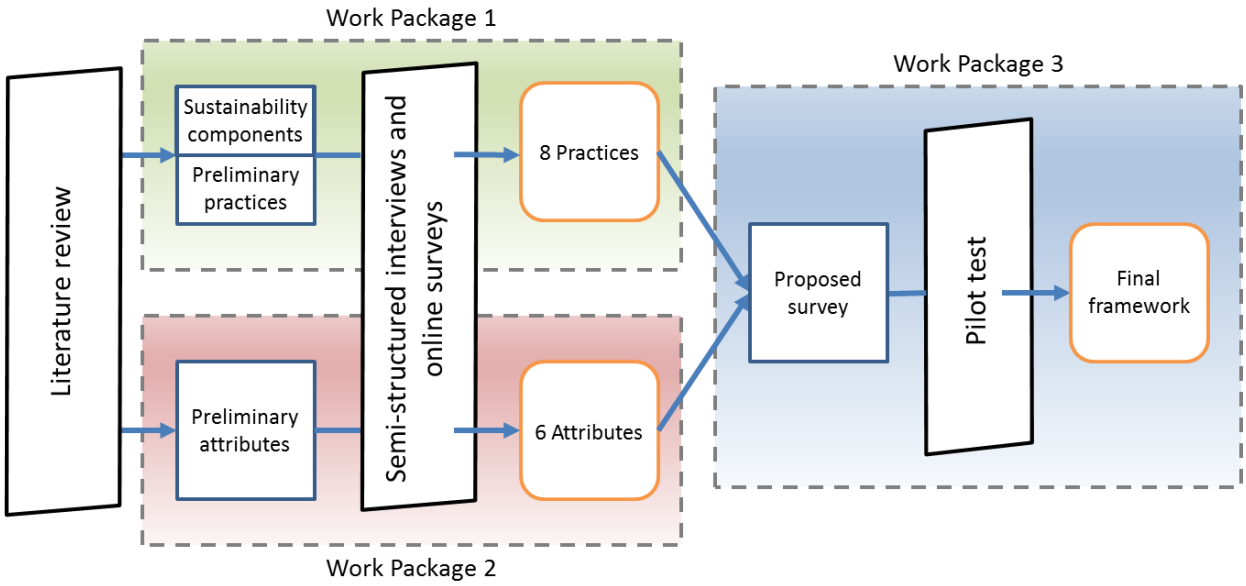


Figure 1.1 Overall Research Structure

1.4 Dissertation Structure

Chapter 2 presents further details on the context and conditions for the research. The complexities of the U.S. water sector, coupled with the lack of sector data, provide the impetus

for the output of this research program – a framework designed to quickly generate data about utility sustainability and organizational attributes. Chapter 2 describes the recognized need for a new sector vision – the "utility of the future" – in addition to related frameworks. Supporting literature for this concept is referenced in Section 2.4 with research gaps noted.

A significant portion of this research is grounded in primary data collected via interviews with U.S. water utility leaders, surveys of water professionals, and pilot testing with water utilities. The methodology for this data collection, pilot testing, and framework development is described in detail in Chapter 3.

Chapter 4 presents background literature and research results contributing to the recommended sustainability index, informed by the interviews and surveys. Chapter 5 does the same for the key organizational attributes of sustainable water utilities. Chapter 6 describes the method to correlate a utility's sustainability rating to its organizational attributes and utility pilot testing of the framework by three utilities. Chapter 7 provides overall conclusions and recommendations based on this research, including recommendations for future research.

This dissertation describes a multi-disciplinary, yet focused research program. The program generated an up-to-date and unique set of qualitative data on U.S. urban water utility sustainability, systematically derived from progressive sector leaders and water professionals. That data defined the elements of the sustainability index and organizational attributes that are the basis of a framework to help assess the key attributes for sustainable, U.S. urban water utilities.

CHAPTER 2: BACKGROUND

2.1 U.S. Water Sector and External Drivers

Access to safe, potable water and adequate sanitation are essential for human and environmental health. Yet globally, the United Nations (U.N.) states that over 660 million people still do not have an adequate water supply and 2.4 billion people do not have access to sanitation facilities (Sustainable Development Goals, 2016). The U.N. highlighted the need to address these global challenges by including in the Sustainable Development Goals a charge to achieve safe and affordable drinking water along with adequate sanitation for all by 2030. In an urban setting, the challenge of potable water supply and sanitation relies on a network of water and wastewater infrastructure to provide these services to populations that are increasing and more concentrated. Globally, more than half of the world's population now lives in urban areas, with that number projected to increase to 67% by 2050 (United Nations, 2012). In the U.S., 80.7% of the population lives in urban areas, defined as having 50,000 or more people (U.S. Census Bureau, 2013, March 7). As such, the vast majority of the nation's population depends on urban utilities that provide water and wastewater treatment services. Therefore, this research focuses on urban, rather than rural, water infrastructure.

In most of the world, urban water supply is typically extracted from either surface water or groundwater, conveyed to a centralized water treatment plant, and then distributed via a network of potable water pipes, known as a distribution system. In most of the developed world, including the U.S., used water from homes and businesses is collected in a collection system and transmitted to a centralized wastewater treatment plant, where it is cleaned before discharge to a

waterbody (Sitzenfrei, Moderl, & Rauch, 2013). The level of wastewater treatment varies, depending on national, state/regional, or local regulatory requirements.

The U.S. has over 51,000 Community Water Systems (CWSs) and almost 15,000 wastewater treatment plants (WWTPs), also known as water resource recovery facilities (WRRFs) (U.S. Environmental Protection Agency (EPA), 2009; EPA, 2013; Jackson, 2013). The majority of water and wastewater systems are small in size. While the larger systems are small in number, they provide most of the country's water services on a volume basis. In addition to these water / wastewater systems, governments are increasingly turning to separately-managed stormwater utilities with an independent enterprise fund to ensure adequate funding and management. There are now over 1,500 stormwater utilities, and this number is increasing rapidly (Campbell, Dymond, Kea, & Dritschel, 2014; EPA Region 1, 2009). All of this contributes to a very diverse and overlapping landscape of water utilities and services in the U.S.

In the U.S., potable water supply and wastewater discharges are regulated by the EPA. All water supply systems in U.S. urban areas are considered CWSs and regulated under the Safe Drinking Water Act. Any WWTPs that discharge to water bodies are regulated with National Pollutant Discharge Elimination System permits under the Clean Water Act. In 2013, EPA reported that 91.8% of CWSs "met all applicable health-based standards," and 88.3% of *major* WWTPs complied with their discharge permits, beating EPA's commitments of 90 and 86% compliance, respectively (EPA, 2014b). This means that the vast majority of U.S. urban areas currently have adequate water quality and sanitation. However, as defined in Section 1.1, sustainability implies *long-term*, inter-generational operations, and water infrastructure vulnerabilities are emerging (2013 Report Card for America's Infrastructure, 2016).

Increasingly, concerns arise about the long-term sustainability of the U.S. water infrastructure. In 2013, the American Society of Civil Engineers (ASCE) gave both water and wastewater infrastructure a grade of "D" in its Report Card for America's Infrastructure, citing aging infrastructure and the stresses of new regulations as complicating factors (2013 Report Card for America's Infrastructure, 2016). A number of external drivers are stressing the infrastructure and the utilities that manage it. Examples are included in the following sections.

2.1.1 Urbanization and Population Growth

By 2050, the U.S. population is projected to grow to 400 million (U.S. Census Bureau, 2013), adding at least 86 million people to urban areas. These new urban dwellers will require water services in addition to the existing population, concentrating demand in these areas. While population growth is not observed in all urban areas, those areas with declining populations create a different challenge of providing adequate rate-based revenue (Koorn, 2014).

2.1.2 Climate Change

The water cycle includes many tangible impacts from climate change. Changes in weather patterns adversely impact water supply systems that were designed around the concept of stationarity, which assumes the future climate will behave like the past (Milly, Betancourt, Falkenmark, Hirsch, & Kundzewicz, 2008). Changes in climate patterns can result in too little water or too much water. As a result, water utilities concerned with long-term water supply were the first to raise climate change awareness in the water sector. Increasingly, wastewater utilities are planning for climate change because it can increase storm intensity, which can result in sewer overflows or upset plant processes. Localized flooding from storms impact wastewater and stormwater infrastructure, which is typically located at or flows to the lowest point in a sewershed to take advantage of gravity, but vulnerable to flooding by adjacent receiving waters.

Additionally that same infrastructure in *coastal regions* is more prone to flooding during storms due to sea level rise. Heberger, Cooley, Herrera, Gleick, and Moore (2009) and Frazier, Wood, Yarnal, and Bauer (2010) cited WRRFs as part of the increasingly-vulnerable built environment. These studies noted that sea level rise also increases the risk of damage to potable water supplies. Impairment to groundwater quality occurs via saltwater intrusion into coastal groundwater and increased risk of damage to water infrastructure, often located along coastal transportation corridors, also at risk.

2.1.3 Fiscal Constraints

The costs to provide water utility services often increase faster than incomes, inflation, and a utility's ability to finance (Koorn, 2014). In addition, the amount of federal funds provided to state revolving loan funds (SRFs), previously a significant source of water infrastructure funding, has decreased since the 1990s (Anderson, 2010). Compounding the problem, the increased costs of operations require additional resources. Approximately 2% of electricity in the U.S. is used for moving and treating water and wastewater and energy used for water systems can be 30 to 40% of a municipality's energy consumption (Copeland, 2014; Pabi, Amarnath, Goldstein, & Reekie, 2013). With future energy prices projected to increase, financial stresses will continue into the future (Kiparsky, Sedlak, Thompson, & Truffer, 2013; U.S. Energy Information Administration, 2013).

2.1.4 Increasing Regulations

Requirements for water quality, monitoring, wastewater treatment effluent, and stormwater management only become more stringent over time, requiring new and/or upgraded technologies and expertise to meet these requirements. In some states, new carbon emissions reporting is an additional requirement. While EPA's draft Integrated Planning Approach

Framework may provide some temporary relief, infrastructure improvements will still be required into the future to meet increasing regulatory requirements (Kiparsky et al., 2013; Stoner & Giles, 2012).

2.1.5 Aging infrastructure

The construction of urban water infrastructure was a key supporting factor in the country's growth during the 19th and 20th centuries. In some cities, pipes that are now over 100 or 200 years old still convey water, wastewater, and stormwater. In addition, much of the country's wastewater treatment infrastructure was built with funds from the construction grants program in the 1970s and 1980s. These federal grants were phased out in 1990 and that infrastructure is now near, or at the end of, its useful life. Potable water infrastructure replacement alone over the next 25 years is estimated to cost at least $1 trillion (American Water Works Association (AWWA), n.d.; Construction Grants Program, 2012).

Each of these external drivers, coupled with the complexity of operating trillions of dollars of existing infrastructure, underscores the need for a more sustainable approach to urban water management to address the sector's current and future challenges. The following sections provide an overview of current performance benchmarking systems, data availability, and the limited research on sustainability in the water sector.

2.2 Water Sector Benchmarking and Data Availability

While several international frameworks exist to benchmark water utility *performance* data, U.S. participation is limited. Benchmarking for the water sector is described as "a tool for performance improvement through systematic search and adaptation of leading practices" (Cabrera, Dane, Haskins, & Theuretzbacher-Fritz, 2011). The World Bank's International Benchmarking Network (IBNET) contains information from over 2,000 utilities in 85 countries,

but only one U.S. utility, the Charleston Water System, provided data (IBNET, 2015). The European Benchmarking Co-operation (EBC) performs an annual exercise and in 2015, 43 utilities from 17 countries participated in the program. Again, Charleston Water Systems is the only U.S. utility that participated in the EBC (EBC, n.d.).

In the United Kingdom (U.K.), water utilities are required to track performance with a set of key performance indicators (KPIs) which are set by the utilities, the government, and the water industry regulator (Ashley & Hopkinson, 2002). Canada has a National Water and Wastewater Benchmarking Initiative that started in 1997 and includes 53 wastewater, 50 water, and 28 stormwater utilities, with results last posted for 2013 (AECOM, 2013). Individual utility data is not available because the researchers aggregate the results. AWWA performs an annual benchmarking survey of mainly North American water and wastewater utilities. The 2013 AWWA report contains data from approximately 125 respondents (S. Passarelli, personal communication, February 25, 2016) who self-selected to provide their data. Data is blinded and presented by region or size of utility, broken down further into water, wastewater, or combined utilities. Raw data is not available for analysis (K. Mercer, personal communication, November 20, 2013). All of this leads to the conclusion that voluntary *performance* assessment programs in the U.S. have very little penetration into the tens of thousands of water utilities. Performance assessment and sustainability assessment have some overlap, as discussed in Section 2.3. However, sustainability assessments have even less usage among U.S. water utilities, meaning sustainability data is not widely available.

Further compounding the challenge of a lack of readily-available data, the U.S. has minimal national water utility reporting requirements compared to KPIs in the UK or some water sector data required by the European Union's Water Framework Directive. American CWSs

must only report potable water quality data and any violations. WRRFs are required to report effluent water quality, as prescribed on their discharge permits, along with overflow or bypass events, if applicable. Unlike the U.K., where some of the required KPIs can be used to assess sustainability, U.S. reporting requirements are limited. Therefore, the data needed for a quantitative sustainability assessment of U.S. water utilities is neither readily available, nor required, per current regulations and would need to be obtained independently.

2.3 Sustainability in the Water Sector

Researchers have attempted to define sustainability, resulting in a variety of definitions and sometimes vague characterizations (Lundin & Morrison, 2002). A frequently-cited explanation of sustainability is linked to the inter-generational nature of the concept when referring to sustainable development. This is reflected in a commonly-used definition of sustainability from the World Commission for Environment and Development's publication, Our Common Future, known as the Brundtland Report (World Commission on Environment and Development, 1987). The report describes sustainable development as "…development that fulfils the needs of the present generation without compromising the abilities of future generations to meet their own needs." Another definition of sustainability uses the concept of the TBL, first used in 1994 to expand a company's bottom line beyond just "profits" and include "people" and the "planet" (Hindle, 2009). This concept is now frequently used and organized around economic, social, and environmental components. The TBL approach provides a useful framework when integrating sustainability with engineering and decision-making for utility project planning (Guest, Skerlos, Daigger, Corbett, & Love, 2010; McLaren & Simonovic, 1999).

Decision-makers in the water sector have limited experience applying all three components of the TBL to U.S. urban water infrastructure. Practitioners have long used economic factors in decision-making, but have very little experience evaluating environmental factors, and even less experience with social factors (Liner, deMonsabert, & Morley, 2012). Nonetheless, there has been some research on the development of social metrics and the compilation of indicators for all three TBL components (Balkema, Preisig, Otterpohl, & Lambert, 2002; Liner et al., 2012).

Some sustainability frameworks have gone beyond the three TBL components and included others based upon the research focus or unit of study. This variant is referred to as the "TBL-plus" and was evaluated for this research. Further information on the TBL-plus is provided in Sections 4.3.2 and 4.4.1.

Indicators used in the benchmarking programs described in Section 2.2 can be useful as a comparative tool when looking at a utility's performance. Some performance indicator frameworks can contain sustainability indicators, depending on the boundaries of the system. However, not all performance indicators are a measurement of sustainability. For example, compliance with a low-level nutrient effluent discharge permit (regulatory compliance) may indicate good performance. However, the chemical and energy requirements to achieve that performance may not be sustainable. Predictive measures are forward-looking and may include both types of indicators. The inter-generational nature of sustainability indicators is a primary differentiator from performance indicators. While the boundaries for a potential set of indicators are not yet fixed, Figure 2.1 represents an example of indicator sets' overlap and independence.

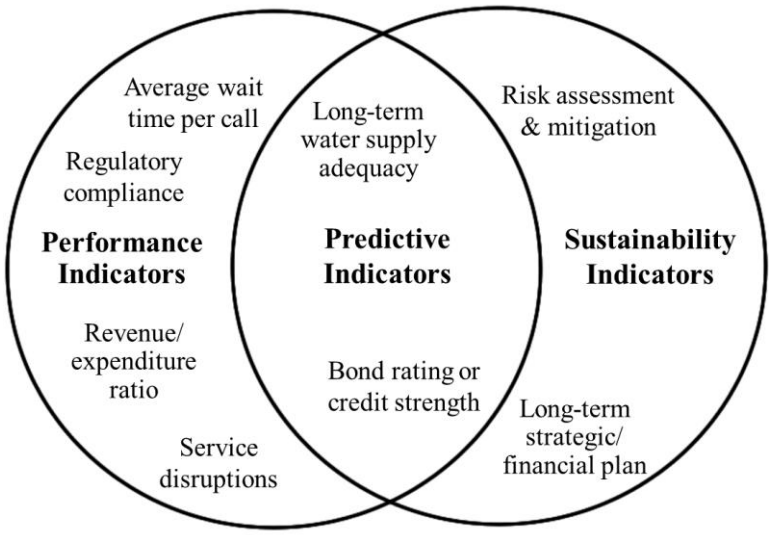


Figure 2.1 Performance and Sustainability Indicator Relationships

2.4 Vision for a New Model

With increased awareness of the external drivers stressing U.S. urban water infrastructure, utility leaders are more mindful of the need to operate more sustainably. Given a perception of unlimited resources, using water in a linear fashion (used once and discharged without intentional recirculation) without significant concern for resource consumption may have seemed acceptable. But now, water scarcity is a reality and is expected to continue into the future due to drought, increased demand, or conflicting uses (Government Accountability Office, 2014). There is increasing awareness of the financial and environmental consequences of a water utility's energy consumption. The chemicals used in water and wastewater treatment and the embedded carbon footprint in massive concrete (e.g. "gray") infrastructure also have an environmental cost.

In response to these challenges, researchers and practitioners are proposing new, systems-based approaches to urban water. Water reuse can significantly reduce potable water usage (Apostolidis, Hertle, & Young, 2011) and reduce carbon footprint in many cases. Rainwater harvesting and other green infrastructure can offset potable water demands and create indirect

benefits (Clements et al., 2012). Embedded energy in wastewater can offset the energy consumed by the treatment process (Tarallo, 2014). Decentralized systems can help facilitate water reuse, resource recovery, and require smaller infrastructure (Daigger, 2009) (Daigger & Crawford, 2007) (Gleick, 2003) (Sitzenfrei et al., 2013).

Even the concept of Effective Utility Management (EUM) has undergone change in a short period of time. The EUM framework was launched in 2007 by the EPA and six U.S. water sector professional associations and trade groups (EPA et al., 2008). The 2008 EUM Primer describes ten attributes and five "keys to success" for effectively managed utilities. While this framework does not specifically seek to develop *sustainable* utilities, it does describe steps to help establish community sustainability as one of the ten attributes. In 2015, EPA and the six associations conducted a review of the original attributes and keys and acknowledged changes in the sector's operating context in just the past few years. This EUM review is ongoing and further detail is provided in Section 4.3.1.

In 2013, three organizations serving the wastewater community released the report, "The Water Resources Utility of the Future: A Blueprint for Action," referred to as the Utility of the Future. The report proposed the changes listed above related to resource recovery and new infrastructure models; described the regulatory and legislative changes needed; and identified research, education, and training needs (NACWA et al., 2013). One of the three contributing organizations, WEF, no longer uses the term wastewater treatment plant and instead uses the term *water resource recovery facility* to "better focus on the products and benefits of treatment rather than the waste coming into such facilities" (Jackson, 2013).

However, simply defining a future, sustainable model alone will not get utilities to the desired state. Work by Brown, Keath, and Wong (2009) described the transition of Australian

urban water utilities through six city states, from a "Water Supply City" to a "Sewered City," and ultimately to a "Water Sensitive City." This work only described the changes in physical infrastructure and institutional structures required in each of the typologies. The Sustainable Water Management Improves Tomorrow's Cities' Health (SWITCH) program ran from 2006 to 2011 and resulted in the *SWITCH approach*, which includes multi-stakeholder learning alliances, implementation of strategic planning process, and demonstration projects to speed up the uptake of SUWM (Howe, Butterworth, Smout, Duffy, & Vairavamoorthy, 2011). The Utility of the Future, the concept of the Water Sensitive City, and SWITCH all provide pieces of the puzzle, but none describe the internal *organizational attributes* needed for a water utility to make the transition to a more sustainable operation. Only recently, Herrick et al. (2013) presented work on water utility attributes to aid in the transition to sustainability and Mukheibir et al. (2014) delineated barriers to institutional changes needed to transition. No work has yet linked water utility organizational attributes to a sustainability assessment, which would help to confirm and prioritize the highest-priority organizational attributes.

CHAPTER 3: METHODOLOGY

3.1 Introduction

Information gathered in the literature review provided the foundation for the mixed methods research approach described in this chapter. Along with the more traditional approaches of qualitative and quantitative research, mixed methods research is recognized as a third major research approach, as described by Johnson, Onwuegbuzie, and Turner (2007):

> Mixed methods research is the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purpose of breadth and depth of understanding and corroboration.

The lack of significant data on U.S. urban water utility sustainability necessitated the qualitative data gathering approach with the research participants. The prioritization and analysis of the qualitative data required a quantitative approach.

This program utilized two qualitative data-gathering methods of semi-structured interviewing and freelisting. First, an external advisory committee (EAC) of U.S. urban utility leaders was formed and interviewed individually about sustainable practices and organizational attributes using the semi-structured interview method. Second, water sector professionals were surveyed online, using the freelisting method to help define domains for sustainable practices and organizational attributes. All methods, procedures, and the informed consent process for the EAC interviews and freelisting surveys were reviewed and approved by the University of South

Florida's (USF) Institutional Review Board / Human Research Protection Program (see Appendix B).

Data from the semi-structured interviews and freelisting surveys were coded, quantitatively analyzed, and cross-checked to develop a list of eight sustainable practices and six organizational attributes. These practices and attributes were mapped against indicators from currently-available benchmarking and performance assessment frameworks for the U.S. water sector, listed in Section 3.6. When currently-available indicators and/or scaling existed in these frameworks, they were incorporated into a draft survey to assess the practices and attributes. When no indicators and/or scaling existed, they were adapted from currently-available frameworks or new ones were developed based upon the data. Finally, this survey was pilot tested with three utilities and feedback informed modifications for the final, proposed framework.

3.2 Semi-structured Interviews

For semi-structured interviews, the researcher used a set of predetermined questions, but unlike structured interviews, which cannot stray from the predetermined questions, semi-structured interviews allow the researcher to ask additional questions that emerge from the interview responses. Semi-structured interviews are scheduled in advance and take place outside of everyday events (Whiting, 2008). The entire interview process, including informed consent, the interview itself, recording, and transcribing, was pilot-tested with a combined water/wastewater utility. This pilot utility was not represented on the EAC. The individual interviews for this research occurred face-to-face whenever possible. The interviews were held at times and locations of convenience for the interviewees. Most interviews took place either at an office at the participant's utility or at a conference where the interviewer and participant were

both present. Two of the interviews took place via teleconference. In all cases, a private room or area was used for the interview. All interviews were conducted between February and June 2015.

3.2.1 EAC Inclusion Criteria

The population of people with familiarity and knowledge of U.S. urban water utilities and attributes of those utilities moving towards sustainability is limited so participants came from targeted groups or were invited to participate based on their background and professional position. All participants stated they were mentally healthy adults, 18 years of age or older. Individuals under the age of 18 or adults who were mentally handicapped who could not provide adequate, written informed consent were not recruited to participate in this research project. Participation was completely voluntary and consenting adults could have withdrawn their participation at any time or elected not to answer interview questions without any negative consequences.

The EAC demographics are shown in Table 3.1. EAC members were selected using the technique of "convenience sampling," representatives to whom the researcher has access and who are also leading transitions to sustainable operations. Convenience sampling "often grants the researcher a level of access to and familiarity with the sample that guarantees a richness of data that could not be attained if the sample were less familiar, and therefore less convenient, to the researcher" (Koerber & McMichael, 2008).

Therefore, four inclusion criteria were established to determine eligibility on, and makeup of, the EAC as key informants:

1. Current or recent general manager or senior manager of a U.S. urban water utility that has made or is making progress towards sustainable operations, described below;
2. Overall EAC composition includes at least one member per geographical region;

3. Overall EAC composition maintains a diversity of treatment plant typology (water, wastewater, or combined water/wastewater utility); and
4. Familiarity to the investigator.

Anyone not meeting the first three of the four criteria was excluded from participating. The fourth criterion ensured access for the researcher.

An effort was made to attempt to balance the overall diversity of the EAC utilities, while ensuring to select those utilities that are making progress towards sustainable operations, as noted in the first criteria. The researcher used sector-wide initiatives and award programs to validate this assessment. Some utilities participated in the Utility of the Future program, described in Section 2.4, on the Task Force and/or provided a case study or reference. Utilities were also cross referenced against national association awards programs that reflect components of sustainable operations. These include recipients of the NACWA's Excellence in Management award since 2012 when "resource efficiency and protection activities" were added to the award criteria (Awards, 2016) and the Association of Metropolitan Water Agencies' (AMWA) Sustainable Water Utility Management Award over the two-year duration of the award program (Sustainable Water Utility Management Award, 2016). The EAC demographics and utility participation and achievements are shown in Table 3.1.

EAC members were asked to not participate in the freelisting portion of the data collection (see Section 3.3). Therefore, the the two populations (semi-structured interview participants and freelisting survey participants) were mutually exclusive.

3.2.2 EAC Demographics

The EAC demographics are provided in Table 3.1. Participant job titles included: Chief Executive Officer, Chief Operating Officer, Commissioner, Deputy Director, Executive Director,

General Manager, and Strategic Systems Manager. Seven EAC members were male, five were female. The combined coverage of the 12 utilities provides water and/or wastewater services to a combined population of almost 27 million people, or over eight percent of the U.S. population.

Table 3.1 External Advisory Committee Demographics

EAC member number	Region	Service	Population served	Governance structure	Utility of the Future	NACWA Excellence Award	AMWA Sustainability Award
1	Southeast	Wastewater	322,000	Authority		X	
2	Southeast	Both	400,000	Authority		X	
3	Midwest	Both	1,100,000	Municipality	X	X	
4	Northeast	Both	2,200,000	Authority	X	X	
5	Northeast	Both	9,000,000	Municipality	X		
6	Midwest	Wastewater	5,250,000	Authority	X	X	
7	Northeast	Both	2,276,000	Municipality	X		
8	West	Both	2,600,000	Municipality	X	X	
9	Northwest	Both	1,352,000	Municipality	X		
10	Southeast	Both	60,000	Both			X
11	Northeast	Wastewater	112,000	Municipality	X		
12	Southwest	Water	2,000,000	Authority	X		

The population served by the EAC's utilities ranged from as small as 60,000 customers to the country's largest utility with over 9 million customers. These utilities were geographically diverse with four utilities from the southeast, three from the northeast, two from the Midwest, and one each from the northwest, southwest, and western U.S. Eight combined water/wastewater utilities, three providing only wastewater service, and one providing only water service achieved service diversity. Seven utilities operating as part of a municipal government and six operating as independent authorities with one combined utility having two different governance structures for their two separate services created governance diversity.

3.2.3 Informed Consent

Informed consent for the semi-structured interviews consisted of a two-step process. First, participants were given the USF Institutional Review Board (IRB) Informed Consent form via e-mail approximately a week before the interview. The participants were informed that they

needed to sign it at the interview and were reminded of the voluntary nature of their involvement. This provision provided the participants adequate time to review the informed consent form and contact the interviewer, the USF IRB, or others if there were questions on the form or about the interview. Second, the interviewer provided the USF IRB Informed Consent form at the beginning of the interviews and discussed the form with the participant, including a reminder of the voluntary nature of their involvement. The semi-structured interview consent form can be found in Appendix C. The form was then signed by both parties before the interview. When the interview was not conducted in person, the form was signed by both parties, scanned, and transmitted electronically to each other.

While the standard USF IRB informed consent form allows for anonymity, it was expected that some, if not all interview participants may *not* wish for the name of their utility to remain anonymous. Therefore, participants had the option to have their utility name affiliated with their responses. A selection box was included on the USF IRB Informed Consent form with the following language:

> If you consent to allow the name of your current (or previous, as applicable) utility in the Ph.D. dissertation and related publications, check the box to the left. The utility name would be used in a narrative description such as "A manager at the X utility implemented a unique community outreach program where impact was measured through annual follow up surveys." At no point would your personal name be used in the publications. Leaving this box unchecked does not exclude you from participating in this research.

Eleven of the 12 interview participants checked the box, allowing the use of their utility's name in the research outputs. The approved USF IRB informed consent form is in Appendix C.

3.2.4 Interview Questions

The questions were developed and then reviewed by members of the doctoral dissertation committee and a combined water/wastewater utility manager who was not affiliated with the EAC. Open-ended questions related to sustainable practices asked of each EAC member, referred to as "key" questions, are listed in Table 3.2. These questions were followed by a series of key questions related to organizational attributes, listed in Table 3.3.

Table 3.2 Key Sustainability Interview Questions

Sustainability question number	**Key Question**
1	What do you think about using the "triple bottom line-plus" framework, with the plus being infrastructure, as a water utility sustainability framework?
2	What do you believe are the most important *economically*-sustainable practices for U.S. urban water utilities?
3	What do you believe are the most important *environmentally* sustainable practices for U.S. urban water utilities?
4	What do you believe are the most important *socially* sustainable practices for U.S. urban water utilities?
5	What do you believe are the most important *infrastructure-related* sustainability practices for U.S. urban water utilities?
6	What do you see as the most significant barriers to more widespread adoption of sustainability indicators?
7	Do you currently, or do you plan to publicly report your utility's sustainability performance, either through Global Reporting Initiative (GRI) formats or others?

Table 3.3 Key Organizational Attributes Interview Questions

Attributes question number	**Key Question**
1	In thinking about your utility and its shift towards sustainable operations, tell me what you believe are the most important organizational attributes that drove your utility towards sustainability?
2	In thinking about water and wastewater utilities, do you think there would be different responses for the most important organizational attributes due to their different services, or do you think the organizational attributes would be the same for water and wastewater utilities?
3	In thinking about the variation among water utilities across the U.S., do you think there would be different responses for the most important organizational attributes due to differences in climate, water availability, infrastructure age, etc., or do you think the organizational attributes would be the same no matter where you are in the country?
4	Do you think you would provide different responses if you were answering these questions 20 years ago…or 20 years in the future?
5	Do you think a utility's governance, that is whether or not a utility is part of a municipal government or an independent authority, has an impact on a utility's ability to operate more sustainably?

The attributes questions were preceded by this explanation, provided verbatim to EAC members:

> For the last part of this interview, I will ask you questions about water utility attributes. These attributes are generally qualitative and influence a utility's ability to operate sustainably. Looking at it another way, certain utility attributes enable a shift to sustainable operations. Attributes are internal and therefore can be controlled by internal decisions and actions, as opposed to external drivers such as increasing regulations, commodities pricing, and climate change.

Questions were given to participants approximately one week before the interview. During the interview, follow-on questions about specific sustainable practices and indicators were based on responses to the key questions. Other questions about practices were asked such as "can they be measured?," "does your utility measure them?," and "do you know if this practice is widespread?," depending on responses and available time during the interview. Ten of these interviews occurred face-to-face and two were conducted via teleconference. All interviews were recorded and lasted an average of 70 minutes in duration, from a minimum of 60 to a maximum of 86 minutes, totaling over 14 hours of interviews.

3.2.5 Interview Transcribing, Coding, and Discourse Analysis

After the interviews, the recordings were transcribed using the Transcribe integrated audio player/text editor to produce the manuscripts. Then, these manuscripts were reviewed and coded. Coding "is the process of organizing the material into chunks or segments of text and assigning a word or phrase to the segment in order to develop a general sense of it" (Creswell, 2014). Therefore, the process of coding inductively reduced the transcripts to significant practices through the selection of individual passages and concepts. This was followed by

recoding where codes were studied for thematic connections and overlap, resulting in recoding and combining, as appropriate. The process of coding and recoding was then repeated via an iterative process. Results from each step were tracked using Microsoft Excel software. This entire process is referred to as discourse analysis, which is broadly defined as the "study of language in use" and refers to linguistic analysis of naturally occurring speech. Discourse analysis searches for language patterns of a given topic and is frequently used in interdisciplinary studies (Alba-Juez, 2009).

An example of coding and recoding is provided for the practice of "Habitat and Watershed Protection." In this case, two participants referred to performing benthic studies, one specifically mentioned habitat restoration, one referred to the sharing of water resources with aquatic species, and another noted how water utilities can enhance the watershed through its operations. Another example of coding and recoding is the combination of several practices under the topic of "Resource Recovery." Resource Recovery is noted specifically in the Utility of the Future Blueprint as part of the clean water paradigm shift in the U.S. It is noted in the context of nutrients, energy, and water, or N-E-W (NACWA et al., 2013; Ries, 2015). Because this research program is developing a *high-level* framework for sustainability assessment, the general topic of resource recovery was chosen rather than delineating this practice into its separate resource components. In this case, responses from the participants such as: energy neutrality (which requires energy generation), energy generation, water reuse, beneficial use of biosolids (nutrients), and the general response of resource recovery were all combined into the practice of "Resource Recovery."

3.3 Freelisting

Freelisting is a method used regularly in anthropology (Libertino, Ferraris, Lopez Osornio, & Hough, 2012) to establish a domain, or items included in a particular category by surveying not more than a few dozen people who are familiar with that category (Schrauf & Sanchez, 2008). Depending on the coherence of the domain, approximately 20 to 30 participants are usually sufficient (Weller & Romney, 1988). For this work, freelisting responses were collected via online surveys and participants remained anonymous. Participants were asked to list both sustainable practices and key attributes that enable a utility's shift towards sustainable operations. All surveys were conducted from February to July 2015.

3.3.1 Freelisting Participant Inclusion Criteria

Like the semi-structured interviews, the population of people with familiarity and knowledge of U.S. urban water utility sustainability and organizational attributes is limited so participants came from targeted groups or were invited to participate based on their background and professional position. Like the EAC, all participants stated they met age and mental health requirements via the informed consent process. Participation was completely voluntary and consenting adults could have withdrawn their participation at any time or elect not to answer survey questions without any negative consequences.

For the freelisting method, survey participants were solicited from groups of water professionals familiar with urban water utility management. The solicitation primarily drew from networks of water professionals (via AWWA's Management and Leadership Division; Strategic Management Practices Committee; and Finance, Accounting and Management Controls Committee; and WEF's Utility Management Committee) and from the researcher's sector contacts using referral and convenience sampling. The AWWA and WEF members could

forward the invitation to participate to other professionals who they thought were knowledgeable about the subject.

3.3.2 Freelisting Participant Demographics

Thirty one participants completed the online survey. Of those, 15 self-reported as primarily working with combined water/wastewater utilities, ten with wastewater-only utilities, and six with water-only utilities. Participants remained anonymous and further information was not requested. However, generalized demographics of the water professionals can be estimated. Unlike the semi-structured interview participants, who were all utility managers, the water professionals surveyed have a more diverse organizational affiliation and are typically not at the upper levels of their organization. For example, the WEF Utility Management Committee of 160 members is comprised of 51% consultants, 42% utility employees, and 7% "other" job categories, such as academics, regulators, and manufacturers. Of the utility employees, 91% are urban utilities and 27% are upper management at their utilities (T. Mixon, personal communication, September 15, 2015).

3.3.3 Informed Consent

Informed consent for the freelisting survey consisted of text adopted from the USF online survey informed consent form with a waiver of informed consent document on the front page of the survey. Participants were required to click a box to indicate they had read the informed consent information and agreed to its contents before proceeding with the survey. The complete text is in Appendix D.

3.3.4 Freelisting Questions

Participants were provided three points of context before receiving the questions. These points, quoted from the survey, were:

1. SUSTAINABLE PRACTICES are inherently inter-generational, meaning they positively impact current and future generations.
2. Water utility ATTRIBUTES are generally qualitative and have influence over a utility's ability to operate sustainably. Looking at it another way, certain utility attributes enable a shift to sustainable operations. Attributes are internal and therefore can be controlled by internal decisions and actions, as opposed to external drivers such as increasing regulations, commodities pricing, and climate change.
3. "Water utilities" can be water, wastewater, or combined water/wastewater utilities.

Then, the survey participants indicated which type of water utility they primarily work with (water, wastewater, or both) and next were asked to answer these two questions:

1. Provide up to 20 brief responses for the following. "LIST EXAMPLES OF SUSTAINABLE PRACTICES FOR U.S. URBAN WATER UTILITIES." Do not research the answers. Rather, simply provide answers in the order they come to mind.
2. Provide up to 20 brief responses for the following. "LIST INTERNAL ATTRIBUTES OF U.S. URBAN WATER UTILITIES THAT YOU BELIEVE CAN ENABLE THE SHIFT TO SUSTAINABLE OPERATIONS." Do not research the answers. Rather, simply provide answers in the order they come to mind.

This resulted in two "free lists" of ideas that helped define the domain of sustainable practices and key organizational attributes, with full results provided in Appendices G and H.

3.3.5 Freelisting Analysis

The online survey used Google Forms to conduct the survey and collect raw results. After the survey completion, results were exported to a Microsoft Excel spreadsheet for data analysis and graphical outputs. Both the sustainable practices and key attributes followed a similar

procedure where results were coded to a list of practices and attributes, respectively. After initial coding, the lists were reduced through recoding with examples and details provided in Sections 3.3.5.1 and 3.3.5.2.

Additional analysis required a check of each participant's responses to ensure that each practice or attribute was only recorded once per participant. For example, one participant listed the following sustainable practices:

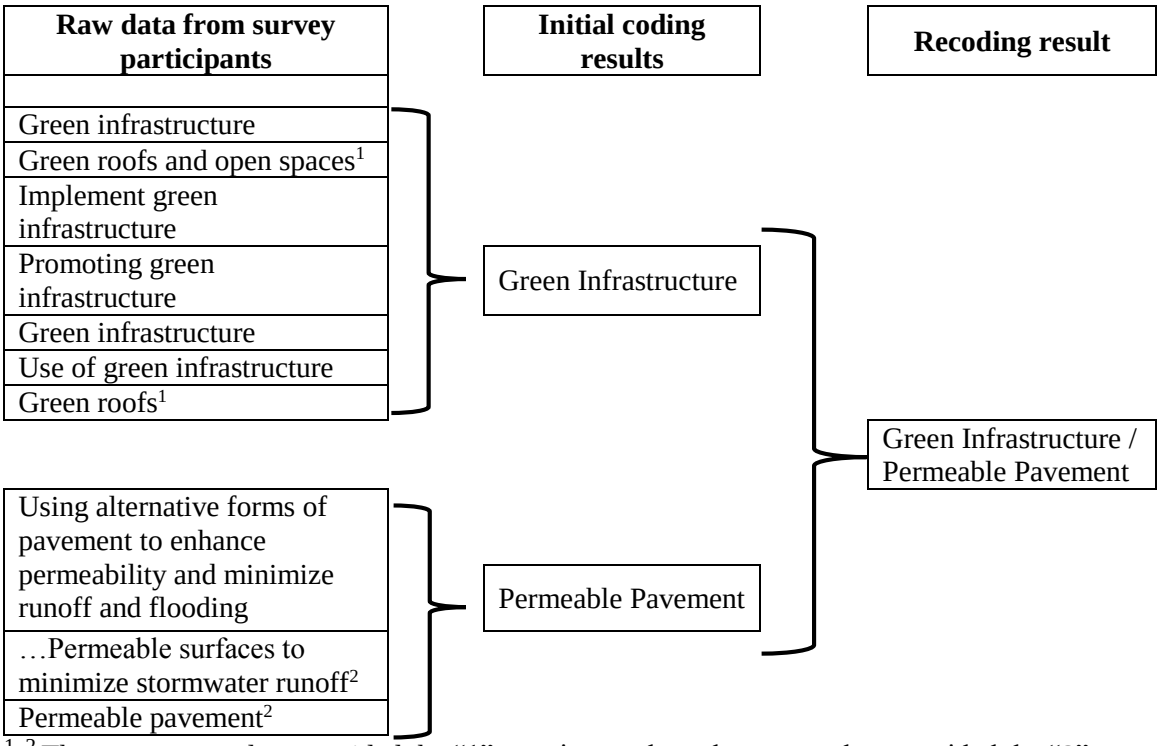
1. Resource recovery
2. Energy recovery through the conversion of biogas to electricity, to biofuels, to fuel cells, for pipeline injection, etc.
3. Combined heat and power (CHP) systems for electricity generation
4. Co-digestion for renewable energy production
5. Nutrient recovery, such as nitrogen and phosphorus
6. Organics recycling and fertilizer replacement

In this case, all of these practices were combined to one response for the practice of "Resource Recovery." This elimination of duplicate responses for a single practice ensured respondents with multiple variations on the same practice or attribute did not skew overall results, a method recommended by Weller & Romney (1988).

3.3.5.1 Sustainable Practices

Initial coding of the practices resulted in a list of 124 practices. Recoding reduced this list to 90 practices through the combination of similar practices. An example for the practice of Green Infrastructure/Permeable Pavement is shown in Figure 3.1. In another example, the codes of "energy efficiency" and "Energy Star" were combined under a single practice of "Energy Efficiency / Energy Star / Energy Conservation." Energy Star is an EPA-sponsored national

program to encourage energy efficiency, including at water utilities. Raw data practices that generated these codes may have explicitly mentioned the Energy Star program, or may have listed specific practices like "improve energy efficiency of blowers and other equipment."



[1, 2] The same respondent provided the "1" practices and another respondent provided the "2" practices so only one mention of the Green Infrastructure / Permeable Pavement practice was attributed for each participant

Figure 3.1 Example of Coding and Recoding Practices

Many other respondents mentioned water efficiency specifically. But in other cases, interpretation of the responses was needed. For example, in one case, the response of "conservation" was assumed to be water efficiency, not energy efficiency. This is aligned with the more prevalent aspect of conservation in the U.S. water utility sector, based upon data gathered in this research program.

3.3.5.2 Key Attributes

Initial coding resulted in a list of 124 attributes. Recoding reduced this list to 99 attributes through the combination of similar attributes. For example, the initial attributes of "Water

Resource Planning" and "Water Resource Adequacy" were combined into a single attribute of "Water Resource Planning/Adequacy." In another example, the initial attributes coded to "Political Support" and "Coalitions with Public Works / Public Officials" were combined into a single attribute of "Political Support/Coalitions with Public Officials."

3.4 Response Ranking

After the coding and recoding, the qualitative responses from the interview and surveys were converted into quantitative data for analysis. The interviews, with n=12 participants, yielded practices and attributes that could be ranked relative to each other. The surveys, with n=31 participants, provided the opportunity for further statistical analysis of results. Ultimately, an absolute ranking of practices and attributes was not needed for the purposes of this research. Rather, this research aimed to obtain the top practices and attributes, captured in as few practices and attributes as possible to facilitate significant data generation from this framework.

3.4.1 Frequency of Responses

The discourse analysis of the interviews resulted in 40 separate practices and 18 attributes. The number of mentions of each of these practices and attributes provided a ranking of each for the interview results datasets. This is shown in Appendix F and Figure 5.1 with responses ranked in order of number of responses, then alphabetical by practice or attribute title.

3.4.2 Saliency of Responses

As noted, the analysis of the survey responses resulted in 90 separate practices and 99 attributes. Like the interview results, the frequency of each of these practices and attributes provided a ranking of each for the survey results datasets. However, unlike the interview dataset, the survey results yield enough data to perform further analysis, namely an assessment of the *saliency* of responses.

Saliency accounts for not only the frequency of a particular response, but also where that response is ranked within each respondent's list. A formal measure of salience, known as Smith's S, accounts for frequency and rank of a particular response. (Schrauf & Sanchez, 2008) S is calculated as:

$$S = (\sum((L_i - R_j + 1)/L_i))/N$$

where S is the salience of a particular practice or attribute; L_i is the length of a respondent's list, R_j is the rank of item j in the list, with the first response = 1; and N is the number of lists, same as the number of participants. (Sutrop, 2001) For this research, N = 31. Calculations for salience were performed using the same Microsoft Excel spreadsheet used for frequency calculations. For this research, calculation of salience permits further differentiation of the survey results among practices and attributes with identical frequencies.

Establishing a boundary of saliency is not a standardized procedure (Quinlan, 2005). For this research, the boundary established which freelisting results were compared to the EAC interview results. Judgement is often required in the data analysis and often, visible breaks in the data can help establish the boundary along with the calculation of salience to prioritize results.

3.5 Comparison of Semi-structured Interviews and Freelisting Results

To determine the final list of practices and attributes, the highest-ranking results from the interview and survey datasets were compared by first listing the interview results and then cross-checking them against the survey results. Quinlan (2005) suggests checking freelisting results with interview results as complimentary data sets to help establish a domain. The goal of this exercise was to establish the highest-priority practices and attributes for sustainable utilities using the smallest number of categories of practices and attributes to help facilitate data generation using this framework. By comparing results from the interview and survey datasets,

results from two segments of the same population, the results reflected a broader perspective than either segment individually, which is needed for the broad application of this framework in future research to all U.S. urban water utilities.

The tables showing the comparison of highest-ranking results from the two datasets are shown in Tables 3.4 and 3.5 for the practices and attributes, respectively. In some cases, the shortened description for the practice or attribute did not exactly match the name given in the other dataset. In these cases, practices or attributes with a similar concept were paired. For example, the attribute of "Board Support / Political Will" from the interviews was paired with "Political Support/Coalitions with Public Officials" from the survey. Similarly, attributes describing a flexible, or open, culture were paired together along with pairing "Link Employees' Jobs to Sustainability" with "Sustainability Management Programs/Goals-Commitment," which describes a sustainability program that is embedded within the utility. Further discussion about this process is provided in Chapters 4 and 5.

Table 3.4 Comparison of Sustainable Practices Datasets

Interview data		**Survey data**		**Use for final framework?**
Rank (of 40)	**Practice**	**Practice**	**Rank (of 90)**	
1	Education and Communication	Education and Communication	10	Yes
2 (T)	Community Return on Investment (ROI)		N/A	No
2 (T)	Bond Rating / Financial Management	Financial Management	5	Yes
2 (T)	Resource Recovery	Resource Recovery	1	Yes
2 (T)	Green Infrastructure	Green Infrastructure / Permeable Pavement	6	Yes
2 (T)	Asset Management	Asset Management	3	Yes
7 (T)	Meet or Exceed Permit	Meet or Exceed Permit	25	No
7 (T)	Environmental Justice		N/A	No
7 (T)	Water Conservation	Water Conservation	2	Yes
7 (T)	Habitat / Watershed Protection	Habitat / Watershed Protection	12	Yes
11	Affordability	Affordability	64	No
12	Long-term Resource Plan	Long-term Resource Plan	6	Yes

Table 3.5 Comparison of Key Attributes Datasets

Interview data		Survey data		Use for final framework?
Rank (of 19)	**Attribute**	**Attribute**	**Rank (of 99)**	
1	Leadership	Leadership	4	Yes
T2	Board Support/Political Will	Political Support/Coalitions with Public Officials	16	Yes
T2	Link Employees' Jobs to Sustainability	Sustainability Mgmt. Programs/Goals-Commitment	7	Yes
4	Training	Staff Training & Development	2	Yes
5	Strategic Planning/Deployment	Strategically Focused	74	No
T6	Staff (flexible)	Culture - Open to New Ideas	8	Yes
T6	Incentives	Incentives / Process Improvement	60	No
T6	Innovative Culture	Innovation – Culture	9	Yes
T6	Organizational Vision	Organizational Vision	88	No

3.6 Selection of Indicators for Practices and Attributes

There are existing frameworks for measuring performance and benchmarking water utilities as noted in Section 2.2. To improve ease of use of this framework for U.S. urban water utilities, existing indicators and measurement were selected or adapted whenever possible. Incorporating existing indices may allow utilities already familiar with or using some of these other frameworks to minimize the effort required to complete the survey generated from this research.

To accomplish this, the final practices and attributes were mapped against a group of nine frameworks which are either performance indicator frameworks, benchmarking frameworks, or surveys. Each is relevant to assessing sustainability or relevant performance indicators of U.S. urban water utilities due to their geographical coverage, sector specificity, and/or focus on sustainability. The nine frameworks are described below.

