Evaluation of Historical Reuse Applications and Summary of Technical/Regulatory Issues and Related Solutions for Industrial Reuse Projects

Managing Industrial Reuse Projects for Success

WateReuse Research Foundation

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About the WateReuse Research Foundation

The WateReuse Research Foundation builds support for the reclamation, recycling, reuse, and desalination of water through research and education. The Foundation's research advances the science of water reuse and supports communities across the United States and abroad in their efforts to create new sources of high quality water for various uses through reclamation, recycling, reuse, and desalination while protecting public health and the environment.

The Foundation sponsors research on all aspects of water reuse, including emerging chemical contaminants, microbiological agents, treatment technologies, reduction of energy requirements, concentrate management and desalination, public perception and acceptance, economics, and marketing. The Foundation's research informs the public of the safety of reclaimed water and provides water professionals with the tools and knowledge to meet their commitment of providing a reliable, safe product for its intended use.

The Foundation's funding partners include the supporters of the California Direct Potable Reuse Initiative, Water Services Association of Australia, Pentair Foundation, and Bureau of Reclamation. Funding is also provided by the Foundation's members, water and wastewater agencies, and other interested organizations.

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Managing Industrial Reuse Projects for Success

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Disclaimer