1. AWWA Benchmarking Performance Indicators for Water and Wastewater Utilities Survey, formerly known as Qualserve, has an objective to "assess the performance of water and wastewater utilities using a variety of performance indicators (Benchmarking, 2016). The survey data, collected annually, results in 37 key

indicators with many of the qualitative assessments scored using a five-level Likert-type scale or a zero-one-two rating. (Benchmarking, 2016)

2. California Water Sustainability Indicators Framework is being developed as part of the California Water Plan. It contains 120 indicators that were developed to help measure and report on California's water sustainability at a state and regional scale. (Shilling, Khan, Juricich, Fong, & Hodge, 2012)
3. The EUM Primer for Water and Wastewater Utilities provides ten attributes of effectively managed utilities and five keys to management success. The EUM Primer's appendix contains example measures for the ten attributes, some drawn from other frameworks such as Qualserve. (EPA et al., 2008)
4. The Envision Rating System for Sustainable Infrastructure, Version 2.0, is "an objective framework of criteria and performance achievements" to "help users identify ways in which sustainable approaches can be used [for]…infrastructure projects (Institute for Sustainable Infrastructure (ISI) and Zofnass Program for Sustainable Infrastructure, 2012). Envision is designed for North American infrastructure, including water infrastructure. It has 55 credits in five categories and each is measured on a five point scale, referred to as "levels of achievement."
5. The International Water Association's (IWA) books on performance indicators for water utilities and wastewater utilities were developed so that "globally diverse economic, demographic, cultural, and climatic characteristics…[can] be acknowledged" (Alegre et al., 2006; Matos. Cardoso, Ashley, Duarte, Molinari, & Schulz, 2003). The two performance indicator systems are therefore broadly-

applicable and comprehensive, with 133 water indicators and 182 wastewater indicators (Cabrera et al., 2011).

6. The NACWA Financial Survey report is produced every four years and includes information beyond a wastewater utility's financial data. It also contains general information about the utilities, staffing data, and information on energy consumption. The report provides consolidated data in over 120 categories in five sections. (NACWA, 2012)
7. The National Water and Wastewater Benchmarking Initiative is a Canadian initiative for water and wastewater utilities. It uses 62 performance measures for water utilities, 49 for wastewater utilities, and 24 for stormwater utilities. (AECOM, 2013)
8. "Performance Benchmarking for Effectively Managed Water Utilities" is a Water Research Foundation (WaterRF) report and tool that builds off of the Effectively Managed Utilities Primer. It provides 117 performance measures, with each measure assessed with both a level of performance achieved (generally a one to five scale) and degree of implementation (also generally a one to five scale). (Matichich, 2014)
9. The San Francisco Public Utilities Commission (SFPUC) publishes an annual Performance/Strategic Sustainability Annual Report. SFPUC provides water, wastewater, and power services. The report contains 32 indicators, scored from one to five, in six categories that integrate TBL approaches. (SFPUC, 2014)

An example of the framework mapping of the Education and Communication practice is provided in Table 3.6. The complete mapping of all selected practices and attributes is provided in Appendix E. After mapping each of the practices and attributes against similar indicators in the nine frameworks, each was analyzed to see if the existing indicator met the intent of the

Table 3.6 Education and Communication Practice Mapping

Sustainable Practice	**AWWA Water and Wastewater Utilities Benchmarking Survey (2012)**	**California Water Sustainability Indicators Framework (2013)**	**EUM: A Primer for Water and Wastewater Utilities (2008)**	**Envision Rating System for Sustainable Infrastructure v2.0 (2012)**
Education and Communication	• Stakeholder outreach index (%) – comprised of surveys, open forums, numerous channels, addressing feedback, each 0-1-2 (never/rarely – less than annual – at least annually) (Q63) • Customer involvement program, 1-5 rating (not practiced – implemented but room for improvement – fully implemented) (Q13)	Participation in Local Stewardship (Participation rates in local stewardship by the local stakeholders such as municipalities, indigenous people, irrigation districts, community organizations, watershed associations, conservation groups, and stewardship groups.)	• Percent of positive or negative customer satisfaction survey responses based on a statistically valid survey or on an immediately after-service survey (p. 28) • ID stakeholders , conduct outreach, actively consult (y/n) (p. 43) • Act upon stakeholder input? (y/n) (p. 43) • Stakeholder satisfaction (overall satisfaction, responsiveness, message recollection) (p. 43) • Media/press coverage (amount, tone, accuracy) (p. 44)	The extent to which project stakeholders are identified and engaged in project decision making, and their satisfaction in the process (information transfer – open to a wider community – community relationship building) LD1.4

Table 3.6 (Continued)

Sustainable Practice	**IWA Performance Indicators (Water, 2006; Wastewater, 2003)**	**NACWA Financial Survey (2011)**	**(Canadian) National Water & Wastewater Benchmarking Initiative (2013)**	**WaterRF Performance Benchmarking for Effectively Managed Water Utilities (2014)**	**SFPUC Performance/ Strategic Sust. Report (2014)**
Education and Communication	• Response to written complaints (%) (QS34 water, wQS27 ww) • Customer service personnel (wPe6 water and ww)		• No. of water pressure complaints by customers / 1,000 people served (p. 18) • No. of wastewater related complaints / 1,000 people served (p. 32)	• Degree of positive customer feedback received via scientific survey (<60% - >90%) (2.3.1) • Success in media interaction (coverage fails – intermittent errors – consistently accurate) (10.4.1) • Success in positive media coverage (<50% negative – 50% positive - >75% positive) (10.4.2) • Stakeholder identification & understanding (few – some – most) (10.1.1) • Stakeholder engagement plan (no understanding – majority – near complete understanding (10.2.1) • Stakeholder support for utility direction (strong resistance – balanced split – strong support) (10.5.1)	• % of customers surveyed that rate SFPUC as good or better CR1.1 • Average wholesale customer satisfaction (1-5 scale) • % of traffic increase in SFPUC social media platforms • Foster engagement with current and developing stakeholder groups CY4.1

attribute or practice as determined by the interviews and survey results. Further discussion of the framework mapping process is provided in Chapters 4 and 5.

In some instances of the mapping process, there was a good match with an existing framework or multiple frameworks and in this case, an existing indicator was used for the pilot test of the survey generated from this research (see Section 3.6). In other instances, existing frameworks may have indicators that were similar to, but not a close enough measure of a particular practice or attributes. In these cases, existing frameworks' indicators and/or measures were adapted or modified. In this situation, a similar scaling scheme or familiarity with a similar construct could still provide the benefit of greater ease of use. As an example, the Education and Communication practice adapted the five-point measurement from question 13 of the AWWA Water and Wastewater Benchmarking Survey, but modified the indicator from AWWA's evaluation of a customer involvement program to include details of a broader communications plan, as described in Section 4.4.5. Finally, some practices or attributes did not have a match with existing frameworks. In these situations, entirely new indicators and scaling schemes were developed.

Practices and attributes were linked to as few indicators as possible to capture the intent of each and maintain simplicity for the survey. Many only had one indicator. However, others required more than one indicator to fully encompass the concept, including up to four indicators for the "Resource Recovery" practice as applied to wastewater and combined utilities.

3.7 Survey Development

The top eight sustainable practices and six key attributes were converted into survey form, listed alphabetically, with supporting guidance provided as needed for the user. This presented the practices and attributes in an order independent of frequency of mention by the

EAC members and survey participants. It also attempted to provide an easy-to-assess format for self-scoring and separate options for water, wastewater, and combined utilities. An instructions page provided background on the research and instructions for the user. References for the practices and attributes were added where existing frameworks were used or adapted as described in Section 3.5

3.7.1 Survey Structure

The survey was developed as a Microsoft Excel spreadsheet with multiple tabs: instructions, water utilities, wastewater utilities, combined utilities, and references. The instructions tab contained background on the project plus instructions for the user. Each user could then select one of the three tabs describing their utility's service: water, wastewater, or combined. The references tab explained how the indicators were selected and how some matched current indicators (a "source") and others were modified ("adapted.")

3.7.2 Survey Format

For ease of use, each practice and attribute was modified as needed to provide consistency throughout the survey. For example, each practice or attribute was assigned an abbreviated title, a noun, if needed. Then, indicators were all converted into a question format. Each indicator had a sentence or two of guidance added to assist the user with further context beyond the title and indicator. Finally, every indicator or practice was assigned a Likert-type scale of one to five for scoring, similar to the AWWA, Envision, and WaterRF frameworks described in Section 3.6.

Users were able to score the survey by simply entering a number, one to five, in the space provided. Upon completion, users were asked to save the file and e-mail it back. The pilot test utilities, described in Section 3.8, were provided an additional open-ended question after each

indicator: “Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.” Finally, three summary questions were provided for the pilot test utilities:

1. What was the approximate total time (in hours) required by all employees to complete this survey?
2. Which employees were needed to complete this survey? (provide titles, not names, e.g. CFO, HR Director, GM, etc.)
3. Do you believe there are any omissions in the questions provided in this survey (e.g. missing sustainable practices or key attributes)?

An example of one of the indicators for all three types of utilities is provided in Figure 3.2. Practice 2, Education & Communication, has two indicators, 2.1 and 2.2, to assess this practice area.

3.8 Pilot Testing

A pilot test of the survey was performed to test the survey’s clarity and required level of effort. Specific goals of the pilot test were to: assess whether the information required for each indicator was available and accessible with limited effort, determine indicator clarity, estimate the time required to complete the survey, determine who (what position(s) within the utility) was needed to complete the survey, and take the opportunity to ask participants if they thought there were any omissions. Pilot tests were completed between November 2015 and January 2016.

3.8.1 Pilot Testing Inclusion Criteria

Three U.S. urban water utilities were selected for testing the framework. Unlike the EAC utilities, these utilities were not selected because they were necessarily progressive utilities, but rather a more diverse cross-section of sustainability progression was sought. Three different

Practice 2: Education & Communication

Indicator 2.1: Does your utility have a public education program about its sustainability efforts?

Guidance: A public education program is externally-focused and designed to build support for and awareness of utility operations and sustainability efforts.

1	2	3	4	5	Score:
This activity is not practiced at our utility	This activity is implemented, but only occasionally or without uniformity	This activity is implemented, but there is room for substantial improvement	This activity is largely implemented, but there is room for improvement	This activity is fully implemented at our utility	

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Indicator 2.2: Does your utility have an effective communications plan that surveys stakeholders and engages them in dialogues?

Guidance: A communications plan solicits responses from and engage stakeholders before, during, and after service events and infrastructure activities.

1	2	3	4	5	Score:
This activity is not practiced at our utility	This activity is implemented, but only occasionally or without uniformity	This activity is implemented, but there is room for substantial improvement	This activity is largely implemented, but there is room for improvement	This activity is fully implemented at our utility	

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Figure 3.2 Example Sustainable Practice Survey Item: Education and Communication

utility typologies were selected, one water, one wastewater, and one combined utility. Three diverse geographic regions were also selected with demographics provided in Table 3.7.

Table 3.7 Pilot Test Utility Demographics

Utility Number	Region	Service	Population Served
1	South	Water	2,300,000
2	East	Wastewater	600,000*
3	West	Water and Wastewater	1,300,000

* Population served not available for utility number 2. Estimate provided is based on average daily flow of 33 million gallons per day (MGD) treated and a typical residential wastewater flowrate of 60 gallons per capita per day, in the middle of a range of a provided values and accounting for some water conservation by customers (WEF & ASCE, 2010).

3.8.2 Pilot Testing Feedback Incorporation

Specific feedback and recommended changes from the pilot test results were assessed and incorporated into the final, recommended survey to be used in subsequent research applying this framework to a larger number of diverse utilities to gather sector-wide data on sustainable practices and key attributes. Results from the sustainable practices indicators and key attributes are provided in Chapter 6. General feedback on the survey and implications for future research are provided in Chapter 7.

CHAPTER 4: A SUSTAINABILITY INDEX FOR THE SCORING AND COMPARISON OF URBAN WATER UTILITIES

4.1 Introduction

This chapter focuses on establishing the highest-ranking sustainable practices for U.S. urban water utilities. These practices are the foundation for the first half of a utility survey that is the framework, and final output, from this research. This framework is described in Chapter 6. Sections 4.4.2.1 and 4.4.3.1 present details of the practices that were selected for the survey and discusses some of the practices that were not ultimately selected, presenting theories for the discrepancies between the participant groups' responses. Overall, chapter 4 describes the work and outputs from Work Package 1, shown in Figure 1.1.

4.2 Research Objectives and Questions

The specific research objective addressed in this chapter is to develop a sustainability index that allows the efficient quantitative scoring and comparison of urban water utilities. This objective answers two of the five research questions for this overall program:

1. What are the components of a sustainable urban water utility in the U.S.?
2. What sustainability indicators make up those components of a sustainable urban water utility?

4.3 Literature

Background literature that helped define the scope for this overall research program is provided in Chapter 2. It describes the current status of the sector, drivers, data availability, sustainability studies, and recent work supporting a new vision for the sector. The literature

referenced in this chapter is specific to sustainability indicators and the components that define the TBL-plus approach to U.S. urban water utility sustainability.

4.3.1 Sustainability Scope and Indicators

Numerous papers have been published on water sustainability and many of these studies recommended sets of metrics or indicators for specific situations. The scope of these studies was usually broad, encompassing large-scale water resource management and reclamation using the IWRM process. Gallego-Ayala's (2013) study of IWRM literature over the past decade, noted in Section 1.1, showed that most of the literature focused on large-scale (at the river basin or country-wide) studies. Other researchers narrowed the scope and used the concept of SUWM. For example, Van Leeuwen, Frijns, van Wezel, & van de Ven (2012) developed the City Blueprint® approach for the comparison of cities' sustainable water management. Limited research has been done on sustainability indicators for urban water and wastewater utilities in the U.S., although information can be gleaned from related research. Outside of the U.S., Hellström, Jepson, and Karrman (2000) provided a framework for analyzing the sustainability of Swedish urban water and wastewater utilities. Balkema, Preisig, Otterpohl, and Lambert (2002) compiled a set of sustainability indicators from 15 studies on wastewater treatment systems, generally in Europe. At a smaller system scale, Guest et al. (2010) evaluated sustainability metrics for decentralized wastewater treatment alternatives. Liner et al. (2012) proposed social metrics for drinking water utilities, focusing on one component of the triple bottom line for a specific water service.

Moving beyond peer-reviewed literature, several reports from government, professional associations, research entities, and utilities provided sets of metrics. The Global Reporting Initiative (GRI) produced its Sustainability Reporting Framework with guidance for businesses

and other entities to understand and report on sustainability performance. There are approximately 23,000 publicly-posted sustainability reports, but filtering results for "water utilities" in "Northern America" (a U.S. option is not available), returns only 11 reports. Of those, only one is a public water utility, SFPUC, and the other ten are private water companies and water equipment manufacturers. (Sustainability Disclosure Database, 2015) The SFPUC report, also referenced in Section 3.6, is called the "Performance/Strategic Sustainability Annual Report" and contains 32 indicators which are scored and presented, unweighted, in six categories. Other U.S. utilities, such as the Metropolitan Sewer District of Greater Cincinnati and the Milwaukee Metropolitan Sewerage District have also produced sustainability reports, but they provide more of a narrative description of the programs, rather than specific measurement via indicators (MMSD, 2011; MSDGC, 2012). Also referenced in Section 3.6 are sustainability frameworks for California water and civil infrastructure in North America. The California Water Sustainability Indicators Framework provides indicators to align with the goals and objectives of the California Water Plan. It takes a statewide and sometimes regional approach to the broad topic of water resource management (Shilling et al., 2012). The Envision Rating System for Sustainable Infrastructure has 55 measures, or "credits," which are measured on a five-point scale for level of achievement (ISI and Zofnass Program for Sustainable Infrastructure, 2012). Finally, an American Water Works Association Research Foundation report by Kenway, Howe, and Maheepala (2007) compiled guidance on TBL reporting for potable water utilities.

With limited literature specific to U.S. urban water and wastewater utility sustainability performance, related performance frameworks were evaluated. Depending on the scope, performance framework indicators may overlap with sustainability indicators. A discussion about the overlap of performance indicators and sustainability indicators is provided in Section

2.3 above. The five *performance* frameworks used for the practices and attribute mapping are described in Section 3.6 and are listed below:

1. AWWA Benchmarking Performance Indicators for Water and Wastewater Utilities Survey
2. IWA books on performance indicators for water utilities and wastewater utilities
3. NACWA Financial Survey
4. National (Canadian) Water and Wastewater Benchmarking Initiative
5. WaterRF Performance Benchmarking for Effectively Managed Water Utilities

Also included in the attribute mapping in Section 3.6 is the EUM Primer for Water and Wastewater Utilities. The EUM program was jointly developed by the EPA and six national water and wastewater associations in 2007, and published the EUM primer in 2008 (EPA et al., 2008). While the program promotes utility *effectiveness*, it also describes many of the key elements of sustainable utilities. The EUM primer describes ten "attributes" for effectively-managed utilities, described as "desired outcomes:"

1. Product Quality;
2. Customer Satisfaction;
3. Employee and Leadership Development;
4. Operational Optimization;
5. Financial Viability;
6. Infrastructure Stability;
7. Operational Resiliency;
8. Community Sustainability;

9. Water Resource Adequacy; and
10. Stakeholder Understanding and Support.

The EUM Primer also includes five "keys to success," described as management approaches and systems:

1. Leadership;
2. Strategic Business Planning;
3. Organizational Approaches;
4. Measurement; and
5. Continual Improvement Management Framework.

In parallel with this research, EPA, the original six water associations, and two additional state regulatory associations convened a group of utility leaders in 2015 to review the original framework, in light of "key operating context shifts" (EPA, 2016). Findings from that review, conducted without any overlap in participation by utility leaders, mirror some of the findings of this research program. These shifts include greater external attention to customer expectations, interest in resource recovery, and the use of green infrastructure for stormwater and watershed management. The 2015 EUM review and relation to this research is described further in Section 4.4.4.4 below.

The TBL framework described in Section 1.1 provides categories to organize sustainability, but ultimately, the selection of indicators will impact the consistency and usefulness of the framework developed in this research. Juwana, Muttil, and Perera (2012) provided a review of indicator-based water sustainability assessments including, for example, that indicators should be sensitive to time change, predictive, and account for data availability. The last point is relevant in this research because there is very limited water utility data reported

consistently to the EPA by all water utilities. National water utility data collection and subsequent reporting in the U.S. is limited to water quality and is not as robust as the European WFD.

Assigning weighting to indicators and components was not included in this research program. The use of pairwise comparisons, for example, to determine indicator weighting by stakeholders and a related sensitivity analysis is suggested as potential follow-on research for regional, or a narrower application of this framework, described in Section 7.7. However, an inherent challenge in the selection of indicators in this project is the extreme diversity of utility typology and climate in the U.S, which will create a broad range of opinions on weighting. Ultimately, a composite score expressing a sustainability index for the utility was calculated and can used for comparative purposes. This non-weighted approach consistent with Van Leeuwen (2013) who made a "pragmatic decision" to give the same weight to the 24 indicators used in the City Blueprint® Framework to develop a Blue City Index for each participating city.

A recent study by Landis (2015) looked not at specific sustainability indicators, but rather assessed the penetration of sustainability plans and policies in Canada, Mexico, and the U.S. The study, commissioned by AWWA, evaluated water supply and combined utilities, with very limited wastewater utility participation. Of the 125 survey respondents, all of whom were AWWA utility members, almost 79% had no sustainability plan and the remaining 21% had either a "sustainability plan and/or policy." Information about the practice of reporting on sustainability was not requested of respondents. The most frequently cited metric to evaluate sustainability was "water delivery efficiency," reflecting the water supply focus of the survey population. Overall, the penetration of sustainability practices, policies, tools, and metrics among the respondents was limited.

4.3.2 Sustainability Components and TBL-plus Concept

Most of the papers referenced in Section 4.3.1used the TBL as a starting point for the development of sustainability criteria, organizing specific indicators under the three TBL components: economic, environmental, and social. Van Leeuwen and Serps (2014) based their City Blueprint® approach on "urban water cycle services" sustainability dimensions, which add the components of governance and assets to the TBL. Hellström et al. (2000) added two components: health and hygiene and functional and technical. Balkema et al. (2002) added a group of technical components, and Guest et al. (2010) added functional metrics, including adaptability, robustness, and resilience.

The initial literature review generated a list of preliminary, often-cited indicators with potential applicability to U.S. urban water utilities. These indicators were categorized in the TBL components, but some indicators did not easily fit within those three components. Initial inspection revealed that those that did not fit appeared to have a common theme of infrastructure. The preliminary list of indicators are shown in Table 4.1, with the fourth component of infrastructure added. Therefore, the concept of the TBL-plus was proposed for this research and added to the EAC interviews for input. Feedback on the TBL-plus concept is provided in Section 4.4.1.

4.4 Results and Discussion

The following sections provide results and discussion on the sustainability components (TBL-plus concept) and input from the EAC and survey participants. Follow-on EAC interview questions about sustainability reporting is also included. All of this informs a final list of highest-priority sustainable practices and an index with indicators to assess overall sustainability.

Table 4.1 Preliminary List of Sustainability Indicators

	TBL-plus Component			
	Economic	**Environmental**	**Social**	**Infrastructure**
Preliminary Indicator	Bond ratings or credit strength[2,6,7,10]	Biosolids beneficially reused (as applicable)[2,10,11]	Internal: workforce sustainability – benefits[11]	Asset renewal/ replacement rates[2,9,10]
	Debt service coverage ratio[2,4,5,10,11]	Energy recovered[11]	Internal: workforce sustainability – employee retention[2, 11]	Preventative maintenance ratio[1,10]
	Long-term financial plan[1,3,10]	Greenhouse gas emissions[5]	Internal: workforce sustainability – health and safety[5]	Resiliency assessment[3,7]
	Revenue/expenditure ratio[2]	Nutrients recovered/ recycled (as applicable)[8]	External: consumer satisfaction[5]	Risk assessment[10]
		Water loss (as applicable)[2]	External: user rate affordability[5]	Short-term/long-term water supply adequacy (as applicable)[2,6,10]
		Water recycling[5]		Strategic plan in place[10]

Note. Data for sustainability indicators from [1]Benchmarking (2016); [2]EPA et al. (2008); [3]EPA (2014a); [4]IBNET (2015); [5]Kenway et al. (2007); [6]Matichich (2014); [7](2012); [8]Palme, Lundin, Tillman, & Molander (2005); [9]Steering Committee & Tel Aviv Water Club (2011); [10]SFPUC (2014); [11]Sustainability Reporting Statements for Wastewater Systems (2012)

4.4.1 Sustainability Components

The first question for the EAC was "What do you think about using the 'triple bottom line-plus' framework, with the plus being infrastructure, as a water utility sustainability framework?" Each EAC member was already familiar with the TBL concept. Eight of the twelve strongly supported the idea of adding infrastructure as the fourth component in the context of this research. A manager at the Philadelphia Water Department stated "I love the plus…I like the idea of plus being infrastructure…it allows [the] economic [component of the TBL] to be more about finances, which is critical." Of the remaining four EAC members who did not strongly

support the idea, none opposed, but two wondered if infrastructure practices would be a part of the economic component of the TBL or distributed throughout. A manager at Alexandria Renew Enterprises asked "Wouldn't the infrastructure piece be covered already [by] the economical piece? It almost transcends all three of them [the TBL components]." However, an analysis of results did not show explicit overlap of infrastructure and economic practices. Figure 4.3 shows that the two practices primarily mentioned as an infrastructure component, Asset Management and Long Term Resource Planning, were not also mentioned as an economically-sustainable practice by the EAC members.

The EAC feedback affirmed the potential application of the TBL concept for this research. Therefore, the final sustainable practices were checked against the TBL-plus components to be sure all components were included in the final framework as discussed later in Section 4.4.4.3. This check was performed to ensure the final list of practices was comprehensive enough to assess a utility's sustainability.

4.4.2 Semi-structured Interviews

The second, third, and fourth key questions for the EAC are shown in Table 3.2. Asking about economically-sustainable, environmentally-sustainable, socially-sustainable, and infrastructure-related sustainability practices separately allowed the highest-frequency responses to be organized by, and checked against each TBL-plus component. After the discourse analysis of the transcripts described in Section 3.2.5, a final list of 40 sustainable practices was generated, shown in Figure 4.1 and in table format in Appendix F. The practices are ordered first by number of responses, then alphabetically.

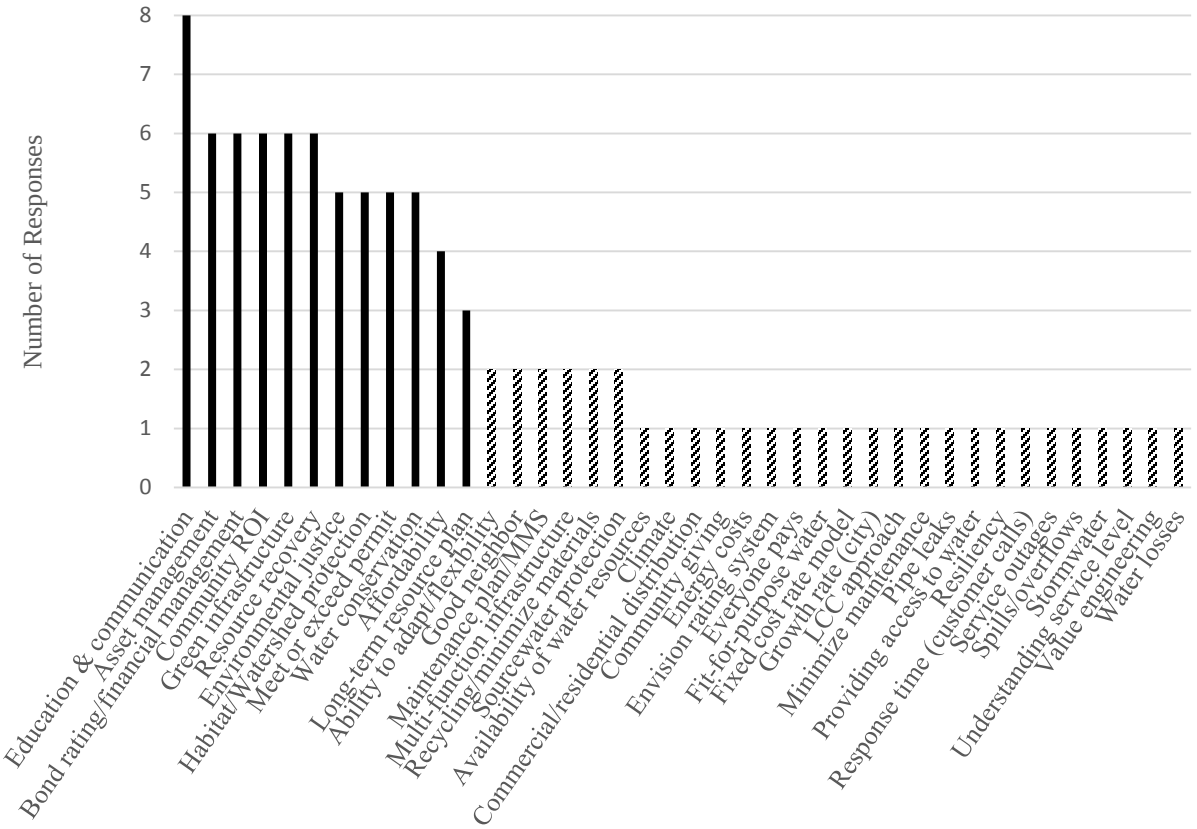


Figure 4.1 Sustainable Practices from EAC Interviews

4.4.2.1 Top 12 Sustainable Practices from the EAC

Figure 4.1 reveals a "break point" in the practices after the top 12 with the highest number of responses, shown as solid bars. Most of the remaining 28 practices received only one mention. This cutoff at 12 practices also improves the potential of generating data from this framework. A smaller number of practices results in a more accessible framework which requires fewer resources to complete. The practice codes shown in Figure 4.1 only provide a short description of the concept for each. Therefore, further description and EAC context are provided in the following sections.

4.4.2.1.1 Education and Communication

Education and Communication was the most-frequently cited sustainable practice and combines public education, communication, and ratepayer surveys as noted practices. It was

always cited as a socially-sustainable practice, and reflects a two-way flow of information between the utility and its engaged stakeholders. A manager from the San Francisco Public Utilities Commission asked "How do you get people to really appreciate the value of water?" and noted, "One of the things we've been doing…is to really educate people on the value of water…because our infrastructure is invisible. You don't see most of it. It's underground." Public education and communication strategies were mentioned as proactive ways to connect with the community, build support, leverage other projects, and overcome past failures and tension with ratepayers. This external focus can positively impact the acceptance of rate increases needed to support future infrastructure needs, helping ensure more sustainable operations.

Related to this practice, the Value of Water Coalition is a convening of water sector leaders seeking to communicate "the importance of water to the economic, environmental, and social well-being of America" (Value of Water Coalition, 2016). Its membership is comprised of 14 utilities, both public and private; water associations; consultants; and a manufacturer. Almost half of the Value of Water Coalition utilities are represented on the EAC. Most of those EAC members mentioned Education and Communication as a sustainable practice, but it was also noted by just as many non-Value of Water Coalition utilities. It appears that recent activity by the coalition may have influenced the EAC members, keeping this issue at the forefront of the water sector's agenda. Table 4.2 shows which EAC members mentioned Education and Communication, and which are participating as Value of Water Coalition utilities.

Interestingly, the high ranking of the Education and Communication practice contrasts with a recent, broad-reaching survey of potable water utility executives. Teodoro (2013) surveyed 300 water utility executives in the U.S., drawing from a random, stratified sample from

Table 4.2 EAC Connection to Education and Communication Practice and Value of Water Coalition

EAC member	Mentioned Education and Communication during interviews	Participating utility in Value of Water Coalition
1	X	X
2	X	
3	X	X
4		X
5		
6		X
7	X	X
8	X	X
9	X	
10		
11	X	
12	X	

the EPA's Safe Drinking Water Information System. Respondents were asked to rank the ten attributes from the EUM framework. The lowest attribute ("well behind the rest") was stakeholder support, which requires significant education and communication efforts. The attribute of customer satisfaction, which includes responsiveness and providing timely feedback, also has some overlap with the Education and Communication practice. It ranked in the second of four tiers of EUM attributes, third of the ten overall attributes. This is one of the higher-ranked attributes in Teodoro's research, but not at the top of the practices, as ranked by the EAC. This suggests that the twelve EAC members do, in fact, think differently about utility operations than a "typical" water utility executive. This is based on a demonstrated difference in priorities and the relative importance of external education, communication, and stakeholder engagement.

4.4.2.1.2 Asset Management

Asset Management was typically cited as an infrastructure-related sustainability practice with one respondent including it as an economically-sustainable practice also. Asset Management was always noted in the context of physical assets rather than, for example, human assets. The practice is described by a manager from Seattle Public Utilities, "An important

infrastructure-related sustainability practice is having a robust asset management system in place and…keeping good data on the infrastructure and having a good sense of when to run to failure versus when to do proactive replacement." Infrastructure is at the core of any water utility and the effective management of assets is essential to a sustainable utility. Specific practices included first knowing what and where the assets are, to knowing their operational condition, to having an asset management strategy for repair versus replacement. This strategy and a longer-term plan for infrastructure renewal or replacement was frequently linked to a utility's financial planning, the Bond Rating / Good Financial Management practice in Section 4.4.2.1.3. The link between asset management and sustainability was cited by Bloomfield, Ritter, and Fortin (2012), who noted the similarities between integrated asset management and sustainability. Each are multi-objective frameworks with a long-term, lifecycle focus. The authors recommended integrating the two frameworks for water utilities as a best management practice.

4.4.2.1.3 Bond Rating / Good Financial Management

Bond Rating/Financial Management combines several financial practices that will impact a utility's bond rating and, therefore, its financial sustainability. It was usually cited as economically-sustainable practice with one EAC member referring to it also as a socially-sustainable practice. It includes practices like:

- full cost pricing, charging rates that cover current expenses and debt service;
- a movement towards coverage of fixed costs, having a rate structure that is not totally dependent on volumetric rates, but rather has some fixed portion independent of water usage;
- keeping rate increases below a certain threshold; and
- maintaining a desirable bond rating, which results in borrowing at lower interest rates.

A former manager from Charleston Water tied several concepts together when he stated "…of course rates impact infrastructure replacement management, so a major focus on rates is very important and part of that would be having a desirable bond rating so you can borrow money to keep the rates down….. We've been recently focusing heavily on what our bond rating agencies are looking at, which has really helped us."

The use of a utility's bond rating as a financial indicator has precedence. Research by Morley (2012) used a utility's bond rating as one of twelve indicators to assess water utility resiliency. This research was incorporated into the AWWA J100-10 (R13) standard, Risk and Resilience Management of Water and Wastewater Systems, an American National Standards Institute-approved standard. However, Morley noted that not all utilities have a bond rating. Hughes et al. (2014) enumerated how many water utilities are rated by the three major rating agencies. Standard and Poor's rated approximately 1300, Moody's rated 800, and Fitch rated 400, based on 2011 and 2012 rating agency reports. Hughes et al. (2014) also noted that these ratings generally are issued to the country's largest utilities because they are issuing the most debt in the water sector. Therefore, use of a bond rating as an indicator must provide accommodations for those utilities that may not have a bond rating so that this framework can have broad applicability. This is addressed in Section 4.4.5.The EUM framework also cites a utility's bond rating as a "general indicator of financial health" (EPA et al., 2008).

4.4.2.1.4 Community Return on Investment

Community Return on Investment (ROI) was usually cited as a socially-sustainable practice, but several also noted it was an economically-sustainable practice. It describes water infrastructure investments that provide a return to and/or support the community at large, not just benefit the utility. A manager from the Cincinnati water utilities noted that "sustainability is all

about creating outcomes. So in the end, if Cincinnati's utility hasn't become successful in supporting the overall economic goal of the community, then we haven't delivered the sustainability for that community." Specific "returns," or benefits, for the community mentioned by the EAC members include the creation of local, green jobs related to infrastructure improvements; increased property values from green infrastructure projects; minimizing disruptions to the community as a result of infrastructure construction; and a reduction in crime due to infrastructure/community upgrades. A former manager at the New York City Department of Environmental Protection described socially-sustainable practices as "practices that people support and will make for a stronger community in the long run…one element might be the labor piece and…actually creating jobs."

The concept of Community ROI was not anticipated, based upon the literature review, and this appears to be a relatively new focus for the U.S. water sector. A 2014 report, National Economic & Labor Impacts of the Water Utility Sector, referred to as the Economic and Labor Impacts report, focused on the economic impacts of water utilities, aggregating 30 utilities' operating and capital budgets (Quinn, Safriet, Feeney, & Lauf, 2014). It is possible this report, released four months before the interviews started, influenced EAC thinking about this topic, even though it was not mentioned specifically. Table 4.3 shows the EAC participation in the study and a cross-reference of utilities that mentioned Community ROI as a practice in the interviews. Of the six EAC members who mentioned Community ROI as a practice, all but one was a participating utility in the study.

Similar to Education and Communication in Section 4.4.2.1.1, Teodoro's 2013 survey of water utility executives also provides a contrasting result. His research showed community sustainability was rated near the bottom of the ten EUM attributes by the 300 surveyed water

Table 4.3 EAC Connection to Community ROI Practice and Economic and Labor Impacts Report

EAC member	Mentioned Community ROI during interviews	Participating utility in Economic and Labor Impacts report
1	X	X
2		
3		X
4	X	X
5	X	X
6		X
7	X	X
8	X	X
9		X
10	X	
11		
12		

executives. Community sustainability has elements of community and watershed health and welfare, and it overlaps with the concepts of the Community ROI practice. Again, this demonstrates the differentiation in priorities and thinking between the twelve EAC members who rated this practice highly (tied for second-*highest*), and the priorities of a random sampling of "typical" water utility executives who gave this a low rating, the second-*lowest* EUM attribute.

4.4.2.1.5 Green Infrastructure

Green Infrastructure is a sustainable practice cited mostly as an environmental practice, but was also noted as both a social and infrastructure-related practice. According to Benedict and McMahon (2006), green infrastructure has different definitions, depending on the context, and they define it broadly as "an interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife." For this research, it was typically mentioned in the context of replacing gray, or conventional infrastructure, with green infrastructure for urban stormwater management. It included specific practices like green roofs and other practices which had multiple benefits, including keeping stormwater out of combined sewer systems, but also

creating green jobs and improving communities at large. A manager from Alexandria Renew Enterprises described green infrastructure as a way to "tie in things that a community needs with [its] wants." Related, a manager from DC Water noted it is a multi-benefit solution that can "control flooding, but have all these other benefits of greening the streets [and] jobs that are created… [to] obtain all of these goals."

4.4.2.1.6 Resource Recovery

Resource Recovery encompasses the concept of recovering resources from water or wastewater in the form of N-E-W. Noted most frequently as an environmental practice, Resource Recovery was also mentioned as an economic and infrastructure-related component of sustainability. Specifically mentioned was: nutrient recovery from struvite precipitation or Biosolids land application; kinetic (in-pipe), heat (heat exchangers), and chemical (biogas conversion to energy) energy recovery; and water reuse programs as a form of water recovery. Energy neutrality was noted as a goal by two of the participants, and one that is easily quantifiable, relatively speaking. A former manager from a northeastern wastewater utility noted "net zero or net positive energy production…is probably the most important thing and the most measurable, the most controllable thing we can do." Approaching Resource Recovery more broadly, a manager at the Metropolitan Water Reclamation District of Greater Chicago stated "I think that as a society we have to move into resource recovery. I think we have to look at this industry differently than just being a waste industry, so we're moving towards those practices."

4.4.2.1.7 Environmental Justice

Environmental Justice noted as both an environmentally- and socially-sustainable practice, combines practices of making sure performance and service level is equitable throughout the service area, regardless of income level; to reaching out specifically to

underserved areas in various languages; to having a specific environmental justice policy in place. Proximity of treatment facilities to surrounding neighborhoods and the subsequent impact on those neighborhoods was mentioned as an environmental justice issue. A manager from SFPUC mentioned that it is "one of the first and only utilities that have an environmental justice policy and also have a community benefit policy," underscoring its commitment to positively impact both the environment and its communities.

4.4.2.1.8 Habitat / Watershed Protection

Habitat/Watershed Protection is a practice that both water and wastewater leaders cited mainly as an environmental component of sustainability, but also a social component. It includes practices that have impact beyond a utility's physical boundaries such as benthic studies, habitat restoration, providing minimum environmental flows, and impacts on commercial fishing. Habitat / Watershed Protection *excludes* source water protection, which was noted, but only by two of the participants. EAC members from wastewater utilities noted the impact their discharges had on aquatic habitat, both from a water quality and quantity perspective. EAC members from water utilities focused on environmental flows, with a former manager at the Southern Nevada Water Authority stating "we have to find ways to share the water resources with all the aquatic habitat [and] aquatic species that we take the water from…and the land that we take the water from."

4.4.2.1.9 Meet or Exceed Permit

Meet or Exceed Permit, cited only as an environmentally-sustainable practice, brings together the practice of meeting one's permit as a necessary environmental practice. However it also includes the practice of going beyond permit requirements as a sustainable practice. Simply meeting the permit is considered good "performance," but in itself, does not necessarily equate to

sustainability. It is included as a *performance* indicator in multiple frameworks, including AWWA's Benchmarking Performance Indicators for Water and Wastewater Utilities (Benchmarking, 2016); the Effective Utility Management Primer (EPA et al., 2008); IWA's books on performance indicators for water utilities (Alegre et al., 2006) and wastewater utilities (Matos et al., 2003); SFPUC's Performance/Strategic Sustainability Annual Report (SFPUC, 2014); and WaterRF's Performance Benchmarking for Effectively Managed Utilities (Matichich, 2014). However, a former manager at the Southern Nevada Water Authority observed that "just adhering to the regulatory standards is…an epidemic in this country, among wastewater agencies. They simply treat to the standard, whether that standard is appropriate or not because conditions change. …I think all of those pieces [including conservation, habitat protection, and water reuse] have to be part of what you would call your environmentally-sustainable utility."

4.4.2.1.10 Water Conservation

Water Conservation was cited exclusively as an environmentally-sustainable practice by EAC members from potable water and combined utilities, including both arid and water-rich regions. This differs from Resource Recovery and specifically water reuse, which focused on the reclamation of used water. This practice included the utility encouraging, coercing, or even forcing water conservation by its customers. It entails comprehensive programs for water users by the water utility, to extend the life of existing supplies. This practice is grounded in the acknowledgement that a sustainable future water supply is going to be dependent on using less water rather than exploiting new water sources to satisfy increasing demand.

4.4.2.1.11 Affordability

Affordability and the challenges of understanding your community's ability to pay is a common challenge for any urban utility and was noted by the EAC primarily as both a socially-

and economically-sustainable practice. None of the utility leaders cited specific thresholds, although some industry standards exist. For example, EPA provides guidance that wastewater bills exceeding 2% of median household income (MHI) can have a high financial impact on households (EPA, 1997). However, a manager at the Cincinnati water utilities noted the shortcomings of the MHI measurement, citing pockets within their service areas where MHI was almost one-third of the averaged MHI. In that situation, rate increases can fall disproportionally on a specific community even if it satisfies EPA's recommended metric. A manager at Spartanburg (South Carolina) Water linked service levels and Affordability by noting that to be sustainable, you have to understand "the cost of your system and the capability of your community to pay for that system. You know you can set a service level way beyond the affordability of your community and you've got to know where that threshold is."

4.4.2.1.12 Long-term Resource Plan

Having a Long-term Resource Plan was exclusively cited as an infrastructure-related sustainability practice. It refers to long-term overall planning, capital plans, and their relation to financial plans. It is independent of whether water is scarce in a particular region. A manager at the Philadelphia Water Department pulled together many of the variables when he described their:

> 50-year planning horizon for all our water and wastewater systems. Looking at everything from the source of water, the impacts of climate change, down to our water treatment plants, distribution systems, our collection systems, our wastewater facilities. And looking at all impacts [to the systems]… whether it be climate change or age and replacement time or looking at new regulations/requirements.

4.4.2.2 Barriers to Adoption of Sustainability Indicators

Follow-up questions about measurement of the cited sustainable practices were asked during the interviews. Data gathered from these questions about the TBL-plus components of sustainable practices for U.S. urban water utilities confirmed that there was limited use of sustainability indicators among the EAC members' utilities. The next key question in the interview was "What do you see as the most significant barriers to more widespread adoption of sustainability indicators?"

Responses revealed a diversity of barriers. Results shown in Table 4.4 are not mutually-exclusive. Some EAC participants may have mentioned more than one barrier. The top response, noted by half of the EAC members, confirms the sentiment by Herrick and Pratt (2013) about the lack of an agreed-to definition of sustainability for the U.S. urban water sector. The second-highest response, a lack of incentive, or lack of competition, is linked to the monopolistic nature of U.S. water utilities. This barrier is beyond the influence of results from this research, but this research can help address the two other highest-ranked barriers. This research suggests an indicator-based TBL-plus framework for defining sustainability to address the lack of a definition. The framework focuses on providing a simple, accessible means for assessing sustainability, addressing the third-highest barrier cited.

Table 4.4 Barriers to More Widespread Adoption of Sustainability Indicators

Barrier number	Response rank	Barrier	Number of mentions
1	1	Lack of definition/complicated nature of sustainability indicators	6
2	2	No incentive / monopolistic nature of US water sector	4
3	3	Resource commitment (time, cost, labor)	3
4	4 (tied)	Community	1
5	4 (tied)	Disconnect from daily operations	1
6	4 (tied)	Politics	1
7	4 (tied)	Risk aversion	1
8	4 (tied)	Short-term thinking	1
9	4 (tied)	Variation among U.S. water utilities	1

While not a key question listed in Table 3.2, the semi-structured interview format permitted a follow-on question of "What actions do you believe would most effectively drive change and the accelerated adoption of the use of sustainability indicators?" The EAC responses from the eight participants who were asked this question did not generate a consensus response. Each action received only one mention and some answers overlapped with the barriers noted in Table 4.4 and answers to the question about who should drive the actions, below. The responses were as follows:

- Grass roots efforts / bottom-up in the utility
- Linking sustainability to operations
- Providing better definitions
- Regionalization
- Regulatory requirements
- Separating utilities from city government
- Sharing successes of early adopters
- Wall Street requirements

Additionally, there was a frequently-added follow-on question of "Who do you think should be the driver of these recommended actions?" Eight EAC members were asked and their responses, shown in Table 4.5, did not generate a consensus. Interestingly, those responses receiving the highest number of mentions were external, meaning even the progressive utility leaders that comprised the EAC saw the need for an external push to drive sustainability reporting. The community/public was cited by four of the EAC members who were asked, politicians were cited by three, and regulators were cited by two. Water associations and rating agencies/Wall Street were each mentioned once. Other research has cited the potential impact of

Wall Street, or the bond rating agencies. Hughes et al. (2014) noted the "driving power of credit rating financial metrics" and water utilities that specifically cite maintaining high credit ratings as parts of their financial policies. This raises the potential role by rating agencies, as a driver of adoption of sustainability indicators. One example of this is the issuance of "green bonds," used to promote infrastructure projects with an environmental benefit (Climate Bonds Initiative, Ceres, World Resources Institute (WRI), CDP, & Alliance for Global Water Adaptation, 2015). Of the 12 EAC members, only the manager from DC Water mentioned green bonds as a funding option as noted in Section 4.4.2.3. Regarding internal drivers of sustainability reporting, only two mentioned the utility itself as the driver and one specifically mentioned utility leaders.

Table 4.5 Who Should Drive Adoption of Sustainability Indicators?

Response number	Response rank	Who should drive actions?	Number of mentions
1	1	Community / public	4
2	2	Politicians	3
3	3 (T)	Regulators	2
4	3 (T)	Utilities themselves	2
5	5 (T)	Sector associations	1
6	5 (T)	Rating agencies / Wall Street	1
7	5 (T)	Utility leaders	1

4.4.2.3 Sustainability Reporting

Data gathered from the first four questions about the TBL-plus components of sustainable practices for U.S. urban water utilities confirmed that there was limited use of sustainability indicators among the EAC members' utilities. The next key question in the interview was "Do you currently, or do you plan to publicly report your utility's sustainability performance, either through Global Reporting Initiative (GRI) formats or others?" Of the 12 EAC members, only two said they were using GRI, while one additional member said they were thinking about it. A manager from DC Water noted their century bond is a certified green bond and that they "committed to measuring sustainability indicators to get the green certification. It was part of the

requirement." Several others were not familiar with GRI or its reporting framework. Considering the EAC members are leaders in some of the most progressive water utilities in the country, this suggests the practice of sustainability reporting has extremely limited penetration into the U.S. urban water utility sector. This is also reflected in Landis' (2015) research, which showed a small percentage of water utilities with either a sustainability plan and/or policy, much less *reporting* results.

4.4.3 Freelisting Surveys

Background information and the questions for the 31 survey participants are provided in Section 3.3.4. The participants' free lists for sustainable practices were initially coded to 108 practices, recoded, statistically analyzed, and ordered first by frequency of response and then Smith's S, a measure of salience of each response. Statistics on the responses and participants are provided in Table 4.6.

Table 4.6 Survey Respondent Statistics: Sustainable Practices

Total number of participants	31
Work primarily with both water and wastewater utilities	15
Work primarily with wastewater utilities	10
Work primarily with water utilities	6
Total number of practices cited	305
Average number of practices per participant	9.8
Median number of practices	9
Maximum number of practices	20
Minimum number of practices	2

After coding and recoding, a final list of 90 sustainable practices was generated, with the response chart shown in Figure 4.2. Individual practices are not shown for clarity in Figure 4.2, but the top 12 practices are provided in Table 4.7 and the full list is provided in table format in Appendix G.

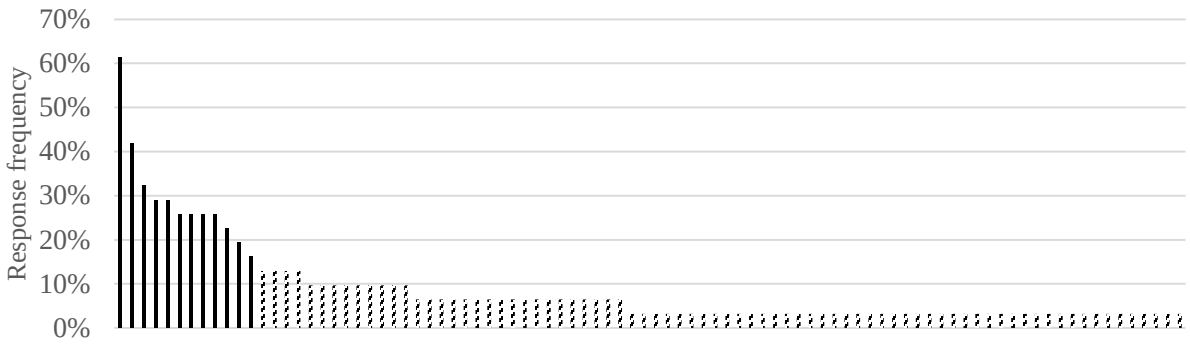


Figure 4.2 Freelisting Results of Sustainable Practices from Survey Participants

Table 4.7 Top 12 Sustainable Practices from Survey Participants

Rank	Practice	% Responses	S
1	Resource recovery	61%	0.4452
2	Water conservation	42%	0.2612
3	Asset management	32%	0.2342
4	Energy eff./ E star / E cons.	29%	0.2507
5	Bond rating/financial management	29%	0.1875
6	Green infra/permeable pvmt	26%	0.1857
7	Renewables	26%	0.1784
8	Employee skills eval/plan/HR	26%	0.1782
9	Long-term resource plan	26%	0.1219
10	Education & communication	23%	0.0819
11	Climate	19%	0.0934
12	Habitat/watershed protection	16%	0.0643

4.4.3.1 Top 12 Sustainable Practices from Survey Participants

Figure 4.2 reveals a breakpoint in the practices after the top 12 with the highest number of responses, shown as solid bars. Most of the remaining 78 practices received only one response, with a few receiving two or three responses. This follows a "core/periphery" structure with a small number of more frequently-cited responses and a larger number of less-frequently-cited responses. Additional respondents would likely produce a longer tail on the curve, but the core responses would not change (Schensul & LeCompte, 2012). Unlike the top practices from the EAC, much less content and context is available for the survey participant responses. But, examples of the raw data responses that coded the top 12 practices are provided in the sections below.

4.4.3.1.1 Resource Recovery

As described in Section in 4.4.2.1.6, the practice of Resource Recovery combines N-E-W resources for the survey data, as well as the interviews. General responses of "resource recovery" were received along with more specific practices. Water reuse was most frequently cited, followed by land application of biosolids and using digester gas to produce electricity. Kinetic energy recovery and nutrient recovery were also mentioned.

4.4.3.1.2 Water Conservation

This practice was most frequently noted as simply Water Conservation. But, other related practices, such as water conservation education, or having a water conservation plan or conservation program were noted multiple times. This practice included specific practices such as rebates to encourage conservation or low flow toilets.

4.4.3.1.3 Asset Management

Asset Management was cited as a practice, along with having an asset management program. The more specific responses of infrastructure condition, or condition assessment, was combined with the more general practice of Asset Management.

4.4.3.1.4 Energy Efficiency / Energy Star / Energy Conservation

The coding of this practice combines several responses as noted in Section 3.3.5.1. General practices, such as energy efficiency and energy conservation, were combined with reference to EPA's Energy Star program, which encourages energy efficiency. Energy reduction programs were mentioned along with specific practices like improving the energy efficiency of blowers, often the largest energy consumer at a WRRF (WEF, 2013). Finally, plant process optimization was noted in the context of minimizing chemicals, with an indirect impact on energy, and reducing energy specifically.

4.4.3.1.5 Financial Management

Responses ranged from the general Financial Management to more specific practices. Financial strength, reporting, planning, and stewardship, along with an ability to finance projects were some of the more general responses. More specific responses included increasing block rates, adequate finances, and full cost accounting.

4.4.3.1.6 Green Infrastructure / Permeable Pavement

Green Infrastructure was most frequently cited as a general practice without further detail. A few other responses cited a more specific green infrastructure technology or installation of green roofs or permeable surfaces.

4.4.3.1.7 Renewables

Renewables is a general descriptor for several responses related to the use of renewable energy. This practice is differentiated from the practice of Resource Recovery in that the source of energy for renewables is not the utility's water or wastewater product itself. The use of renewable energy is not unique to water utilities; it can be utilized by businesses, other utilities, or individuals as well. Many participants citing this practice provided a more general response of switching to or using renewable energy. Others specifically noted solar, wind, and/or hydroelectric projects. One noted the practice of purchasing renewable energy credits and carbon offsets.

4.4.3.1.8 Human Resources / Staff Development

This concept brings together several practices, all related to the human resource function at a water utility. One participant covered much of this practice in their response, citing the "HR necessary to sustain their business: hiring, training, succession." Multiple participants noted workforce, staff, or professional development along with training. Others noted the specific need

for succession planning. This concept was highly rated as a utility attribute and categorized as such, as shown in Sections 5.4.1.1.4 and 5.4.2.1.1. This aligns with feedback on attributes from the EAC and previous research by Herrick & Pratt (2013).

4.4.3.1.9 Long-term Resource Plan

This practice combined several practices with long-term planning implications. One respondent cited having a "long-term view of capital needs" and another, a "future vision of where a plant wants to go." These were combined with more detailed actions like growth management, master planning, and population/demand projections.

4.4.3.1.10 Education and Communication

Survey responses for this practice reflected both the concepts of two-way communication and public education. Specific education topics included: science, technology, engineering, and math (STEM) as well as stakeholder engagement and stakeholder collaboration. Participants noted community support of a utility's sustainability efforts, while another noted the practice of simply having a communication plan.

4.4.3.1.11 Climate Adaptation and Mitigation

The practice of Climate Adaptation and Mitigation describes a response to or attempt to mitigate climate change. It encompasses several responses, which mainly, but not exclusively, describe elements of climate *adaptation*. Climate resiliency was noted, along with specifics like "storm surge" and "climate forcings/change – drought management," and accounting for climate change in a utility's capital improvement plan. EPA's Climate Ready Water Utilities program was specifically noted, a program designed to help water utility managers adapt to climate change ("Climate Ready Water Utilities," 2016). Climate mitigation was cited in the context of the reduction of greenhouse gases from WRRFs via specific technologies.

4.4.3.1.12 Habitat / Watershed Protection

This practice combined several responses describing actions and outcomes. Watershed Protection was specifically noted along with watershed management. Biodiversity, wetlands, and environmental water were also mentioned by participants.

4.4.4 Final Sustainable Practices

Section 3.5 describes the process for determining the final list of the highest-ranked and cross-referenced sustainable practices, shown in Table 3.4. In doing so, some highly-ranked practices from both the EAC and survey participants were not included in the final list. The sections below provide discussion about those eliminated practices and the indicators assigned to the final, selected practices.

4.4.4.1 Sustainable Practices from EAC Interviews Excluded from Final Framework

Four of the top twelve sustainable practices from the EAC were either not mentioned or were not highly-ranked by the survey respondents. The most noteworthy discrepancy is for the practice of Community ROI. It tied for the second-highest practice for the EAC, but was not mentioned by the survey respondents. One noted "quality of life" as a practice, but without additional context, it is not clear whether this refers to the community or perhaps utility employees. Regardless, it was only one response. The assessment of Community ROI and communication of the concept is fairly new in the sector and Section 4.4.2.1.4 describes the recent report by Quinn et al. (2014) on the topic. It is inherently externally-focused, measuring community returns on infrastructure investment, not necessarily just the returns for the utility. It was brought up primarily as a socially-sustainable practice. This practice was adopted in the 2016 Water Services Association of Australia's (WSAA) Asset Management Customer Value (AMCV) international benchmarking project, described in Section 7.6.1.

Two other practices that were excluded were also noted primarily as socially-sustainable practices: Environmental Justice and Affordability. The first, Environmental Justice, was not specifically mentioned by the survey respondents and Affordability was only mentioned once. The second, Meet or Exceed Permit, received three responses in the survey. Regardless, the practice of meeting the permit, as noted in Section 4.4.2.1.9, is good performance, but does not necessarily equate to sustainable operations. Going beyond the permit may not be sustainable from an overall net environmental benefit perspective and is location- and permit-specific without broad applicability across U.S. urban utilities.

A common element of three of the four excluded practices (Community ROI, Environmental Justice, and Affordability) is that they were noted as socially-sustainable practices. Additionally, they are externally-focused, centering on the community rather than the utility itself. This may reflect the different perspective of the collective EAC, whose members are at the highest levels of their utility and due to the nature of their positions, are externally focused. Teodoro (2013) estimated that the CEO of a potable water utility with more than 10,000 customer accounts spends from 15 to 35% of their time interacting with people outside the utility. The percentage increases as the number of customer accounts increase. This contrasts with the lower-level utility managers, consultants, and others as described in Section 3.3.2. Their focus will tend to be more on internal operations and management.

4.4.4.2 Sustainable Practices from Freelisting Surveys Excluded from Final Framework

Four of the top twelve sustainable practices from the survey respondents were either not mentioned or were not highly-ranked by the EAC. The fourth-highest response, energy efficiency/Energy Star/energy conservation, was not mentioned by the EAC. However, keeping energy costs down, a result of energy efficiency, was noted by one committee member. The use

of renewables, the seventh-highest survey response, was not mentioned by any EAC members in response to the open-ended questions about sustainable practices. The next-highest response, employee skills/staff planning/HR is effectively captured as one of the key *attributes* of U.S. urban water utilities, further described in Section 5.4.1.1.1

The practice of Climate Adaptation and Mitigation was only mentioned once by the EAC. This low response frequency *might* have been expected if the EAC's utilities were located in places that are not experiencing climate change, but that was not the case. Eight of the 12 EAC utilities are located on the coast or by tidally-influenced waterbodies. Two of the twelve are experiencing water scarcity challenges. Therefore, the infrequent reference to climate issues by the EAC is not easily explained, but due to the low response frequency, the practice was not carried over to the final list of sustainable practices. The lower priority given to climate change and mitigation was also shown in Landis' 2015 research, where in a pre-populated list of 13 factors influencing sustainability practices, lowering greenhouse gas emissions (climate mitigation) was ranked ninth and climate change readiness (climate adaptation) was ranked thirteenth.

4.4.4.3 Sustainable Practices for Final Framework and TBL-plus

A cross-reference of the datasets resulted in eight high-priority practices for use in the evaluation framework. The practice names from the two datasets were merged and resulted in the following list, ordered alphabetically so as not to bias perceived level of importance for those using the final framework from this research:

1. Asset Management
2. Education and Communication
3. Financial Management

4. Green Infrastructure
5. Habitat/Watershed Protection
6. Long-term Resource Plan
7. Resource Recovery
8. Water Conservation

Sections 4.3.2 and 4.4.1 describe the TBL-plus and the EAC reaction to the concept. The highest-priority practices were checked against the TBL-plus components, with results provided in Figure 4.3. Black boxes indicate the primary TBL-plus component where each practice was exclusively or most frequently mentioned in response to questions 2 through 5 in Table 3.2. Gray boxes indicate when a practice was mentioned in response to something other than the primary TBL-plus component. Three practices were mentioned only in response to one question. For example, Asset Management was only mentioned in response to the question about the most important infrastructure-related sustainable practices. Other practices, like Green Infrastructure and Resource Recovery, were mentioned in response to three of the four sustainability questions.

Practice	**Economic**	**Environmental**	**Social**	**Infrastructure**
Asset Management				
Education and Communication				
Financial management				
Green Infrastructure				
Habitat/watershed Protection				
Long-term Resource Plan				
Resource Recovery				
Water Conservation				

Figure 4.3 TBL-plus Component Check

The purpose of the check was to ensure that the final list of practices, narrowed down to the highest-priority practices, were sufficiently broad to encompass all the TBL-plus components. Figure 4.3 shows at least one black box in each of the TBL-plus component columns, meeting the requirement of TBL-plus coverage. If the final list was missing primary coverage in one of the four TBL-plus components, the results would have to be re-considered to have a list of practices that truly measure the sustainability of a U.S. urban water utility when using the TBL-plus framework for sustainability assessment. For example, if the top results did not include a practice that was primarily economically-sustainable, then the final framework would not truly encompass urban water utility sustainability as presented in this research and discussed in Section 4.4.1. The sector's inclination to thinking about sustainability primarily as environmentally-beneficial activities was noted in the Herrick et al. (2013) study on organizational culture and sustainable water operations. This check on the TBL-plus components also demonstrates the multi-dimensional nature of many of the final practices. Sustainability is inherently a concept with overlapping and often undefined boundaries and the multiple gray boxes in Figure 4.3 reflects this.

4.4.4.4 Effective Utility Management Key Operating Context Shifts

The EUM program and the 2015 review are described in Section 4.3.1. The review was performed in response to an acknowledgement that a number of key operating context shifts had occurred in the water sector since the original EUM Primer publication in 2008. These context shifts were delineated after interviews with utility management leaders in 2015 and released in February 2016. A comparison of the EUM review findings (EPA, 2016) and the results from this research are provided in Table 4.8. The comparison reveals that the final sustainable practices and key attributes established by this research were generally reflected in the EUM findings.

Four of the seven key operating context shifts are reflected in the priority practices and attributes from this research, and the other three were either lower priority or a fundamental driver for this research. Only the smart data context shift was not reflected in this research. The independent EUM results help independently confirm the prioritized results from this research.

Table 4.8 EUM Key Operating Context Shifts Compared to Research Findings

EUM key operating context shift	**Research Findings**
Accelerated adoption of automated and "smart" systems and data integration	Was not highly-ranked by survey participants and EAC members
Growing climate variability and extremes	Highly-ranked practice by survey participants but not high enough ranking by EAC members so was not selected as a final practice
Enhanced customer expectations and public awareness	Reflected in Education and Communication practice
Expanded challenges associated with employee recruitment and retention	Highly-ranked practice by survey participants but not by EAC members so was not selected as a final practice
Increased focus on resource recovery	Reflected in Resource Recovery practice
Continued regulatory requirements and operating condition changes	Noted as a driver for sustainability in Section 2.1.4
Greater consideration of stormwater and watershed management	Reflected in Green Infrastructure as well as Habitat / Watershed Protection practices

4.4.5 Framework Mapping and Indicator Selection

As described in Section 3.6 and shown in Appendix E, the eight sustainable practices were mapped against nine frameworks to utilize existing indicators and/or measurement systems whenever possible. For some practices, there was a close match with an existing indicator or indicators. For others, there was not a good match, which implied that the practice was somewhat unique or perhaps a newer concept for the U.S. water sector. In these cases, indicators were developed independently from existing frameworks. Results are reviewed below in alphabetical order. Each of the indicators, written as a question, are supplemented with a short guidance description to provide further context for the end user.

1. Asset Management was well-covered by almost all of the frameworks with a good match from the Performance Benchmarking for Effectively Managed Utilities report. Indicator 1.1 was used for water, wastewater, and combined utilities.
    - Indicator 1.1: How developed is your utility's Asset Management (AM) framework?
        - Guidance: The AM framework may include a "policy" depending upon the legislative, regulatory, and fiduciary arrangements in place for each utility.
2. Education and Communication practices are tracked by all but one of the frameworks, but most provide practices that are too specific to effectively capture the practice developed in this research program. The AWWA Benchmarking Performance Indicators for Water and Wastewater Utilities program has indicators that were adapted for use in this research with two separate indicators comprising an assessment of a utility's education and communication plans. Indicators 2.1 and 2.2 were used for water, wastewater, and combined utilities.
    - Indicator 2.1: Does your utility have a public education program about its sustainability efforts?
        - Guidance: A public education program is externally-focused and designed to build support for and awareness of utility operations and sustainability efforts.
    - Indicator 2.2: Does your utility have an effective communications plan that surveys stakeholders and engages them in dialogues?
        - Guidance: A communications plan solicits responses from and engage stakeholders before, during, and after service events and infrastructure activities.

3. Financial Management can be measured in a variety of ways and is fundamentally a practice based on quantitative data. A utility's bond rating is an indicator in three of the nine frameworks described in Section 3.6. It was also used in previous research (Morley, 2012), now adopted into a national standard, and was used for this research program. Indicator 3.1 was used for water, wastewater, and combined utilities.
    - Indicator 3.1: What is your utility's bond rating?
        - Guidance: Rating may be for the utility itself or the municipality if your utility is part of a city/municipal government. Rating may be a "whisper" rating if one is not formally established. If no bond rating is available, provide an estimate of utility Financial Management progression, taking into account factors such as financial position, debt, governance, covenants, and ability to repay debt.
4. Green Infrastructure is a practice that is not frequently mentioned in other frameworks. It is a somewhat new approach to sustainable utility management and the indicator selected was adapted from a similar measure in the Performance Benchmarking for Effectively Managed Utilities report. Indicator 4.1 was used for water, wastewater, and combined utilities.
    - Indicator 4.1: How defined is your utility's Green Infrastructure-based planning?
        - Guidance: "Green Infrastructure-based planning" is defined as employing decision processes and criteria that promote source water protection and conservation for both the built and natural/unbuilt environment and/or the use of green infrastructure practices to improve stormwater quality, reduce

quantity, and alleviate combined sewer overflows, achieving triple bottom line (economic, environmental, social) benefits.

5. Habitat/Watershed Protection is also not frequently measured in other frameworks. Ultimately, the indicator for this practice was developed independently with the scaling from the AWWA Benchmarking Performance Indicators for Water and Wastewater Utilities program. Indicator 5.1 was used for water, wastewater, and combined utilities.
    - Indicator 5.1: To what extent has your utility engaged in habitat restoration and watershed protection efforts?
        - Guidance: Habitat/watershed protection may include studies to assess (e.g. benthic studies) and protect (e.g. ensuring adequate environmental flows) natural habitats and watersheds.
6. A Long-term Resource Plan was measured in this research with two indicators: a long-term resource plan and long-term water supply adequacy. These indicators have limited overlap with existing frameworks. The long term resource plan indicator was developed independently, but long-term water supply adequacy matched an indicator in the Performance Benchmarking for Effectively Managed Utilities report. Indicator 6.1 was used for water, wastewater, and combined utilities, and Indicator 6.2 was used with water and combined utilities.
    - Indicator 6.1: To what extent is your utility's long-term capital planning horizon linked to its financial plan?

    - Guidance: A long-term capital plan can include longer planning horizons with more detail in the immediate years. It should be linked to financial plans and rate projections and updated on a regular basis.
- Indicator 6.2: How far out does your utility plan for long-term water supply adequacy?
    - Guidance: Projected future annual supply relative to projected future annual demand for at least the next 50 years.

7. Resource Recovery is comprised of up to four practices, depending on the utility service provided. The four indicators comprising water reuse, energy generation, biosolids use, and nutrient recovery were all adapted from indicators in the Performance Benchmarking for Effectively Managed Utilities report. Of the four practices, the first three are included in many existing frameworks, but nutrient recovery was not included in any, except indirectly via biosolids land application. Indicator 7.1 was used for water and combined utilities. Indicators 7.2, 7.3, 7.4, and 7.5 were used for wastewater and combined utilities.
    - Indicator 7.1: To what level is your utility achieving water reuse (as a % of water supply)?
        - Guidance: Water Reuse Factor (WaRe) is defined as 100x (amount of water supplied that is from reused or recycled water/total amount of water supplied)
    - Indicator 7.2: To what extent is your utility achieving water reuse (as a % of wastewater discharged)?

    - Guidance: Wastewater Reuse Factor (WWaRe) is defined as 100x (amount of wastewater discharged that is from reused or recycled water/total amount of wastewater supplied)
- Indicator 7.3: To what extent is your utility achieving beneficial biosolids use?
    - Guidance: Biosolids put to beneficial use (BeneBio) is defined as 100x (amount of biosolids produced that are put to a beneficial use/total amount of biosolids produced)
- Indicator 7.4: How defined is your utility's energy generation plan?
    - Guidance: An energy generation plan is defined as an energy use plan that takes into consideration opportunities for energy conservation and to produce energy from various sources. Plan endorsement implies implementation.
- Indicator 7.5: How defined is your utility's nutrient recovery plan?
    - Guidance: A nutrient recovery plan is defined as a plan that takes into consideration opportunities for nutrient recovery, including phosphorus recovery via struvite precipitation or other means and/or nitrogen recovery via biosolids land application or other means. Plan endorsement implies implementation.

8. Water Conservation is included in many of the frameworks and a match from the Performance Benchmarking for Effectively Managed Utilities report was used for this report. Indicator 8.1 was used for water, wastewater, and combined utilities.
    - Indicator 8.1: How defined is your utility's approach to water conservation?
        - Guidance: Water conservation is defined as the set of activities and behaviors that reduce demand for treated water and minimize wastewater generation.

Water conservation efforts should address both internal usage by the utility in its activities and efforts to promote conservation among external customers or other customers.

While not selected as one of the top eight sustainable practices for this research, Community ROI was highly-ranked by the EAC members. Only three of the nine studied frameworks have indicators that reflect the concept of Community ROI, again reinforcing the leading-edge nature of this practice.

4.4.6 Sustainability Index

The eight practices, related indicators, and guidance were grouped together in a spreadsheet that served as the survey tool. A five-point Likert-type scale ranging from one to five (low to high rating) for each indicator was assigned to provide a quantitative assessment of each indicator. When indicators were a match with an existing framework (six of the thirteen indicators), the framework's scaling was used. For most of the other indicators, scaling from an existing framework was used with a new or modified indicators. For two indicators, an entirely new scaling was developed. An example of the scaling for the Education and Communication indicators was provided in Figure 3.2. Final scaling for each of the indicators along with the entire survey tool are provided in Appendix J.

The eight sustainable practices, measured via eleven to fourteen indicators, depending on the utility service type, can be assessed, scored and combined into a final sustainability index score. Practices with more than one indicator have their scores averaged and a single score for each practice is recorded. The final index score for each utility is calculated as the average score from the eight practices, with a theoretical low score of one and high score of five.

As noted in Section 4.3.1, no weighting is applied to the practices. This follows the approach of the Blue City Index, part of the City Blueprint Framework, which has been applied to cities and regions mainly across Europe, but also on six other continents. The lack of weighting is a reflection of the challenge of applying this sustainability index across U.S. urban water utilities with their extreme variation in climate, politics, and access to resources. For example, while water conservation may be a priority in drought-stricken regions of the country, it may not be as important in water-abundant regions. Applying additional weighting to Water Conservation for one region may not be appropriate for another. Therefore, no weighting is used for this framework.

Sustainability indices were developed for three types of utilities, water supply only, wastewater, and combined utilities. Indicators are applied to each index, depending on applicability. For example, indicators on energy generation, biosolids use, and nutrient recovery are not part of the water supply utility index. Calculations for the indices are provided below. The Water Utility Sustainability Index (WUSI) is calculated as:

$$WUSI = \{I_{1.1} + [(I_{2.1} + I_{2.2})/2] + I_{3.1} + I_{4.1} + I_{5.1} + [(I_{6.1} + I_{6.2})/2] + [(I_{7.1} + I_{7.2})/2] + I_{8.1}\} \div 8.$$

The Wastewater Utility Sustainability Index (WUSI) is calculated as:

$$WWUSI = \{I_{1.1} + [(I_{2.1} + I_{2.2})/2] + I_{3.1} + I_{4.1} + I_{5.1} + I_{6.1} + [(I_{7.2} + I_{7.3} + I_{7.4} + I_{7.5})/4] + I_{8.1}\} \div 8.$$

The Combined Utility Sustainability Index (CUSI) is calculated as:

$$CUSI = \{I_{1.1} + [(I_{2.1} + I_{2.2})/2] + I_{3.1} + I_{4.1} + I_{5.1} + [(I_{6.1} + I_{6.2})/2] + [(I_{7.1} + I_{7.2} + I_{7.3} + I_{7.4} + I_{7.5})/5] + I_{8.1}\} \div 8.$$

Each of the indicator scores, $I_{x.y}$, with x being the practice number and y the indicator number, were scored from one to five. Practices with more than one indicator were averaged to provide a single practice score, independent of the number of indicators for that practice. With eight

practices, the minimum possible sum of the practice scores was eight and the maximum was 40. The sum of practice scores was divided by eight to provide a final index score ranging from one to five.

4.5 Conclusions

The specific research objective addressed in this chapter was to develop a sustainability index that allows the efficient quantitative scoring and comparison of urban water utilities. The index described in Sections 4.4.5 and 4.4.5 above meets this objective. This was accomplished by answering two research questions applicable for this part of the research program. First, what are the components of a sustainable urban water utility in the U.S.? Second, what sustainability indicators make up those components of a sustainable urban water utility?

This index builds upon the four TBL-plus components (economic, environmental, social, and infrastructure) to organize eight high-priority sustainable practices:

1. Asset Management
2. Education and Communication
3. Financial Management
4. Green Infrastructure
5. Habitat/Watershed Protection
6. Long-term Resource Plan
7. Resource Recovery
8. Water Conservation

The eight practices, measured via a total of eleven to fourteen indicators, depending on the service provided, is a parsimonious approach to assessing a utility's sustainability in that it is a fairly small number of indicators which minimizes resources required to gather data for utilities

to self-assess. The indicator approach is also quantitative, with one to five scaling applied to each of the indicators which contribute to an overall utility sustainability index.

CHAPTER 5: KEY ORGANIZATIONAL ATTRIBUTES AFFILIATED WITH A SUSTAINABLE URBAN WATER UTILITY

5.1 Introduction

This chapter focuses on establishing key organizational attributes that are affiliated with a sustainable U.S. urban water utility. These attributes are the foundation for the second half of a utility survey that is the framework, and final output, from this research. This framework is described in Chapter 6. Sections 5.4.1.1 and 5.4.2.1 present details of the attributes that were selected for the survey and discuss some of the attributes that were not ultimately selected, presenting theories for the discrepancies between the participant groups' responses. Overall, chapter 5 describes the work and outputs from Work Package 2, shown in Figure 1.1. This chapter also presents data which helped to evaluate whether a common set of organizational attributes for water utilities could be developed, or whether the variation across the U.S. was so extreme that a single set of attributes was not feasible.

5.2 Research Objectives and Questions

The specific research objective addressed in this chapter is to establish key organizational attributes that are affiliated with a sustainable urban water utility. This objective answers the third of five research questions for this program, "what organizational attributes are affiliated with a sustainable utility?"

5.3 Literature

The literature described below for organizational attributes draws from general research on organizational change. It also includes the limited research applying organizational change

and establishing key organizational attributes for water utilities. Of the previous studies, the unit of study (e.g. region, government, utility), location (global location), and service (water, wastewater, or combined) varied. Some focused on local governments managing water systems, some are global in nature, and others focused on a specific region outside the U.S. Yet another studied organizations that broadly managed infrastructure assets, not just water infrastructure. Therefore, there is limited published research specifically on organizational attributes for sustainable, U.S. urban water utilities.

5.3.1 Organizational Change

Researchers have studied the theory of organizational change for several decades (Armenakis & Bedeian, 1999), but they have rarely focused on water utilities. The concepts related to an organization's readiness for implementing change have been studied in other fields, including health care, business, education, and government (Shea, Jacobs, Esserman, Bruce, & Weiner, 2014) (Weiner B. J., 2009) (Weiner, Amick, & Lee, 2008). Bouckenooghe, Devos, and Van den Broeck (2009) validated an instrument to assess organizational change via a survey of over 3,000 public and private sector organizations. The instrument revealed eleven dimensions in three categories: climate-of-change dimensions, process-of-change dimensions, and readiness-for-change dimensions. The dimensions include factors such as team cohesion, supervisor support, communications, and attitude of top management. These particular factors were also revealed among the top attributes established in this research program. From this perspective, enabling factors for organizational change for water utilities may not necessarily be unique to that specific sector. Rather, the top *practices*, more quantitative and actionable, were unique to water utilities. The next section reviews the application of organizational change theory to water utilities specifically.

5.3.2 Organizational Change and Attributes of Water Utilities

The application of these concepts to water utilities and the related delineation of water utilities' organizational attributes have not been studied comprehensively. As urban water utilities consider the shift to the utility of the future model, better internal management and attention to the "softer," non-technical aspects of the organization is critical. A vision for the future model has been delineated. The attributes that will enable the transition to that model have not been prioritized however.

Two recent studies by Herrick et al. (2013) and Mukheibir et al. (2014) looked at organizational change for water utilities related to sustainable operations and the integration of urban water management, respectively. Results from these studies present potential options for key organizational attributes of transitioning utilities.

Herrick et al. (2013) looked outside the water sector first for organizational attributes that might be applicable to water utilities. Their findings were then narrowed via interviews and a focus group with U.S. water utilities to develop nine internal and three external factors that can promote or hinder the adoption of traits, or attributes, of "organizations that are successful in operating in a sustainable manner," as shown in Table 5.1.

Table 5.1 Internal and External Factors that Influence Organizational Culture Change

	Internal	**External**
Factors	1. Leadership style and issue inclination	1. Stakeholder and customer receptivity
	2. Organizational structure	2. Policy and legal environment
	3. Learning mechanisms	3. Regulatory restrictions
	4. Staff motivation	
	5. Management information system capacity	
	6. Technical capacity	
	7. Human resources practices	
	8. Budgetary and financial models and systems	
	9. Funding	

Note. Adapted from Herrick et al. (2013).

The utilities that participated in the Herrick et al. (2013) study citied sustainable *activities* that were almost entirely associated with environmental practices, an observation confirmed with the authors (C. Herrick & J. Pratt, personal communication, December 20, 2013). Prior to the 2013 report, Herrick and Pratt (2012) published preliminary findings from their research, including only five of the eventual twelve factors. A separate article from the same body of research focused on the communications aspects of sustainable utilities (Herrick & Pratt, 2013). They noted that their "observations are suggestive rather than demonstrative [and they] hope that they will spark ongoing research in areas such as social learning for sustainability, sustainability policy, leadership studies, and organizational transformation" (Herrick & Pratt, 2012).

This research program completed a constructive replication of the Herrick et al. (2013) work. Lykken (1968) describes the three types of replication in human subjects research: literal, operational, and constructive. *Literal* replication is an exact duplication of sampling, experimental conditions, measurements, and methods. *Operational* replication duplicates "just the sampling and experimental procedures." A *constructive* replication is a research method that attempts to corroborate another researcher's theories, but the methods are not replicated. *Constructive* replication uses different "sampling, measurement, and data analysis" than the original experiment. This research program, used different sampling (EAC and water professionals), measurement (sustainable practices in a TBL-plus context and generally internal, organizational attributes), and analysis (discourse analysis, freelisting, and cross-comparison of results to establish highest-priority practices and key attributes).

This research program builds on the body of work by Herrick et al. (2013). For *this* research, the sustainability definition was purposefully broadened to encompass the three components of the triple bottom line, plus the fourth component of infrastructure. It focused on

internal attributes over which the utility has control and narrowed the unit of study to urban water utilities. The use of individual interviews and corroboration of results with online survey results differed from the focus group approach by Herrick et al. (2013). Results from the constructive replication and mapping of results are provided in Section 5.4.3.4 and Figure 5.3.

In another recent research program, Mukheibir et al. (2014) took an institutional approach to the aspects of "one water" systems," essentially an integrated, sustainable approach to urban water management that is closely aligned with IWRM approaches. They identified five major challenges to needed institutional changes, sourced from a literature review: legislation and regulations; economics and finance; planning and collaboration; culture and capacity; and citizen engagement. Of specific relevance for this research, the culture and capacity challenge identified specific organizational attributes for the water sector that can be barriers: a rigid culture; lack of incentives and rewards; and capacity development. They also noted the lack of individual "champions" within water organizations as a barrier.

Brunetto, Xerri, and Nelson (2014) examined the concepts of organizational support and related leadership / employee engagement and their impacts on organizational culture. This study was performed in Australia on 90 employees at organizations that manage infrastructure assets. These organizations were broadly defined as entities that "provide services [and] ensure that assets…are in working order," including water utilities. They proposed that moving beyond typically poor asset management and achieving asset sustainability is dependent on "perceived organizational support" (POS) and the "manager-technical employee relationship." They stated a proactive asset management culture is essential to creating POS and that senior management must lead such changes.

Brown (2008) studied 14 local governments around Sydney, Australia, focusing on SUWM and the organizational change needed to enable SUWM. She found that institutions needed to institutionalize "environmental concern" and that commitment was needed by local leaders in addition to organizational learning on the subject. The needed institutional capacity building included three categories. Institutional reform included incentives, developing political support, and measurement/benchmarking programs. Organizational strengthening included having a corporate policy for sustainability and inter-departmental policies. Human resource development included skills and knowledge development in areas like change management, sustainable development, and urban water. Brown's unit of study was "local government organizations" near Sydney. This was both broader than urban water utilities and somewhat different from a regulatory, cultural, and climatological perspective. However, many of the specifics she identified for capacity development needs were noted as part of the key attributes from this research, demonstrating their applicability beyond just U.S. urban water utilities.

Work by the EPA and partners on the EUM can also provide input on potential attributes. The EUM program is organized around ten attributes of effectively-managed utilities and five keys to success, as described in Section 4.3.1. The EUM attributes are defined as "a characteristic or outcome of a utility that indicates effective performance." The keys are defined as "frequently used management approaches and systems that experience indicates help water and wastewater utilities manage more effectively" (EPA et al., 2008).

For *this* research program, practices are quantitative and attributes are generally qualitative and largely internal to an organization, meaning they can be controlled or influenced by the utility. Attributes enable a shift to sustainable operations. The *EUM attributes* and keys have some overlap with the attributes from *this research* that enable sustainability shifts.

In summary, prior work by provided insights to organizational attributes affiliated with shifting water utility organizations (Brown, 2008; Brunetto et al., 2014; EPA et al., 2008; Herrick et al., 2013; Mukheibir et al., 2014). The unit of study varies from all U.S. water utilities to asset management and local government organizations in Australia. The attributes in these studies are affiliated with shifts towards sustainability, effectiveness, and SUWM. This research builds off of this work with a focus on a TBL-plus approach to sustainability for U.S. urban water utilities.

5.4 Results and Discussion

The following sections provide results and discussion of the organizational attributes, based on input from the EAC and survey participants. Follow-on EAC interview questions were included about potential variability of responses and applicability of the framework across the entire U.S. Questions focused on the variation of utilities due to: service provided, local conditions, the date of the survey/assessment, and governance structure. All of this informed a final, proposed list of key organizational attributes with indicators to assess overall sustainability.

5.4.1 Semi-structured Interviews

The key questions about organizational attributes for the EAC are shown in Table 3.3. Most of the data in this chapter originates from answers to the open-ended question: "In thinking about your utility and its shift towards sustainable operations, tell me what you believe are the most important organizational attributes that drove your utility towards sustainability?" After the discourse analysis of the transcripts, described in Section 3.2.5, a final list of 19 sustainable practices was generated, shown in Figure 5.1 and in table format in Appendix F. The practices are ordered first by number of responses, then alphabetically.

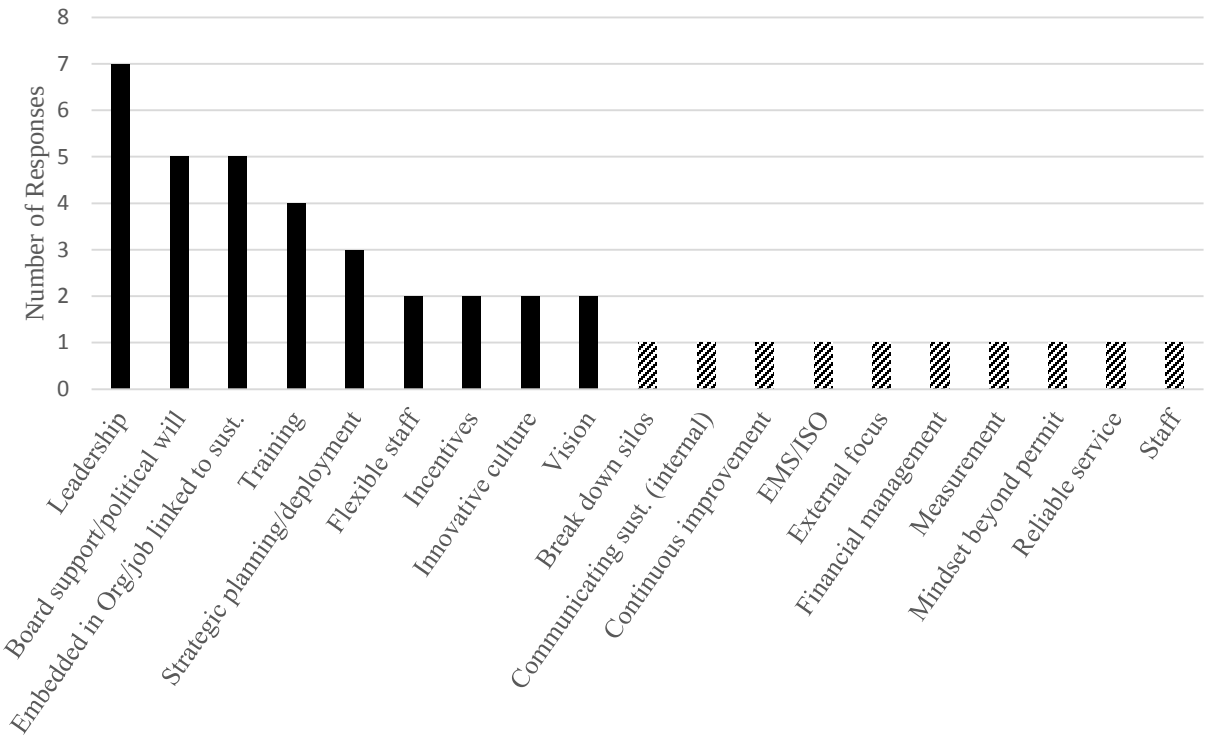


Figure 5.1 Organizational Attributes from EAC Interviews

5.4.1.1 Top Nine Attributes from the EAC

While Figure 5.1 reveals a "break point" after the top five responses, additional attributes were needed for cross-comparison with the freelisting results, or the final number of attributes may have been too limited to broadly assess U.S. urban water utilities. Therefore, any attribute receiving multiple responses was considered for further comparison. All considered attributes are shown as the nine solid bars in Figure 5.1. Like the list of top sustainable practices in Section 4.4.2, this cutoff at 9 attributes is not too numerous compared to other assessment frameworks. The relatively small number of attributes will help improve participants' willingness to participate and increases the potential of generating data from this framework. A smaller number of attributes results in a more accessible framework, which requires fewer resources to complete. The coding process is described in Section 3.3.5.1 and 3.3.5.1 above. The attribute codes shown

on the horizontal axis in Figure 5.1 only provide a short description of the concept for each. Therefore, further description and EAC context are provided in the following sections.

5.4.1.1.1 Leadership

Leadership was the most-frequently cited attribute, mentioned by over half the EAC members who provided additional context of leadership qualities and actions. Among those citing Leadership, the concept of having a leader who truly believes in, and understands, the concepts of sustainability was mentioned more often than any other aspect of Leadership. Several members noted the need to both establish and focus on organizational strategy. A future-oriented vision for those leaders is also important. Several EAC members cited the importance of focusing on the future and the ability to implement the organization's vision, which is inherently a long-term endeavor. A manager from the Metropolitan Water Reclamation District of Greater Chicago said:

> Leadership is huge…in any business, in any venture.…Whatever game you're playing, it's the leaders that set the strategy, it's the leaders that are going to inspire the team…. It is probably the number one attribute of a sustainable utility, having leadership that can see a future, and get an organization to see that future successfully.

Leadership, as it was described in the EAC interviews, originates at the top of the organization. An EAC member specifically mentioned the need for top-down leadership to achieve sustainability, echoing findings from Brunetto et al. (2014). Another EAC member from DC Water said:

> When there's consistent leadership from the top, what's remarkable to me is to see the whole organization follow in place…that's been a transformation of the enterprise. It

does take on the attributes of the leadership…over time and I think it's now pretty deeply ingrained in DC Water.

As a manager from the Metropolitan Water Reclamation District of Greater Chicago noted, the ability for a leader to *communicate* the organization's vision is also important. The importance of communication is described in detail in Herrick and Pratt's 2013 paper. Based on their research, they describe two types of needed communication to establish and maintain sustainability programs in water utilities. First, communications must start with constitutive discourse which helps describe and enable a new way of operating an enterprise. Then, transactional discourse is needed to foster an ongoing dialogue over time to keep the process moving. "Communicating the importance of sustainability" was noted by a former manager from a northeastern wastewater utility, but it was not mentioned in the context of Leadership and was therefore coded as a separate attribute, describing more general internal communications.

Leadership is one of the five Keys to Management Success of the EUM program, as noted in Section 4.3.1. For that program, the definition of leadership includes the elements of commitment and communications, similar to above. However, the EUM description broadened the leadership concept to include teams as well as individuals, something that was not specifically brought out in the EAC members' responses to the question about attributes driving sustainability.

5.4.1.1.2 Board Support / Political Will

The attribute of Board Support / Political Will reflects the general sentiment of utility governance support for sustainability initiatives. The EAC utilities had a mix of governance structure types. Therefore, the specific details in this attribute may vary, but they reflect governance support and/or political will, positively influencing sustainability initiatives from just

above the CEO or General Manager level. For those utilities governed by a board of directors, having board support and even specifically, the board chair's interest in sustainability is important. Boards have the responsibility of hiring utility directors and they have the ability to purposefully hire a director with a sustainability vision, which will set the direction for the utility. For those utilities that are part of a municipal government, having mayoral and city engagement and support is needed. In any structure, political will is needed. A manager from Seattle Public Utilities noted the need for "interested elected officials [who]…want to push the [sustainability] agenda and are asking the hard questions [about sustainability]."

Board support and political will may seem like factors that are external and beyond the control of a utility. This is true for some utilities. However, some EAC members citing this attribute also mentioned how they had taken a proactive approach to shape and influence their board and the political influences on the utility. A manager at DC Water recalled "having a very direct conversation [with the board]…over several interviews" about shifting toward sustainable operations, generating board support even before taking the position. A manager at the Philadelphia Water Department discussed going out and "finding the…political will," proactively searching for support to implement the utility's vision. These examples demonstrate that board support and political will can be influenced by internal actions.

5.4.1.1.3 Employees' Jobs Linked to Sustainability

This attribute not only includes the specific action of linking the utility employees' jobs to sustainability, but also having a broader organizational culture of sustainability in place. The culture of sustainability and supporting mission must be in place so that employees' jobs and responsibilities can be explicitly tied back to that mission of sustainability. The EAC emphasized the importance of having all employees' jobs linked to sustainability. It is not just the

responsibility of upper management or specific groups like public relations. This explicit link to, and continual emphasis of, sustainability can help develop the needed staff buy-in over time. A manager from Alexandria Renew Enterprises noted the need to "tie everybody's everyday actions to [sustainability] because shifting the culture is incredibly difficult." This challenge was also mentioned by a manager from the San Francisco Public Utilities Commission, which publishes the comprehensive Performance/Strategic Sustainability Annual Report described in Section 3.6. The manager noted "the next step is to revisit the [report] indicators and make [them] the driver on how we operate the system…and tie it into performance appraisals of employees." Similarly, a former manager at the Southern Nevada Water Authority said, "To make this [sustainability] come alive, it has to be embedded in the performance evaluations of the individual employees."

5.4.1.1.4 Training

The attribute of Training, as described by the EAC, refers not only to traditional technical training for operators and technical staff, but the broader concept of employee development and *leadership* training. Water utilities are inherently asset-focused organizations with changing regulations and technologies. Combined with a significant staff turnover resulting from a generational retirement wave, changing demographics, and fewer science and technical degrees being awarded, employee training is needed to shift to sustainable operations and maintenance of these assets (Brueck, Isbell, O'Berry, & Brink, 2010). A manager at Spartanburg Water described "employee and leadership development" as the "base" of the organizational attributes, something that is "critical, and one of the big changes" for the water sector. A manager from the Cincinnati water utilities noted people and their development as the primary attribute driving a

utility towards sustainability. A former manager at the Southern Nevada Water Authority described the unique challenge and need for *leadership* training in the water sector:

> The higher you are in the organization, the more the leadership responsibilities fall to you. And you're judged more on leadership than you are on 'did you buy the right pump last week?' And what happens in water utilities is that traditionally, those that become the heads of…organizations are traditionally engineers. In their engineering education, leadership isn't necessarily part of the curriculum. And so having training and an internal education process…attending classes in other [disciplines is needed]. Training [and] tutoring to bring these people up to where they can lead the organization is all-important.

5.4.1.1.5 Strategic Planning / Deployment

EAC members citing Strategic Planning also emphasized the continuous upkeep and active utilization of that plan. A former manager from Charleston Water noted "Strategic planning is a huge driver and it's not just planning, it's deployment. That's where most organizations fail…in deployment, especially water utilities. [They need] a constant focus on strategy." A former manager at the Southern Nevada Water Authority ranked this attribute at the top of their list of attributes:

> First and foremost, [you must have] the presence of a strategic plan. But this is not a strategic plant that sits on a shelf…. The process of putting together a strategic plan is more important than the end product. It gets everyone on the same page…involving all aspects of the organization and every tier of the organization in the end product is all-important. Because then, you have to turn around, to make this thing come alive."

5.4.1.1.6 Flexible Staff

EAC members recognized that a water utility's shift toward sustainability is a change from current practices. Willingness to change and acceptance of changes were cited as important attributes. This was described as having staff that are flexible and adaptable. When asked about the most important organizational attributes in the context of measurement, a former manager from the New York City Department of Environmental Protection said, "It's hard to put your finger on it, but if you could measure willingness to change and accept[ing] change," that could help assess a utility.

5.4.1.1.7 Incentives

Incentives were mentioned by the EAC as a means to both reward good behavior, with respect to driving a utility toward sustainability, and encourage more of those same behaviors. Incentives did not have to be monetary. A former manager form a northeast utility cited something as simple as a staff pizza party to incentivize sustainable behaviors, such as recycling. A former manager from Charleston Water, speaking about continuous improvement programs that drove sustainability at the utility said, "one of the most significant things we did were annual programs…continuous improvement programs. We attach[ed] a monetary award…Eventually it turned into something called 'team incentives.'" The lack of incentives in the water sector was noted by Mukheibir et al. (2014) as a barrier to achieving sustainable IWRM.

5.4.1.1.8 Innovative Culture

EAC members cited the need for a culture of innovation to enable the shift towards sustainable operations. This is distinguished from, but related to, the attribute of having Flexible Staff. Flexible Staff enables a culture of innovation to flourish, but doesn't necessarily lead to an innovative culture without additional elements. A culture of innovation allows risks to be taken,

and even encourages it. It may support research and development efforts through staff and funding and it values the publication of results and/or generation of intellectual property. This culture has to exist not only at the top levels, but throughout the utility. A manager at Seattle Public Utilities noted "having an ability and willingness to innovate is…important…and [it must] be not just the director, but mid-level managers or…certain staff that are interested in helping push the agenda." An innovative culture, built by individuals, can permeate a utility over time. This can create an innovation ethos, or utility with an "innovative personality," a concept described by a manager at the Metropolitan Water Reclamation District of Greater Chicago.

5.4.1.1.9 Organizational Vision

The attribute of vision refers to the concept of the vision of the organization to see and define a future scenario. The Leadership attribute in Section 5.4.1.1.1 references vision, but in the context of having an individual, a leader, who has a vision and can implement that vision. Having an Organizational Vision is essential to drive a utility towards sustainability. A manager at the Philadelphia Water Department described the utility's vision as driven by external factors, but established internally. The department's vision is "To unite Philadelphia with its water environment, creating a green legacy while incorporating a balance between ecology, economics, and equity" (Philadelphia Water, 2016). The manager noted that "having this vision and then spreading it out there and getting this reputation has attracted an incredible crew of talent to us," citing ancillary benefits from the Organizational Vision.

5.4.1.2 Questions about Variation of U.S. Urban Water Utilities

After the open-ended question about key utility attributes, EAC members were asked four questions related to sustainability and the variation of U.S. urban water utilities, a diverse and numerous group of organizations. The purpose of the two of the three of these questions was to

determine whether a common set of organizational attributes for water utilities could be developed, or whether the variation across the U.S. was so extreme that a single set of attributes was not feasible. The last two questions about variation related to potential changes in the sustainability discussion over time, and the impact of a utility's governance structure on sustainability.

5.4.1.2.1 Variation due to Service Provided

The first question related to differences between water and wastewater utilities was: "In thinking about water and wastewater utilities, do you think there would be different responses for the most important organizational attributes due to their different services, or do you think the organizational attributes would be the same for water and wastewater utilities?" Answers to this question revealed no consensus among the EAC members, with several not having a clear opinion. The particular service provided did not correlate to consistent responses as shown in Table 5.2. For example, all the wastewater-only EAC members did not answer this question the same way. However, the specific service provided by a particular utility, and the approach to providing that service, was mentioned as a potential reason why there might be differences in sustainable water utility attributes. Three of the five EAC members who thought attributes would be different all thought the additional complexity of wastewater service delivery was a factor. This complexity can have an impact on human resource needs, ability to recover resources, and the overall mission of the organization. A manager from the Cincinnati water utilities thought that there would be differences due to service provided, citing the externalities inherent in wastewater treatment.

> …On the water side it's a very clear business. You have a product…, a responsibility to treat, and then you sell to the customer and get money for it. That is a business, very

clear, very well defined. On the wastewater side…they're in the business of sustainability, in the business of externalities which [are] created by the water [utility]. So if the business was done right, the water [utility] should have thought about how they will dispose of the water they bring to somebody's house in the first place.

A manager from the Philadelphia Water Department also thought there were differences, but approached it from a different perspective, incorporating the element of risk:

I think the water and wastewater industries are very different animals. The water industry is a lot more conservative, has a lot more risk on a daily basis, providing drinking water that is safe to drink 24 hrs a day, 7 days a week, whenever anyone wants it. It leaves you with a very different point of view of what you're trying to accomplish than on the wastewater side, where there's a better sense and perhaps better ability to move forward in the environmental arena.

Table 5.2 EAC Responses to Variation in Attributes due to Utility Service*

EAC member	Service	Variation due to Service?	
		Yes	No
1	Wastewater	1	
2	Water		1
3	Wastewater	1	
4	Combined	1	
5	Combined		
6	Water		
7	Combined		
8	Combined	1	
9	Combined	1	1
10	Combined		1
11	Combined		
12	Wastewater		1
	Totals	5	4

* EAC members without a yes or no answer indicates no strong opinion was provided in response to this question.

Two other EAC members noted that the principles of Asset Management and the shared driver of aging infrastructure would be common for both types of service. A former manager from a northeastern wastewater utility thought the answer would be dependent on whether the

utilities were publicly or privately-owned. “If they’re…municipally-owned, then…there’s not going to be really very many differences, if any.” But they thought that the profit motive of a private water company could be a differentiator in attributes compared to public utilities. “How will that [profit motive] impact sustainability and measuring sustainability? They’re going to measure sustainability by their fiscal health…where at a municipality, they’re going to be more in line with ensuring the environment is protected, that your costs are reduced.”

Overall, EAC members who thought there would and would not be differences due to utility service were almost evenly divided. Several others did not have a strong opinion one way or another. Therefore, without a compelling push by the EAC members to separate attributes based on utility service, this research continued with the development of a single set of attributes for all service types.

5.4.1.2.2 Variation due to Local Conditions

The second of four questions about variation of utilities was about differences in local conditions. It was stated as follows: “In thinking about the variation among water utilities across the U.S., do you think there would be different responses for the most important organizational attributes due to differences in climate, water availability, infrastructure age, etc., or do you think the organizational attributes would be the same no matter where you are in the country?” Like the responses about service types, there was no consensus among the EAC members. Those thinking there would be differences, and those thinking there would not, did not correlate to the service provided, as shown in Table 5.3 below, and they did not correlate to the responses shown in Table 5.2 above. Also like the previous question about service differences, several EAC members noted Asset Management and aging infrastructure was a common driver for utility attributes. Three of the five who thought local conditions could impact the most important

attributes mentioned water availability as a significant factor influencing attributes that drive the integration of water services. A manager from DC Water said:

> The core of [the attributes] are the same: infrastructure age, capital replacement…[but] what changes dramatically from one side of the country to the other…[is] integration of water [which] happens faster when there's a crisis at hand.… One could argue that some of the problems on the drinking water side have required the integration of water…more than in other places where you're water rich. If you're water rich, you essentially think of them as separate…integration [is] happening far faster out of necessity where scarcity has come to the forefront.

Table 5.3 EAC Responses to Variation due to Local Conditions

EAC member	Service	Variation due to Local Conditions?	
		Yes	No
1	Wastewater		
2	Water	1	
3	Wastewater	1	
4	Combined		1
5	Combined		
6	Water	1	
7	Combined		1
8	Combined	1	
9	Combined		
10	Combined		1
11	Combined		
12	Wastewater		1
	Totals	4	4

Note. EAC members without a yes or no answer indicates no strong opinion was provided in response to this question.

Overall, EAC members who thought there would and would not be differences due to local conditions were evenly divided. Several others did not have a strong opinion one way or another. Therefore, without a compelling push by the EAC members to separate attributes based on local conditions such as climate, water availability, or infrastructure age, this research continued with the development of a single set of attributes for all regions of the country.

5.4.1.2.3 Variation due to Date of Assessment

The third of four questions about variation of utilities was about the concept of sustainability now compared to 20 years ago and predicting the state of the discussion 20 years in the future. The question was: "Do you think you would provide different responses if you were answering these questions 20 years ago…or 20 years in the future?" The first part of this question generated a unanimous result: all EAC members thought the sustainability discussion had shifted significantly compared to 20 years ago. Two members noted the wastewater sector's reliance on federal construction grants as a factor that diminished the need to consider sustainability. Three others mentioned a lack of any discussion about, or culture of, sustainability 20 years ago. A former manager from a northeastern wastewater utility said: "I don't think there was a culture of sustainability. The culture 20 years ago was: we've got plenty of resources, we don't have to think about our resources, we can burn off methane, we don't have to recover it. So the mindset 20 years ago was very different than it is now."

The EAC was split on whether we would be having the same sustainability discussion 20 years in the future, with results shown in Table 5.4. A manager from Alexandria Renew Enterprises thought the attributes of sustainable utilities "might be more *enhanced*," but was unsure whether they would be *different*. A manager from SFPUC thought the sector would be significantly different:

> With technology, with organizational development, and a lot of the things that we're doing in the industry, we're going to be in a totally different place 20 years from now. …No matter what, we'll still have aging infrastructure, but we'll probably have a better way of prioritizing because we will probably have more advanced systems to determine the state of our infrastructure.

Table 5.4 EAC Responses to Variation due to Date of Assessment

EAC member	Service	Different responses 20 years ago?		Different responses 20 years in the future?	
		Yes	No	Yes	No
1	Wastewater	1			1
2	Water	1			
3	Wastewater	1		1	
4	Combined	1			
5	Combined	1			
6	Water	1			1
7	Combined	1			1
8	Combined	1			
9	Combined	1		1	
10	Combined	1		1	
11	Combined	1			1
12	Wastewater	1		1	
	Totals	12	0	4	4

Note. EAC members without a yes or no answer indicates no strong opinion was provided in response to this question.

Results from this question did not impact the final results of the survey. Rather, it suggests that the concept of sustainability for the U.S. urban water utility sector may change over time. Therefore, the framework developed in this research should be re-visited after a period of several years to ensure it still reflects current thinking about sustainability. This is similar to the ongoing EUM refresh started in 2015 after the original 2008 EUM Primer publication, which demonstrated key operational shifts had occurred in those seven years.

5.4.1.2.4 Variation due to Governance Structure

The fourth question about variation due to differences in governance structures was: "Do you think a utility's governance, that is whether a utility is part of a municipal government or an independent authority, has an impact on a utility's ability to operate more sustainably?" Answers to this question went beyond a binary yes-no and included several who answered "it depends," which implies more than simply not having an opinion as indicated by blank responses in Tables 5.2, 5.3, and 5.4. Results are shown in Table 5.5, which also lists each EAC members' utility governance structure to show correlation (or not) of the answer with the members' utility.

Table 5.5 EAC Responses to Variation due to Governance Structure

EAC member	Service	EAC utility governance		Variation due to governance?		
		Municipality	Authority	Yes	No	It depends
1	Wastewater		1			1
2	Water		1	1		
3	Wastewater	1		1		
4	Combined		1			1
5	Combined	1		1		
6	Water		1	1		
7	Combined	1		1		
8	Combined	1		1		
9	Combined	1				1
10	Combined	1	1	1		
11	Combined	1			1	
12	Wastewater		1	1		
	Totals	7	6	8	1	3

Note. EAC members without a yes or no answer indicates no strong opinion was provided in response to this question.

Two-thirds thought the governance structure did have an impact on a utility's ability to operate more sustainably. Those responding affirmatively did not necessarily work at a municipality or authority, meaning like answers did not correlate with the EAC utility governance type. This reflected a sentiment that the local governmental conditions influence the ability to operate sustainably, more so than simply whether a utility is part of a municipality or an independent authority. A manager at the Metropolitan Water Reclamation District of Greater Chicago thought governance was extremely important:

> If you are in an environment where the mayor is changing out every four to eight years, forget it. And there's such competing interests in [any] city. You also have to have a mayor that has integrity and can resist the opportunity of stealing the utility revenue stream to take care of the streets [for example]….There's so many competing interests in [a] city structure. They set up [utilities] as enterprise funds, but they get raided by mayors. So you have to have the right mayors. It's got to be a mayor with integrity.

A former manager from a northeastern wastewater utility who has managed in both governance structures thought that there were benefits to an independent authority:

> An independent authority will be, I believe, a much more sustainable authority. …They have better control over budget, better control over workforce, better control on communications with the customer. …The ratepayers [have much more] ability to track things…than when it's part of a large, municipal, tax-funded system.

5.4.2 Freelisting Surveys

Data on key organizational attributes was also collected via anonymous, online surveys. Background information and the questions for the 31 survey participants are provided in Section 3.3.4. The participants' free lists for water utility attributes were initially coded to 124 practices, recoded, statistically analyzed, and ordered first by frequency of response, and then Smith's S, a measure of salience of each response. Statistics on the responses and participants are provided in Table 5.6.

Table 5.6 Survey Respondent Statistics: Organizational Attributes

Total number of participants	31
Work primarily with both water and wastewater utilities	15
Work primarily with wastewater utilities	10
Work primarily with water utilities	6
Total number of attributes cited	250
Average number of attributes per participant	8.3
Median number of attributes	7
Maximum number of attributes	18
Minimum number of attributes	2

After coding and recoding, a final list of 99 attributes was generated, with the response chart shown in Figure 5.2. Individual attributes are not shown for clarity, but the top 13 attributes are provided in Table 5.7 and shown as solid bars in Figure 5.2. The full list is provided in Appendix H.

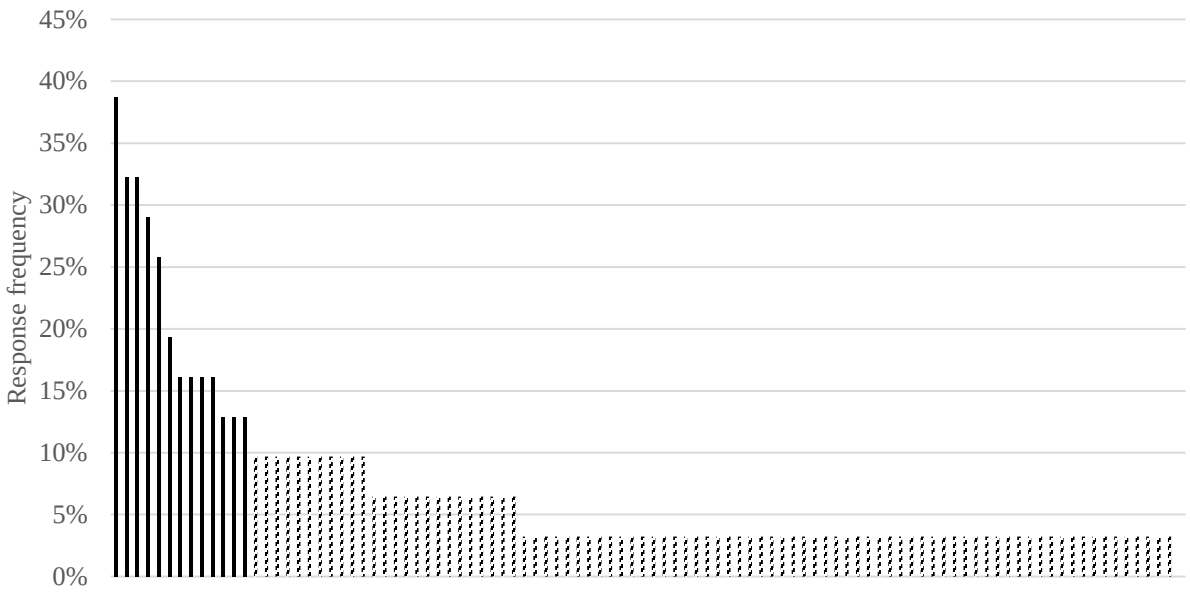


Figure 5.2 Freelisting Results of Organizational Attributes from Survey Participants

Table 5.7 Top 13 Organizational Attributes from Survey Participants

Rank	Attributes	% Response	S
1	Public/stakeholder outreach & engagem't	39%	0.2288
2	Staff training & development	32%	0.2712
3	financial management/stewardship	32%	0.1506
4	Leadership	29%	0.2513
5	Cooperation with other orgs/utilities	26%	0.1096
6	Climate adaptation/mitigation / goals	19%	0.0827
7	Sust. Mgmt. Prog./Goals-commitment	16%	0.1189
8	Culture - open to new ideas	16%	0.1090
9	Innovation - culture	16%	0.1013
10	CI	16%	0.0584
11	infrastructure planning & maintenance	13%	0.1035
12	Systems thinking	13%	0.0828
13	Rates support updgrades (full cost $?)	13%	0.0784

5.4.2.1 Top 13 Attributes from Survey Participants

Figure 5.2 reveals a breakpoint in the practices after the top 13 responses, shown as solid bars. Most of the remaining 86 practices received only one response, with a few receiving two or three responses. This long “tail” of responses is expected with freelisting results where a domain is not explicitly defined. Unlike the top practices from the EAC, much less content and context is available for the survey participant responses. Also unlike the EAC, the survey responses had

some overlap with sustainable *practices* discussed in Chapter 4. This was likely due to the lack of direct communication and feedback with the survey participants and a limitation of any anonymous survey methodology. However, overlap with the practices does reinforce the importance of those particular practices. Examples of the raw data responses that coded the top 13 practices, plus Political Support/Coalitions with Public Officials, are provided in the sections below.

5.4.2.1.1 Public / Stakeholder Outreach and Engagement

The concept captured in this attribute was similar to the Education and Communication practice described in Sections 4.4.2.1.1 and 4.4.3.1.10. Responses typically described actions such as public outreach and community engagement. As a practice for sustainable utilities, Education and Communication was highly ranked by both the EAC participants and the survey respondents. In response to the question about *attributes* of utilities that enable the shift to sustainable operations, the EAC did *not* mention external outreach and engagement, and only one participant mentioned *internal* communication about sustainability specifically. This is not because the EAC thought education and communication was unimportant. Rather, there may have been more clarity during the face-to-face EAC interviews, compared to the anonymous online surveys. In the interviews, an explanation of attributes was read directly to the participant. The surveys relied on the participant to read and understand the difference between practices and attributes on their own. This phenomenon is further described in Section 5.4.3.2. Ultimately, the concept of public/stakeholder outreach and engagement was captured as one of the top eight sustainable *practices* for this research, not as an *attribute*.

5.4.2.1.2 Staff Training / Development

The importance of employee training and development was the highest-ranked attribute from the survey, not including results that were accounted for as practices. This attribute included concepts like staff / workforce development, having an educated workforce, and specifically, increasing worker skills with new technologies. It also encompassed leadership development, both as a general concept and described with specifically. One survey participant noted "developing leaders possessing character and judgement."

5.4.2.1.3 Financial Management / Stewardship

This concept encompassed in this attribute was similar to the Financial Management practice described in Sections 4.4.2.1.3 and 4.4.3.1.5. Responses typically described actions such as financial planning, strength, and stewardship; investing in the future and establishing fair rates. As a *practice* for sustainable utilities, Financial Management was highly ranked by both the EAC participants and the survey respondents. In response to the question about *attributes* of utilities that enable the shift to sustainable operations, only one EAC member mentioned Financial Management. Like Public/Stakeholder Outreach and Engagement above, this is not because the EAC thought Financial Management was unimportant. Rather, there was more clarity about the differentiation between practices and attributes with the EAC. Therefore, this concept was captured as one of the top eight sustainable practices for this research, not as an attribute.

5.4.2.1.4 Leadership

The attribute of Leadership was augmented with multiple descriptors, including "knowledgeable" and "having a wide range of skills and experiences." "Forward-thinking" and "change-agent" leadership was mentioned. Also, leadership "from the top" was noted in the

survey responses, in Brunetto et al. (2014), and quoted by an EAC member in Section 5.4.1.1.1. However, leadership *throughout* the organization was not specifically noted. Responses for the Leadership attribute are grouped to reflect the presence of leadership, not the attribute of leadership *development*, which is described in Section 5.4.2.1.2.

5.4.2.1.5 Cooperation with Other Organizations / Utilities

This attribute describes a utility that is collaborating with other organizations in general, but some specifics were mentioned by respondents. These included collaborating with neighboring or regional utilities and partners, collaborating with non-governmental organizations, and collaborating with universities. One could assume university collaboration referred to an innovation program, but without further context, that attribute was coded under collaboration. Integrated planning with other utilities was coded in this attribute.

5.4.2.1.6 Climate Adaptation and Mitigation

The attribute of Climate Adaptation and Mitigation, for the most part, reflected actions such as reducing greenhouse gases and adapting to climate change, without more specifics given. Some noted *understanding* climate as an attribute in addition to considering climate change in decision-making.

5.4.2.1.7 Sustainability Management Program / Goals and Commitment

This attribute describes a utility where sustainability is embedded within the utility culture and ethos. Supporting this attribute were specifics from respondents like having sustainability as a strategic goal, a sustainability management program, an understanding of sustainability, a designated champion within the organizations, and commitment by the utility's executive leadership.

5.4.2.1.8 Organizational Culture – Open to New Ideas

This organizational attribute describes a culture where employees are not only open to new ideas, but there is a wiliness to advocate for doing things differently, moving from ideas into action. Respondents noted that *management* needs to be open to new ideas and that ideas from *all* employees are welcome. Brick and Lewis (2014) studied commonly-accepted personality dimensions among 345 U.S. adults and found that "openness" was the dimension most associated with environmentalism. While environmentalism does not exactly equate to sustainability, the two are closely linked and sometimes interchanged, as observed by Herrick et al. (2013).

5.4.2.1.9 Culture of Innovation

This attribute is differentiated from a culture that is open to new ideas in that responses specifically called out innovative actions. The EPA Office of Water defines technology innovation as: "The development and deployment of new technologies and processes; new applications of existing technology; production changes; and organizational, management and cultural changes that can improve the condition and sustainability of our water resources" (EPA, 2014c). Being open to new ideas may be a prerequisite for an Innovative Culture, but it is the Innovative Culture and support of that culture that drives action. Survey responses described a formal innovation program, encouraging innovation both within the utility and via partnerships, having an interest in being on the cutting edge, and having an innovation culture throughout the utility.

5.4.2.1.10 Continuous Improvement

Continuous Improvement (CI) is one of the five keys to success in the Effective Utility Management Primer (EPA et al., 2008). This management approach was mentioned several

times with regards to having a CI policy, CI management system, and using a plan-do-check-act management system. Other attributes, coded separately, noted the use of CI for financial planning, KPIs, capital planning, and staffing planning.

5.4.2.1.11 Infrastructure Planning and Maintenance

Survey responses for this attribute reflected the concepts of system maintenance and preservation. It also included infrastructure renewal. It describes an action that is generally encompassed in the Asset Management practice selected as one of the top eight sustainable practices in Chapter 4.

5.4.2.1.12 Systems Thinking

This attribute encompassed responses from survey participants that specifically mentioned systems thinking and concepts that are essentially descriptors of systems thinking. For example, respondents cited “willing to think holistically,” “understanding the water system's interconnectedness with all things,” and accounting for externalities.

5.4.2.1.13 Rates Support Upgrades / Full Cost Pricing

More specific than the Financial Management concept in 5.4.2.1.3, this attribute reflects the concept of full cost pricing. Responses cited having an appropriate rate structure, and the willingness to maintain that structure, to fully support needed upgrades, operations, and maintenance, covering the *full cost* of the enterprise. This attribute did not specifically mention having a good bond rating or generating revenue from non-traditional sources.

5.4.2.1.14 Political Support / Coalitions with Public Officials

This attribute was ranked number 16 overall, but as discussed in Section 5.4.3.1, was included in the cross-check with the EAC responses. The attribute describes proactively seeking the needed political buy-in and support to help drive a utility towards sustainability. This needed

support ranged from public works and public officials for municipal utilities, to board support for independent authorities.

5.4.3 Final Organizational Attributes

Section 3.5 describes the process for determining the final list of the highest-ranked and cross-referenced organizational attributes, shown in Table 3.4. In doing so, some highly-ranked attributes from both the EAC and survey participants were not included in the final list. The sections below provide discussion about those attributes that did not get used in the final framework and the indicators assigned to the final, selected attributes.

5.4.3.1 Attributes from EAC Interviews Excluded from Final Framework

Four of the top nine organizational attributes from the EAC were not highly-ranked by the survey respondents. "Highly-ranked" refers to the top 13 attributes listed in Table 5.7. This resulted in only five selected attributes which was a relatively small number for use in the final framework for surveying utilities. Therefore, the lower boundary for cross-checking the top EAC attributes with only the top 13 survey attributes was slightly extended. This resulted in the 16th-highest ranked attribute, Political Support/Coalitions with Public Officials, matching the second highest-ranked EAC attribute, Board Support / Political Will. The Political Support/Coalitions with Public Officials attribute had a relatively high saliency compared to other attributes with three mentions by survey participants. Other top EAC attributes were cross-checked with the survey results, but relative rankings of those attributes were much lower (60th, 74th, and 88th of 99, respectively) and not used for the final framework.

The three EAC attributes that were not selected were: Strategic Planning / Deployment, Incentives, and vision. Of these three, two are more likely to be part of the responsibility of top or upper management at any organization: Strategic Planning / Deployment and vision. As noted

in Section 4.4.4.1, the EAC members are at the highest levels at their utility and more likely to be focused on strategic issues and Organizational Vision than the lower-level utility managers, consultants, and others who completed the survey. Mukheibir et al. (2014) noted the need for incentives in the water sector and an incentive program could be viewed differently from the EAC members and the survey participants. EAC members may be more likely to develop and implement incentive programs and therefore, this may have been a higher-ranked attribute for them. This contrasts with the survey participants who may be more likely to be just participants in an incentive program developed by others.

5.4.3.2 Attributes from Freelisting Surveys Excluded from Final Framework

Like the sustainable practices excluded from the final framework described in Section 4.4.4.2, several highly-ranked attributes from the surveys were also excluded. More so than with the excluded practices, some of this discrepancy may have resulted from a blending of the concept of attributes with the concept of practices. This may have been due to the anonymous, online nature of the survey compared to the in-person interviews where the explanation of an attribute was conveyed in person. This is an example of one of the limitations to freelisting data compared to the "richness" of the data gathered in the semi-structured interviews. For the interviews, the participants were read the definition of an attribute and follow-up questions could be asked to clarify responses. While the definition of an attribute was provided in the online survey, there was no guarantee the participant fully read the instructions or understood the difference between the generally quantitative practices and qualitative attributes.

Regardless, many of the high-ranked attributes that were excluded from the final framework were accounted for, in concept, in the final list of sustainable practices. This includes two of the three highest-ranked attributes from the surveys: Public/Stakeholder Outreach and

Engagement and Financial Management / Stewardship. Both concepts were captured in the top eight sustainable practices.

Cooperation with Other Organizations/Utilities was ranked 5th by survey participants, but was not mentioned by the EAC in their open-ended responses to the question about key organizational attributes driving sustainability. This attribute, reflecting regional cooperation and collaboration with universities and other entities, is distinguished from having board or political support, an attribute that was highly ranked by both the EAC and survey participants.

Climate Adaptation / Mitigation was again mentioned by the survey participants, but not supported by the EAC as a high priority. A similar response occurred with the practices as described in 4.4.4.2 where other recent research is cited that demonstrated climate adaptation and mitigation was not highly ranked as a factor influencing sustainability.

Of the remaining four attributes that were not cross-referenced with highly-ranked attributes from the EAC interviews, numbers 10 through 13 in Table 5.7, concepts from two are captured elsewhere in the final framework. Number 11, Infrastructure Planning and Maintenance, is reflected in the Asset Management practice. Number 13, having rates that support upgrades is a component of good Financial Management, a highly-ranked sustainable practice.

The other two of the remaining four attributes that were not cross-referenced with highly-ranked attributes form the EAC interviews were somewhat unique responses. Continuous Improvement is a concept that was mentioned by only one EAC member. Systems Thinking was not specifically mentioned by the EAC members and is a relatively new concept for the water sector. Howe and Mitchell (2012) noted that the "institutional and physical structures created to

manage natural resources over the last decades do not reflect a translation of systems thinking into practice."

A number of attributes referenced some aspect of the utility's culture. The specific cultures of openness and innovation were ranked high enough to match the EAC attributes and were selected for the final framework. However, other responses are worth noting as a potential contribution to an overall sustainable, organizational culture. Having an aligned culture received three mentions. Other cultural descriptors receiving one mention and listed in order of decreasing saliency included: teamwork, risk-taking, listen to all employees, and empowerment. This agglomeration of cultural descriptors were used as a significant contribution to the clean water sector's Utility of the Future Today Recognition Program requirements, described in Section 7.6.2.

5.4.3.3 Attributes for Final Framework

A cross-reference of the datasets resulted in six key attributes for use in the evaluation framework. The attribute names from the two datasets were merged and resulted in the following list, re-ordered alphabetically so as not to bias perceived level of importance for those using the final framework from this research:

1. Board Support / Political Will
2. Flexible Staff
3. Innovative Culture
4. Leadership
5. Organizational Commitment
6. Staff Training / Development

These six attributes, in combination with the eight practices from Chapter 4, were compared to previous research by Herrick et al. (2013), as described in the following section.

5.4.3.4 Constructive Replication of Herrick et al. (2013)

Herrick et al. (2013) performed a general literature review, convened a focus group, and developed case studies, which resulted in 12 organizational attributes "that can facilitate or constrain a utility's capacity to adopt traits" that enable sustainable organizational operation. They did not state an attempt to minimize this list or include only essential attributes. Their results are mapped in Figure 5.3 against both the top sustainable practices and key attributes for water utilities resulting from this research. Attributes and practices with very similar concepts are shown with a black box. Those with partial coverage are shown with a gray box. No shading indicates no overlap of concepts.

Figure 5.3 demonstrates that most of the *internal* attributes cited by Herrick et al. (2013) were captured, at least in concept, in this research framework. This framework explicitly identified attributes as "…internal and therefore can be controlled by internal decisions and actions" as contrasted with Herrick et al. (2016) who extended the definition of attributes to external factors also. The sustainable practices were added to the mapping in Figure 5.3 because some of the concepts captured in these practices overlap with the attributes from Herrick et al. (2013). A review of the internal factors from Herrick et al. (2013) revealed the following:

- Leadership style and issue inclination closely mapped with the Leadership attribute in this research.
- Organizational structure includes the way decisions are made and how departments and employees with different skills and backgrounds work together. The flexible staff attribute somewhat captured this attribute.

		Herrick et al (2013). organizational attributes											
		Internal factors									External factors		
		Leadership style and issue inclination	Organizational structure	Learning mechanisms	Staff motivation	Management information systems capacity	Technical capacity	Human resources practices	Budgetary and financial models and systems	Funding	Stakeholder and customer receptivity	Policy and legal environment	Regulatory restrictions
Sustainable Practices	Asset Management												
	Education and Communication										■		
	Financial Management								■	■			
	Green Infrastructure												
	Habitat / watershed Protection												
	Long-term Resource Plan												
	Resource Recovery												
	Water Conservation												
Key attributes	Board Support / Political Will										▒		
	Flexible Staff		▒										
	Innovative Culture												
	Leadership	■											
	Organizational Commitment				■								
	Staff Training / Development			■			■	▒					

Figure 5.3 Constructive Replication Results Mapping

- Learning mechanisms, which includes effective training and development, closely mapped with the Staff Training / Development attribute.
- Staff motivation, which includes supporting and understanding change, was fairly well-captured in the Organizational Commitment attribute.

- Management information systems capacity was neither brought up in this research as a practice nor an attribute.
- Technical capacity is also fairly well-captured in the Staff Training / development attribute.
- Human resources practices were not explicitly covered in the Staff Training/Development indicators, but they were indirectly linked to the attribute and mentioned in the EAC interviews.
- Both budgetary and financial models and systems and funding were captured in the Financial Management practice concept.

Therefore, almost every internal factor from Herrick at al. (2013) with the exception of management information systems capacity, was also brought forward as a priority practice or a key attribute in this research. Management information systems capacity is important for present-day urban water utilities, but it is a fairly specific technical solution compared to the other attributes.

The three external factors from Herrick et al. (2013) were also mapped. The first factor, stakeholder and customer receptivity, is essentially a *result of* the Education and Communication practice and in part, the Board Support / Political Will attribute from this research. Board Support / Political Will can also be influenced by internal actions as noted in Sections 5.4.1.1.2 and 5.4.2.1.14. The other two external factors, policy and legal environment; and regulatory restrictions, are generally beyond the influence of a utility and were outside the scope of this study.

One attribute from this research, Innovative Culture, was not a cited factor by Herrick et al. (2013). This attribute may reflect the relatively recent interest in innovation by the water

sector and the study by Herrick et al. (2013), even just a few years old, may not have captured this concept. In fact, the WaterRF, one of the sponsors of the Herrick et al. (2013) report, is currently sponsoring ongoing research on providing guidance for developing an innovative culture for water sector utilities ("Fostering Research and Innovation within Water Utilities," 2016). Most of the sustainable *practices* in this research were not captured in Herrick et al. (2013). This observation would be expected because these are specific actions originally generated with progressive water sector leaders and utility management professionals. Practices like Asset Management, Green Infrastructure, Habitat / Watershed Protection, having a Long-term Resource Plan, Resource Recovery, and Water Conservation are generally unique to water utilities or at least large, asset-based infrastructure organizations. Herrick et al. (2013) started with general literature on organizational change and then vetted these results with water utility leaders and the results are accordingly, more general in nature. Overall, the research by Herrick et al. (2013) affirms many of the results from this research program and may also demonstrate the dynamic nature of U.S. urban water utility sustainability.

5.5 Conclusions

The specific research objective addressed in this chapter was to establish key organizational attributes that are affiliated with a sustainable urban water utility. The attributes described in Sections 5.4.1.1, 5.4.2.1 and provided in Appendix H meet this objective and answers the research question, what organizational attributes are affiliated with a sustainable utility?

The EAC was asked a series of questions about the variation of U.S. urban water utilities. The purpose of some of these questions was to try to determine whether a common set of organizational attributes for water utilities could be developed, or whether the variation across

the U.S. was so extreme that a single set of attributes was not feasible. Results were not conclusive with respect to variation of service provided or local conditions, meaning separate sets of attributes were not needed to address this variation. The EAC members did agree that the concept of sustainability has shifted over time and that their thoughts on key attributes were different now than they would have been 20 years ago. They were split on whether the concepts would shift significantly 20 years in the future. Finally, the EAC was asked whether a utility's governance structure impacted a utility's ability to operate more sustainably. Most thought governance would have some influence, and that an independent authority would allow more flexibility and freedom in sustainable operations. However, this predication was not unanimous and others noted that local conditions and leadership also have significant influence and thus, operating sustainably may be independent of the type of governance structure.

Results from the EAC and the survey participants were ranked and the highest-priority attributes were mapped against each other. This resulted in the most important attributes driving a utility towards sustainability. The six final, key attributes in alphabetical order are as follows:

1. Board Support / Political Will
2. Innovative Culture
3. Leadership
4. Flexible Staff
5. Organizational Commitment
6. Staff Training / Development

The six attributes, measured via a total of seven indicators, is a parsimonious approach to assessing a utility's attributes that are affiliated with a sustainable utility because it is a fairly

small number of attributes, which minimizes resources required to gather data for utilities to self-assess.

Previous research on organizational attributes of water utilities by Herrick et al. (2013) was compared to this work via a constructive replication. The six key attributes and the overall research framework mapped fairly well to the 2013 research results, with eight of the nine internal attributes by Herrick et al. (2013) in this research program. Only the Innovative Culture attribute, a relatively new concept in the water sector, was an addition to the Herrick et al. (2013) report.

CHAPTER 6: METHOD TO LINK THE SUSTAINABILITY INDEX TO ORGANIZATIONAL ATTRIBUTES AND PILOT TESTING THE FRAMEWORK

6.1 Introduction

This chapter focuses on developing a method to link the quantitative sustainability index to the generally qualitative organizational attributes. It also describes the development of a framework, in the form of a survey, and the pilot testing of that framework for three U.S. urban water utilities. Section 6.4.3 presents the results from the pilot test survey, shown in Appendix I. Results from this pilot provided modifications for the final framework, provided in Appendix J. Overall, Chapter 6 describes the work and outputs from Work Package 3, shown in Figure 1.1.

6.2 Research Objectives and Questions

The specific research objectives addressed in this chapter are to:

1. Select a methodology for linking a quantitative sustainability index to qualitative organizational attributes for urban water utilities; and
2. Apply the overall framework to several U.S. urban water utilities.

These objectives answer the last two of the five research questions for this program:

4. How can a water utility's organizational attributes be measured, quantifying gradations of a qualitative attribute?
5. What methodologies and approaches can link quantitative variables (sustainability index and indicators) to qualitative variables (organizational attributes) in the context of U.S. urban water utilities?

6.3 Literature

The field of mixed methods research, also known as multi-method, hybrid, or combined research, describes research where both quantitative and qualitative data is collected in a single study (Driscoll, Appiah-Yeboah, Salib, & Rupert, 2007). Mixed methods research is referred to as the third major research approach by Johnson et al. (2007), as described in Section 3.1. This research approach usually refers to data collection types, not necessarily data correlation. However, mixed methods research often requires linking quantitative and qualitative data. Mixed methods proponents often cite the benefits of nuanced, data-rich information obtained with qualitative procedures (Driscoll et al., 2007) (Koerber & McMichael, 2008). Sustainability-related research in particular, with its multi-layered elements, can benefit from this approach.

To ultimately understand which organizational attributes are the highest priorities for sustainable utilities, a method to correlate the organizational attributes with the sustainability index is required. This correlation will establish which attributes correlate with the most sustainable utilities. Given enough data (i.e. urban water utilities' sustainability index scores) to provide statistical validity, methods exist to correlate data sets and establish linkages between organizational attributes and sustainability.

Several approaches exist to correlate data assessing organizational culture with performance or effectiveness, two concepts with characteristics similar to sustainability (as noted in Sections 2.3 and 4.3.1). Two examples are provided below, followed by an approach by Schweitzer and Mihelcic (2012) which is particularly relevant to this research. It was applied in an assessment of rural water systems and correlation to a sustainability index for these systems.

Deem, Barnes, Segal, and Preziosi (2010) studied the relationship of organizational culture to Balanced Scorecard (BSC) effectiveness in a study of county and municipal

government organizations from ten of the largest counties in the U.S. They used the organizational culture survey instrument by Denison and Neale to assess organizational culture via an online survey. The BSC is a performance measurement system that takes into account a variety of perspectives for performance measurement: the customer perspective, an internal perspective, an innovation and learning perspective, and a financial perspective (Kaplan & Norton, 1996). Deem et al. (2010) used analysis of variance (ANOVA) and correlation analysis to analyze an organization's Balanced Scorecard effectiveness and its relationship to organizational culture.

In another example, Eker and Eker (2009) surveyed 122 of the top 500 manufacturing companies in Turkey to determine the association between organizational culture and performance measurement systems (PMS). Like Deem et al. (2010), they employed an assessment of BSC measures and also used the Competitive Values model to determine organizational culture. They used correlation analysis and regression analysis to assess the connection between organizational culture and a company's PMS. Their results showed a flexible culture, contrasted with a "control culture," significantly correlated with companies that use a PMS for non-financial reporting measures, focusing attention, and strategic decision making.

Schweitzer and Mihelcic (2012) assessed the sustainability of 61 rural water systems in the Dominican Republic using a Sustainability Assessment Tool. The tool consisted of eight indicators, each with one to five measures. The 21 total measures were appropriate for a developing-world, rural water context. The sustainability scores, both overall and for each indicator, were correlated to other independent variables using bivariate correlation analysis. Correlation coefficients were calculated using Pearson's Product for parametric data and

Spearman's Rho for non-parametric data. Significance was measured at three confidence levels: 0.01, 0.05, and 0.10, based on the correlation coefficients. Results showed a strong correlation to the overall sustainability score for water system age (a negative correlation), wages for plumbers, and level of maintenance.

The studies described above convert the qualitative organizational attribute data to quantitative data to facilitate correlation between the dependent and independent variables. This entails developing a process to scale and measure organizational attributes, essentially transforming a qualitative data into a quantitative measure using cardinal criterion, meaning a specific value can be assigned.

6.4 Results and Discussion

The following sections describe the method used to correlate organizational attributes with sustainable practices measured via the water/wastewater/combined utility sustainability index described in Section 4.4.6. Section 6.4.3 describes the framework pilot test and feedback from the pilot participants. It concludes with the final, recommended framework from this research program to generate data to identify which organizational attributes are affiliated with sustainable utilities.

6.4.1 Linking Sustainability Index to Organizational Attributes

The research cited in Section 6.3 shows examples of the correlation of various datasets, some related to organizational culture and another related to sustainability of water systems. For each study, the two datasets were assessed using some type of correlation analysis. If one dataset contained qualitative data, it was quantified using a rating scale, often a one to five Likert scale.

This approach will be used for follow-on work from this research. After organizational attributes are quantified using a set of indicators (see Figure 6.1 for an example from this

research), correlation analysis can be performed after data is obtained from a representative sample of U.S. urban water utilities. The analysis can determine whether there is a statistical correlation between the organizational attributes and both the overall water / wastewater / combined water utility sustainability index and the individual sustainable practices that make up the overall index. Depending on whether the datasets are normally-distributed, Pearson's Product or Spearman's Rho can be used to calculate correlation coefficients.

6.4.2 Quantifying Organizational Attributes

Examples of quantification of organizational attributes are provided in existing frameworks. For example, the Institute for Sustainable Infrastructure (ISI) Envision™ certification program provides guidance on five categories of sustainable infrastructure projects. One category is leadership which overlaps with a key organizational attribute from this research. The Envision™ program provides descriptive details on four distinct and progressing levels of "effective leadership and commitment" to achieve a project's sustainability goals and permitting the quantification of a qualitative leadership attribute (ISI and Zofnass Program for Sustainable Infrastructure, 2012).

The WaterRF Benchmarking Effective Utility Management report also provides examples of the quantification of qualitative attributes (Matichich, 2014). Similar to Envision™, the WaterRF also assesses a performance measure of leadership (number 8.1.1. in the framework) using five levels of performance achieved. The lowest level of achievement is "Utility mangers are either uninformed or have not chosen to act." The highest level of achievements is "utility mangers are fully informed and promote appropriate applications of sustainability." The middle of five levels is "About 50% of utility managers are informed and/or

promote sustainability in utility governance." In this way, the framework takes the qualitative attribute of Leadership and breaks it down into five quantifiable levels.

Using these frameworks as examples, the six key attributes from this research were assigned one or two indicators each, with a one to five Likert scale rating. This approach is similar to the approach taken for the sustainable practices in Section 4.4.6. The next section provides the indicators for each attribute. A benefit to this approach is that it provides consistency for the final, overall framework, using a similar rating approach for both the sustainable practices and key attributes.

6.4.2.1 Framework Mapping and Attribute Selection

As described in Section 3.6 and shown in Appendix E, the six key attributes were mapped against nine frameworks to utilize existing indicators and/or measurement systems whenever possible. This process enabled the generally qualitative attributes to be measured in a quantitative manner. For one of the six attributes, the Staff Training / Development attribute, there was a close match with an existing framework. For others, there was not a good match, which implied that the attributes were somewhat unique or perhaps a newer concept for the U.S. water sector, at least in terms of measurement. Results are reviewed below in alphabetical order. For the survey, each of the attributes were written as a question and supplemented with a short guidance description to provide further context for the end user. Unlike the sustainable practices, *all* indicators below are applicable to water, wastewater, and combined utilities.

1. Board Commitment / Political Will is an attribute that is not covered in the other frameworks, although one has an indicator which measures oversight body *understanding*. A new attribute question and guidance was developed independently

with the scaling from the AWWA Benchmarking Performance Indicators for Water and Wastewater Utilities program.

- Indicator 1.1: To what extent does your utility have the necessary board commitment /political will to achieve sustainability?
    - Guidance: Political support and/or Board support is needed to successfully implement a sustainability agenda for the utility.

2. Innovative Culture is an attribute that is not well-covered in the other frameworks. The SFPUC Performance / Strategic Sustainability Annual Report tracks the "number of innovative and/or pilot projects using new technology (ies) that targets the Objectives and improves quality of service" (SFPUC, 2014) However, this indicator did not receive a score in three of the last four reporting years. This indicator is also far more specific than measurement of an overall innovative culture. Therefore, for this research, a new attribute question and guidance was developed independently from existing frameworks with scaling from the AWWA Benchmarking Performance Indicators for Water and Wastewater Utilities program.
    - Indicator 2.1: How innovative is your utility's culture?
        - Guidance: A culture of innovation needs to be evident throughout the utility, with day-to-day tasks tied to innovation, input accepted from all levels, and novel approaches rewarded. An innovative culture encourages research, internal and external collaborations, and a staff-wide commitment to provide better solutions using or adapting more effective approaches and technologies.
3. Leadership, in the context of the data collected for this research, is an attribute that is not well-covered in the other frameworks. The WaterRF Benchmarking for

Effectively Managed Water Utilities report has an indicator that assesses managers' integration with the organization's policy / vision / mission and the Envision Rating System assessed the project owner and team's commitment to sustainability. However, neither specifically addressed the leadership characteristics described by the EAC and survey participants. Therefore, a new attribute question, guidance, and scaling was developed independently for this research.

- Indicator 3.1: To what extent is leadership driving your utility towards sustainability?
    - Guidance: Is your utility leader (1) articulating a sustainable vision for the utility, (2) strategically-focused, and (3) dedicated to sustainability?

4. Flexible Staff is an attribute that was not covered in any of the frameworks analyzed for this research. A new attribute question and guidance was developed independently with scaling from the AWWA Benchmarking Performance Indicators for Water and Wastewater Utilities program.
    - Indicator 4.1: How flexible is your utility's staff?
        - Guidance: Utility has a cultural willingness to change and flexible staff who are open to new ideas from all levels of employees.
5. Organizational Commitment is not effectively captured in other frameworks. Some assessed the presence of and/or compliance with a sustainability plan and measures, but none assessed organizational commitment to sustainability and a connection between each employee's job and sustainability. The indicator for this practice was developed independently with scaling from the AWWA Benchmarking Performance Indicators for Water and Wastewater Utilities program.

- Indicator 5.1: To what extent does your utility have an organizational commitment to sustainability?
    - Guidance: Organization as a whole committed to sustainability with everyday operations linked to the utility's sustainability programs/goals. For example, are individuals' job descriptions and performance linked to the utility's sustainability plan and/or goals?

6. Staff Training / Development was measured in this research in two ways: an assessment of how learning programs have been implemented and the level of management training. Specifics of training programs are included in many of the frameworks and a match from the WaterRF Performance Benchmarking for Effectively Managed Utilities report was used to assess both elements of this attribute.
    - Indicator 6.1: What is your utility's degree of implementation of learning programs?
        - Guidance: Well developed learning programs should include both internal and external/distance learning training, particularly in emerging fields where internal resources may not represent the best state of practice in the industry.
    - Indicator 6.2: What is the level of management training achieved by your utility?
        - Guidance: Management training should address all key areas needed to provide for sound oversight and leadership of the staff below each supervisory level. Examples of key topics for management training are: organizational mission, vision; organizational culture; safety, HR policies, leadership, diversity, etc.

6.4.2.2 Attribute Scoring

The eight attributes, related indicators, and guidance were grouped together in the second part of the survey. A five-point Likert-type scale ranging from one to five (low to high rating) for each indicator was assigned to provide a quantitative assessment of each attribute. When attributes were a match with an existing framework, as with Staff Training / Development, that framework's scaling was used. For the other attributes, scaling from an existing framework was used or an entirely new scaling was developed. Final scaling for each of the attributes is included in the survey tool used for the pilot test, provided in Appendix I. An example of the Leadership attribute guidance scaling from the survey is provided in Figure 6.1.

Attribute 3: Leadership

Attribute 3.1: To what extent is leadership driving your utility towards sustainability?

Guidance: Is your utility leader (1) articulating a sustainable vision for the utility, (2) strategically-focused, and (3) dedicated to sustainability?

1	2	3	4	5	Score:
None of these characteristics apply to our utility's leader	One of these characteristics apply to our utility's leader	Two of these characteristics apply to our utility's leader	All of these characteristics somewhat describe our utility's leader	All of these characteristics accurately describe our utility's leader	

Figure 6.1 Example Organizational Attribute Survey Item: Leadership

Using this process, the six key attributes can be assessed and scored via a total of seven indicators. Each attribute but the last, Staff Training / Development, is assessed using one indicator. Staff Training / Development has two indicators and those two scores can be averaged to provide an overall attribute score. However, unlike the practices, the intent of the attribute assessment is not to provide an overall score via an index. There is no overall organizational attribute index. Rather, the framework from this research will permit the correlation of individual attributes with an overall sustainability index or the individual components of that index. Like the sustainable practices, weighting is not suggested for these indicators as discussed in Section

4.3.1 and 4.4.6. Scores for the attributes can then be correlated to a utility's overall sustainability index and individual practices as described in Section 6.4.1.

6.4.3 Pilot Test

The following three sections show results from the pilot test of the framework. It provides separate results from the two parts of the survey: sustainable practices, Section 6.4.3.1, and organizational attributes, Section 6.4.3.2. Unlike the final framework, the pilot-tested survey contained a third section with summary questions about the level of effort required and general feedback. This is shown in Section 6.4.3.3. Also unlike the final framework, feedback was requested from the participants for each indicator and those results are included below. The feedback is the primary driver for changes to the final framework compared to the pilot-tested version.

Tables 6.1, 6.2, and 6.3 contain all the scores, applicable feedback, and resulting actions from the three pilot tests of the framework. As noted in Section 3.8.1, the three utilities were selected to provide a diversity in service type and geography. There was variation in utility size as well, measured by population served.

The utility description and title of primary participant(s) are provided at the beginning. Blank table cells indicate no response given. N/A indicates a response was not applicable due to the type of service provided. Pilot test participants' identities are confidential and utility names and identifying information were blacked out. Comments for each indicator are in response to the question, "Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed." General feedback from participants on the survey is provided in Section 6.4.3.3.

6.4.3.1 Sustainable Practices

Table 6.1 shows results from the pilot test of the sustainable practices section of the framework along with actions resulting from participant feedback. Discussion of results and actions are provided at the end of this section.

Table 6.1 Sustainable Practices Pilot Test Results and Actions

Utility number	1	2	3
Service provided	Water	Wastewater	Both water and wastewater
Title of primary contact	Chief Communications Officer	Maintenance Engineer and Manager	Director of Wastewater Engineering; Environmental Affairs Officer
Practice 1: Asset management			
Indicator 1.1: How developed is your utility's Asset Management (AM) framework?			
Score	4	4	2
Comments	This information was readily available from the executive team members.	Yes, the information is readily available, however it seems to assume that if we don't have a written asset management plan, we cannot have a good asset management program. [redacted] has a very active asset management program that is integrated in our Enterprise Resource Planning (ERP) software that merges data from multiple disciplines (maintenance, finance, purchasing, etc.). We use data to create performance measures, and make business decisions (including capital planning) on a daily basis. However, we do not have a written asset management plan.	Yes. While the [redacted] Wastewater Dept. practices asset management and has an Asset Management group, there is no formalized framework with specific program goals and reporting.
Action	None. Scaling descriptions, including having a written, formal framework, sourced from peer-reviewed WaterRF Effective Utility Management Benchmarking Tool.		

Table 6.1 (Continued)

Practice 2: Education & Communication			
Indicator 2.1: Does your utility have a public education program about its sustainability efforts?			
Score	3	1	3
Comments	Yes	Yes, the information is readily available. [redacted] does not have a formal outreach program, other than tours (which we conduct when asked). We are a wholesale utility with only [redacted] customers. So we don't deal a lot with the public.	More specific indicators (e.g., has a public tour program, maintains a customer-oriented website, collaborates with schools, etc.) to help define the level could be helpful.
Action	None.		
Indicator 2.2: Does your utility have an effective communications plan that surveys stakeholders and engages them in dialogues?			
Score	5	1	4
Comments		Yes, the information is readily available. We do not have a communications plan. We use consultants to set up meetings when we have infrastructure activities (CIP projects) that require public input.	Clarify that the intent is with regard to external stakeholders (or is it both?).
Action	Clarify that this indicator is focused on *external* stakeholders.		
Practice 3: Financial management			
Indicator 3.1: What is your utility's bond rating?			
Score	4	5	5
Comments	We also are rated by Fitch (aa) - perhaps add Fitch to the list of rating agencies.	Yes, the information is readily available. It is shared with [redacted] staff every year at the [redacted] presentation from upper management. It is also shown in our annual financial report. S&P: AAA, Fitch's AA+, and Moody's AaI. You may want to include all three and use "or".	Could be difficult to answer if Moody's and S&P rating are not the same (e.g., Moody's = AA; S&P = AAA, so that's a 4.5?). S&P AAA, Moody's Aa1, Fitch Aa+
Action	Add equivalent Fitch ratings to the scoring (Source: U.S. Securities and Exchange Commission, 2012). Add note to choose highest score if ratings from multiple rating agencies span more than one assigned score.		

Table 6.1 (Continued)

Practice 4: Green Infrastructure			
Indicator 4.1: How defined is your utility's Green Infrastructure-based planning?			
Score	4	1	2
Comments	This question was more difficult to answer because we use different terminology and are not familiar with the term "green infrastructure-based planning." This question took additional discussion and thought by agency leadership to answer due to the discrepancy in terminology.	As a wholesale utility with no storm water permit (we are exempt) this question is hard to answer. The reason for our existence is to protect [redacted] reservoir (a drinking water source for [redacted] people), but we don't use any green infrastructure practices to achieve this. All our decisions are aimed at meeting our permit now and into the future (and thus protecting the receiving waters).	This question does not seem relevant to a Wastewater Utility.
Action	None. Scaling descriptions sourced from peer-reviewed WaterRF Effective Utility Management Benchmarking Tool. Guidance is written to reflect applicability to water, wastewater, or combined utilities.		
Practice 5: Habitat/watershed protection			
Indicator 5.1: To what extent has your utility engaged in habitat restoration and watershed protection efforts?			
Score	5	2	4
Comments		It is implemented during CIP projects, when required by stakeholders and/or code.	
Action	None.		
Practice 6: Long-term resource plan			
Indicator 6.1: To what extent is your utility's long-term capital planning horizon linked to its financial plan?			
Score	2	5	5
Comments	After some discussion, we felt that the answer choices in this question didn't allow for variations on the choices. For example, our 5-year Capital Improvement Plan is linked to our financial plan and is updated annually.	Yes, our 10-year CIP plan is shared with managers and rate projections for our four jurisdictions are shared and discussed at board meetings.	
Action	None. 5 and 10 year terms for capital plan reflect specific feedback from EAC members and reflect longer-term nature of sustainable utilities compared to just good-performing utilities.		

Table 6.1 (Continued)

Indicator 6.2: How far out does your utility plan for long-term water supply adequacy?			
Score	2	N/A	3
Comments	Our Interlocal Agreement requires a long-term plan that looks out 20 years and is updated every 5 years. Perhaps question could add the option of how often these plans are updated.		
Action	None. Scaling descriptions sourced from peer-reviewed WaterRF Effective Utility Management Benchmarking Tool. Guidance is written to reflect long-term water supply *adequacy*, not necessarily frequency of planning updates.		
Practice 7: Resource recovery			
Indicator 7.X: To what level is your utility achieving water reuse (as a % of water supply)?			
Score	4	N/A	1
Comments	As a wholesale drinking water provider, the Interlocal Agreement that created us specifically prohibits us from being involved in the use of reclaimed water for demand reduction. However, as a region, our 6 member governments achieve 60%.		
Action	None.		
Indicator 7.X: To what extent is your utility achieving water reuse (as a % of wastewater discharged)?			
Score	N/A	5	1
Comments		Yes, [redacted]% of our effluent is used for indirect potable use. I think all our employees know that.	
Action	None.		
Indicator 7.X: To what extent Is your utility achieving beneficial biosolids use?			
Score	N/A	4	5
Comments		Yes, the information is readily available ([redacted]% of solids reused for beneficial use according to recent [redacted] presentation).	It would be helpful to specify whether specific criteria should be used to differentiate beneficial use, and state the criteria, or clarify that beneficial is to be defined by the agency. As alternative daily cover in landfills is not considered "disposal" in [redacted], we gave the highest rating.
Action	Add to the Guidance: "'Beneficial use' may be based on local regulations and is to be determined by the utility."		

Table 6.1 (Continued)

Indicator 7.X: How defined is your utility's energy generation plan?			
Score	4	5	5
Comments	Recommended change to scoring: On 5 - delete the word "fully" and add "all" before the word staff to provide a clearer explanation.	We don't have a written plan, but we have a set goal and have several improvements (including a Cogen facility) to move towards this goal. Wording may be revised to indicate that it's not necessary to have a written plan.	Consider expanding the definition of "energy generation plan" to include a strategy and activities related to energy management (both generation and conservation). The guidance is somewhat unclear: why is implementation defined? How does that relate to the scoring?
Action	Add to the guidance language: "Plan endorsement implies implementation, *moving beyond just planning to action taken*." Scaling descriptions sourced from peer-reviewed WaterRF Effective Utility Management Benchmarking Tool.		
Indicator 7.X: How defined is your utility's nutrient recovery plan?			
Score	N/A	3	2
Comments		Again, there is no written plan (to my knowledge). But we have goals of biosolids beneficial reuse.	Same comment as above regarding the use of the word "plan"
Action	Add to the guidance language: "Plan endorsement implies implementation, *moving beyond just planning to action taken*."		
Practice 8: Water conservation			
Indicator 8.1: How defined is your utility's approach to water conservation?			
Score	5	3	5
Comments	As a wholesale provider, we do not directly implement demand management/ conservation programs. However, we are very actively involved as the coordinator/planner for programs and play a large part in the region's conservation efforts.	We use reclaimed water (our effluent) for plant processes (including irrigation) whenever we can. However, there are no goals for using low flow faucets etc.	
Action	Clarify in guidance that this practice is directed at consumer behavior, not the utility itself. Add "…set of activities and behaviors that reduce *customer* demand for treated water and *thereby* minimize wastewater generation…"		

The three pilot test are regarded as well-run utilities, even though they did not have written, formalized plans for many of the practices. This demonstrates that the formal actions of planning, endorsement, and implementation may separate *sustainable* utilities from just *well-performing* utilities. Two of the three utilities are wholesale service providers and some comments reflected a wholesaler's degree of separation from the end user. As a result, some

modification was made to the guidance where applicable. Ultimately, being a wholesale utility would not exclude a utility from taking actions toward more sustainable practices and completing this survey as written for the final framework. The wholesale versus retail difference in customer base is an example of the wide variation of water utilities and relationships in U.S. urban water utilities.

The combined water and wastewater utility had two employees fill out two separate tabs in the survey spreadsheet, despite the request to only fill out the combined utility tab. The combined utility tab was completed by their Environmental Affairs Officer and the wastewater tab was completed by their Director of Wastewater Engineering. In this case, where indicators were scored by each participant and there was a discrepancy, the score provided in Table 6.1 is an average, rounded to the nearest integer. This example reinforced the need to clarify that combined utilities only need to fill out the combined utility tab.

Final scores for the three utilities were calculated based on the equations provided in Section 4.4.6. For utility 1, the WUSI was 4.00. For utility 2, the WWUSI was 3.16. For utility 3, the CUSI was 3.54, all out of a maximum score of 5.0. These scores provide some spread in the range of potential scores, but more data is needed to assess the range and distribution of scores from a random sample of U.S. urban water utilities.

6.4.3.2 Organizational Attributes

Table 6.2 shows results from the pilot test of the organizational attributes section of the framework along with actions resulting from participant feedback. Discussion of results and actions are provided at the end of this section.

Table 6.2 Organizational Attributes Pilot Test Results and Actions

Utility number	1	2	3
Service provided	Water	Wastewater	Both water and wastewater
Title of primary contact	Chief Communications Officer	Maintenance Engineer and Manager	Director of Wastewater Engineering; Environmental Affairs Officer
Attribute 1: Board support / political will			
Attribute 1.1: To what extent does your utility have the necessary board commitment / political will to achieve sustainability?			
Score	5	3	5
Comments	This question required quite a bit of discussion. We felt the word sustainability needs to be defined and perhaps this question should be broken up into more specific questions regarding the type of sustainability - financial, environmental, reliability, etc.	Our board is very supportive of financial sustainability efforts. Not sure how well aware they are of other sustainability efforts.	
Action	Add brief definition of sustainability to the instructions tab: "Sustainability for the purposes of this study is based on a triple bottom line (economic, social, and environmental) approach to all components of a utility's operations and includes an overall consideration of infrastructure sustainability.		
Attribute 2: Innovative culture			
Attribute 2.1: How innovative is your utility's culture?			
Score	4	4	4
Comments		I think the answer to this question depends on who in the organization you ask. Management will probably give you a different answer than the blue collar folks.	
Action	None		
Attribute 3: Leadership			
Attribute 3.1: To what extent is leadership driving your utility towards sustainability?			
Score	5	1	5
Comments	Suggest expanding this to the utility's leadership team - not just the specific CEO or ED.	We have no written vision or mission.	
Action	None. Data from this research suggested individual leadership a key factor of this attribute and did not extend to a leadership team.		
Attribute 4: Flexible staff			
Attribute 4.1: How flexible is your utility's staff?			
Score	3	4	3
Comments			
Action	None		

Table 6.2 (Continued)

Attribute 5: Organizational commitment			
Attribute 5.1: To what extent does your utility have an organizational commitment to sustainability?			
Score	4	2	4
Comments	Again - a clearer definition of sustainability would aid in answering this question.	Our sustainability plan is not well known among [redacted] employees, which makes it hard to give a high score.	
Action	Add brief definition of sustainability to the instructions tab: "Sustainability for the purposes of this study is defined by a triple bottom line (economic, social, and environmental) approach to all components of a utility's operations and includes an overall consideration of infrastructure sustainability.		
Attribute 6: Staff training / development			
Attribute 6.1: What is your utility's degree of implementation of learning programs?			
Score	4	4	3
Comments		What constitutes a learning program? We have a training budget, safety training program, and career ladders, but it is up to each manager to approve employees training requests.	
Action	None. Scaling descriptions, including having a written, formal framework, sourced from peer-reviewed WaterRF Effective Utility Management Benchmarking Tool. Learning programs are defined as training in the guidance.		
Attribute 6.2: What is the level of management training achieved by your utility?			
Score	3	2	4
Comments		Our training is on ad-hoc basis but not always done by peers. There is no training program aimed at supervisors or managers.	
Action	None.		

Organizational attribute guidance and scaling was generally well-received. Some definition of sustainability will be added where applicable. The feedback on defining sustainability, repeated in the next section with summary feedback, relates to the lack of an agreed-to definition of sustainability for the sector as noted in Section 1.1.

6.4.3.3 Summary Questions

Table 6.3 shows results from the pilot test of the summary questions section of the framework along with actions resulting from participant feedback. Discussion of results and actions are provided at the end of this section.

The reported time required to complete the survey was relatively short, as little as 30 minutes and no more than two hours. This nominal amount of time will help address the sustainability reporting barrier of resource (time) requirements, noted by the EAC in Section 4.4.2.2. The labor requirement was another cited resource barrier. The number and variety of employees required to complete the survey varied from one person to as many as six. The only utility that needed just one person to fill out the survey was also the smallest by far, measured by population served (Table 3.7). This observation may relate to the complexity and compartmentalization of larger utilities. That one individual also had the lowest-ranking title of the three primary contacts completing the survey, manager. This occurrence is contrasted with the titles of chief, director, and officer, the other primary contacts. Yet the manager was still able to complete the survey independently.

The general feedback highlighted the need to define sustainability. A TBL-plus framing for sustainability was provided in the final framework as an action after Attribute 1.1 in Table 6.2. The maintenance engineer and manager at the wastewater utility cited the potential omission of a reliability practice. This observation may reflect that individual's bias toward that practice, based on their title and assumed job responsibilities. Resiliency was also noted as a potential omission. Resiliency was noted as a practice in the data gathering for this research, but it was not highly-ranked. Finally, the limited assessment of social aspects was noted by the combined utility. However, Figure 4.3 shows that all four components of the TBL-plus are covered in this framework. The Education and Communication practice was primarily noted as a socially-sustainable practice by the EAC. They also mentioned the practices of Financial Management and Green Infrastructure in response to the interview question about socially-sustainable

Table 6.3 Pilot Test Summary Questions Results and Actions

Utility number	1	2	3
Service provided	Water	Wastewater	Both water and wastewater
Title of primary contact	Chief Communications Officer	Maintenance Engineer and Manager	Director of Wastewater Engineering; Environmental Affairs Officer
Question 1: What was the approximate total time (in hours) required by all employees to complete this survey?			
	Approximately 30 to 45 minutes.	1 hour	Under 2 hours
Question 2: Which employees were needed to complete this survey? (provide titles, not names, e.g. CFO, HR Director, GM, etc.)			
	Chief Communications Officer, Chief Technical Officer, Chief Operating Officer	Just me. If I hadn't been able to find the information on our intranet, then I would have asked Division Directors (Operations and Finance).	Operations and Maintenance Dept. Manager, Manager of Regulatory Compliance, Environmental Affairs Officer, Director of Finance, Manager of Employee Development.
Question 3: Do you believe there are any omissions in the questions provided in this survey (e.g. missing sustainable practices or key attributes)?			
	We felt the only omission was in providing a better definition for sustainability and perhaps breaking some of the questions out to more specific examples of sustainability - financial, environmental, etc.	It didn't include anything about equipment reliability and it's importance to the triple bottom line. Also Resiliency (the ability to overcome catastrophic events within acceptable time and cost limits) wasn't addressed.	Other than the training element, there wasn't much in the way of the social/people aspect of the triple bottom line. For a survey of this length, the questions were generally well crafted.

practices. These responses indicate there are social elements of those practices even though they may not be primarily affiliated with the social component of the TBL-plus.

6.4.4 Final Framework

Based on feedback received from the pilot test utilities, significant changes are not needed before full-scale implementation of the framework. Several indicators' guidance were modified as noted in Sections 6.4.3.1 and 6.4.3.2. The survey tool was successful in that it is a "snapshot" assessment of U.S. urban water utility sustainability and key organizational attributes. The eight sustainable practices and six organizational attributes were assessed by the pilot test utilities in a relatively short period of time. In some cases, several senior-level managers were

required to complete the survey. However, a single point of contact at each utility was able to complete the survey with other help when needed. Appendix J contains the *final* framework and output from this research program. It is separated by the tabs provided in the Excel spreadsheet that corresponds to the water, wastewater, and combined utility surveys.

6.5 Conclusions

There were two research objectives addressed in this chapter. First, select a methodology for linking a quantitative sustainability index to qualitative organizational attributes for urban water utilities. Second, apply the overall framework to several U.S. urban water utilities. The first objective answers two of the five research questions for this program:

- How can a water utility's organizational attributes be measured, quantifying gradations of a qualitative attribute? and
- What methodologies and approaches can link quantitative variables (sustainability index and indicators) to qualitative variables (organizational attributes) in the context of U.S. urban water utilities?

Following examples from earlier research, the key organizational attributes established in this research program were assessed using a one to five Likert scale for each attribute. This enabled the generally qualitative attributes to be quantified. This is described in Section 6.4.2.2 and with results shown in Appendix I. This approach is similar to the indicator assessment approach used with the sustainable practices in Chapter 4, which helps to provide a consistent approach for the end user. Once the attributes are assessed quantitatively, correlation analysis can be performed on data from a representative sample of U.S. urban water utilities.

The overall framework was pilot tested with three U.S. urban water utilities to meet the second objective. This testing provided valuable feedback about both the details of the

assessment tool and also the required level of effort. Results determined that significant changes were not needed for the final framework. Clarification was needed for some indicators, including providing a definition of sustainability. Overall, the survey was completed in less than two hours by a small number of utility staff. This nominal investment of time satisfied the need to develop a framework which minimizes required resources, while providing a comprehensive assessment of utility sustainability and organizational attributes.

CHAPTER 7: CONCLUSIONS AND DIRECTIONS FOR FUTURE RESEARCH

The U.S water utility sector is under pressure, driven by external drivers such as aging infrastructure, fiscal constraints, increased regulations, and a changing climate with direct impacts on a utility's ability to provide expected services. The vast majority of the U.S. population is served by urban water utilities that are undergoing additional pressures due to urbanization and an increasing population.

Given similar external drivers, some U.S. urban utilities are emerging as sustainable leaders, while others remain behind. Sustainability remains an ill-defined concept for the sector, but new models, such as the Utility of the Future, provide a narrative description of a future vision. Until now, there was no system to assess a utility's sustainability and link that assessment to a utility's attributes.

This research program developed a framework to assess the difference between the leading, more sustainable utilities, and others in the sector. It did this by developing a sustainability index to measure urban water utility sustainability. Then, the key organizational attributes enabling the shift to sustainability were defined. These generally qualitative, internal attributes can be quantified via a set of indicators and correlated with a utility's sustainability score. Therefore, the overall framework developed in this research program can be used to generate data to determine which organizational attributes correlate to the most sustainable utilities.

The five research questions that led into the development of the framework are listed in the sections below. Beyond the final framework development, results from this research have

been incorporated into two related programs for water utility assessment. A description is provided for each. Finally, recommendations for potential future research emerging from this program are provided in Section 7.4.

7.1 What are the Components of a Sustainable Urban Water Utility in the U.S.?

Many researchers have used the TBL framework for sustainability, accounting for economic, social, and environmental components when assessing projects or organizations. Depending on the unit of study, some researchers have gone beyond the TBL to include other components, referred to as a TBL-plus framework. Preliminary results from the literature review revealed several potential indicators for a sustainability assessment that were grouped in a fourth component, infrastructure. A TBL-plus approach to assessing sustainability in the U.S. urban water sector was vetted with the EAC members.

Results from the EAC feedback affirmed the potential application of the TBL-plus concept for this research. Therefore, the eight final sustainable practices, listed in Section 7.2, were checked against all four TBL-plus components to be sure all components were included in the final framework. This check affirmed that the final list of practices was comprehensive enough to assess all components of a utility's overall sustainability. Additionally, the EAC concurrence on the inclusion of infrastructure as the fourth component reinforces the TBL-plus approach used in earlier research. This research program also suggests a slightly different approach to the TBL-plus, using the infrastructure component instead of a "technical" or "functional" component, which included adaptability, robustness, and resilience, all descriptors of sustainable infrastructure (Balkema et al., 2002; Guest et al., 2010; Hellström et al., 2000).

7.2 What Sustainability Indicators Make Up Those Components of a Sustainable Urban Water Utility?

Data collected from the EAC via semi-structured interviews and water professionals via online surveys was analyzed using discourse analysis and freelisting techniques. Top responses from each dataset were cross-checked, resulting in eight high-priority sustainable practices. Practices are actionable, quantitative, and in some cases, unique to the water sector. The practices are measured via a total of eleven to fourteen indicators, depending on the service provided. Existing indicators and measurement were selected or adapted whenever possible to minimize effort by the end user and build on previous research. The eight practices and all fourteen indicators, each in the form of a question, are listed below in alphabetical order.

1. Asset Management

    1.1 How developed is your utility's asset management (AM) framework?

2. Education and Communication

    2.1 Does your utility have a public education program about its sustainability efforts?

    2.2 Does your utility have an effective communications plan that surveys stakeholders and engages them in dialogues?

3. Financial Management

    3.1.What is your utility's bond rating?

4. Green Infrastructure

    4.1 How defined is your utility's Green Infrastructure-based planning?

5. Habitat/Watershed Protection

    5.1 To what extent has your utility engaged in habitat restoration and watershed protection efforts?

6. Long-term Resource Plan
    6.1 To what extent is your utility's long-term capital planning horizon linked to its financial plan?
    6.2 How far out does your utility plan for long-term water supply adequacy?
7. Resource Recovery
    7.1 To what level is your utility achieving water reuse (as a % of water supply)?
    7.2 To what extent is your utility achieving water reuse (as a % of wastewater discharged)?
    7.3 To what extent Is your utility achieving beneficial biosolids use?
    7.4 How defined is your utility's energy generation plan?
    7.5 How defined is your utility's nutrient recovery plan?
8 Water Conservation
    8.1 How defined is your utility's approach to Water Conservation?

These practices and indicators provide a parsimonious approach to assessing a utility's sustainability. It is a fairly small number of indicators which minimizes resources required to gather data for utilities to self-assess. The indicator approach is also quantitative, with a one to five scaling applied to each of the indicators which contribute to an overall utility sustainability index score. These eight practices and fourteen indicators contribute to the body of water sustainability literature as a result of their application for U.S., urban water utilities. Additionally, the development of a concise, priority list can help utilities focus their practices, compared to lengthier lists of sustainability indicators provided in other systems, such as the California Water Sustainability Indicators Framework (120 indicators) and the Envision Rating

System for Sustainable Infrastructure (55 credits) (ISI and Zofnass Program for Sustainable Infrastructure, 2012; Shilling et al., 2012).

7.3 What Organizational Attributes are Affiliated with a Sustainable Utility?

The key organizational attributes that enable a shift to more sustainable operations were determined via a process similar to the sustainable practices above. Attributes are generally qualitative and influence a utility's ability to operate sustainably. They are largely internal and therefore can be controlled by internal decisions and actions. Data collected from the EAC and water professionals was analyzed and top responses from each dataset were cross-checked, resulting in six key organizational attributes, listed below in alphabetical order.

1. Board Support / Political Will
2. Innovative Culture
3. Leadership
4. Flexible Staff
5. Organizational Commitment
6. Staff Training / Development

7.4 How Can a Water Utility's Organizational Attributes be Measured, Quantifying Gradations of a Qualitative Attribute?

Organizational attributes are generally qualitative and most have not been assessed in current frameworks. However, these frameworks provided a model for the development of new attribute measurements. Following examples from earlier research, the key organizational attributes established in this research program were assessed using a one to five Likert scale for each attribute. This enabled the generally qualitative attributes to be quantified. The seven indicators affiliated with the six organizational attributes are listed below.

1. Board Support / Political Will

    1.1 To what extent does your utility have the necessary Board Commitment / Political Will to achieve sustainability?

2. Innovative Culture

    2.1 How innovative is your utility's culture?

3. Leadership

    3.1 To what extent is Leadership driving your utility towards sustainability?

4. Flexible Staff

    4.1 How flexible is your utility's staff?

5 Organizational Commitment

    5.1 To what extent does your utility have an organizational commitment to sustainability?

6 Staff Training / Development

    6.1 What is your utility's degree of implementation of learning programs?

    6.2 What is the level of management training achieved by your utility?

The use of the seven indicators is a parsimonious approach to assessing a utility's attributes because it is a fairly small number of attributes. This minimizes resources required to gather data for utilities to self-assess. The attributes assessment used a similar approach to the sustainable practices assessment, which helps to provide consistency for the end user of the framework. These six attributes and seven indicators contribute to the body of water sustainability literature with their focus on the highest-priority, generally internal attributes that can be influenced by a utility's actions. Additionally, the attributes were compiled during data collection in 2015,

reflecting influential sector reports, such as the Utility of the Future and the Economic and Labor Impacts report (NACWA et al., 2013; Quinn et al., 2014).

7.5 What Methodologies and Approaches Can Link Quantitative Variables (Sustainability Index and Indicators) to Qualitative Variables (Organizational Attributes) in the Context of U.S. Urban Water Utilities?

There are a variety of ways to approach correlation analysis that can be used to statistically link two variables. The distribution of the data determines the method to calculate correlation coefficients to assess the connection between variables that make up the datasets or components of those datasets. In this case, data from a sustainability index and an assessment of a utility's attributes.

However, correlation analysis requires two quantified datasets. The quantification of the qualitative organizational attributes described in Section 7.5 allows the data generated from this framework to be analyzed using correlation analysis. Ultimately, this research program produced a framework that can be used to generate data to determine which organizational attributes correlate to the most sustainable utilities for U.S. urban water utilities.

7.6 Integration of Research Findings into Water Sector Programs

Results from this research have been published in a peer-reviewed journal and conference proceedings (both peer-reviewed and non-peer-reviewed), and presented at numerous workshops, conferences, companies, and at the EPA. Beyond publishing results, findings from this research have been incorporated into ongoing and new benchmarking and recognition programs. The sections below describe these programs and research elements that were integrated into the programs.

7.6.1 Asset Management Customer Value Project

AMCV is a quadrennial benchmarking and performance improvement program managed by WSAA. WSAA has managed the program since its inception in 2004 and 50 organizations from Asia, Australia, Europe, and North America have participated (2016 Asset Management Customer Value Project, n.d.). For the 2016 program, nine utilities in North America will be participating (P. Bloomfield, personal communication, February 24, 2016). The AMCV framework consists of a comprehensive hierarchy of 7 functions, 49 processes, 203 sub-processes, and 533 measures for assessment (AMCV "Learn" Information Booklet, n.d.). Details of the program are proprietary. In late 2015, WaterRF funded a review of the AMCV framework against other assessment tools, including the AWWA Water/Wastewater Benchmarking Survey, EUM, and preliminary results from this research (Collaborative Water Utility Benchmarking in North America – 4659, 2015).

Sustainable practices and organizational attributes from this research were proposed for consideration in the 2016 AMCV program and checked against the 533 measures by the AMCV advisory committee. One of the practices, Community ROI, was selected for inclusion into the program, with attribution provided to this research. The new measure, 1.5.2, is titled "Understanding Stakeholders Level of Service Expectations," with a description, "The organization considers and tracks community return on investment." Most measures are linked to further context, referred to as "intent" in the AMCV framework. The intent for Measure 1.5.2 reads "Return on organization's investment can include jobs, economic development, increased property values, and related impacts that support the economic goals of the community. Source: M. Ries (2016)" (G. Ryan, personal communication, February 21, 2016).

In addition to the direct inclusion of a new measure in AMCV, the advisory committee proposed an additional modification to a current measure, 1.12.4, "Culture of Innovation." The description was amended "to capture the need to include the need for staff to be flexible and that the organisation is open to new ideas from all levels of employee," pulling specific elements of the flexible staff attribute from this research. Additionally, measure 1.4.4, "Risk and Opportunity," was expanded so that the participating organization considers resiliency in its decision making (G. Ryan, personal communication, February 21, 2016).

7.6.2 Utility of the Future Today Recognition Program

"The Utility of the Future Today" is a wastewater utility recognition program, jointly organized by four organizational program partners: NACWA, WEF, WERF, and the WateReuse Association (WateReuse) with EPA as an advisory partner (EPA, NACWA, WEF, WERF, WateReuse, 2016). It was launched in April 2016, with the first utilities to be recognized in September 2016. The program seeks to motivate a broad-reaching community of utilities to transform their operations via nine activity areas originating in the 2015 Utility of the Future Blueprint:

1. Organizational culture
2. Beneficial biosolids use
3. Community partnering and engagement
4. Energy efficiency
5. Energy generation and recovery
6. Integrated growth and planning
7. Materials recovery

8. Water reuse
9. Watershed stewardship

During the development of the nine activity areas, comprehensive results from this research on organizational attributes were presented to the program partners' representatives. Specifically, the data on specific elements of organizational culture for sustainable utilities was presented and incorporated into the organizational culture activity area for the recognition program. After discussion, the description for the organizational culture activity area in the recognition program application was re-written as:

> Organizational culture relates to the intentional establishment of organizational excellence that inspires and embraces positive change and empowers the workforce to imagine, create, test and implement innovative approaches from every day work to extreme challenges. It promotes leadership that establishes a long-term vision for the organization, embodies a commitment to cultivating the organization's culture, and embodies communication that creates employee understanding, makes knowledge more productive, and harnesses the power of employee buy in.

Additionally, the program partners' representatives agreed that organizational culture was fundamental to the utility of the future concept. As a result, it is not only one of the nine activity areas, but it is the *only* activity area required by all applicants. At least one additional activity area from the remaining eight is required for the application.

7.7 Recommendations for Future Research

There are two options for future research emerging from this research program. The first option is a direct continuation of the research, using the framework that is the output from this

program. The second option includes related research that applies methods and concepts from this research to related research programs.

7.7.1 Continuation of This Research Program

This research program provided a framework, in the form of a survey tool, to assess the sustainability of a U.S. urban water utility via a sustainability index. That same tool assesses the key organizational attributes of participating utilities. The deployment of this tool to a statistically-representative sample of U.S. urban water utilities will generate data to determine which organizational attributes correlate with the most sustainable utilities. While estimates vary, a rule of thumb for a minimum sample size is n=30 for a parametric statistical test. This means at least 30 utilities should complete the survey and generate results before correlation analysis is performed and conclusions are developed.

Gaining access to a *representative* sample of U.S. urban water utilities is important if results will truly represent the diversity of these utilities. This research used convenience sampling for EAC members and two professional water associations to gain access to a variety of water utility managers. Teodoro's (2013) research on potable water utility executive leadership used a "randomized, stratified sample…drawn from the EPA's Safe Drinking Water Information System" and could serve as a sampling model.

7.7.2 Related Research Concepts

This research focused on public utilities, whether they were part of a municipal government or an independent authority. One EAC member noted that they thought the profit motive of private water companies would generate different responses for an organization's key attributes. Repeating the semi-structured interview process with private water company leaders could test this hypothesis. Another differentiator between public and private utilities is public

reporting on sustainability. It was noted in Section 4.3.1 that only one public water utility had posted a sustainability report on the GRI database, and the rest of the 11 other North American postings were private water companies and water equipment manufacturers. The drivers and differentiators for public sustainability reporting could also be explored.

Herrick & Pratt's (2013) reporting on communication and sustainability recommended follow-on research to their program that is applicable to this program as well. They recommended the comparison of results from their research to other sectors, outside of the U.S. water sector. This differentiation could be investigated via two different units of study, as follows.

First, the methodology and results could be compared to non-urban U.S. utilities. Smaller utilities have fewer staff, smaller budgets, and less infrastructure to manage. But, many of the challenges remain the same: climate change, fiscal constraints, increasing regulations, and aging infrastructure. Unlike urban utilities though, urbanization and population growth are not a trend in rural areas of the U.S. Furthermore, declining populations provide a different challenge associated with decreasing rate-based revenue (Koorn, 2014). Previous research on sustainability of technologies for small (less than 5 MGD) WRRFs was completed by Muga and Mihelcic (2008) and may provide insights to sustainability for smaller utilities.

Second, the methodology and results could be compared to non-U.S. utilities, particularly in the developing world. In those countries, the fundamental practices and key attributes of a sustainable utility may differ from U.S. urban water utilities were adequate water quality, water supply, and sanitation services are not as reliable as in the U.S. Previous research on developing-country water supply system sustainability includes Schweitzer and Mihelcic's (2012) study in rural Dominican Republic.

Finally, this research did not apply weighting criteria to the eight practices of the sustainability indices in Section 4.4.6. This was due to the extreme variation of utilities across the U.S. and the associated challenge of finding agreement on relative priorities. However, individual utilities adopting this framework to assess their own sustainability and benchmark against regional utilities or *themselves* may wish to modify the framework based on local conditions. This would entail applying weighting criteria to the practices. The use of pairwise comparisons, for example, can be used to determine indicator weighting by stakeholders. Then, a sensitivity analysis is recommended as related research after the weighting exercise.

In conclusion, the framework developed in this research will generate data to determine which organizational attributes correlate with the most sustainable utilities. The framework also provides a means to evaluate sustainability and organizational attributes at specific utilities or regions; at private water utilities; and at other water utilities outside of the U.S. urban water sector. Furthermore, the methods and findings from this research program could be applied both within and outside the water sector. Results from this framework have already been incorporated into a comprehensive performance measurement tool and will be deployed to participating utilities around the world every four years as part of the AMCV program. Additionally, findings on key elements of a sustainable utility's organizational culture helped form a foundational component of a national recognition program for "utilities of the future" to be launched this year. Ultimately, this research program will help water utilities be more sustainable, maximizing limited resources to help ensure protection of public and environmental health and strengthening communities for generations.

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APPENDIX A: LIST OF ACRONYMS

AM	Asset Management
AMCV	Asset Management Customer Value
AMWA	Association of Metropolitan Water Agencies
ANOVA	Analysis of variance
AWWA	American Water Works Association
BeneBio	Biosolids put to beneficial use
BSC	Balanced Scorecard
BOD	Biochemical Oxygen Demand
CEO	Chief Executive Officer
CFO	Chief Financial Officer
CHP	Combined heat and power
CI	Continuous improvement
CUSI	Combined Utility Sustainability Index
CWS	Community Water System
ED	Executive Director
EPA	U.S. Environmental Protection Agency
EAC	External advisory committee
EBC	European Benchmarking Co-operation
EEA	European Environmental Agency
EMS	Environmental Management System

EUM	Effective Utility Management
GRI	Global Reporting Initiative
GM	General Manager
HR	Human resources
IBNET	International Benchmarking Network
IRB	Institutional Review Board
ISI	Institute for Sustainable Infrastructure
ISO	International Organization for Standardization
IWA	International Water Association
IWRM	Integrated Water Resources Management
KPI	Key performance indicator
MHI	Median household income
MMS	Maintenance management system
N/A	Not applicable
NACWA	National Association of Clean Water Agencies
N-E-W	Nutrients, energy, water
POS	Perceived organizational support
PMS	Performance management system
ROI	Return on investment
S&P	Standard & Poor's
SFPUC	San Francisco Public Utilities Commission
STEM	Science, technology, engineering, and math
SRF	State revolving loan fund

SUWM	Sustainable Urban Water Management
SWITCH	Sustainable Water Management Improves Tomorrow's Cities' Health
TBL	Triple bottom line
U.K.	United Kingdom
U.S.	United States
USF	University of South Florida
WaRe	Water Reuse Factor
WaterRF	Water Research Foundation
WEF	Water Environment Federation
WERF	Water Environment Research Foundation
WRRF	Water reuse recovery facility
WSAA	Water Services Association of Australia
WUSI	Water Utility Sustainability Index
WWaRe	Wastewater Reuse Factor
WWTP	Wastewater treatment plant
WWUSI	Wastewater Utility Sustainability Index

APPENDIX B: INSTITUTIONAL REVIEW BOARD CLEARANCE

USF
UNIVERSITY OF
SOUTH FLORIDA

RESEARCH INTEGRITY AND COMPLIANCE
Institutional Review Boards, FWA No. 00001669
12901 Bruce B. Downs Blvd., MDC035 • Tampa, FL 33612-4799
(813) 974-5638 • FAX(813)974-7091

2/25/2015

Matthew Ries
USF Department of Civil and Environmental Engineering
4202 E. Fowler Avenue, ENB 118
Tampa, FL 33620

RE: **Expedited Approval for Amendment**
IRB#: Ame1_Pro00020370
Title: A Framework to Assess Key Attributes Driving Sustainability for U.S. Urban Water Utilities

Dear Mr. Ries:

On 2/24/2015, the Institutional Review Board (IRB) reviewed and **APPROVED** your Amendment. The submitted request has been approved for the following:

Revised Consent Document version 2, dated 2/23/2015;
Addition in study sites;
Addition in Letters of Support, from the Philadelphia Water Department and the Water Environment Federation.

Approved Item(s):
Protocol Document(s):
Pro00020370 study protocol v1 01-06-15.docx

Consent Document(s)*:
Pro00023070 SB Adult Minimal Risk v2 02-23-15 interview CLEAN.docx.pdf

*Please use only the official IRB stamped informed consent/assent document(s) found under the "Attachments" tab on the main study's workspace. Please note, these consent/assent document(s) are only valid during the approval period indicated at the top of the form(s) and replace previously approved versions.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

[redacted]

John Schinka, Ph.D., Chairperson
USF Institutional Review Board

APPENDIX C: SEMI-STRUCTURED INTERVIEW INFORMED CONSENT FORM

USF
UNIVERSITY OF
SOUTH FLORIDA

Informed Consent to Participate in Research Involving Minimal Risk
Information to Consider Before Taking Part in this Research Study

IRB Study # Pro00020370

You are being asked to take part in a research study. Research studies include only people who choose to take part. This document is called an informed consent form. Please read this information carefully and take your time making your decision. Ask the researcher to discuss this consent form with you, please ask him to explain any words or information you do not clearly understand.

We are asking you to take part in a research study called: ***A Framework to Assess Key Attributes Driving Sustainability for U.S. Urban Water Utilities.***

The person who is in charge of this research study is Matthew Ries**.** This person is called the Principal Investigator. However, other research staff may be involved and can act on behalf of the person in charge. He is being guided in this research by Drs. Kala Vairavamoorthy and Maya Trotz.

The research will be conducted in conjunction with meetings in Illinois and Texas and in New York, Pennsylvania, South Carolina, and Virginia, or by teleconference/webmeeting.

Purpose of the study

The purpose of this study is to determine:

- What are the components of a sustainable urban water utility in the U.S.?
- What sustainability indicators make up those components of a sustainable urban water utility?
- What organizational attributes are affiliated with a sustainable utility?

The research for this dissertation will develop a framework to assess and prioritize key organizational attributes that drive sustainability for U.S. urban water utilities. It will build upon previous work to develop an indicator-based approach to assess sustainability, specifically for U.S. urban water utilities. It will also establish a set of representative organizational attributes that can be efficiently assessed. Finally, the dissertation will propose a methodology to correlate a utility's sustainability rating to its organizational attributes. It is anticipated that subsequent research applying this framework to a large number of utilities will produce results to prioritize activities and accelerate the transition towards sustainable urban water utilities.

Why are you being asked to take part?

We are asking you to take part in this research study because of your knowledge of and experience with sustainable, U.S. urban water utility management.

Study Procedures: What will happen during this study?

If you take part in this study, you will be asked to:

- Participate in an interview with the Principal Investigator. The interview will last approximately one hour at a private meeting room at a meeting in Illinois, New York, Pennsylvania, South Carolina, Texas, or Virginia, or by teleconference/webmeeting.
- Answer questions about sustainable practices and indicators at urban water utilities. Examples include:
    1. **What do you think about using the "triple bottom line plus" framework, with the *plus* being infrastructure, as a water utility sustainability framework?**
    2. **What do you believe are the most important *economically*-sustainable practices for U.S. urban water utilities?**
        1. Can they be measured?
        2. Does your utility measure them?
        3. Do you know if this practice is widespread?
    3. **What do you believe are the most important *environmentally* sustainable practices for U.S. urban water utilities?**
        1. Can they be measured?
        2. Does your utility measure them?
        3. Do you know if this practice is widespread?
    4. **What do you believe are the most important *socially* sustainable practices for U.S. urban water utilities?**
        1. Can they be measured?
        2. Does your utility measure them?
        3. Do you know if this practice is widespread?
    5. **What do you believe are the most important *infrastructure-related* sustainability practices for U.S. urban water utilities?**
        1. Can they be measured?
        2. Does your utility measure them?
        3. Do you know if this practice is widespread?
    6. **What do you see as the most significant barriers to more widespread adoption of sustainability indicators?**
    7. **Do you currently, or are you planning on publicly reporting your utility's sustainability performance, either through Global Reporting Initiative (GRI) formats or others?**
- Answer questions about organizational attributes of utilities that are making or have made a shift towards more sustainable operations. Examples include:
    1. **In thinking about your utility and its shift towards sustainable operations, tell me what you believe are the most important organizational attributes that drove your utility towards sustainability?**

2. **In thinking about water and wastewater utilities, do you think there would be different responses for the most important organizational attributes due to their different services, or do you think the organizational attributes would be the same for water and wastewater utilities?**
3. **In thinking about the variation among water utilities across the U.S., do you think there would be different responses for the most important organizational attributes due to differences in climate, water availability, infrastructure age, etc., or do you think the organizational attributes would be the same no matter where you are in the country?**
4. **Do you think you would provide different responses if you were answering these questions 20 years ago…or 20 years in the future?**
5. **Do you think a utility's governance, that is whether or not a utility is part of a municipal government or an independent authority, has an impact on a utility's ability to operate more sustainably?**

- As applicable, answer possible follow up questions via a short telephone interview after the face-to-face interview.
- Agree to audio recording of the face-to-face and telephone (if applicable) interviews. Digital recordings from the interviews along with interview notes and transcriptions will be stored in a secure, locked desk in the PI's locked office. Digital files (recordings and electronic files) will be password protected and stored on password-protected cloud storage. Access to these files will be made available to the PI, faculty advisor, and transcriber, if used. All of the physical and digital files and data will be stored for at least five years upon completion of the research project, after which the paper/physical copies of notes, files, and other data will be shredded and disposed of, and digital files will be deleted and emptied from computer recycle bins.

Total Number of Participants

About 12 individuals will take part in this study at all sites.

Alternatives / Voluntary Participation / Withdrawal

You do not have to participate in this research study.

You should only take part in this study if you want to volunteer. You should not feel that there is any pressure to take part in the study. You are free to participate in this research or withdraw at any time. There will be no penalty or loss of benefits you are entitled to receive if you stop taking part in this study.

Benefits

The potential benefits of participating in this research study include contributing to a body of knowledge that can help identify priority attributes for water utilities making the transition to a sustainable utility. These results could be beneficial to your utility and the water sector as a whole.

Risks or Discomfort

This research is considered to be minimal risk. That means that the risks associated with this study are the same as what you face every day. There are no known additional risks to those who take part in this study.

Compensation

You will receive no payment or other compensation for taking part in this study.

Privacy and Confidentiality

We will keep your study records private and confidential. Certain people may need to see your study records. By law, anyone who looks at your records must keep them completely confidential. The only people who will be allowed to see these records are:

- The research team, including the Principal Investigator, faculty advisors, and all other research staff.
- Certain government and university people who need to know more about the study. For example, individuals who provide oversight on this study may need to look at your records. This is done to make sure that we are doing the study in the right way. They also need to make sure that we are protecting your rights and your safety.
- Any agency of the federal, state, or local government that regulates this research. This includes the Department of Health and Human Services (DHHS) and the Office for Human Research Protection (OHRP).
- The USF Institutional Review Board (IRB) and its related staff who have oversight responsibilities for this study, staff in the USF Office of Research and Innovation, USF Division of Research Integrity and Compliance, and other USF offices who oversee this research.

We may publish what we learn from this study. If we do, we will not include your name. We will not publish anything that would let people know who you are.

For the Research Participant (you) to complete:

☐ If you consent to allow the name of your current (or previous, as applicable) utility in the PhD dissertation and related publications, check the box to the left. The utility name would be used in a narrative description such as "A manager at the X utility implemented a unique community outreach program where impact was measured through annual follow up surveys." At no point would your personal name be used in the publications. Leaving this box unchecked does not exclude you from participating in this research. (if blank, then no utility name will be included)

You can get the answers to your questions, concerns, or complaints

If you have any questions, concerns or complaints about this study, or experience an unanticipated problem, call Matthew Ries at 703-463-6728.

If you have questions about your rights as a participant in this study, general questions, or have complaints, concerns or issues you want to discuss with someone outside the research, call the USF IRB at (813) 974-5638.

Consent to Take Part in this Research Study

It is up to you to decide whether you want to take part in this study. If you want to take part, please sign the form, if the following statements are true.

I freely give my consent to take part in this study. I understand that by signing this form I am agreeing to take part in research. I have received a copy of this form to take with me.

_____ _____

Signature of Person Taking Part in Study Date

_____

Printed Name of Person Taking Part in Study

Statement of Person Obtaining Informed Consent

I have carefully explained to the person taking part in the study what he or she can expect from their participation. I hereby certify that when this person signs this form, to the best of my knowledge, he/she understands:

- What the study is about;
- What procedures will be used;
- What the potential benefits might be; and
- What the known risks might be.

I can confirm that this research subject speaks the language that was used to explain this research and is receiving an informed consent form in the appropriate language. Additionally, this subject reads well enough to understand this document or, if not, this person is able to hear and understand when the form is read to him or her. This subject does not have a medical/psychological problem that would compromise comprehension and therefore make it hard to understand what is being explained and can, therefore, give legally effective informed consent.

_____ _____

Signature of Person obtaining Informed Consent Date

_____

Printed Name of Person Obtaining Informed Consent

APPENDIX D: FREELISTING INFORMED CONSENT FORM

USF
UNIVERSITY OF
SOUTH FLORIDA

INFORMED CONSENT TO PARTICIPATE IN RESEARCH
Information to Consider Before Taking Part in this Research Study

IRB Study # Pro00020370

Researchers at the University of South Florida (USF) study many topics. To do this, we need the help of people who agree to take part in a research study. This form tells you about this research study. We are asking you to take part in a research study that is called: *A Framework to Assess Key Attributes Driving Sustainability for U.S. Urban Water Utilities.*

The person who is in charge of this research study is Matthew Ries. This person is called the Principal Investigator.

PURPOSE OF THE STUDY
You are being asked to participate because your knowledge of and experience with U.S. urban water utility management. The purpose of this study is to determine *what are sustainable practices for U.S. urban water utilities* and *what organizational attributes are affiliated with a sustainable utility?*

STUDY PROCEDURES
If you take part in this study, you will be asked to answer 3 questions via an online survey. Participants in the online survey will remain anonymous. No personally identifiable information will be requested in the survey.

ALTERNATIVES/VOLUNTARY PARTICIPATION/WITHDRAWAL
You have the alternative to choose not to participate in this research study.

You should only take part in this study if you want to volunteer; you are free to participate in this research or withdraw at any time. There will be no penalty or loss of benefits you are entitled to receive if you stop taking part in this study.

BENEFITS and RISKS
The potential benefits of participating in this research study include contributing to a body of knowledge, disseminated through the dissertation and publications, that can help identify priority attributes for water utilities making the transition to a sustainable utility. These results could be beneficial to any water professional and the water sector as a whole. This research is considered to be minimal risk.

COMPENSATION
We will not pay you for the time you volunteer while being in this study.

PRIVACY & CONFIDENTIALITY
We must keep your study records as confidential as possible. No personally identifiable information will be requested in the survey. It is possible, although unlikely, that unauthorized individuals could gain access to your responses because you are responding online. This

survey will use Google Forms. For information on Google's Privacy Policy and Terms of Service see http://www.google.com/intl/en/policies.

However, certain people may need to see your study records. By law, anyone who looks at your records must keep them completely confidential. The only people who will be allowed to see these records are the Principal Investigator and advising professors.

Examples of others who may see the data:
o The University of South Florida Institutional Review Board (IRB), government offices such as, The Department of Health and Human Services (DHHS).

- It is possible, although unlikely, that unauthorized individuals could gain access to your responses. Confidentiality will be maintained to the degree permitted by the technology used. No guarantees can be made regarding the interception of data sent via the Internet. However, your participation in this online survey involves risks similar to a person's everyday use of the Internet. If you complete and submit an anonymous survey and later request your data be withdrawn, this may or may not be possible as the researcher may be unable to extract anonymous data from the database.

CONTACT INFORMATION
If you have any questions please contact the USF IRB at 813-974-5638 or the Principal Investigator at mries@mail.usf.edu.

We may publish what we learn from this study. If we do, we will not let anyone know your name. We will not publish anything else that would let people know who you are. You can print a copy of this consent form for your records.

I freely give my consent to take part in this study. I understand that by proceeding with this survey that I am agreeing to take part in research and I am 18 years of age or older.

Note that clicking "Continue" below indicates consent and is required to proceed to the survey.

APPENDIX E: MAPPING OF PRACTICES AND ATTRIBUTES AGAINST EXISTING FRAMEWORKS

Table E.1 Mapping of Practices and Attributes against Existing Frameworks

Sustainable Practice	**AWWA Water and Wastewater Utilities Benchmarking Survey (2012)**	**California Water Sustainability Indicators Framework (2013)**	**EUM: A Primer for Water and Wastewater Utilities (2008)**	**Envision Rating System for Sustainable Infrastructure v2.0 (2012)**
Education and Communication	• Stakeholder outreach index (%) – comprised of surveys, open forums, numerous channels, addressing feedback, each 0-1-2 (never/rarely – less than annual – at least annually) (Q63) • Customer involvement program, 1-5 rating (not practiced – implemented but room for improvement – fully implemented) (Q13)	• Participation in Local Stewardship (Participation rates in local stewardship by the local stakeholders such as municipalities, indigenous people, irrigation districts, community organizations, watershed associations, conservation groups, and stewardship groups.)	• Percent of positive or negative customer satisfaction survey responses based on a statistically valid survey or on an immediately after-service survey (p. 28) • ID stakeholders , conduct outreach, actively consult (y/n) (p. 43) • Act upon stakeholder input? (y/n) (p. 43) • Stakeholder satisfaction (overall satisfaction, responsiveness, message recollection) (p. 43) • Media/press coverage (amount, tone, accuracy) (p. 44)	• The extent to which project stakeholders are identified and engaged in project decision making, and their satisfaction in the process (information transfer – open to a wider community – community relationship building) LD1.4

Table E.1 (Continued)

Sustainable Practice	**IWA Performance Indicators (Water, 2006; Wastewater, 2003)**	**NACWA Financial Survey (2011)**	**(Canadian) National Water & Wastewater Benchmarking Initiative (2013)**	**WaterRF Performance Benchmarking for Effectively Managed Water Utilities (2014)**	**SFPUC Performance/ Strategic Sust. Report (2014)**
Education and Communication	• Response to written complaints (%) (QS34 water, wQS27 ww) • Customer service personnel (wPe6 water and ww)		• No. of water pressure complaints by customers / 1,000 people served (p. 18) • No. of wastewater related complaints / 1,000 people served (p. 32)	• Degree of positive customer feedback received via scientific survey (<60% - >90%) (2.3.1) • Success in media interaction (coverage fails – intermittent errors – consistently accurate) (10.4.1) • Success in positive media coverage (<50% negative – 50% positive - >75% positive) (10.4.2) • Stakeholder identification & understanding (few – some – most) (10.1.1) • Stakeholder engagement plan (no understanding – majority – near complete understanding (10.2.1) • Stakeholder support for utility direction (strong resistance – balanced split – strong support) (10.5.1)	• % of customers surveyed that rate SFPUC as good or better CR1.1 • Average wholesale customer satisfaction (1-5 scale) • % of traffic increase in SFPUC social media platforms • Foster engagement with current and developing stakeholder groups CY4.1

Table E.1 (Continued)

Sustainable Practice	AWWA Water and Wastewater Utilities Bench-marking Survey (2012)	California Water Sustain-ability Indicators Framework (2013)	EUM: A Primer for Water and Wastewater Utilities (2008)	Envision Rating System for Sustain-able Infra-structure v2.0 (2012)	IWA Performance Indicators (Water, 2006; Wastewater, 2003)	NACWA Financial Survey (2011)	(Canadian) National Water & Wastewater Bench-marking Initiative (2013)	WaterRF Performance Benchmarking for Effectively Managed Water Utilities (2014)	SFPUC Performance/ Strategic Sustainability Report (2014)
Bond rating/ financial manage-ment	• Long-term financial planning, 1-5 rating (not practiced – implemented but room for improvement – fully implemented) (Q9) • Corporate bond rating (fill in the blank) (Q28)	• Public support and awareness of water system protection	• Long-term budget management effectiveness & LCC accounting (p. 32-33) • Financial procedure integrity (accounting policies, audit, etc.) (p. 33) • Bond rating (p. 33) • Rate adequacy (p. 34)		• Debt service coverage ratio = DSC (%) (Fi39 water and ww)) • Debt equity ratio (wFi40 water and ww)	• Debt ratio (p. 84) • Credit rating (p. 85)	• Total operating cost with actual indirect charge-back (‘000) / km length (p. 47)	• Degree to which fin. Planning supports strong bond ratings (no rating - decline in rating – increase or maintain) (5.1.1) • Rate planning horizon (yr-by-yr – 2 to 5 yrs - >10 years) (5.1.3) • Balance of capital spending btw debt and equity (100% debt – 6-10% equity - >20% equity) (5.1.4) • Financial policy/ procedure integrity (no policy – not consistently used – routinely used) (5.2.1 and 5.2.2) • Reserves consistent with industry guidelines (AWWA and WEF p. A-44) • Debt/equity target (A-46)	• Credit rating GM 2.1

Table E.1 (Continued)

Sustainable Practice	AWWA Water and Wastewater Utilities Bench-marking Survey (2012)	California Water Sustain-ability Indicators Framework (2013)	EUM: A Primer for Water and Wastewater Utilities (2008)	Envision Rating System for Sustain-able Infra-structure v2.0 (2012)	IWA Performance Indicators (Water, 2006; Wastewater, 2003)	NACWA Financial Survey (2011)	(Canadian) National Water & Wastewater Bench-marking Initiative (2013)	WaterRF Performance Benchmarking for Effectively Managed Water Utilities (2014)	SFPUC Performance/ Strategic Sustainability Report (2014)
Resource Recovery	• Public Water Infor-mation Report-ing System	• Water reuse (amount and %) (p. 26) • Biosolids put to beneficial use (%) (p. 26)	• % of water reductions achieved (10-30% - 51-70% - >70%) RA2.1 • % and total volume of water recycled and reused (GRI-SFPUC p. A-6)	• Sludge utilization (wNe7 ww) • WWT energy recovery from co-generation processes (wOp19 ww) Pumping energy recovery (%) (Ph7 water)	• Biosolids reused (tons) (via land app, composting, heat dry/ pelletization) (p. 28) • Plant electricity needs generated onsite (%) (p. 155)		• Water Reuse Factor (<60% up to >90%) (1.3.1) • Biosolids put to beneficial reuse (<60& up to >90% (1.3.2) • Degree of energy optimization (no targets set – set for some but not all – set for all depts.) (4.2.2) • Energy optimization plan (incl. E prod.) (no plan – moderately defined – well defined/fully endorsed (8.3.4)	• Percent sewage sludge going to beneficial use EN9.4 • Percent of electricity supplied from greenhouse gas emissions-free and/or renewables EN3.2	

Table E.1 (Continued)

Sustainable Practice	AWWA Water and Wastewater Utilities Bench-marking Survey (2012)	California Water Sustain-ability Indicators Framework (2013)	EUM: A Primer for Water and Wastewater Utilities (2008)	Envision Rating System for Sustain-able Infra-structure v2.0 (2012)	IWA Performance Indicators (Water, 2006; Wastewater, 2003)	NACWA Financial Survey (2011)	(Canadian) National Water & Wastewater Bench-marking Initiative (2013)	WaterRF Performance Benchmarking for Effectively Managed Water Utilities (2014)	SFPUC Performance/ Strategic Sustainability Report (2014)
Green Infrastructure			• Has the utility explored GI approaches…? (y/n) (p. 40) • Procedures to incorporate GI into new infrastructure investments? (y/n) (p. 40)	• Infiltration and ET capacity of the site and return to pre-development, includes LID (increased storage – extended storage – enhanced stormwater management) NW2.1				• GI-based planning (none – moderate – well-defined/endorsed) (8.3.3)	• Reduction in peak storm flows to combined system due to LID or surface drainage management EN1.3

Table E.1 (Continued)

Sustainable Practice	AWWA Water and Wastewater Utilities Bench-marking Survey (2012)	California Water Sustain-ability Indicators Framework (2013)	EUM: A Primer for Water and Wastewater Utilities (2008)	Envision Rating System for Sustain-able Infra-structure v2.0 (2012)	IWA Performance Indicators (Water, 2006; Wastewater, 2003)	NACWA Financial Survey (2011)	(Canadian) National Water & Wastewater Bench-marking Initiative (2013)	WaterRF Performance Benchmarking for Effectively Managed Water Utilities (2014)	SFPUC Performance/ Strategic Sustainability Report (2014)
Asset Manage-ment	• Optimized asset manage-ment program, 1-5 rating (not practiced – implement-ed but room for improve-ment – fully implement-ed) (Q12)		• Planned main-tenance ratio for hours or cost (p. 36)		• Investments for asset replacement and renovation (%) (Fi27 water, wFi29 ww)	• Has your agency implemented or begun to implement an asset management program? (y/n) (p. 71) • Do you have staff that are dedicated to asset management activities? (y/n) (p. 72)	• Five year running average capital reinvestment/ replacement value (p. 64)	• Degree of implementation of AM framework (none – written/ad hoc – strategic & routine management reporting) (6.1.1) • Degree of development of AM plan (none – established – has actions/timelines) (6.1.3) • Level of asset inventory / condition / performance (6.2.1, 2, & 3) • Asset management plan developed every 5 years, audited annually (p. A-52)	• Develop and implement an SFPUC-wide AM plan IA4.1 (% covered, % operating assets w/ risk score rating, % poor, failed, etc)

Table E.1 (Continued)

Sustainable Practice	AWWA Water and Wastewater Utilities Bench-marking Survey (2012)	California Water Sustain-ability Indicators Framework (2013)	EUM: A Primer for Water and Wastewater Utilities (2008)	Envision Rating System for Sustain-able Infra-structure v2.0 (2012)	IWA Performance Indicators (Water, 2006; Wastewater, 2003)	NACWA Financial Survey (2011)	(Canadian) National Water & Wastewater Bench-marking Initiative (2013)	WaterRF Performance Benchmarking for Effectively Managed Water Utilities (2014)	SFPUC Performance/ Strategic Sustainability Report (2014)
Water Conservation		• Percent Recycled Water (Use of recycled water as a percent of total water used.)	• Demand management/ reduction plan (y/n) (p. 42) • Conservation-oriented, demand pricing (y/n) (p. 42)	Percentage of water reduction (25% - 75% - 100% + recycle) RA3.2			• Cost of water conservation program / population served (p. 16)	• Water conservation activities/behavior s (no approach – moderately defined – well-defined) (8.3.2)	• % of retail rate and fee structure that encourages conservatio n CR6.4
Habitat/ watershed Protection				Size of natural buffer zone around wetlands, shorelines, and water bodies (>50' - >200' - >300' + restoration)			• Total no. of reported overflows / 100 km length (p. 61) [under the goal of "Protect the environment"] • kg of BOD discharged to the environment per capita (p. 70)		• Show progress on habitats protected, restored, or preserved EN2.3

Table E.1 (Continued)

Sustainable Practice	AWWA Water and Wastewater Utilities Bench-marking Survey (2012)	California Water Sustain-ability Indicators Framework (2013)	EUM: A Primer for Water and Wastewater Utilities (2008)	Envision Rating System for Sustain-able Infra-structure v2.0 (2012)	IWA Performance Indicators (Water, 2006; Wastewater, 2003)	NACWA Financial Survey (2011)	(Canadian) National Water & Wastewater Bench-marking Initiative (2013)	WaterRF Performance Benchmarking for Effectively Managed Water Utilities (2014)	SFPUC Performance/ Strategic Sustainability Report (2014)
Long-term Resource Plan	• Drought response/water shortage contingency planning, 1-5 rating (not practiced – implemented but room for improvement – fully implemented) (Q16) • Sourcewater protection planning, 1-5 rating (not practiced – implemented but room for improvement – fully implemented) (Q17) Years available water supply = % current 5-year avg / avg annual available water supplies based on current yield		• Long-term water supply adequacy (p. 42) • Sourcewater protection plan (y/n) (p. 42) • Policies in place that address new service areas / water availability (y/n (p. 42)					• Long-term water supply adequacy (<10 – 25-40 - >50 yrs) (9.1.1) • P. A-86, refers back to EUM	• Show progress on long-term, integrated resource planning to meet future water/wastewater demand GM4.2

Table E.1 (Continued)

Key Attribute	AWWA Water and Wastewater Utilities Bench-marking Survey (2012)	California Water Sustain-ability Indicators Framework (2013)	EUM: A Primer for Water and Wastewater Utilities (2008)	Envision Rating System for Sustain-able Infra-structure v2.0 (2012)	IWA Performance Indicators (Water, 2006; Wastewater, 2003)	NACWA Financial Survey (2011)	(Canadian) National Water & Wastewater Bench-marking Initiative (2013)	WaterRF Performance Benchmarking for Effectively Managed Water Utilities (2014)	SFPUC Performance/ Strategic Sustainability Report (2014)
Leadership				• Demonstration of meaningful commitment of the project owner and… team to the principles of sustainability… (limited commitment - walking the talk – sustainability is a core value) LD1.1				• Integration of sustainability within policy/ vision/mission (managers uninformed – 50% promote sust. – fully informed) (8.1.1)	•
Board support/polit ical will								• Success in gaining oversight body understanding (no detailed knowledge – multiple members – all) (10.3.1)	

Table E.1 (Continued)

Key Attribute	AWWA Water and Wastewater Utilities Bench-marking Survey (2012)	California Water Sustain-ability Indicators Framework (2013)	EUM: A Primer for Water and Wastewater Utilities (2008)	Envision Rating System for Sustain-able Infra-structure v2.0 (2012)	IWA Performance Indicators (Water, 2006; Wastewater, 2003)	NACWA Financial Survey (2011)	(Canadian) National Water & Wastewater Bench-marking Initiative (2013)	WaterRF Performance Benchmarking for Effectively Managed Water Utilities (2014)	SFPUC Performance/ Strategic Sustainability Report (2014)
Link jobs to sustainability/ organizational Commitment	• Strategic plan with TBL goals/targets/ objectives, scaled 0-1-2 (none/little – some evidence – full compliance) (Q64b) TBL performance measures for organization and managers, scaled 0-1-2 (none/little – some evidence – full compliance) (Q64e)		• Presence of employee objectives and targets *linked to sustain-ability* (adapted from EUM) (p. 30)	• The organizational policies, procedures…are sufficient for the scope…of the project (sparse mechanisms – plan-do-check-act – full implementation) LD1.2				• Enterprise sustainability plan established (no support – frequent support – full support) (8.1.2) • Sustainability reporting (limited – moderate – full disclosure) (8.1.4)	• Percent of all staff who have undergone training on environmental stewardship EN2.2 • Advance SFPUC-wide Strategic Sust Plan & annual performance reporting GM5.1

Table E.1 (Continued)

Key Attribute	AWWA Water and Wastewater Utilities Bench-marking Survey (2012)	California Water Sustain-ability Indicators Framework (2013)	EUM: A Primer for Water and Wastewater Utilities (2008)	Envision Rating System for Sustain-able Infra-structure v2.0 (2012)	IWA Performance Indicators (Water, 2006; Wastewater, 2003)	NACWA Financial Survey (2011)	(Canadian) National Water & Wastewater Bench-marking Initiative (2013)	WaterRF Performance Benchmarking for Effectively Managed Water Utilities (2014)	SFPUC Performance/ Strategic Sustainability Report (2014)
Staff Training / Development	• Training hours per employee = Total training hours completed by all employees during the reporting period / total FTEs (Q3 and 4)		• Training hours per employee (p. 30) Certificati on coverage (# of certificatio ns achieved / number needed per year) (p. 30)	GRI: Avg hours of training per year per employee (SFPUC p. A-19)	• Total training (hours/ employee / year), internal & external (Pe19 water) Total training of personnel (wPe17 ww)			• Degree of implement-ation of learning programs (no learning – basic – robust…) (3.4.2) • Level of Management training achieved (none – generic – formal) (3.4.3)	• Average hours of training per year per employee (not exactly the same as AWWA) WP8.1 EWP: advocates for training on water stewardship to promote internal awareness and preparedness (SFPUC p. A-4)
Flexible Staff									
Culture of innovation									• Number of innovative/pilot projects using new tech that target objectives GM4.1

APPENDIX F: SUSTAINABLE PRACTICES FROM EAC INTERVIEWS

Table F.1 Sustainable Practices from EAC Interviews

	Rank	Practice	No. responses
1	1	Education & communication	8
2	T2	Asset management	6
3	T2	Bond rating/financial management	6
4	T2	Community ROI	6
5	T2	Green infrastructure	6
6	T2	Resource recovery	6
7	T7	Environmental justice	5
8	T7	Habitat/Watershed protection	5
9	T7	Meet or exceed permit	5
10	T7	Water conservation	5
11	11	Affordability	4
12	12	Long-term resource plan	3
13	T13	Ability to adapt/flexibility	2
14	T13	Good neighbor	2
15	T13	Maintenance plan/MMS	2
16	T13	Multi-function infrastructure	2
17	T13	Recycling/minimize materials	2
18	T13	Sourcewater protection	2
19	T21	Availability of water resources	1
20	T21	Climate	1
21	T21	Commercial/residential distribution	1
22	T21	Community giving	1
23	T21	Energy costs	1
24	T21	Envision rating system	1
25	T21	Everyone pays	1
26	T21	Fit-for-purpose water	1
27	T21	Fixed cost rate model	1
28	T21	Growth rate (city)	1
29	T21	LCC approach	1
30	T21	Minimize maintenance	1
31	T21	Pipe leaks	1
32	T21	Providing access to water	1
33	T21	Resiliency	1
34	T21	Response time (customer calls)	1
35	T21	Service outages	1
36	T21	Spills/overflows	1
37	T21	Stormwater	1
38	T21	Understanding service level	1
39	T21	Value engineering	1
40	T21	Water losses	1

APPENDIX G: SUSTAINABLE PRACTICES FROM FREELISTING SURVEYS

Table G.1 Sustainable Practices from Freelisting Surveys

Rank	Practice	% Responses	S
1	Resource recovery	61%	0.4452
2	Water conservation	42%	0.2612
3	Asset management	32%	0.2342
4	Energy eff./ E star / E cons.	29%	0.2507
5	Bond rating/financial management	29%	0.1875
6	Green infra/permeable pvmt	26%	0.1857
7	Renewables	26%	0.1784
8	Employee skills eval/plan/HR	26%	0.1782
9	Long-term resource plan	26%	0.1219
10	Education & communication	23%	0.0819
11	Climate	19%	0.0934
12	Habitat/watershed protection	16%	0.0643
13	Envision/LEED rating system	13%	0.0782
14	Recycling/min. materials	13%	0.0733
15	Risk analy./vulnerability assess.	13%	0.0686
16	Green chemistry	13%	0.0592
17	Continuous improvement	10%	0.0806
18	Availability of water resources	10%	0.0780
19	Performance measures/KPIs	10%	0.0689
20	Sourcewater protection	10%	0.0505
21	Treatment wetlands/natural sys.	10%	0.0490
22	Sustainability analysis	10%	0.0382
23	Leadership	10%	0.0296
24	AMI	10%	0.0279
25	Meet or exceed permit	10%	0.0200
26	Water audits / water losses	6%	0.0571
27	Mitigation/adapt & flood barriers	6%	0.0563
28	Decentralization/Dist. Systems	6%	0.0448
29	Environmental mitigation	6%	0.0438
30	Health & safety	6%	0.0414
31	Minimize maintenance	6%	0.0403
32	Regulatory knowledge	6%	0.0392
33	Audits	6%	0.0388
34	Strategic business plan	6%	0.0381
35	Stormwater	6%	0.0346
36	Document controls	6%	0.0292
37	Integrated water management	6%	0.0282
38	Benchmarking	6%	0.0276
39	Organizational responsibility plan	6%	0.0256
40	Training	6%	0.0206
41	Regional partnerships	6%	0.0179
42	Automation	6%	0.0145

Table G.1 (Continued)

43	Emergency response plan	6%	0.0077
44	ISO…	3%	0.0323
45	Non-corrosive coll. System	3%	0.0323
46	VFDs	3%	0.0323
47	Water quality/quantity data	3%	0.0296
48	Environmental stewardship	3%	0.0282
49	Water supply diversification	3%	0.0269
50	LCC approach	3%	0.0247
51	Flexible management	3%	0.0242
52	SOPs	3%	0.0228
53	Supply chain management	3%	0.0223
54	Resiliency	3%	0.0222
55	Brackish groundwater usage	3%	0.0215
56	Reduced I/I	3%	0.0215
57	Corrective/preventative action plans	3%	0.0209
58	Fit-for-purpose water	3%	0.0202
59	Regulatory support - sust. meas.	3%	0.0202
60	Succession planning	3%	0.0202
61	Peak shaving	3%	0.0194
62	Water markets (private exchanges)	3%	0.0184
63	Ability to adapt/flexibility	3%	0.0161
64	Affordability	3%	0.0161
65	Cross-functional teams	3%	0.0161
66	Mobile technology	3%	0.0161
67	Composting	3%	0.0138
68	EMS	3%	0.0133
69	Business-minded CIP	3%	0.0129
70	Source control/pretreatment	3%	0.0129
71	Smart irrigation	3%	0.0124
72	Source separation	3%	0.0121
73	Smart cities	3%	0.0115
74	Mgmt review of org. improvement	3%	0.0114
75	Anammox	3%	0.0108
76	Goal-setting & planning	3%	0.0108
77	Understanding service level	3%	0.0099
78	FOG recycling	3%	0.0092
79	Composting toilets	3%	0.0081
80	EUM	3%	0.0076
81	Cultural preservation	3%	0.0072
82	Tankless water heaters	3%	0.0072
83	Innovative financing	3%	0.0069
84	GHG measurement	3%	0.0054
85	GRI	3%	0.0050
86	Cultural/organizational alignment	3%	0.0040
87	Sustainability mgmt systems	3%	0.0040
88	Transboundary water laws	3%	0.0040
89	Quality of life	3%	0.0036
90	Behavioral economics (billing)	3%	0.0025

APPENDIX H: ORGANIZATIONAL ATTRIBUTES FROM FREELISTING SURVEYS

Table H.1 Organizational Attributes from Freelisting Surveys

Rank	Attributes	% Response	S
1	Public/stakeholder outreach & engagem't	39%	0.2288
2	Staff training & development	32%	0.2712
3	financial management/stewardship	32%	0.1506
4	Leadership	29%	0.2513
5	Cooperation with other orgs/utilities	26%	0.1096
6	Climate adaptation/mitigation / goals	19%	0.0827
7	Sust. Mgmt. Prog./Goals-commitment	16%	0.1189
8	Culture - open to new ideas	16%	0.1090
9	Innovation - culture	16%	0.1013
10	CI	16%	0.0584
11	infrastructure planning & maintenance	13%	0.1035
12	Systems thinking	13%	0.0828
13	Rates support upgrades (full cost $?)	13%	0.0784
14	EUM	10%	0.0846
15	Energy efficiency	10%	0.0793
16	Pol. support/coalitions w/ pub. officials	10%	0.0624
17	Resource recovery	10%	0.0593
18	water resources planning/adequacy	10%	0.0573
19	Water reuse	10%	0.0554
20	Environmental awareness/stewardship	10%	0.0534
21	Objectives / targets	10%	0.0484
22	Culture - aligned	10%	0.0457
23	Regulatory compliance	10%	0.0402
24	TBL	10%	0.0346
25	Asset Management	6%	0.0516
26	CI - KPIs	6%	0.0516
27	Sourcewater/watershed protection	6%	0.0409
28	Staffing efficiency	6%	0.0403
29	Industry awareness	6%	0.0387
30	Community ROI/QOL	6%	0.0313
31	Audits	6%	0.0280
32	Integrated planning	6%	0.0249
33	P3 / innovative financing	6%	0.0231
34	Technology (CMMS, SCADA) / Intelligent WS	6%	0.0215
35	Operational resilience	6%	0.0215
36	Research	6%	0.0208
37	Flexibility (infrastructure)	6%	0.0183
38	Safety program	6%	0.0093
39	CI - financial reporting	3%	0.0323
40	Commitment to public health	3%	0.0323
41	Culture - risk taking	3%	0.0323
42	Culture - teamwork	3%	0.0323

Table H.1 (Continued)

43	Link land use / water management	3%	0.0323
44	Community sustainability	3%	0.0301
45	Regulatory understanding (TMDL)	3%	0.0282
46	CI - Long and short term cap. planning	3%	0.0280
47	Data / tools	3%	0.0269
48	Use of best effective practices	3%	0.0269
49	CI - staffing planning	3%	0.0258
50	Cost avoidance	3%	0.0258
51	Technology to reduce costs	3%	0.0258
52	Culture - listen to all employees	3%	0.0251
53	Utility integration	3%	0.0251
54	EPA's willingness to try new solutions	3%	0.0242
55	E-W Nexus	3%	0.0242
56	Infrastructure stability	3%	0.0242
57	Staff - self-motivated	3%	0.0242
58	Customer feedback	3%	0.0237
59	Creativity	3%	0.0215
60	Incentives / process improvement	3%	0.0215
61	Long term planning	3%	0.0215
62	Private sector experience	3%	0.0215
63	Growth management	3%	0.0202
64	Water conservation innovation	3%	0.0202
65	Consent decrees	3%	0.0194
66	Desal advances	3%	0.0194
67	Pilot projects	3%	0.0194
68	Succession planning	3%	0.0194
69	Organization approaches	3%	0.0188
70	Transparency	3%	0.0188
71	LCC	3%	0.0184
72	Dynamic simulation modeling	3%	0.0179
73	Internal ideas (not all contractors)	3%	0.0179
74	Strategically focused	3%	0.0174
75	Policies/procedures	3%	0.0172
76	Affordability	3%	0.0161
77	Crisis	3%	0.0161
78	Green infrastructure	3%	0.0161
79	Organizational management	3%	0.0161
80	Water markets	3%	0.0161
81	Benchmarking	3%	0.0143
82	New staff	3%	0.0129
83	Operational efficiency	3%	0.0129
84	Outside industry awareness	3%	0.0124
85	Offstream storage	3%	0.0121
86	Stormwater management	3%	0.0121
87	Customer service	3%	0.0108
88	Organizational vision	3%	0.0108
89	Recycled materials	3%	0.0108
90	Reduce fossil fuels	3%	0.0108
91	Pollution prevention	3%	0.0086
92	Customer-oriented	3%	0.0074
93	Culture - empowerment	3%	0.0072

Table H.1 (Continued)

94	Happiness	3%	0.0072
95	Risk assessment	3%	0.0065
96	Reduce chemicals	3%	0.0054
97	Leak management	3%	0.0040
98	Optimism	3%	0.0036
99	Lean manufacturing	3%	0.0027

APPENDIX I: SURVEY TOOL USED FOR PILOT TEST

USF
UNIVERSITY OF SOUTH FLORIDA

Survey v.1.1
17-Nov-15

Thank you for participating in this research study, ***A Framework to Assess Key Attributes Driving Sustainability for U.S. Urban Water Utilities.***

Background

This research is being conducted by Matthew Ries, the "primary investigator" and a PhD candidate in the Department of Civil and Environmental Engineering at the University of South Florida.

The research for this dissertation will develop a framework to assess and prioritize key organizational attributes that drive sustainability for U.S. urban water utilities. It will build upon previous work to develop an indicator-based approach to assess sustainability, specifically for U.S. urban water utilities. It will also establish a set of representative organizational attributes that can be efficiently assessed. Finally, the dissertation will propose a methodology to correlate a utility's sustainability rating to its organizational attributes. It is anticipated that subsequent research applying this framework to a large number of utilities will produce results to prioritize activities and accelerate the transition towards sustainable urban water utilities.

This survey is a part of the overall project and will "pilot test" a proposed survey for water utilities to assess their sustainability based on eight priority practices identified via interviews with water sector leaders and surveys of water professionals from AWWA and WEF. It will also assess six key utility attributes identified by this same group of participants.

Individuals filling out the form will remain confidential, except to the primary investigator. Individual names will not be used in the dissertation, publications, or presentations of this research. The names of participating *utilities* will only be used if consent is given in a post-survey phone call with the primary investigator. If no consent is given, utilities will be identified by service type and geographical region, e.g. "a wastewater utility in the Northeast."

Instructions

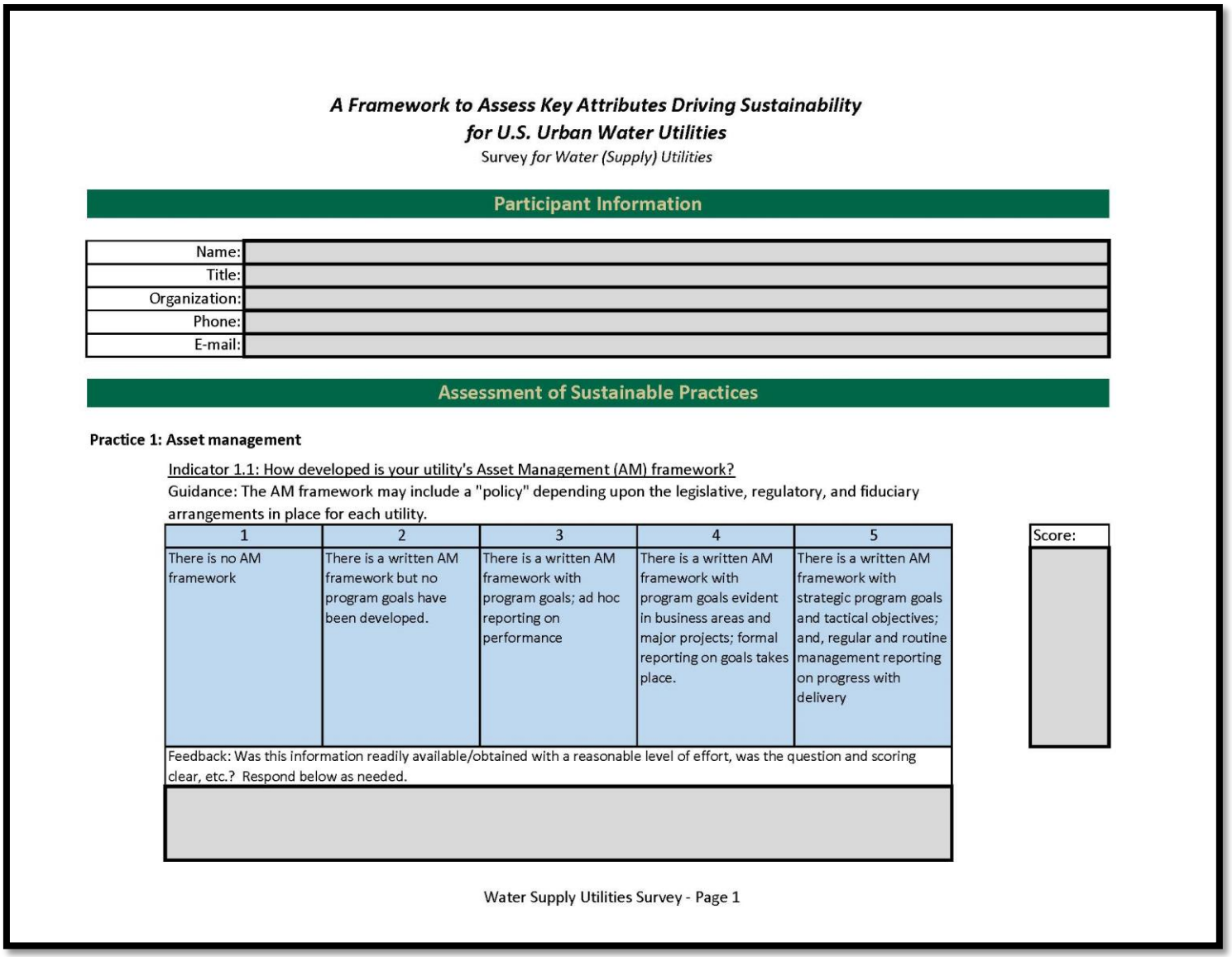
Users are asked to fill out the form at the appropriate tab in the spreadsheet for water, wastewater, or combined utilities.

If a question cannot be answered with precision based on the available scaling, participants are encouraged to provide an estimated answer and note this in the comments section of the indicator in question.

Upon completion, please save and return your completed survey to the primary investigator by December 4 at mries@mail.usf.edu. Any questions can be directed to the same e-mail

Thank you for your participation.

Figure I.1 Instructions Tab for Pilot Test



A Framework to Assess Key Attributes Driving Sustainability for U.S. Urban Water Utilities

Survey *for Water (Supply) Utilities*

Participant Information

Name:	
Title:	
Organization:	
Phone:	
E-mail:	

Assessment of Sustainable Practices

Practice 1: Asset management

Indicator 1.1: How developed is your utility's Asset Management (AM) framework?

Guidance: The AM framework may include a "policy" depending upon the legislative, regulatory, and fiduciary arrangements in place for each utility.

1	2	3	4	5	Score:
There is no AM framework	There is a written AM framework but no program goals have been developed.	There is a written AM framework with program goals; ad hoc reporting on performance	There is a written AM framework with program goals evident in business areas and major projects; formal reporting on goals takes place.	There is a written AM framework with strategic program goals and tactical objectives; and, regular and routine management reporting on progress with delivery	

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Water Supply Utilities Survey - Page 1

Figure I.2 Water Utilities Tab for Pilot Test

Practice 2: Education & Communication

Indicator 2.1: Does your utility have a public education program about its sustainability efforts?

Guidance: A public education program is externally-focused and designed to build support for and awareness of utility operations and sustainability efforts.

1	2	3	4	5	Score:
This activity is not practiced at our utility	This activity is implemented, but only occasionally or without uniformity	This activity is implemented, but there is room for substantial improvement	This activity is largely implemented, but there is room for improvement	This activity is fully implemented at our utility	
Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.					

Indicator 2.2: Does your utility have an effective communications plan that surveys stakeholders and engages them in dialogues?

Guidance: A communications plan solicits responses from and engage stakeholders before, during, and after service events and infrastructure activities.

1	2	3	4	5	Score:
This activity is not practiced at our utility	This activity is implemented, but only occasionally or without uniformity	This activity is implemented, but there is room for substantial improvement	This activity is largely implemented, but there is room for improvement	This activity is fully implemented at our utility	
Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.					

Figure I.2 (Continued)

Practice 3: Financial management

Indicator 3.1: What is your utility's bond rating?

Guidance: Rating may be for the utility itself or the municipality if your utility is part of a city/municipal government. Rating may be a "whisper" rating if one is not formally established. If no bond rating is available, provide an estimate of utility financial management progression, taking into account factors such as financial position, debt, governance, covenants, and ability to repay debt.

1	2	3	4	5
Moodys: ≤Caa S&P: ≤CCC+	Moodys: B to Ba S&P: B- to BB+	Moodys: Baa to A S&P: BBB- to A+	Moodys: AA S&P: AA	Moodys: Aaa S&P: AAA
Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.				

Score:

Figure I.2 (Continued)

Practice 4: Green Infrastructure

Indicator 4.1: How defined is your utility's green Infrastructure-based planning?

Guidance: "Green infrastructure-based planning" is defined as employing decision processes and criteria that promote source water protection and conservation for both the built and natural/unbuilt environment and/or the use of green infrastructure practices to improve stormwater quality, reduce quantity, and alleviate combined sewer overflows, achieving triple bottom line (economic, environmental, social) benefits.

1	2	3	4	5
No green infrastructure based planning approach defined or endorsed	Green infrastructure-based planning approach has been somewhat defined. The plan has been endorsed by few or no staff, stakeholders, and decision-maker.	Green infrastructure-based planning approach has been moderately defined.	Green infrastructure-based planning approach is well-defined. The plan has been endorsed by most staff, stakeholders, and decision-makers.	Green infrastructure-based planning approach is well-defined. The plan has been fully endorsed by staff, stakeholders and decision-makers.

Score:

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Figure I.2 (Continued)

Practice 5: Habitat/watershed protection

Indicator 5.1: To what extent has your utility engaged in habitat restoration and watershed protection efforts?

Guidance: Habitat/watershed protection may include studies to assess (e.g. benthic studies) and protect (e.g. ensuring adequate environmental flows) natural habitats and watersheds.

1	2	3	4	5
This activity is not practiced at our utility	This activity is implemented, but only occasionally or without uniformity	This activity is implemented, but there is room for substantial improvement	This activity is largely implemented, but there is room for improvement	This activity is fully implemented at our utility

Score:

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Figure I.2 (Continued)

Practice 6: Long-term resource plan

Indicator 6.1: To what extent is your utility's long-term capital planning horizon linked to its financial plan?

Guidance: A long-term capital can include longer planning horizons with more detail in the immediate years. It should be linked to financial plans and rate projections and updated on a regular basis.

1	2	3	4	5
<5 years capital plan	>5 to <10 year capital plan	≥10 year capital plan	≥10 year capital plan linked to financial plan	≥10 year capital plan linked to financial plan with rate projections

Score:

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Indicator 6.2: How far out does your utility plan for long-term water supply adequacy?

Guidance: Projected future annual supply relative to projected future annual demand for at least the next 50 years.

1	2	3	4	5
Projected supply adequate for <10 years	Projected supply adequate for 10-25 years	Projected supply adequate for 25-40 years	Projected supply adequate for 40-50 years	Projected supply adequate for <50 years

Score:

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Figure I.2 (Continued)

Practice 7: Resource recovery

Indicator 7.1: To what level is your utility achieving water reuse (as a % of water supply)?

Guidance: Water Reuse Factor (WaRe) is defined as 100x (amount of water supplied that is from reused or recycled water/total amount of water supplied)

1	2	3	4	5
WaRe < 60%	WaRe 60 to 69%	WaRe 70 to 79%	WaRe 80 to 90%	WaRe >90%
Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.				

Score:

Indicator 7.2: How defined is your utility's energy generation plan?

Guidance: An energy generation plan is defined as an energy use plan that takes into consideration opportunities for energy conservation and to produce energy from various sources. Plan endorsement implies implementation.

1	2	3	4	5
No energy generation plan has been developed	Energy generation plan has been somewhat defined. The plan has been endorsed by few or no staff, stakeholders, and decision makers.	Energy generation plan has been moderately defined	Energy generation plan is well-defined. The plan has been endorsed by most staff, stakeholders, and decision-makers.	The energy generation plan is well-defined. The plan has been fully endorsed by staff, stakeholders and decision-makers.
Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.				

Score:

Figure I.2 (Continued)

Practice 8: Water conservation

Indicator 8.1: How defined is your utility's approach to water conservation?

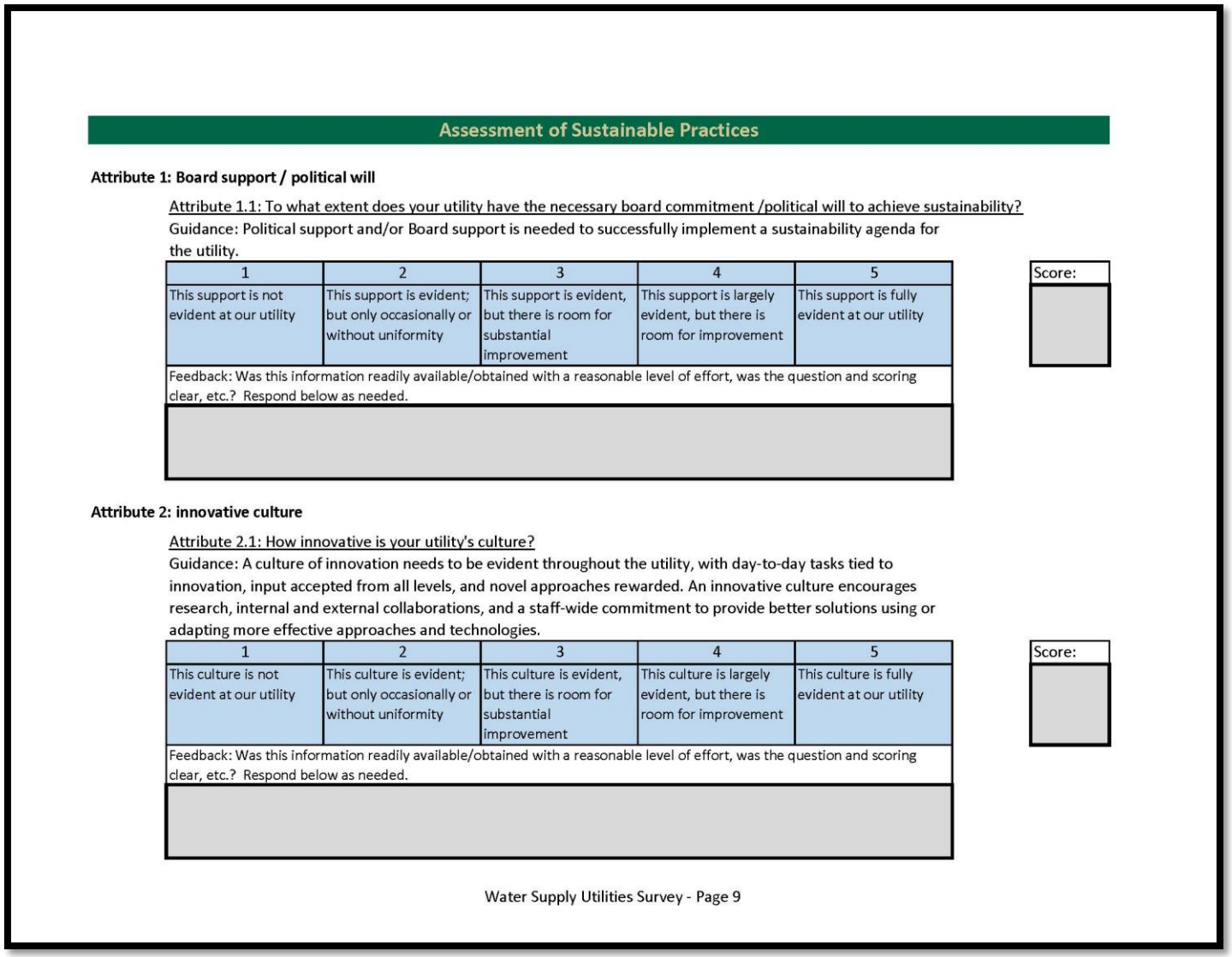
Guidance: Water conservation is defined as the set of activities and behaviors that reduce demand for treated water and minimize wastewater generation. Water conservation efforts should address both internal usage by the utility in its activities and efforts to promote conservation among external customers or other customers.

1	2	3	4	5
A water conservation approach is defined or endorsed	A water conservation approach has been somewhat defined. Approach is endorsed by few or no staff, stakeholders, and decision-makers	A water conservation approach has been moderately defined. Approach is endorsed by some staff, stakeholders, and decision-makers.	A water conservation approach is well-defined. Approach is endorsed by most staff, stakeholders, and decision-makers	A water conservation approach is well-defined. The approach is fully endorsed by staff, stakeholders, and decision-makers.

Score:

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Figure I.2 (Continued)



Assessment of Sustainable Practices

Attribute 1: Board support / political will

Attribute 1.1: To what extent does your utility have the necessary board commitment /political will to achieve sustainability?

Guidance: Political support and/or Board support is needed to successfully implement a sustainability agenda for the utility.

1	2	3	4	5	Score:
This support is not evident at our utility	This support is evident; but only occasionally or without uniformity	This support is evident, but there is room for substantial improvement	This support is largely evident, but there is room for improvement	This support is fully evident at our utility	

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Attribute 2: innovative culture

Attribute 2.1: How innovative is your utility's culture?

Guidance: A culture of innovation needs to be evident throughout the utility, with day-to-day tasks tied to innovation, input accepted from all levels, and novel approaches rewarded. An innovative culture encourages research, internal and external collaborations, and a staff-wide commitment to provide better solutions using or adapting more effective approaches and technologies.

1	2	3	4	5	Score:
This culture is not evident at our utility	This culture is evident; but only occasionally or without uniformity	This culture is evident, but there is room for substantial improvement	This culture is largely evident, but there is room for improvement	This culture is fully evident at our utility	

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Water Supply Utilities Survey - Page 9

Figure I.2 (Continued)

Attribute 3: Leadership

Attribute 3.1: To what extent is leadership driving your utility towards sustainability?

Guidance: Is your utility leader (1) articulating a sustainable vision for the utility, (2) strategically-focused, and (3) dedicated to sustainability?

1	2	3	4	5
None of these characteristics apply to our utility's leader	One of these characteristics apply to our utility's leader	Two of these characteristics apply to our utility's leader	All of these characteristics somewhat describe our utility's leader	All of these characteristics accurately describe our utility's leader

Score:

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Attribute 4: Flexible staff

Attribute 4.1: How flexible is your utility's staff?

Guidance: Utility has a cultural willingness to change and flexible staff who are open to new ideas from all levels of employees.

1	2	3	4	5
This culture is not evident at our utility	This culture is evident; but only occasionally or without uniformity	This culture is evident, but there is room for substantial improvement	This culture is largely evident, but there is room for improvement	This culture is fully evident at our utility

Score:

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Figure I.2 (Continued)

Attribute 5: Organizational commitment

Attribute 5.1: To what extent does your utility have an organizational commitment to sustainability?

Guidance: Organization as a whole committed to sustainability with everyday operations linked to the utility's sustainability programs/goals. For example, are individuals' job descriptions and performance linked to the utility's sustainability plan and/or goals?

1	2	3	4	5
This commitment is not evident at our utility	This commitment is evident; but only occasionally or without uniformity	This commitment is evident, but there is room for substantial improvement	This commitment is largely evident, but there is room for improvement	This support is fully evident at our utility

Score:

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Figure I.2 (Continued)

Attribute 6: Staff training / development

Attribute 6.1: What is your utility's degree of implementation of learning programs?

Guidance: Well developed learning programs should include both internal and external/distance learning training, particularly in emerging fields where internal resources may not represent the best state of practice in the industry.

1	2	3	4	5
No learning program	Rudimentary learning program which provides some guidance on employee training opportunities	Basic learning program with policies and/or guidance suggesting learning content and tracking of hours	Learning program consisting of instructor-led (live or remote) and/or self-paced; includes a range of content; hours are tracked	Robust learning program consisting of instructor-led (live or remote) and/or self-paced; includes a range of content appropriate to the employee; hours and activities are tracked

Score:

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Figure I.2 (Continued)

Attribute 6.2: What is the level of management training achieved by your utility?

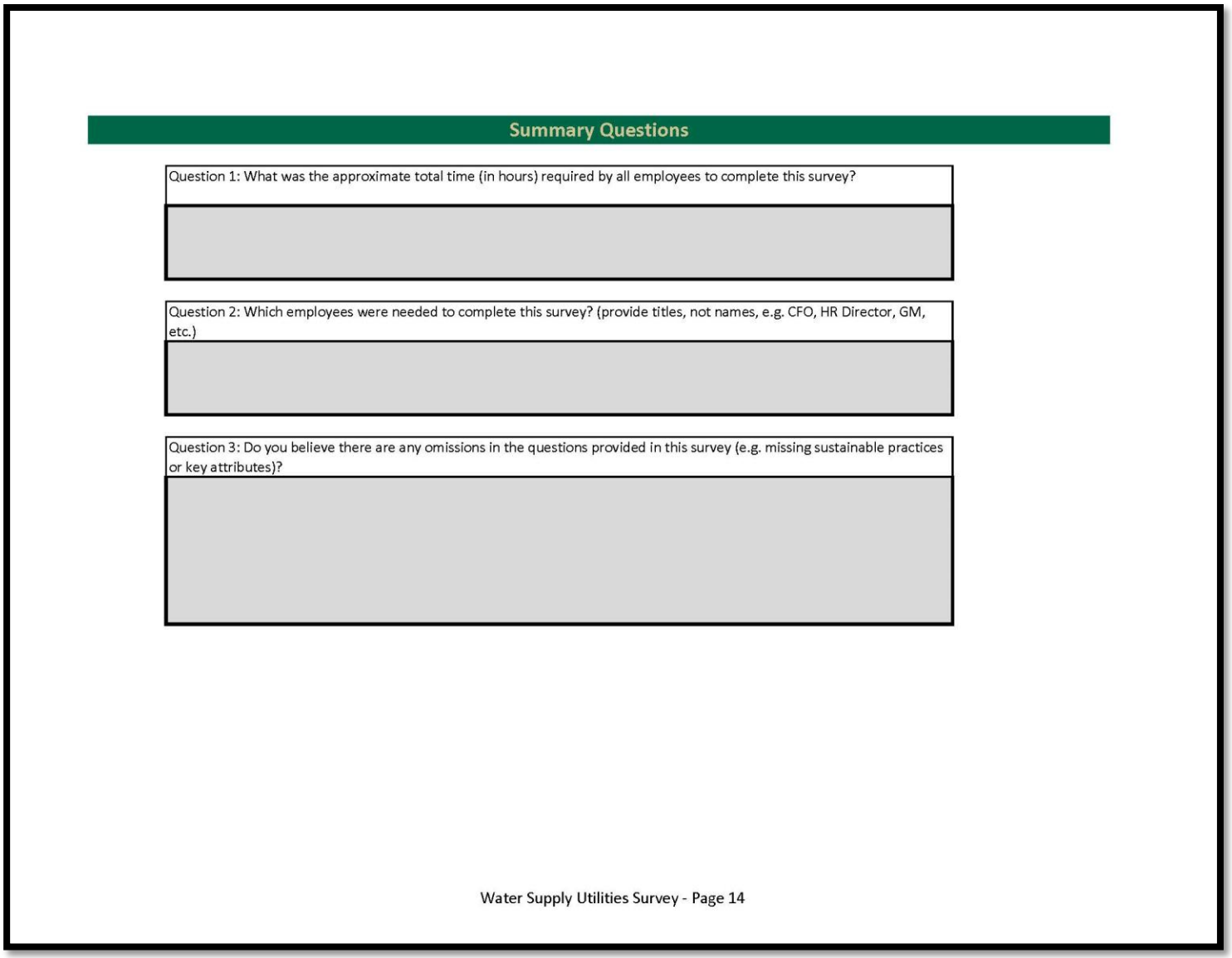
Guidance: Management training should address all key areas needed to provide for sound oversight and leadership of the staff below each supervisory level. Examples of key topics for management training are: organizational mission, vision; organizational culture; safety, HR policies, leadership, diversity, etc.

1	2	3	4	5
No specific supervisor or manager training program	Informal supervisor and manager training done on an ad-hoc basis by peers or higher level managers	Generic supervisor and manager training through self-directed coursework	Supervisor and manager training program that is utility specific instructor led or self-paced;	Formal supervisor and manager training program specific to the utility that is instructor led with required periodic refresher course

Score:

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Figure I.2 (Continued)



Summary Questions

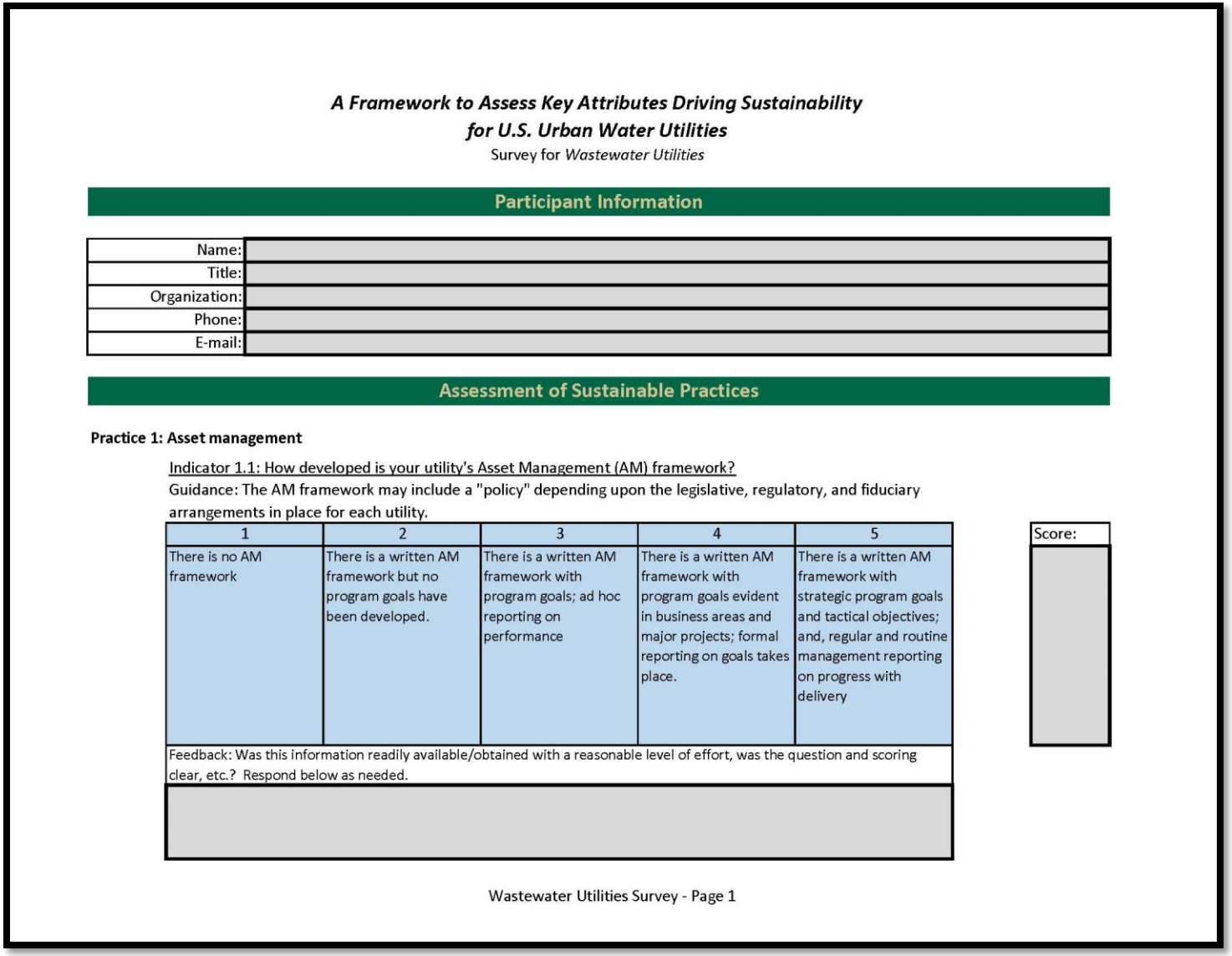
Question 1: What was the approximate total time (in hours) required by all employees to complete this survey?

Question 2: Which employees were needed to complete this survey? (provide titles, not names, e.g. CFO, HR Director, GM, etc.)

Question 3: Do you believe there are any omissions in the questions provided in this survey (e.g. missing sustainable practices or key attributes)?

Water Supply Utilities Survey - Page 14

Figure I.2 (Continued)



A Framework to Assess Key Attributes Driving Sustainability for U.S. Urban Water Utilities

Survey for *Wastewater Utilities*

Participant Information

Name:	
Title:	
Organization:	
Phone:	
E-mail:	

Assessment of Sustainable Practices

Practice 1: Asset management

Indicator 1.1: How developed is your utility's Asset Management (AM) framework?

Guidance: The AM framework may include a "policy" depending upon the legislative, regulatory, and fiduciary arrangements in place for each utility.

1	2	3	4	5
There is no AM framework	There is a written AM framework but no program goals have been developed.	There is a written AM framework with program goals; ad hoc reporting on performance	There is a written AM framework with program goals evident in business areas and major projects; formal reporting on goals takes place.	There is a written AM framework with strategic program goals and tactical objectives; and, regular and routine management reporting on progress with delivery

Score:

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Wastewater Utilities Survey - Page 1

Figure I.3 Wastewater Utilities Tab for Pilot Test

Practice 2: Education & Communication

Indicator 2.1: Does your utility have a public education program about its sustainability efforts?

Guidance: A public education program is externally-focused and designed to build support for and awareness of utility operations and sustainability efforts.

1	2	3	4	5	Score:
This activity is not practiced at our utility	This activity is implemented, but only occasionally or without uniformity	This activity is implemented, but there is room for substantial improvement	This activity is largely implemented, but there is room for improvement	This activity is fully implemented at our utility	
Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.					

Indicator 2.2: Does your utility have an effective communications plan that surveys stakeholders and engages them in dialogues?

Guidance: A communications plan solicits responses from and engage stakeholders before, during, and after service events and infrastructure activities.

1	2	3	4	5	Score:
This activity is not practiced at our utility	This activity is implemented, but only occasionally or without uniformity	This activity is implemented, but there is room for substantial improvement	This activity is largely implemented, but there is room for improvement	This activity is fully implemented at our utility	
Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.					

Figure I.3 (Continued)

Practice 3: Financial management

Indicator 3.1: What is your utility's bond rating?

Guidance: Rating may be for the utility itself or the municipality if your utility is part of a city/municipal government. Rating may be a "whisper" rating if one is not formally established. If no bond rating is available, provide an estimate of utility financial management progression, taking into account factors such as financial position, debt, governance, covenants, and ability to repay debt.

1	2	3	4	5
Moodys: ≤Caa S&P: ≤CCC+	Moodys: B to Ba S&P: B- to BB+	Moodys: Baa to A S&P: BBB- to A+	Moodys: AA S&P: AA	Moodys: Aaa S&P: AAA
Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.				

Score:

Figure I.3 (Continued)

Practice 4: Green Infrastructure

Indicator 4.1: How defined is your utility's green Infrastructure-based planning?

Guidance: "Green infrastructure-based planning" is defined as employing decision processes and criteria that promote source water protection and conservation for both the built and natural/unbuilt environment and/or the use of green infrastructure practices to improve stormwater quality, reduce quantity, and alleviate combined sewer overflows, achieving triple bottom line (economic, environmental, social) benefits.

1	2	3	4	5
No green infrastructure based planning approach defined or endorsed	Green infrastructure-based planning approach has been somewhat defined. The plan has been endorsed by few or no staff, stakeholders, and decision-maker.	Green infrastructure-based planning approach has been moderately defined.	Green infrastructure-based planning approach is well-defined. The plan has been endorsed by most staff, stakeholders, and decision-makers.	Green infrastructure-based planning approach is well-defined. The plan has been fully endorsed by staff, stakeholders and decision-makers.

Score:

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Figure I.3 (Continued)

Practice 5: Habitat/watershed protection

Indicator 5.1: To what extent has your utility engaged in habitat restoration and watershed protection efforts?

Guidance: Habitat/watershed protection may include studies to assess (e.g. benthic studies) and protect (e.g. ensuring adequate environmental flows) natural habitats and watersheds.

1	2	3	4	5
This activity is not practiced at our utility	This activity is implemented, but only occasionally or without uniformity	This activity is implemented, but there is room for substantial improvement	This activity is largely implemented, but there is room for improvement	This activity is fully implemented at our utility

Score:

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Figure I.3 (Continued)

Practice 6: Long-term resource plan

Indicator 6.1: To what extent is your utility's long-term capital planning horizon linked to its financial plan?

Guidance: A long-term capital can include longer planning horizons with more detail in the immediate years. It should be linked to financial plans and rate projections and updated on a regular basis.

1	2	3	4	5
<5 years capital plan	>5 to <10 year capital plan	≥10 year capital plan	≥10 year capital plan linked to financial plan	≥10 year capital plan linked to financial plan with rate projections

Score:

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Indicator 6.2: How far out does your utility plan for long-term water supply adequacy?

Guidance: Projected future annual supply relative to projected future annual demand for at least the next 50 years.

1	2	3	4	5
Projected supply adequate for <10 years	Projected supply adequate for 10-25 years	Projected supply adequate for 25-40 years	Projected supply adequate for 40-50 years	Projected supply adequate for <50 years

Score:

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Figure I.3 (Continued)

Practice 7: Resource recovery

Indicator 7.1: To what extent is your utility achieving water reuse (as a % of wastewater discharged)?

Guidance: Wastewater Reuse Factor (WWaRe) is defined as 100x (amount of wastewater discharged that is from reused or recycled water/total amount of wastewater supplied)

1	2	3	4	5
WWaRe < 60%	WWaRe 60 to 69%	WWaRe 70 to 79%	WWaRe 80 to 90%	WWaRe >90%
Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.				

Score:

Indicator 7.2: To what extent Is your utility achieving beneficial biosolids use?

Guidance: Biosolids put to beneficial use (BeneBio) is defined as 100x (amount of biosolids produced that are put to a beneficial use/total amount of biosolids produced)

1	2	3	4	5
BeneBio < 60%	BeneBio 60 to 69%	BeneBio 70 to 79%	BeneBio 80 to 90%	BeneBio >90%
Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.				

Score:

Figure I.3 (Continued)

Indicator 7.3: How defined is your utility's energy generation plan?

Guidance: An energy generation plan is defined as an energy use plan that takes into consideration opportunities for energy conservation and to produce energy from various sources. Plan endorsement implies implementation.

1	2	3	4	5
No energy generation plan has been developed	Energy generation plan has been somewhat defined. The plan has been endorsed by few or no staff, stakeholders, and decision makers.	Energy generation plan has been moderately defined	Energy generation plan is well-defined. The plan has been endorsed by most staff, stakeholders, and decision-makers.	The energy generation plan is well-defined. The plan has been fully endorsed by staff, stakeholders and decision-makers.

Score:

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Wastewater Utilities Survey - Page 8

Figure I.3 (Continued)

Indicator 7.4: How defined is your utility's nutrient recovery plan?

Guidance: A nutrient recovery plan is defined as a plan that takes into consideration opportunities for nutrient recovery, including phosphorus recovery via struvite precipitation or other means and/or nitrogen recovery via biosolids land application or other means. Plan endorsement implies implementation.

1	2	3	4	5
No nutrient recovery plan has been developed	Nutrient recovery plan has been somewhat defined. The plan has been endorsed by few or no staff, stakeholders, and decision makers.	Nutrient recovery plan has been moderately defined	Nutrient recovery plan is well-defined. The plan has been endorsed by most staff, stakeholders, and decision-makers.	The nutrient recovery plan is well-defined. The plan has been fully endorsed by staff, stakeholders and decision-makers.

Score:

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Figure I.3 (Continued)

Practice 8: Water conservation

Indicator 8.1: How defined is your utility's approach to water conservation?

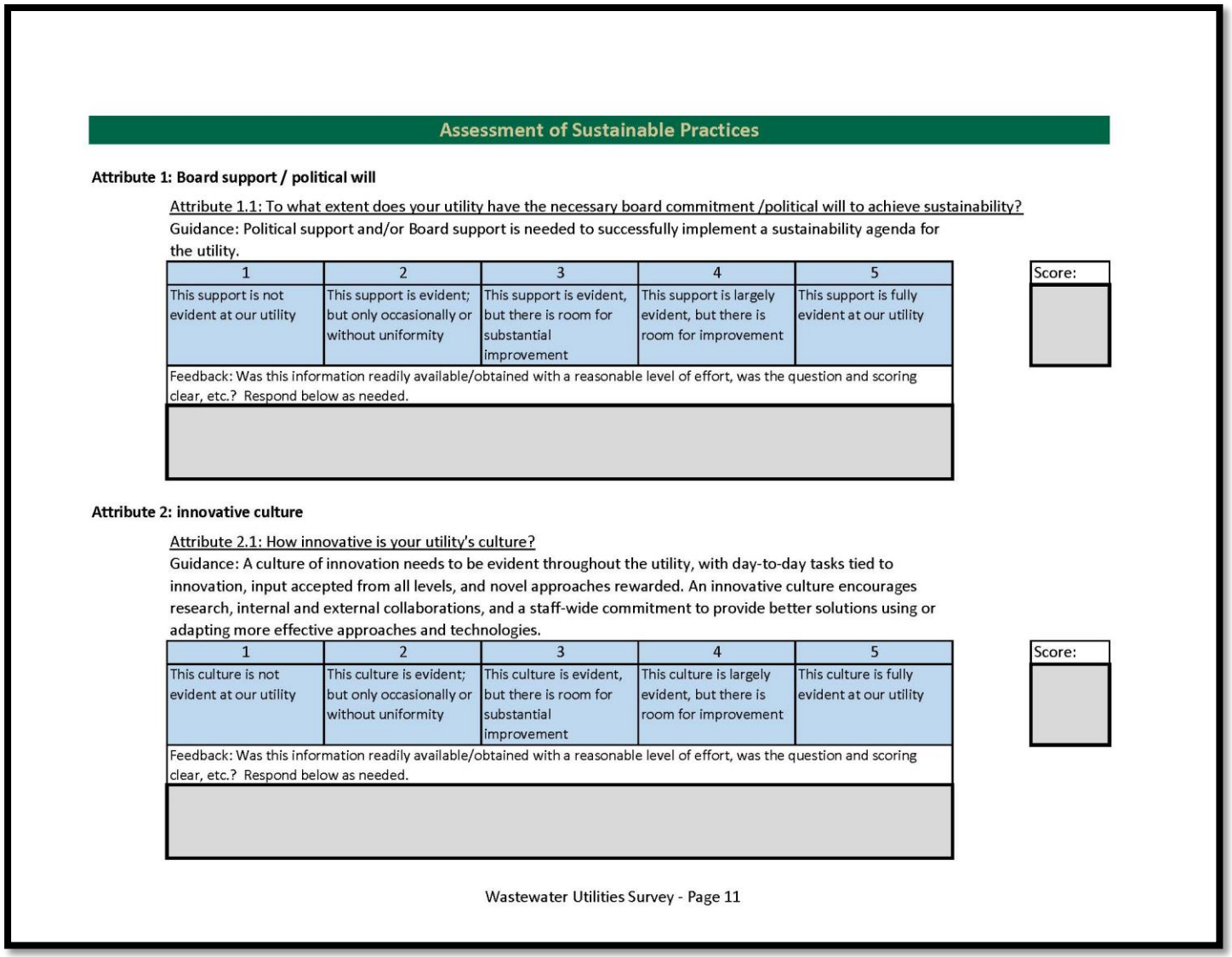
Guidance: Water conservation is defined as the set of activities and behaviors that reduce demand for treated water and minimize wastewater generation. Water conservation efforts should address both internal usage by the utility in its activities and efforts to promote conservation among external customers or other customers.

1	2	3	4	5
A water conservation approach is defined or endorsed	A water conservation approach has been somewhat defined. Approach is endorsed by few or no staff, stakeholders, and decision-makers	A water conservation approach has been moderately defined. Approach is endorsed by some staff, stakeholders, and decision-makers.	A water conservation approach is well-defined. Approach is endorsed by most staff, stakeholders, and decision-makers	A water conservation approach is well-defined. The approach is fully endorsed by staff, stakeholders, and decision-makers.

Score:

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Figure I.3 (Continued)



Assessment of Sustainable Practices

Attribute 1: Board support / political will

Attribute 1.1: To what extent does your utility have the necessary board commitment /political will to achieve sustainability?

Guidance: Political support and/or Board support is needed to successfully implement a sustainability agenda for the utility.

1	2	3	4	5	Score:
This support is not evident at our utility	This support is evident; but only occasionally or without uniformity	This support is evident, but there is room for substantial improvement	This support is largely evident, but there is room for improvement	This support is fully evident at our utility	
Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.					

Attribute 2: innovative culture

Attribute 2.1: How innovative is your utility's culture?

Guidance: A culture of innovation needs to be evident throughout the utility, with day-to-day tasks tied to innovation, input accepted from all levels, and novel approaches rewarded. An innovative culture encourages research, internal and external collaborations, and a staff-wide commitment to provide better solutions using or adapting more effective approaches and technologies.

1	2	3	4	5	Score:
This culture is not evident at our utility	This culture is evident; but only occasionally or without uniformity	This culture is evident, but there is room for substantial improvement	This culture is largely evident, but there is room for improvement	This culture is fully evident at our utility	
Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.					

Wastewater Utilities Survey - Page 11

Figure I.3 (Continued)

Attribute 3: Leadership

Attribute 3.1: To what extent is leadership driving your utility towards sustainability?

Guidance: Is your utility leader (1) articulating a sustainable vision for the utility, (2) strategically-focused, and (3) dedicated to sustainability?

1	2	3	4	5
None of these characteristics apply to our utility's leader	One of these characteristics apply to our utility's leader	Two of these characteristics apply to our utility's leader	All of these characteristics somewhat describe our utility's leader	All of these characteristics accurately describe our utility's leader
Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.				

Score:

Attribute 4: Flexible staff

Attribute 4.1: How flexible is your utility's staff?

Guidance: Utility has a cultural willingness to change and flexible staff who are open to new ideas from all levels of employees.

1	2	3	4	5
This culture is not evident at our utility	This culture is evident; but only occasionally or without uniformity	This culture is evident, but there is room for substantial improvement	This culture is largely evident, but there is room for improvement	This culture is fully evident at our utility
Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.				

Score:

Figure I.3 (Continued)

Attribute 5: Organizational commitment

Attribute 5.1: To what extent does your utility have an organizational commitment to sustainability?

Guidance: Organization as a whole committed to sustainability with everyday operations linked to the utility's sustainability programs/goals. For example, are individuals' job descriptions and performance linked to the utility's sustainability plan and/or goals?

1	2	3	4	5
This commitment is not evident at our utility	This commitment is evident; but only occasionally or without uniformity	This commitment is evident, but there is room for substantial improvement	This commitment is largely evident, but there is room for improvement	This support is fully evident at our utility

Score:

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Figure I.3 (Continued)

Attribute 6: Staff training / development

Attribute 6.1: What is your utility's degree of implementation of learning programs?

Guidance: Well developed learning programs should include both internal and external/distance learning training, particularly in emerging fields where internal resources may not represent the best state of practice in the industry.

1	2	3	4	5
No learning program	Rudimentary learning program which provides some guidance on employee training opportunities	Basic learning program with policies and/or guidance suggesting learning content and tracking of hours	Learning program consisting of instructor-led (live or remote) and/or self-paced; includes a range of content; hours are tracked	Robust learning program consisting of instructor-led (live or remote) and/or self-paced; includes a range of content appropriate to the employee; hours and activities are tracked

Score:

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Figure I.3 (Continued)

Attribute 6.2: What is the level of management training achieved by your utility?

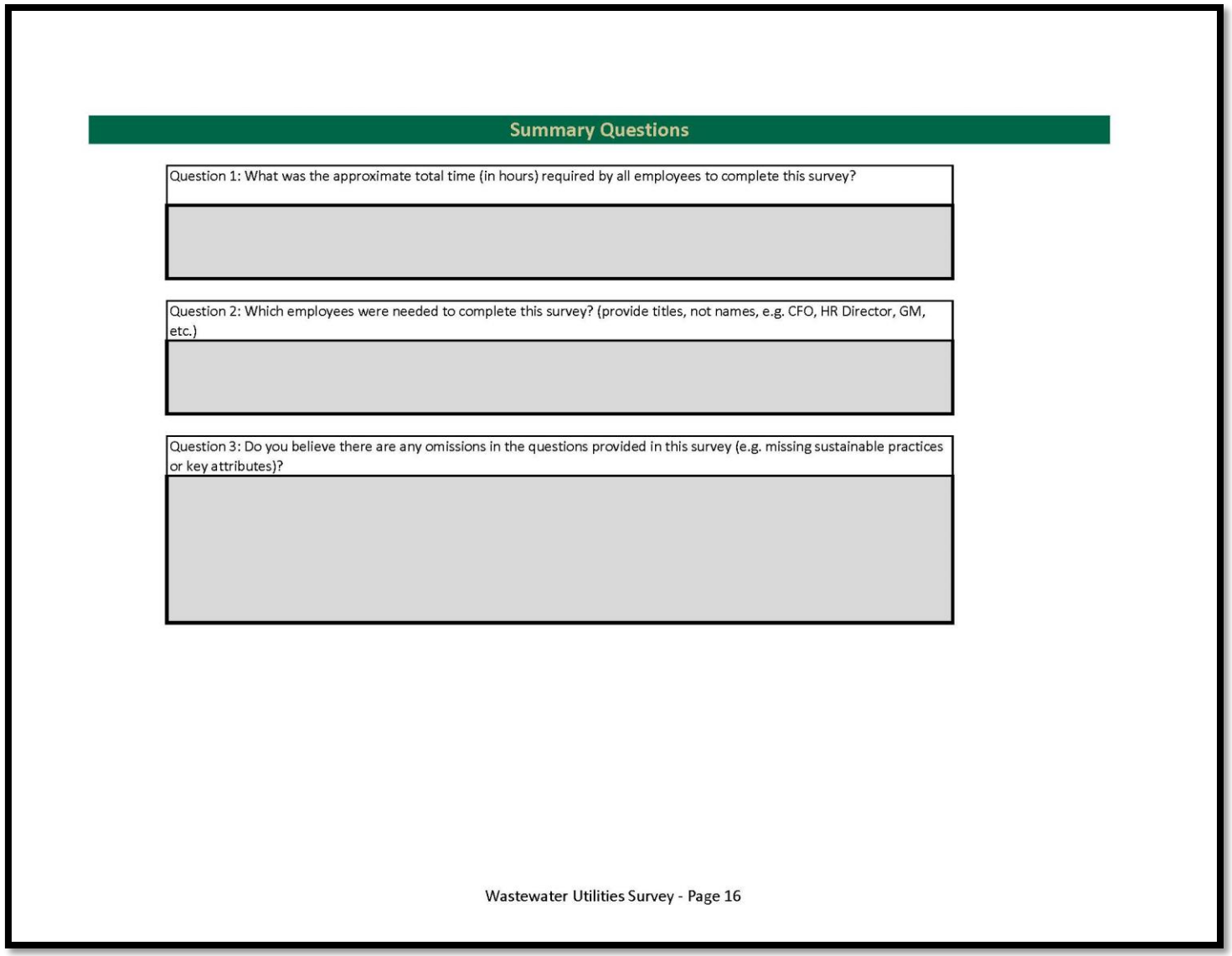
Guidance: Management training should address all key areas needed to provide for sound oversight and leadership of the staff below each supervisory level. Examples of key topics for management training are: organizational mission, vision; organizational culture; safety, HR policies, leadership, diversity, etc.

1	2	3	4	5
No specific supervisor or manager training program	Informal supervisor and manager training done on an ad-hoc basis by peers or higher level managers	Generic supervisor and manager training through self-directed coursework	Supervisor and manager training program that is utility specific instructor led or self-paced;	Formal supervisor and manager training program specific to the utility that is instructor led with required periodic refresher course

Score:

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Figure I.3 (Continued)



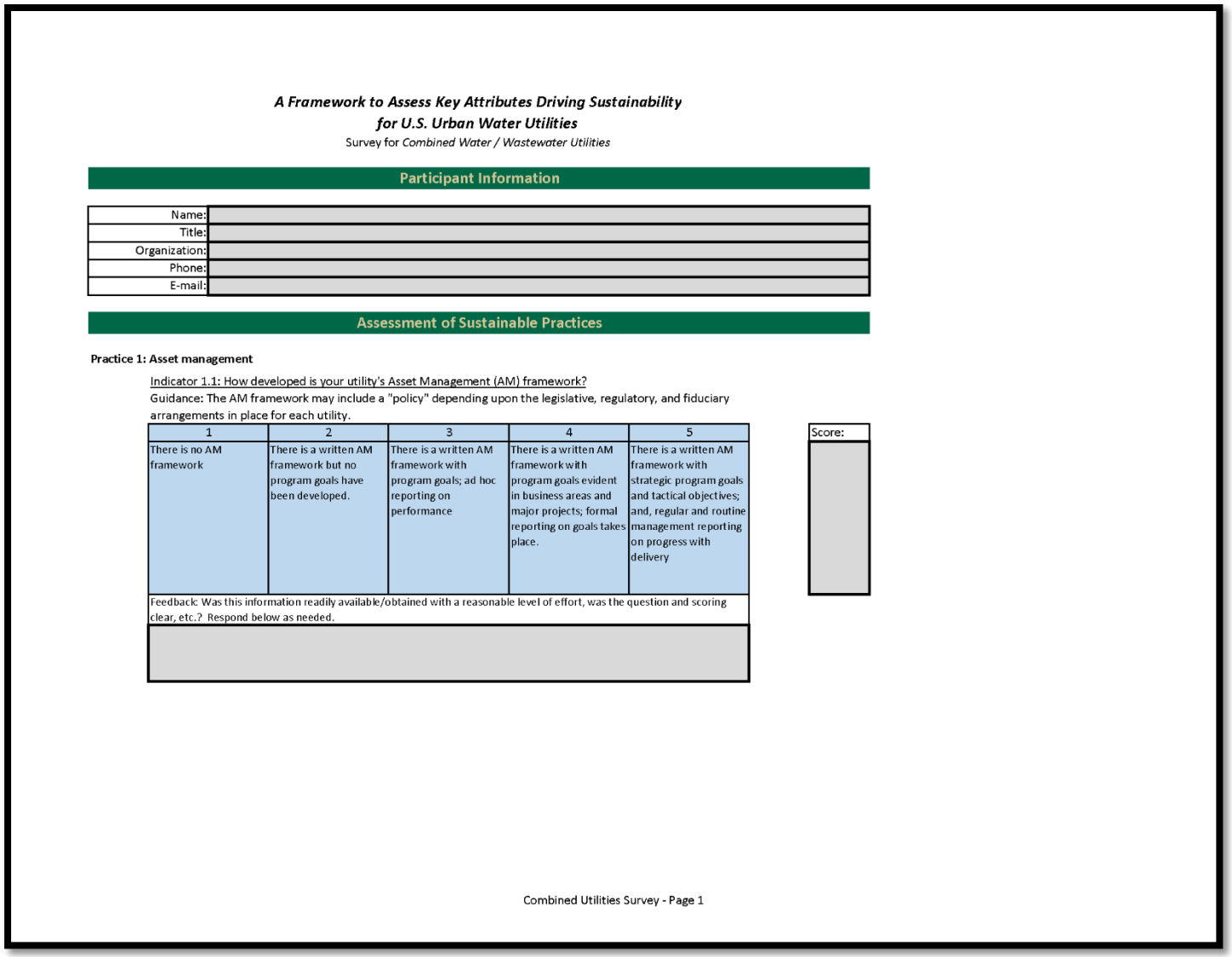
Summary Questions

Question 1: What was the approximate total time (in hours) required by all employees to complete this survey?

Question 2: Which employees were needed to complete this survey? (provide titles, not names, e.g. CFO, HR Director, GM, etc.)

Question 3: Do you believe there are any omissions in the questions provided in this survey (e.g. missing sustainable practices or key attributes)?

Figure I.3 (Continued)



A Framework to Assess Key Attributes Driving Sustainability for U.S. Urban Water Utilities

Survey for *Combined Water / Wastewater Utilities*

Participant Information

Name:	
Title:	
Organization:	
Phone:	
E-mail:	

Assessment of Sustainable Practices

Practice 1: Asset management

Indicator 1.1: How developed is your utility's Asset Management (AM) framework?

Guidance: The AM framework may include a "policy" depending upon the legislative, regulatory, and fiduciary arrangements in place for each utility.

1	2	3	4	5	Score:
There is no AM framework	There is a written AM framework but no program goals have been developed.	There is a written AM framework with program goals; ad hoc reporting on performance	There is a written AM framework with program goals evident in business areas and major projects; formal reporting on goals takes place.	There is a written AM framework with strategic program goals and tactical objectives; and, regular and routine management reporting on progress with delivery	

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Combined Utilities Survey - Page 1

Figure I.4 Combined Utilities Tab for Pilot Test

Practice 2: Education & Communication

Indicator 2.1: Does your utility have a public education program about its sustainability efforts?

Guidance: A public education program is externally-focused and designed to build support for and awareness of utility operations and sustainability efforts.

1	2	3	4	5	Score:
This activity is not practiced at our utility	This activity is implemented, but only occasionally or without uniformity	This activity is implemented, but there is room for substantial improvement	This activity is largely implemented, but there is room for improvement	This activity is fully implemented at our utility	

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Indicator 2.2: Does your utility have an effective communications plan that surveys stakeholders and engages them in dialogues?

Guidance: A communications plan solicits responses from and engage stakeholders before, during, and after service events and infrastructure activities.

1	2	3	4	5	Score:
This activity is not practiced at our utility	This activity is implemented, but only occasionally or without uniformity	This activity is implemented, but there is room for substantial improvement	This activity is largely implemented, but there is room for improvement	This activity is fully implemented at our utility	

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Figure I.4 (Continued)

Practice 3: Financial management

Indicator 3.1: What is your utility's bond rating?

Guidance: Rating may be for the utility itself or the municipality if your utility is part of a city/municipal government. Rating may be a "whisper" rating if one is not formally established. If no bond rating is available, provide an estimate of utility financial management progression, taking into account factors such as financial position, debt, governance, covenants, and ability to repay debt.

1	2	3	4	5
Moodys: ≤Caa S&P: ≤CCC+	Moodys: B to Ba S&P: B- to BB+	Moodys: Baa to A S&P: BBB- to A+	Moodys: AA S&P: AA	Moodys: Aaa S&P: AAA
Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.				

Score:

Figure I.4 (Continued)

Practice 4: Green Infrastructure

Indicator 4.1: How defined is your utility's green Infrastructure-based planning?

Guidance: "Green infrastructure-based planning" is defined as employing decision processes and criteria that promote source water protection and conservation for both the built and natural/unbuilt environment and/or the use of green infrastructure practices to improve stormwater quality, reduce quantity, and alleviate combined sewer overflows, achieving triple bottom line (economic, environmental, social) benefits.

1	2	3	4	5
No green infrastructure-based planning approach defined or endorsed	Green infrastructure-based planning approach has been somewhat defined. The plan has been endorsed by few or no staff, stakeholders, and decision-maker.	Green infrastructure-based planning approach has been moderately defined.	Green infrastructure-based planning approach is well-defined. The plan has been endorsed by most staff, stakeholders, and decision-makers.	Green infrastructure-based planning approach is well-defined. The plan has been fully endorsed by staff, stakeholders and decision-makers.

Score:

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Figure I.4 (Continued)

Practice 5: Habitat/watershed protection

Indicator 5.1: To what extent has your utility engaged in habitat restoration and watershed protection efforts?
Guidance: Habitat/watershed protection may include studies to assess (e.g. benthic studies) and protect (e.g. ensuring adequate environmental flows) natural habitats and watersheds.

1	2	3	4	5
This activity is not practiced at our utility	This activity is implemented, but only occasionally or without uniformity	This activity is implemented, but there is room for substantial improvement	This activity is largely implemented, but there is room for improvement	This activity is fully implemented at our utility

Score:

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Figure I.4 (Continued)

Practice 6: Long-term resource plan

Indicator 6.1: To what extent is your utility's long-term capital planning horizon linked to its financial plan?
Guidance: A long-term capital can include longer planning horizons with more detail in the immediate years. It should be linked to financial plans and rate projections and updated on a regular basis.

1	2	3	4	5	Score:
<5 years capital plan	>5 to <10 year capital plan	≥10 year capital plan	≥10 year capital plan linked to financial plan	≥10 year capital plan linked to financial plan with rate projections	
Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.					

Indicator 6.2: How far out does your utility plan for long-term water supply adequacy?
Guidance: Projected future annual supply relative to projected future annual demand for at least the next 50 years.

1	2	3	4	5	Score:
Projected supply adequate for <10 years	Projected supply adequate for 10-25 years	Projected supply adequate for 25-40 years	Projected supply adequate for 40-50 years	Projected supply adequate for <50 years	
Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.					

Figure I.4 (Continued)

Practice 7: Resource recovery

Indicator 7.1: To what level is your utility achieving water reuse (as a % of water supply)?

Guidance: Water Reuse Factor (WaRe) is defined as 100x (amount of water supplied that is from reused or recycled water/total amount of water supplied)

1	2	3	4	5
WaRe < 60%	WaRe 60 to 69%	WaRe 70 to 79%	WaRe 80 to 90%	WaRe >90%
Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.				

Score:

Indicator 7.2: To what extent is your utility achieving water reuse (as a % of wastewater discharged)?

Guidance: Wastewater Reuse Factor (WWaRe) is defined as 100x (amount of wastewater discharged that is from reused or recycled water/total amount of wastewater supplied)

1	2	3	4	5
WWaRe < 60%	WWaRe 60 to 69%	WWaRe 70 to 79%	WWaRe 80 to 90%	WWaRe >90%
Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.				

Score:

Indicator 7.3: To what extent Is your utility achieving beneficial biosolids use?

Guidance: Biosolids put to beneficial use (BeneBio) is defined as 100x (amount of biosolids produced that are put to a beneficial use/total amount of biosolids produced)

1	2	3	4	5
BeneBio < 60%	BeneBio 60 to 69%	BeneBio 70 to 79%	BeneBio 80 to 90%	BeneBio >90%
Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.				

Score:

Figure I.4 (Continued)

Indicator 7.4: How defined is your utility's energy generation plan?

Guidance: An energy generation plan is defined as an energy use plan that takes into consideration opportunities for energy conservation and to produce energy from various sources. Plan endorsement implies implementation.

1	2	3	4	5	Score:
No energy generation plan has been developed	Energy generation plan has been somewhat defined. The plan has been endorsed by few or no staff, stakeholders, and decision makers.	Energy generation plan has been moderately defined	Energy generation plan is well-defined. The plan has been endorsed by most staff, stakeholders, and decision-makers.	The energy generation plan is well-defined. The plan has been fully endorsed by staff, stakeholders and decision-makers.	

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Indicator 7.5: How defined is your utility's nutrient recovery plan?

Guidance: A nutrient recovery plan is defined as a plan that takes into consideration opportunities for nutrient recovery, including phosphorus recovery via struvite precipitation or other means and/or nitrogen recovery via biosolids land application or other means. Plan endorsement implies implementation.

1	2	3	4	5	Score:
No nutrient recovery plan has been developed	Nutrient recovery plan has been somewhat defined. The plan has been endorsed by few or no staff, stakeholders, and decision makers.	Nutrient recovery plan has been moderately defined	Nutrient recovery plan is well-defined. The plan has been endorsed by most staff, stakeholders, and decision-makers.	The nutrient recovery plan is well-defined. The plan has been fully endorsed by staff, stakeholders and decision-makers.	

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Figure I.4 (Continued)

Practice 8: Water conservation

Indicator 8.1: How defined is your utility's approach to water conservation?

Guidance: Water conservation is defined as the set of activities and behaviors that reduce demand for treated water and minimize wastewater generation. Water conservation efforts should address both internal usage by the utility in its activities and efforts to promote conservation among external customers or other customers.

1	2	3	4	5
A water conservation approach is defined or endorsed	A water conservation approach has been somewhat defined. Approach is endorsed by few or no staff, stakeholders, and decision-makers	A water conservation approach has been moderately defined. Approach is endorsed by some staff, stakeholders, and decision-makers.	A water conservation approach is well-defined. Approach is endorsed by most staff, stakeholders, and decision-makers	A water conservation approach is well-defined. The approach is fully endorsed by staff, stakeholders, and decision-makers.

Score:

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Figure I.4 (Continued)

Assessment of Organizational Attributes

Attribute 1: Board support / political will

Attribute 1.1: To what extent does your utility have the necessary board commitment /political will to achieve sustainability?

Guidance: Political support and/or Board support is needed to successfully implement a sustainability agenda for the utility.

1	2	3	4	5	Score:
This support is not evident at our utility	This support is evident; but only occasionally or without uniformity	This support is evident, but there is room for substantial improvement	This support is largely evident, but there is room for improvement	This support is fully evident at our utility	
Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.					

Attribute 2: innovative culture

Attribute 2.1: How innovative is your utility's culture?

Guidance: A culture of innovation needs to be evident throughout the utility, with day-to-day tasks tied to innovation, input accepted from all levels, and novel approaches rewarded. An innovative culture encourages research, internal and external collaborations, and a staff-wide commitment to provide better solutions using or adapting more effective approaches and technologies.

1	2	3	4	5	Score:
This culture is not evident at our utility	This culture is evident; but only occasionally or without uniformity	This culture is evident, but there is room for substantial improvement	This culture is largely evident, but there is room for improvement	This culture is fully evident at our utility	
Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.					

Figure I.4 (Continued)

Attribute 3: Leadership

Attribute 3.1: To what extent is leadership driving your utility towards sustainability?

Guidance: Is your utility leader (1) articulating a sustainable vision for the utility, (2) strategically-focused, and (3) dedicated to sustainability?

1	2	3	4	5
None of these characteristics apply to our utility's leader	One of these characteristics apply to our utility's leader	Two of these characteristics apply to our utility's leader	All of these characteristics somewhat describe our utility's leader	All of these characteristics accurately describe our utility's leader

Score:

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Figure I.4 (Continued)

Attribute 4: Flexible staff

Attribute 4.1: How flexible is your utility's staff?

Guidance: Utility has a cultural willingness to change and flexible staff who are open to new ideas from all levels of employees.

1	2	3	4	5	Score:
This culture is not evident at our utility	This culture is evident; but only occasionally or without uniformity	This culture is evident, but there is room for substantial improvement	This culture is largely evident, but there is room for improvement	This culture is fully evident at our utility	
Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.					

Attribute 5: Organizational commitment

Attribute 5.1: To what extent does your utility have an organizational commitment to sustainability?

Guidance: Organization as a whole committed to sustainability with everyday operations linked to the utility's sustainability programs/goals. For example, are individuals' job descriptions and performance linked to the utility's sustainability plan and/or goals?

1	2	3	4	5	Score:
This commitment is not evident at our utility	This commitment is evident; but only occasionally or without uniformity	This commitment is evident, but there is room for substantial improvement	This commitment is largely evident, but there is room for improvement	This support is fully evident at our utility	
Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.					

Figure I.4 (Continued)

Attribute 6: Staff training / development

Attribute 6.1: What is your utility's degree of implementation of learning programs?

Guidance: Well developed learning programs should include both internal and external/distance learning training, particularly in emerging fields where internal resources may not represent the best state of practice in the industry.

1	2	3	4	5	Score:
No learning program	Rudimentary learning program which provides some guidance on employee training opportunities	Basic learning program with policies and/or guidance suggesting learning content and tracking of hours	Learning program consisting of instructor-led (live or remote) and/or self-paced; includes a range of content; hours are tracked	Robust learning program consisting of instructor-led (live or remote) and/or self-paced; includes a range of content appropriate to the employee; hours and activities are tracked	

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

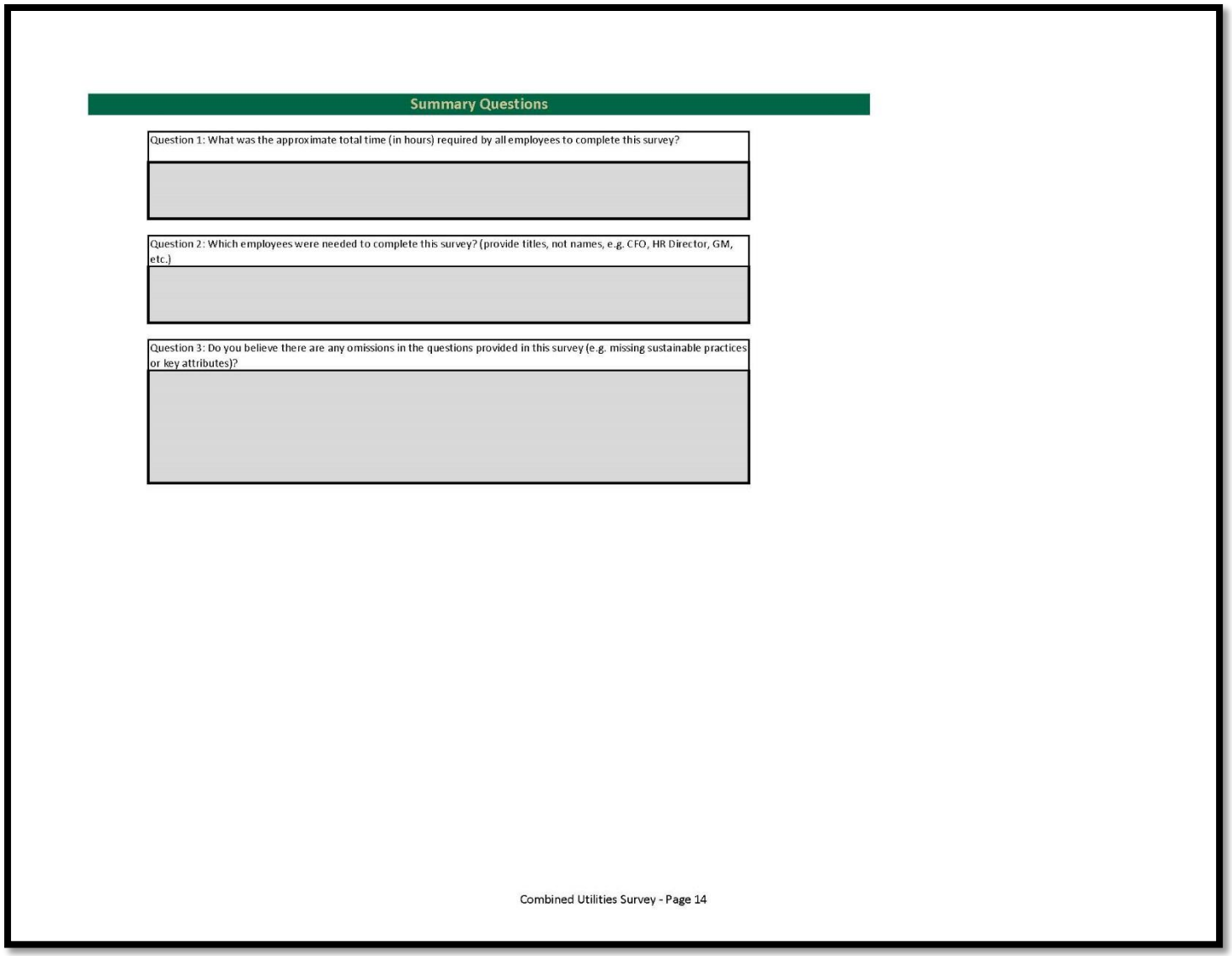
Attribute 6.2: What is the level of management training achieved by your utility?

Guidance: Management training should address all key areas needed to provide for sound oversight and leadership of the staff below each supervisory level. Examples of key topics for management training are: organizational mission, vision; organizational culture; safety, HR policies, leadership, diversity, etc.

1	2	3	4	5	Score:
No specific supervisor or manager training program	Informal supervisor and manager training done on an ad-hoc basis by peers or higher level managers	Generic supervisor and manager training through self-directed coursework	Supervisor and manager training program that is utility specific instructor led or self-paced;	Formal supervisor and manager training program specific to the utility that is instructor led with required periodic refresher course	

Feedback: Was this information readily available/obtained with a reasonable level of effort, was the question and scoring clear, etc.? Respond below as needed.

Figure I.4 (Continued)



Summary Questions

Question 1: What was the approximate total time (in hours) required by all employees to complete this survey?

Question 2: Which employees were needed to complete this survey? (provide titles, not names, e.g. CFO, HR Director, GM, etc.)

Question 3: Do you believe there are any omissions in the questions provided in this survey (e.g. missing sustainable practices or key attributes)?

Combined Utilities Survey - Page 14

Figure I.4 (Continued)

References
The 8 sustainable practices and 6 organizational attributes in this survey were derived from a series of interviews with water sector leaders and water professionals from AWWA and WEF.
Each practice and attribute were then mapped against a series of existing benchmarking frameworks, indicator systems, utility sustainability reports, and sustainability assessment tools.
Whenver possible, existing indicators and scaling (1 to 5) were used when they matched the intent of the practices and attributes developed in this research program (noted as "source" below). In some cases, existing systems were modified (noted as "adapted" below). In other cases, new indicators and scaling were developed. Where applicable, existing systems are referenced below.
Indicator 1.1 - Asset management. Source: WateRF (2014), performance measure 6.1.1
Indicator 2.1 - Public education program. Adapted from: AWWA (2013), question 13
Indicator 2.2 - Communications plan. Adapted from: AWWA (2013), question 13
Indicator 3.1 - Bond rating. Source: Morley (2012) which was adopted into AWWA's J100-10 standard for risk and resilience. S&P equivalency to Moodys from SFPUC (2014).
Indicator 4.1 - Green infrastructure. Adapted from WateRF (2014), performance measure 8.3.3
Indicator 5.1 - Habitat/watershed protection. Scaling source: AWWA (2013), questions 8 to 18.
Indicator 6.1 - Long-term capital plan. New indicator and scaling.
Indicator 6.2 - Long-term water supply adequacy. Source: WaterRF (2014), performance measure 9.1.1
Indicator 7.1 - Water reuse. Adapted from WaterRF (2014), performance measure 1.3.1
Indicator 7.X - Energy generation. Adapted from WateRF (2014), performance measure 8.3.4
Indicator 7.X - Biosolids use. Adapted from WateRF (2014), performance measure 1.3.2
Indicator 7.X - Nutrient recovery. Adapted from WateRF (2014), performance measure 8.3.4
Indicator 8.1 - Water conservation. Source: WatewRF (2014), performance measure 8.3.2
Attribute 1.1 - Board commitment/political will. Scaling adapted from AWWA (2013), questions 8 to 18.
Attribute 2.1 - Innovative culture. Scaling adapted from AWWA (2013), questions 8 to 18
Attribute 3.1 - Leadership. New attribute and scaling.
Attribute 4.1 - Organizational commitment. Scaling adapted from AWWA (2013), questions 8
Attribute 5.1 - Flexible staff. Scaling adapted from AWWA (2013), questions 8 to 18.
Attribute 6.1 - Staff training/development. Source: WaterRF (2014), performance measure 3.4.2
Attribute 6.2 - Management training. Source: WaterRF (2014), performance measure 3.4.3
AWWA. Utility Benchmarking Survey: Performance Indicators for Water & Wastewater Utilities. MS Excel spreadsheet (2013).
Morley, K.M. Evaluating Resilience in the Water Sector: Application of the Utility Resilience Index (URI). Doctoral dissertation. George Mason University (2012).
SFPUC. Performance/Strategic Sustainability Annual Report FY2013-14 (2014).
WateRF. Effective Utility Management Benchmarking Tool. MS Excel spreadsheet (2014).

Figure I.5 References Tab for Pilot Test

APPENDIX J: FINAL FRAMEWORK

USF
UNIVERSITY OF SOUTH FLORIDA

Survey v.2.1
21-May-16

Thank you for participating in this research study, ***A Framework to Assess Key Attributes Driving Sustainability for U.S. Urban Water Utilities.***

Background

This research is being conducted by Matthew Ries, the "primary investigator" and a PhD candidate in the Department of Civil and Environmental Engineering at the University of South Florida.

This research will use a framework to prioritize key organizational attributes that drive sustainability for U.S. urban water utilities. It uses an indicator-based approach to assess sustainability, specifically for U.S. urban water utilities. It also uses a set of representative organizational attributes that can be efficiently assessed. Applying this framework to a large number of utilities will produce results to prioritize activities and accelerate the transition towards sustainable urban water utilities.

Sustainability for the purposes of this study is based on a triple bottom line (economic, social, and environmental) approach to all components of a utility's operations and includes an overall consideration of infrastructure sustainability.

Individuals filling out the form will remain confidential, except to the primary investigator. Individual names will not be used in publications or presentations of this research. The names of participating *utilities* will only be used if consent is given in a post-survey phone call with the primary investigator. If no consent is given, utilities will be identified by service type and geographical region, e.g. "a wastewater utility in the Northeast."

Instructions

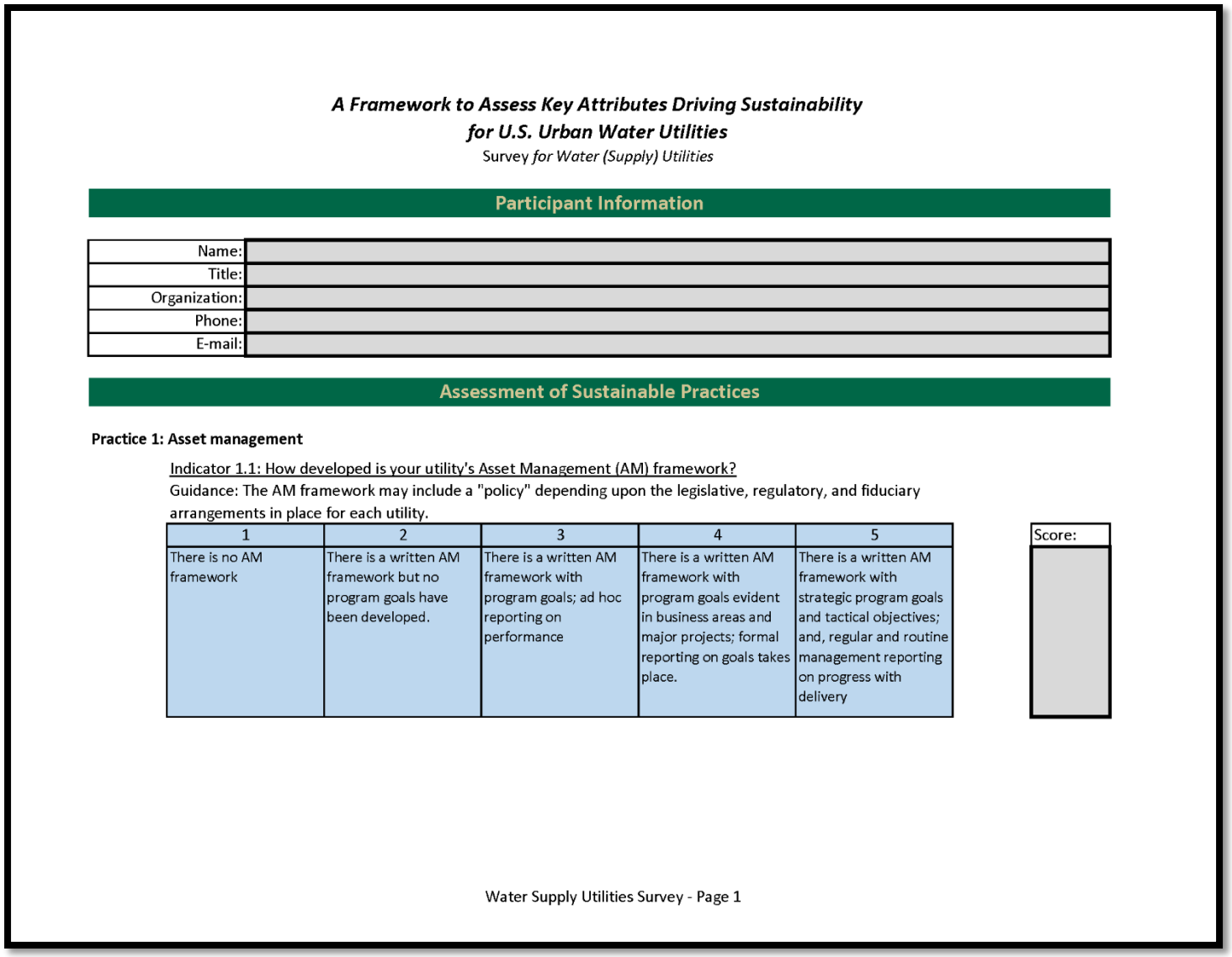
Users are asked to fill out the form at the appropriate tab in the spreadsheet for water, wastewater, or combined utilities.

If a question cannot be answered with precision based on the available scaling, participants are encouraged to provide an estimated answer and note this in the comments section of the indicator in question.

Upon completion, please save and return your completed survey to the primary investigator by [DATE] at mries@mail.usf.edu. Any questions can be directed to the same e-mail address.

Thank you for your participation.

Figure J.1 Instructions Tab for Final Framework



A Framework to Assess Key Attributes Driving Sustainability for U.S. Urban Water Utilities

Survey *for Water (Supply) Utilities*

Participant Information

Name:	
Title:	
Organization:	
Phone:	
E-mail:	

Assessment of Sustainable Practices

Practice 1: Asset management

Indicator 1.1: How developed is your utility's Asset Management (AM) framework?

Guidance: The AM framework may include a "policy" depending upon the legislative, regulatory, and fiduciary arrangements in place for each utility.

1	2	3	4	5	Score:
There is no AM framework	There is a written AM framework but no program goals have been developed.	There is a written AM framework with program goals; ad hoc reporting on performance	There is a written AM framework with program goals evident in business areas and major projects; formal reporting on goals takes place.	There is a written AM framework with strategic program goals and tactical objectives; and, regular and routine management reporting on progress with delivery	

Water Supply Utilities Survey - Page 1

Figure J.2 Water Utilities Tab for Final Framework

Practice 2: Education & Communication

Indicator 2.1: Does your utility have a public education program about its sustainability efforts?

Guidance: A public education program is externally-focused and designed to build support for and awareness of utility operations and sustainability efforts.

1	2	3	4	5	Score:
This activity is not practiced at our utility	This activity is implemented, but only occasionally or without uniformity	This activity is implemented, but there is room for substantial improvement	This activity is largely implemented, but there is room for improvement	This activity is fully implemented at our utility	

Indicator 2.2: Does your utility have an effective communications plan that surveys external stakeholders and engages them in dialogues?

Guidance: A communications plan solicits responses from and engages the community / external stakeholders before, during, and after service events and infrastructure activities.

1	2	3	4	5	Score:
This activity is not practiced at our utility	This activity is implemented, but only occasionally or without uniformity	This activity is implemented, but there is room for substantial improvement	This activity is largely implemented, but there is room for improvement	This activity is fully implemented at our utility	

Practice 3: Financial management

Indicator 3.1: What is your utility's bond rating?

Guidance: Rating may be for the utility itself or the municipality if your utility is part of a city/municipal government. Choose highest score if ratings from multiple rating agencies span more than one assigned score. Rating may be a "whisper" rating if one is not formally established. If no bond rating is available, provide an estimate of utility financial management progression, taking into account factors such as financial position, debt, governance, covenants, and ability to repay debt.

1	2	3	4	5	Score:
Moodys: ≤Caa S&P: ≤CCC+ Fitch: ≤CCC	Moodys: B to Ba S&P: B- to BB+ Fitch: BB to B	Moodys: Baa to A S&P: BBB- to A+ Fitch: BBB to A	Moodys: AA S&P: AA Fitch: AA	Moodys: Aaa S&P: AAA Fitch: AAA	

Figure J.2 (Continued)

Practice 4: Green Infrastructure

Indicator 4.1: How defined is your utility's green Infrastructure-based planning?

Guidance: "Green infrastructure-based planning" is defined as employing decision processes and criteria that promote source water protection and conservation for both the built and natural/unbuilt environment and/or the use of green infrastructure practices to improve stormwater quality, reduce quantity, and alleviate combined sewer overflows, achieving triple bottom line (economic, environmental, social) benefits.

1	2	3	4	5	Score:
No green infrastructure based planning approach defined or endorsed	Green infrastructure-based planning approach has been somewhat defined. The plan has been endorsed by few or no staff, stakeholders, and decision-maker.	Green infrastructure-based planning approach has been moderately defined.	Green infrastructure-based planning approach is well-defined. The plan has been endorsed by most staff, stakeholders, and decision-makers.	Green infrastructure-based planning approach is well-defined. The plan has been fully endorsed by staff, stakeholders and decision-makers.	

Practice 5: Habitat/watershed protection

Indicator 5.1: To what extent has your utility engaged in habitat restoration and watershed protection efforts?
Guidance: Habitat/watershed protection may include studies to assess (e.g. benthic studies) and protect (e.g. ensuring adequate environmental flows) natural habitats and watersheds.

1	2	3	4	5	Score:
This activity is not practiced at our utility	This activity is implemented, but only occasionally or without uniformity	This activity is implemented, but there is room for substantial improvement	This activity is largely implemented, but there is room for improvement	This activity is fully implemented at our utility	

Figure J.2 (Continued)

Practice 6: Long-term resource plan

Indicator 6.1: To what extent is your utility's long-term capital planning horizon linked to its financial plan?

Guidance: A long-term capital plan can include longer planning horizons with more detail in the immediate years. It should be linked to financial plans and rate projections and updated on a regular basis.

1	2	3	4	5
<5 years capital plan	>5 to <10 year capital plan	≥10 year capital plan	≥10 year capital plan linked to financial plan	≥10 year capital plan linked to financial plan with rate projections

Score:

Indicator 6.2: How far out does your utility plan for long-term water supply adequacy?

Guidance: Projected future annual supply relative to projected future annual demand for at least the next 50 years.

1	2	3	4	5
Projected supply adequate for <10 years	Projected supply adequate for 10-25 years	Projected supply adequate for 25-40 years	Projected supply adequate for 40-50 years	Projected supply adequate for <50 years

Score:

Figure J.2 (Continued)

Practice 7: Resource recovery

Indicator 7.1: To what level is your utility achieving water reuse (as a % of water supply)?

Guidance: Water Reuse Factor (WaRe) is defined as 100x (amount of water supplied that is from reused or recycled water/total amount of water supplied)

1	2	3	4	5
WaRe < 60%	WaRe 60 to 69%	WaRe 70 to 79%	WaRe 80 to 90%	WaRe >90%

Score:

Indicator 7.2: How defined is your utility's energy generation plan?

Guidance: An energy generation plan is defined as an energy use plan that takes into consideration opportunities for energy conservation and to produce energy from various sources. Plan endorsement implies implementation, moving beyond just planning to acton taken.

1	2	3	4	5
No energy generation plan has been developed	Energy generation plan has been somewhat defined. The plan has been endorsed by few or no staff, stakeholders, and decision makers.	Energy generation plan has been moderately defined	Energy generation plan is well-defined. The plan has been endorsed by most staff, stakeholders, and decision-makers.	The energy generation plan is well-defined. The plan has been fully endorsed by staff, stakeholders and decision-makers.

Score:

Practice 8: Water conservation

Indicator 8.1: How defined is your utility's approach to water conservation?

Guidance: Water conservation is defined as the set of activities and behaviors that reduce customer demand for treated water and thereby minimize wastewater generation. Water conservation efforts should address both internal usage by the utility in its activities and efforts to promote conservation among external customers or other customers.

1	2	3	4	5
A water conservation approach is defined or endorsed	A water conservation approach has been somewhat defined. Approach is endorsed by few or no staff, stakeholders, and decision-makers	A water conservation approach has been moderately defined. Approach is endorsed by some staff, stakeholders, and decision-makers.	A water conservation approach is well-defined. Approach is endorsed by most staff, stakeholders, and decision-makers	A water conservation approach is well-defined. The approach is fully endorsed by staff, stakeholders, and decision-makers.

Score:

Figure J.2 (Continued)

Assessment of Organizational Attributes

Attribute 1: Board support / political will

Indicator 1.1: To what extent does your utility have the necessary board commitment /political will to achieve sustainability?

Guidance: Political support and/or Board support is needed to successfully implement a sustainability agenda for the utility.

1	2	3	4	5	Score:
This support is not evident at our utility	This support is evident; but only occasionally or without uniformity	This support is evident, but there is room for substantial improvement	This support is largely evident, but there is room for improvement	This support is fully evident at our utility	

Attribute 2: innovative culture

Indicator 2.1: How innovative is your utility's culture?

Guidance: A culture of innovation needs to be evident throughout the utility, with day-to-day tasks tied to innovation, input accepted from all levels, and novel approaches rewarded. An innovative culture encourages research, internal and external collaborations, and a staff-wide commitment to provide better solutions using or adapting more effective approaches and technologies.

1	2	3	4	5	Score:
This culture is not evident at our utility	This culture is evident; but only occasionally or without uniformity	This culture is evident, but there is room for substantial improvement	This culture is largely evident, but there is room for improvement	This culture is fully evident at our utility	

Attribute 3: Leadership

Indicator 3.1: To what extent is leadership driving your utility towards sustainability?

Guidance: Is your utility leader (1) articulating a sustainable vision for the utility, (2) strategically-focused, and (3) dedicated to sustainability?

1	2	3	4	5	Score:
None of these characteristics apply to our utility's leader	One of these characteristics apply to our utility's leader	Two of these characteristics apply to our utility's leader	All of these characteristics somewhat describe our utility's leader	All of these characteristics accurately describe our utility's leader	

Figure J.2 (Continued)

Attribute 4: Flexible staff

Indicator 4.1: How flexible is your utility's staff?

Guidance: Utility has a cultural willingness to change and flexible staff who are open to new ideas from all levels of employees.

1	2	3	4	5	Score:
This culture is not evident at our utility	This culture is evident; but only occasionally or without uniformity	This culture is evident, but there is room for substantial improvement	This culture is largely evident, but there is room for improvement	This culture is fully evident at our utility	

Attribute 5: Organizational commitment

Indicator 5.1: To what extent does your utility have an organizational commitment to sustainability?

Guidance: Organization as a whole committed to sustainability with everyday operations linked to the utility's sustainability programs/goals. For example, are individuals' job descriptions and performance linked to the utility's sustainability plan and/or goals?

1	2	3	4	5	Score:
This commitment is not evident at our utility	This commitment is evident; but only occasionally or without uniformity	This commitment is evident, but there is room for substantial improvement	This commitment is largely evident, but there is room for improvement	This support is fully evident at our utility	

Figure J.2 (Continued)

Attribute 6: Staff training / development

Indicator 6.1: What is your utility's degree of implementation of learning programs?

Guidance: Well developed learning programs should include both internal and external/distance learning training, particularly in emerging fields where internal resources may not represent the best state of practice in the industry.

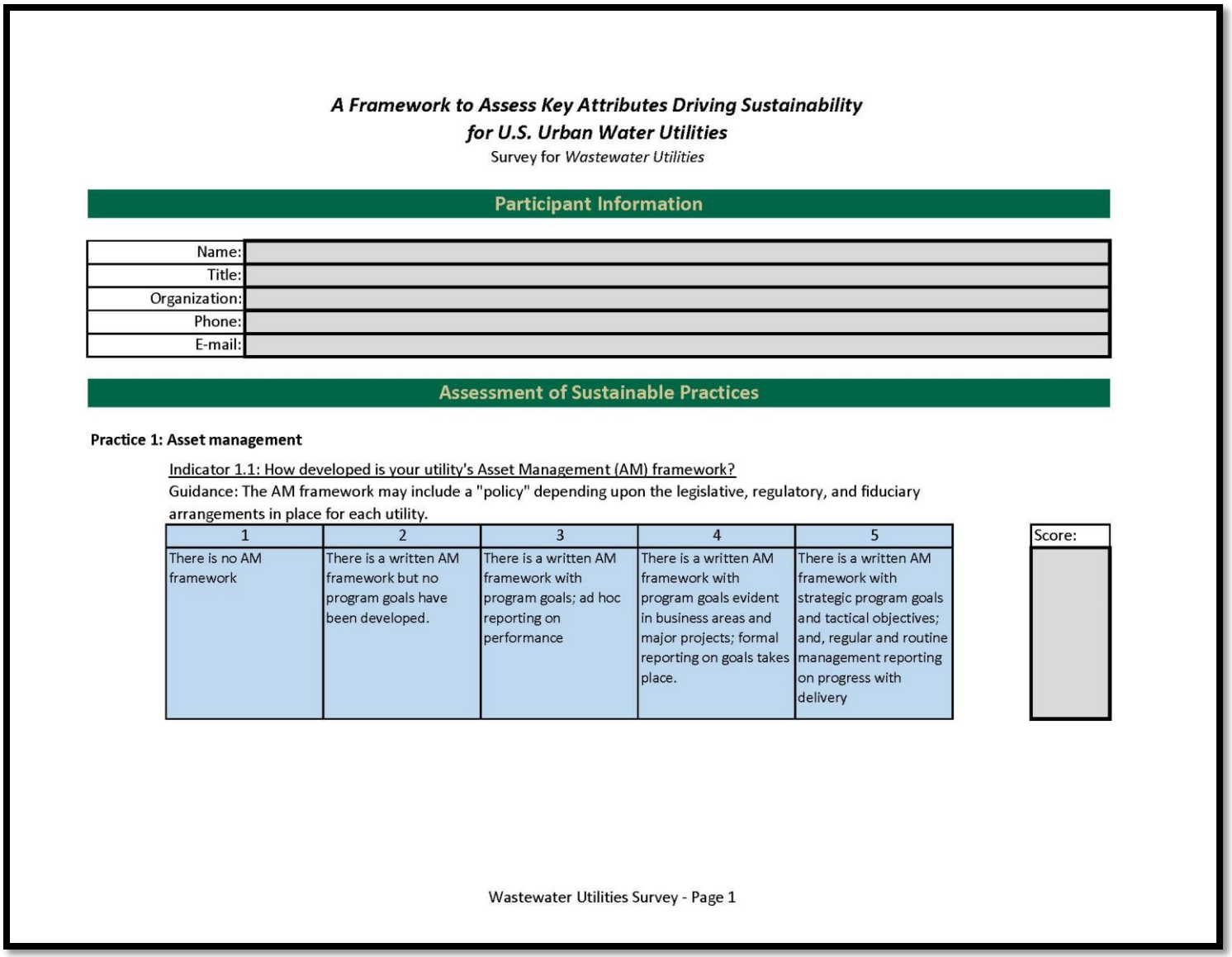
1	2	3	4	5	Score:
No learning program	Rudimentary learning program which provides some guidance on employee training opportunities	Basic learning program with policies and/or guidance suggesting learning content and tracking of hours	Learning program consisting of instructor-led (live or remote) and/or self-paced; includes a range of content; hours are tracked	Robust learning program consisting of instructor-led (live or remote) and/or self-paced; includes a range of content appropriate to the employee; hours and activities are tracked	

Indicator 6.2: What is the level of management training achieved by your utility?

Guidance: Management training should address all key areas needed to provide for sound oversight and leadership of the staff below each supervisory level. Examples of key topics for management training are: organizational mission, vision; organizational culture; safety, HR policies, leadership, diversity, etc.

1	2	3	4	5	Score:
No specific supervisor or manager training program	Informal supervisor and manager training done on an ad-hoc basis by peers or higher level managers	Generic supervisor and manager training through self-directed coursework	Supervisor and manager training program that is utility specific instructor led or self-paced;	Formal supervisor and manager training program specific to the utility that is instructor led with required periodic refresher course	

Figure J.2 (Continued)



A Framework to Assess Key Attributes Driving Sustainability for U.S. Urban Water Utilities

Survey for *Wastewater Utilities*

Participant Information

Name:	
Title:	
Organization:	
Phone:	
E-mail:	

Assessment of Sustainable Practices

Practice 1: Asset management

Indicator 1.1: How developed is your utility's Asset Management (AM) framework?

Guidance: The AM framework may include a "policy" depending upon the legislative, regulatory, and fiduciary arrangements in place for each utility.

1	2	3	4	5
There is no AM framework	There is a written AM framework but no program goals have been developed.	There is a written AM framework with program goals; ad hoc reporting on performance	There is a written AM framework with program goals evident in business areas and major projects; formal reporting on goals takes place.	There is a written AM framework with strategic program goals and tactical objectives; and, regular and routine management reporting on progress with delivery

Score:

Wastewater Utilities Survey - Page 1

Figure J.3 Wastewater Utilities Tab for Final Framework

Practice 2: Education & Communication

Indicator 2.1: Does your utility have a public education program about its sustainability efforts?

Guidance: A public education program is externally-focused and designed to build support for and awareness of utility operations and sustainability efforts.

1	2	3	4	5	Score:
This activity is not practiced at our utility	This activity is implemented, but only occasionally or without uniformity	This activity is implemented, but there is room for substantial improvement	This activity is largely implemented, but there is room for improvement	This activity is fully implemented at our utility	

Indicator 2.2: Does your utility have an effective communications plan that surveys external stakeholders and engages them in dialogues?

Guidance: A communications plan solicits responses from and engages the community / external stakeholders before, during, and after service events and infrastructure activities.

1	2	3	4	5	Score:
This activity is not practiced at our utility	This activity is implemented, but only occasionally or without uniformity	This activity is implemented, but there is room for substantial improvement	This activity is largely implemented, but there is room for improvement	This activity is fully implemented at our utility	

Practice 3: Financial management

Indicator 3.1: What is your utility's bond rating?

Guidance: Rating may be for the utility itself or the municipality if your utility is part of a city/municipal government. Choose highest score if ratings from multiple rating agencies span more than one assigned score. Rating may be a "whisper" rating if one is not formally established. If no bond rating is available, provide an estimate of utility financial management progression, taking into account factors such as financial position, debt, governance, covenants, and ability to repay debt.

1	2	3	4	5	Score:
Moodys: ≤Caa S&P: ≤CCC+ Fitch: ≤CCC	Moodys: B to Ba S&P: B- to BB+ Fitch: BB to B	Moodys: Baa to A S&P: BBB- to A+ Fitch: BBB to A	Moodys: AA S&P: AA Fitch: AA	Moodys: Aaa S&P: AAA Fitch: AAA	

Figure J.3 (Continued)

Practice 4: Green Infrastructure

Indicator 4.1: How defined is your utility's green Infrastructure-based planning?

Guidance: "Green infrastructure-based planning" is defined as employing decision processes and criteria that promote source water protection and conservation for both the built and natural/unbuilt environment and/or the use of green infrastructure practices to improve stormwater quality, reduce quantity, and alleviate combined sewer overflows, achieving triple bottom line (economic, environmental, social) benefits.

1	2	3	4	5	Score:
No green infrastructure based planning approach defined or endorsed	Green infrastructure-based planning approach has been somewhat defined. The plan has been endorsed by few or no staff, stakeholders, and decision-maker.	Green infrastructure-based planning approach has been moderately defined.	Green infrastructure-based planning approach is well-defined. The plan has been endorsed by most staff, stakeholders, and decision-makers.	Green infrastructure-based planning approach is well-defined. The plan has been fully endorsed by staff, stakeholders and decision-makers.	

Practice 5: Habitat/watershed protection

Indicator 5.1: To what extent has your utility engaged in habitat restoration and watershed protection efforts?

Guidance: Habitat/watershed protection may include studies to assess (e.g. benthic studies) and protect (e.g. ensuring adequate environmental flows) natural habitats and watersheds.

1	2	3	4	5	Score:
This activity is not practiced at our utility	This activity is implemented, but only occasionally or without uniformity	This activity is implemented, but there is room for substantial improvement	This activity is largely implemented, but there is room for improvement	This activity is fully implemented at our utility	

Figure J.3 (Continued)

Practice 6: Long-term resource plan

Indicator 6.1: To what extent is your utility's long-term capital planning horizon linked to its financial plan?

Guidance: A long-term capital plan can include longer planning horizons with more detail in the immediate years. It should be linked to financial plans and rate projections and updated on a regular basis.

1	2	3	4	5
<5 years capital plan	>5 to <10 year capital plan	≥10 year capital plan	≥10 year capital plan linked to financial plan	≥10 year capital plan linked to financial plan with rate projections

Score:

Indicator 6.2: How far out does your utility plan for long-term water supply adequacy?

Guidance: Projected future annual supply relative to projected future annual demand for at least the next 50 years.

1	2	3	4	5
Projected supply adequate for <10 years	Projected supply adequate for 10-25 years	Projected supply adequate for 25-40 years	Projected supply adequate for 40-50 years	Projected supply adequate for <50 years

Score:

Figure J.3 (Continued)

Practice 7: Resource recovery

Indicator 7.1: To what extent is your utility achieving water reuse (as a % of wastewater discharged)?

Guidance: Wastewater Reuse Factor (WWaRe) is defined as 100x (amount of wastewater discharged that is from reused or recycled water/total amount of wastewater supplied)

1	2	3	4	5	Score:
WWaRe < 60%	WWaRe 60 to 69%	WWaRe 70 to 79%	WWaRe 80 to 90%	WWaRe >90%	

Indicator 7.2: To what extent Is your utility achieving beneficial biosolids use?

Guidance: Biosolids put to beneficial use (BeneBio) is defined as 100x (amount of biosolids produced that are put to a beneficial use/total amount of biosolids produced). Beneficial use may be based on local regulations and is to be determined by the utility.

1	2	3	4	5	Score:
BeneBio < 60%	BeneBio 60 to 69%	BeneBio 70 to 79%	BeneBio 80 to 90%	BeneBio >90%	

Indicator 7.3: How defined is your utility's energy generation plan?

Guidance: An energy generation plan is defined as an energy use plan that takes into consideration opportunities for energy conservation and to produce energy from various sources. Plan endorsement implies implementation, moving beyond just planning to acton taken.

1	2	3	4	5	Score:
No energy generation plan has been developed	Energy generation plan has been somewhat defined. The plan has been endorsed by few or no staff, stakeholders, and decision makers.	Energy generation plan has been moderately defined	Energy generation plan is well-defined. The plan has been endorsed by most staff, stakeholders, and decision-makers.	The energy generation plan is well-defined. The plan has been fully endorsed by staff, stakeholders and decision-makers.	

Figure J.3 (Continued)

Indicator 7.4: How defined is your utility's nutrient recovery plan?

Guidance: A nutrient recovery plan is defined as a plan that takes into consideration opportunities for nutrient recovery, including phosphorus recovery via struvite precipitation or other means and/or nitrogen recovery via biosolids land application or other means. Plan endorsement implies implementation, moving beyond just planning to acton taken.

1	2	3	4	5	Score:
No nutrient recovery plan has been developed	Nutrient recovery plan has been somewhat defined. The plan has been endorsed by few or no staff, stakeholders, and decision makers.	Nutrient recovery plan has been moderately defined	Nutrient recovery plan is well-defined. The plan has been endorsed by most staff, stakeholders, and decision-makers.	The nutrient recovery plan is well-defined. The plan has been fully endorsed by staff, stakeholders and decision-makers.	

Practice 8: Water conservation

Indicator 8.1: How defined is your utility's approach to water conservation?

Guidance: Water conservation is defined as the set of activities and behaviors that reduce customer demand for treated water and thereby minimize wastewater generation. Water conservation efforts should address both internal usage by the utility in its activities and efforts to promote conservation among external customers or other customers.

1	2	3	4	5	Score:
A water conservation approach is defined or endorsed	A water conservation approach has been somewhat defined. Approach is endorsed by few or no staff, stakeholders, and decision-makers	A water conservation approach has been moderately defined. Approach is endorsed by some staff, stakeholders, and decision-makers	A water conservation approach is well-defined. Approach is endorsed by most staff, stakeholders, and decision-makers	A water conservation approach is well-defined. The approach is fully endorsed by staff, stakeholders, and decision-makers.	

Figure J.3 (Continued)

Assessment of Organizational Attributes

Attribute 1: Board support / political will

Indicator 1.1: To what extent does your utility have the necessary board commitment /political will to achieve sustainability?

Guidance: Political support and/or Board support is needed to successfully implement a sustainability agenda for the utility.

1	2	3	4	5	Score:
This support is not evident at our utility	This support is evident; but only occasionally or without uniformity	This support is evident, but there is room for substantial improvement	This support is largely evident, but there is room for improvement	This support is fully evident at our utility	

Attribute 2: innovative culture

Indicator 2.1: How innovative is your utility's culture?

Guidance: A culture of innovation needs to be evident throughout the utility, with day-to-day tasks tied to innovation, input accepted from all levels, and novel approaches rewarded. An innovative culture encourages research, internal and external collaborations, and a staff-wide commitment to provide better solutions using or adapting more effective approaches and technologies.

1	2	3	4	5	Score:
This culture is not evident at our utility	This culture is evident; but only occasionally or without uniformity	This culture is evident, but there is room for substantial improvement	This culture is largely evident, but there is room for improvement	This culture is fully evident at our utility	

Attribute 3: Leadership

Indicator 3.1: To what extent is leadership driving your utility towards sustainability?

Guidance: Is your utility leader (1) articulating a sustainable vision for the utility, (2) strategically-focused, and (3) dedicated to sustainability?

1	2	3	4	5	Score:
None of these characteristics apply to our utility's leader	One of these characteristics apply to our utility's leader	Two of these characteristics apply to our utility's leader	All of these characteristics somewhat describe our utility's leader	All of these characteristics accurately describe our utility's leader	

Figure J.3 (Continued)

Attribute 4: Flexible staff

Indicator 4.1: How flexible is your utility's staff?

Guidance: Utility has a cultural willingness to change and flexible staff who are open to new ideas from all levels of employees.

1	2	3	4	5	Score:
This culture is not evident at our utility	This culture is evident; but only occasionally or without uniformity	This culture is evident, but there is room for substantial improvement	This culture is largely evident, but there is room for improvement	This culture is fully evident at our utility	

Attribute 5: Organizational commitment

Indicator 5.1: To what extent does your utility have an organizational commitment to sustainability?

Guidance: Organization as a whole committed to sustainability with everyday operations linked to the utility's sustainability programs/goals. For example, are individuals' job descriptions and performance linked to the utility's sustainability plan and/or goals?

1	2	3	4	5	Score:
This commitment is not evident at our utility	This commitment is evident; but only occasionally or without uniformity	This commitment is evident, but there is room for substantial improvement	This commitment is largely evident, but there is room for improvement	This support is fully evident at our utility	

Figure J.3 (Continued)

Attribute 6: Staff training / development

Indicator 6.1: What is your utility's degree of implementation of learning programs?

Guidance: Well developed learning programs should include both internal and external/distance learning training, particularly in emerging fields where internal resources may not represent the best state of practice in the industry.

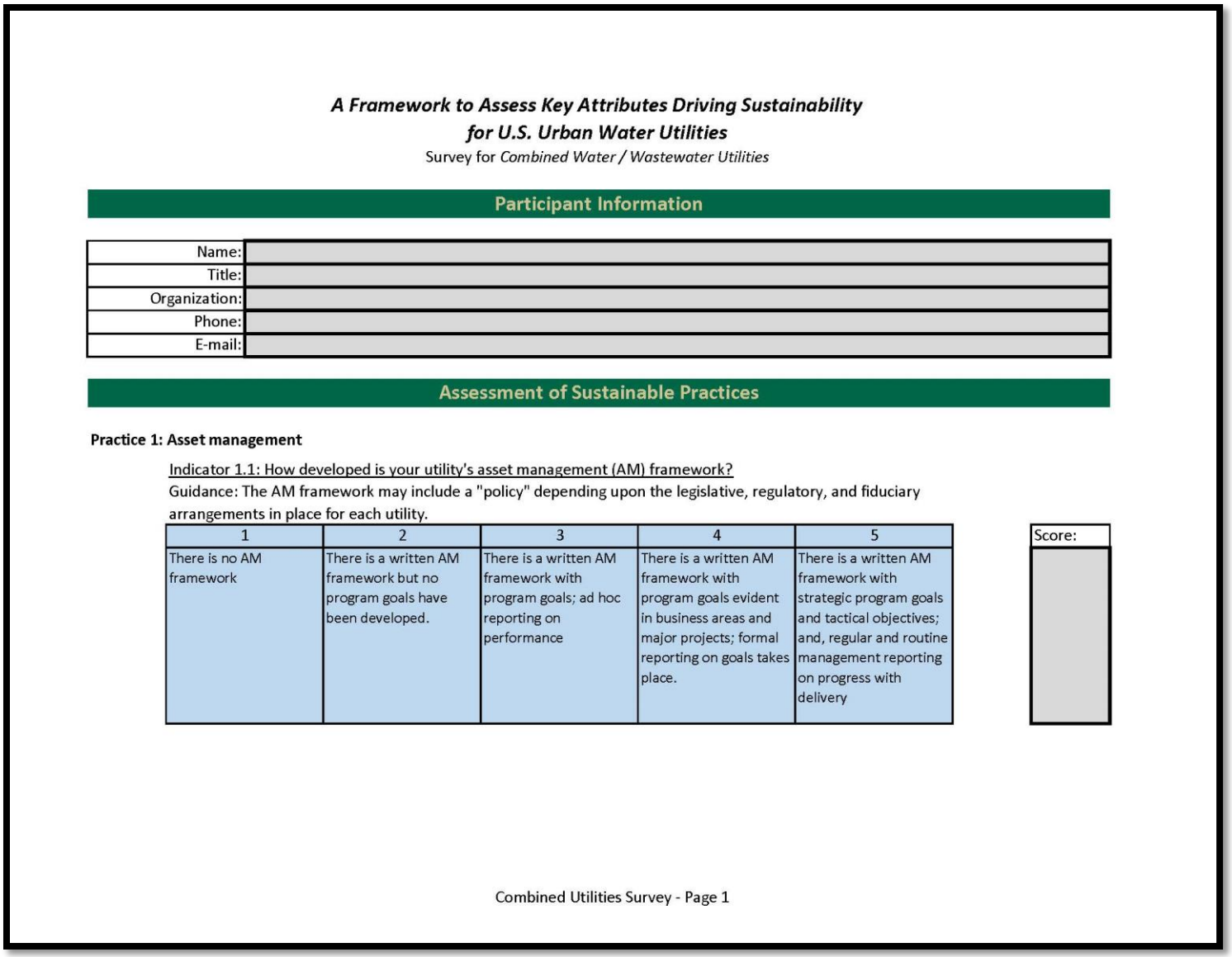
1	2	3	4	5	Score:
No learning program	Rudimentary learning program which provides some guidance on employee training opportunities	Basic learning program with policies and/or guidance suggesting learning content and tracking of hours	Learning program consisting of instructor-led (live or remote) and/or self-paced; includes a range of content; hours are tracked	Robust learning program consisting of instructor-led (live or remote) and/or self-paced; includes a range of content appropriate to the employee; hours and activities are tracked	

Indicator 6.2: What is the level of management training achieved by your utility?

Guidance: Management training should address all key areas needed to provide for sound oversight and leadership of the staff below each supervisory level. Examples of key topics for management training are: organizational mission, vision; organizational culture; safety, HR policies, leadership, diversity, etc.

1	2	3	4	5	Score:
No specific supervisor or manager training program	Informal supervisor and manager training done on an ad-hoc basis by peers or higher level managers	Generic supervisor and manager training through self-directed coursework	Supervisor and manager training program that is utility specific instructor led or self-paced;	Formal supervisor and manager training program specific to the utility that is instructor led with required periodic refresher course	

Figure J.3 (Continued)



A Framework to Assess Key Attributes Driving Sustainability for U.S. Urban Water Utilities

Survey for *Combined Water / Wastewater Utilities*

Participant Information

Name:	
Title:	
Organization:	
Phone:	
E-mail:	

Assessment of Sustainable Practices

Practice 1: Asset management

Indicator 1.1: How developed is your utility's asset management (AM) framework?

Guidance: The AM framework may include a "policy" depending upon the legislative, regulatory, and fiduciary arrangements in place for each utility.

1	2	3	4	5
There is no AM framework	There is a written AM framework but no program goals have been developed.	There is a written AM framework with program goals; ad hoc reporting on performance	There is a written AM framework with program goals evident in business areas and major projects; formal reporting on goals takes place.	There is a written AM framework with strategic program goals and tactical objectives; and, regular and routine management reporting on progress with delivery

Score:

Combined Utilities Survey - Page 1

Figure J.4 Combined Utilities Tab for Final Framework

Practice 2: Education & Communication

Indicator 2.1: Does your utility have a public education program about its sustainability efforts?

Guidance: A public education program is externally-focused and designed to build support for and awareness of utility operations and sustainability efforts.

1	2	3	4	5	Score:
This activity is not practiced at our utility	This activity is implemented, but only occasionally or without uniformity	This activity is implemented, but there is room for substantial improvement	This activity is largely implemented, but there is room for improvement	This activity is fully implemented at our utility	

Indicator 2.2: Does your utility have an effective communications plan that surveys external stakeholders and engages them in dialogues?

Guidance: A communications plan solicits responses from and engages the community / external stakeholders before, during, and after service events and infrastructure activities.

1	2	3	4	5	Score:
This activity is not practiced at our utility	This activity is implemented, but only occasionally or without uniformity	This activity is implemented, but there is room for substantial improvement	This activity is largely implemented, but there is room for improvement	This activity is fully implemented at our utility	

Practice 3: Financial management

Indicator 3.1: What is your utility's bond rating?

Guidance: Rating may be for the utility itself or the municipality if your utility is part of a city/municipal government. Choose highest score if ratings from multiple rating agencies span more than one assigned score. Rating may be a "whisper" rating if one is not formally established. If no bond rating is available, provide an estimate of utility financial management progression, taking into account factors such as financial position, debt, governance, covenants, and ability to repay debt.

1	2	3	4	5	Score:
Moodys: ≤Caa S&P: ≤CCC+ Fitch: ≤CCC	Moodys: B to Ba S&P: B- to BB+ Fitch: BB to B	Moodys: Baa to A S&P: BBB- to A+ Fitch: BBB to A	Moodys: AA S&P: AA Fitch: AA	Moodys: Aaa S&P: AAA Fitch: AAA	

Figure J.4 (Continued)

Practice 4: Green Infrastructure

Indicator 4.1: How defined is your utility's green infrastructure-based planning?

Guidance: "Green infrastructure-based planning" is defined as employing decision processes and criteria that promote source water protection and conservation for both the built and natural/unbuilt environment and/or the use of green infrastructure practices to improve stormwater quality, reduce quantity, and alleviate combined sewer overflows, achieving triple bottom line (economic, environmental, social) benefits.

1	2	3	4	5	Score:
No green infrastructure based planning approach defined or endorsed	Green infrastructure-based planning approach has been somewhat defined. The plan has been endorsed by few or no staff, stakeholders, and decision-maker.	Green infrastructure-based planning approach has been moderately defined.	Green infrastructure-based planning approach is well-defined. The plan has been endorsed by most staff, stakeholders, and decision-makers.	Green infrastructure-based planning approach is well-defined. The plan has been fully endorsed by staff, stakeholders and decision-makers.	

Practice 5: Habitat/watershed protection

Indicator 5.1: To what extent has your utility engaged in habitat restoration and watershed protection efforts?
Guidance: Habitat/watershed protection may include studies to assess (e.g. benthic studies) and protect (e.g. ensuring adequate environmental flows) natural habitats and watersheds.

1	2	3	4	5	Score:
This activity is not practiced at our utility	This activity is implemented, but only occasionally or without uniformity	This activity is implemented, but there is room for substantial improvement	This activity is largely implemented, but there is room for improvement	This activity is fully implemented at our utility	

Figure J.4 (Continued)

Practice 6: Long-term resource plan

Indicator 6.1: To what extent is your utility's long-term capital planning horizon linked to its financial plan?

Guidance: A long-term capital plan can include longer planning horizons with more detail in the immediate years. It should be linked to financial plans and rate projections and updated on a regular basis.

1	2	3	4	5
<5 years capital plan	>5 to <10 year capital plan	≥10 year capital plan	≥10 year capital plan linked to financial plan	≥10 year capital plan linked to financial plan with rate projections

Score:

Indicator 6.2: How far out does your utility plan for long-term water supply adequacy?

Guidance: Projected future annual supply relative to projected future annual demand for at least the next 50 years.

1	2	3	4	5
Projected supply adequate for <10 years	Projected supply adequate for 10-25 years	Projected supply adequate for 25-40 years	Projected supply adequate for 40-50 years	Projected supply adequate for <50 years

Score:

Figure J.4 (Continued)

Practice 7: Resource recovery

Indicator 7.1: To what level is your utility achieving water reuse (as a % of water supply)?

Guidance: Water Reuse Factor (WaRe) is defined as 100x (amount of water supplied that is from reused or recycled water/total amount of water supplied)

1	2	3	4	5	Score:
WaRe < 60%	WaRe 60 to 69%	WaRe 70 to 79%	WaRe 80 to 90%	WaRe >90%	

Indicator 7.2: To what extent is your utility achieving water reuse (as a % of wastewater discharged)?

Guidance: Wastewater Reuse Factor (WWaRe) is defined as 100x (amount of wastewater discharged that is from reused or recycled water/total amount of wastewater supplied)

1	2	3	4	5	Score:
WWaRe < 60%	WWaRe 60 to 69%	WWaRe 70 to 79%	WWaRe 80 to 90%	WWaRe >90%	

Indicator 7.3: To what extent Is your utility achieving beneficial biosolids use?

Guidance: Biosolids put to beneficial use (BeneBio) is defined as 100x (amount of biosolids produced that are put to a beneficial use/total amount of biosolids produced). Beneficial use may be based on local regulations and is to be determined by the utility.

1	2	3	4	5	Score:
BeneBio < 60%	BeneBio 60 to 69%	BeneBio 70 to 79%	BeneBio 80 to 90%	BeneBio >90%	

Indicator 7.4: How defined is your utility's energy generation plan?

Guidance: An energy generation plan is defined as an energy use plan that takes into consideration opportunities for energy conservation and to produce energy from various sources. Plan endorsement implies implementation, moving beyond just planning to acton taken.

1	2	3	4	5	Score:
No energy generation plan has been developed	Energy generation plan has been somewhat defined. The plan has been endorsed by few or no staff, stakeholders, and decision makers.	Energy generation plan has been moderately defined	Energy generation plan is well-defined. The plan has been endorsed by most staff, stakeholders, and decision-makers.	The energy generation plan is well-defined. The plan has been fully endorsed by staff, stakeholders and decision-makers.	

Figure J.4 (Continued)

Indicator 7.5: How defined is your utility's nutrient recovery plan?

Guidance: A nutrient recovery plan is defined as a plan that takes into consideration opportunities for nutrient recovery, including phosphorus recovery via struvite precipitation or other means and/or nitrogen recovery via biosolids land application or other means. Plan endorsement implies implementation, moving beyond just planning to acton taken.

1	2	3	4	5	Score:
No nutrient recovery plan has been developed	Nutrient recovery plan has been somewhat defined. The plan has been endorsed by few or no staff, stakeholders, and decision makers	Nutrient recovery plan has been moderately defined	Nutrient recovery plan is well-defined. The plan has been endorsed by most staff, stakeholders, and decision-makers.	The nutrient recovery plan is well-defined. The plan has been fully endorsed by staff, stakeholders and decision-makers.	

Practice 8: Water conservation

Indicator 8.1: How defined is your utility's approach to water conservation?

Guidance: Water conservation is defined as the set of activities and behaviors that reduce customer demand for treated water and thereby minimize wastewater generation. Water conservation efforts should address both internal usage by the utility in its activities and efforts to promote conservation among external customers or other customers.

1	2	3	4	5	Score:
A water conservation approach is defined or endorsed	A water conservation approach has been somewhat defined. Approach is endorsed by few or no staff, stakeholders, and decision-makers	A water conservation approach has been moderately defined. Approach is endorsed by some staff, stakeholders, and decision-makers	A water conservation approach is well-defined. Approach is endorsed by most staff, stakeholders, and decision-makers	A water conservation approach is well-defined. The approach is fully endorsed by staff, stakeholders, and decision-makers.	

Figure J.4 (Continued)

Assessment of Organizational Attributes

Attribute 1: Board support / political will

Indicator 1.1: To what extent does your utility have the necessary board commitment /political will to achieve sustainability?
Guidance: Political support and/or Board support is needed to successfully implement a sustainability agenda for the utility.

1	2	3	4	5	Score:
This support is not evident at our utility	This support is evident; but only occasionally or without uniformity	This support is evident, but there is room for substantial improvement	This support is largely evident, but there is room for improvement	This support is fully evident at our utility	

Attribute 2: Innovative culture

Indicator 2.1: How innovative is your utility's culture?
Guidance: A culture of innovation needs to be evident throughout the utility, with day-to-day tasks tied to innovation, input accepted from all levels, and novel approaches rewarded. An innovative culture encourages research, internal and external collaborations, and a staff-wide commitment to provide better solutions using or adapting more effective approaches and technologies.

1	2	3	4	5	Score:
This culture is not evident at our utility	This culture is evident; but only occasionally or without uniformity	This culture is evident, but there is room for substantial improvement	This culture is largely evident, but there is room for improvement	This culture is fully evident at our utility	

Attribute 3: Leadership

Indicator 3.1: To what extent is leadership driving your utility towards sustainability?
Guidance: Is your utility leader (1) articulating a sustainable vision for the utility, (2) strategically-focused, and (3) dedicated to sustainability?

1	2	3	4	5	Score:
None of these characteristics apply to our utility's leader	One of these characteristics apply to our utility's leader	Two of these characteristics apply to our utility's leader	All of these characteristics somewhat describe our utility's leader	All of these characteristics accurately describe our utility's leader	

Figure J.4 (Continued)

Attribute 4: Flexible staff

Indicator 4.1: How flexible is your utility's staff?

Guidance: Utility has a cultural willingness to change and flexible staff who are open to new ideas from all levels of employees.

1	2	3	4	5	Score:
This culture is not evident at our utility	This culture is evident; but only occasionally or without uniformity	This culture is evident, but there is room for substantial improvement	This culture is largely evident, but there is room for improvement	This culture is fully evident at our utility	

Attribute 5: Organizational commitment

Indicator 5.1: To what extent does your utility have an organizational commitment to sustainability?

Guidance: Organization as a whole committed to sustainability with everyday operations linked to the utility's sustainability programs/goals. For example, are individuals' job descriptions and performance linked to the utility's sustainability plan and/or goals?

1	2	3	4	5	Score:
This commitment is not evident at our utility	This commitment is evident; but only occasionally or without uniformity	This commitment is evident, but there is room for substantial improvement	This commitment is largely evident, but there is room for improvement	This support is fully evident at our utility	

Figure J.4 (Continued)

Attribute 6: Staff training / development

Indicator 6.1: What is your utility's degree of implementation of learning programs?

Guidance: Well developed learning programs should include both internal and external/distance learning training, particularly in emerging fields where internal resources may not represent the best state of practice in the industry.

1	2	3	4	5	Score:
No learning program	Rudimentary learning program which provides some guidance on employee training opportunities	Basic learning program with policies and/or guidance suggesting learning content and tracking of hours	Learning program consisting of instructor-led (live or remote) and/or self-paced; includes a range of content; hours are tracked	Robust learning program consisting of instructor-led (live or remote) and/or self-paced; includes a range of content appropriate to the employee; hours and activities are tracked	

Indicator 6.2: What is the level of management training achieved by your utility?

Guidance: Management training should address all key areas needed to provide for sound oversight and leadership of the staff below each supervisory level. Examples of key topics for management training are: organizational mission, vision; organizational culture; safety, HR policies, leadership, diversity, etc.

1	2	3	4	5	Score:
No specific supervisor or manager training program	Informal supervisor and manager training done on an ad-hoc basis by peers or higher level managers	Generic supervisor and manager training through self-directed coursework	Supervisor and manager training program that is utility specific instructor led or self-paced;	Formal supervisor and manager training program specific to the utility that is instructor led with required periodic refresher course	

Figure J.4 (Continued)

References
The 8 sustainable practices and 6 organizational attributes in this survey were derived from a series of interviews with water sector leaders and water professionals from AWWA and WEF.
Each practice and attribute were then mapped against a series of existing benchmarking frameworks, indicator systems, utility sustainability reports, and sustainability assessment tools.
Whenver possible, existing indicators and scaling (1 to 5) were used when they matched the intent of the practices and attributes developed in this research program (noted as "source" below). In some cases, existing systems were modified (noted as "adapted" below). In other cases, new indicators and scaling were developed. Where applicable, existing systems are referenced below.
Indicator 1.1 - Asset management. Source: WateRF (2014), performance measure 6.1.1
Indicator 2.1 - Public education program. Adapted from: AWWA (2013), question 13
Indicator 2.2 - Communications plan. Adapted from: AWWA (2013), question 13
Indicator 3.1 - Financial management. Source: Morley (2012) which was adopted into AWWA's J100-10 standard for risk and resilience. S&P equivalency to Moodys from SFPUC
Indicator 4.1 - Green infrastructure. Adapted from WateRF (2014), performance measure 8.3.3
Indicator 5.1 - Habitat/watershed protection. Scaling source: AWWA (2013), questions 8 to 18.
Indicator 6.1 - Long-term capital plan. New indicator and scaling.
Indicator 6.2 - Long-term water supply adequacy. Source: WaterRF (2014), performance measure 9.1.1
Indicator 7.1 - Water reuse. Adapted from WaterRF (2014), performance measure 1.3.1
Indicator 7.X - Energy generation. Adapted from WateRF (2014), performance measure 8.3.4
Indicator 7.X - Biosolids use. Adapted from WateRF (2014), performance measure 1.3.2
Indicator 7.X - Nutrient recovery. Adapted from WateRF (2014), performance measure 8.3.4
Indicator 8.1 - Water conservation. Source: WatewRF (2014), performance measure 8.3.2
Indicator 1.1 - Board commitment/political will. Scaling adapted from AWWA (2013), questions 8 to 18.
Indicator 2.1 - Innovative culture. Scaling adapted from AWWA (2013), questions 8 to 18
Indicator 3.1 - Leadership. New attribute and scaling.
Indicator 4.1 - Flexible staff. Scaling adapted from AWWA (2013), questions 8 to 18.
Indicator 5.1 - Organizational commitment. Scaling adapted from AWWA (2013), questions 8
Indicator 6.1 - Staff training/development. Source: WaterRF (2014), performance measure 3.4.2
Indicator 6.2 - Management training. Source: WaterRF (2014), performance measure 3.4.3
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Morley, K.M. Evaluating Resilience in the Water Sector: Application of the Utility Resilience Index (URI). Doctoral dissertation. George Mason University (2012).
SFPUC. Performance/Strategic Sustainability Annual Report FY2013-14 (2014).
WateRF. Effective Utility Management Benchmarking Tool. MS Excel spreadsheet (2014).

Figure J.5 References Tab for Final Framework

ABOUT THE AUTHOR

Matthew Ries, P.E. is the Chief Technical Officer at WEF in Alexandria, Virginia. WEF is a not-for-profit technical and educational organization of 33,000 members representing water quality professionals. He oversees WEF's education and training programs, including WEFTEC, the world's largest annual water conference and exhibition. He also oversees WEF's technical committees and initiatives on innovation, sustainability, nutrients, energy, stormwater, and others. He serves as the staff liaison to WEF's Utility Management Committee. Before WEF, Matt worked as a consultant in the planning, design, construction, and startup of municipal and industrial water, wastewater, and stormwater facilities. He is a registered Professional Engineer in the Commonwealth of Virginia. He earned his BS in Civil Engineering from Valparaiso University and an MS in Environmental Engineering from the University of Notre Dame.

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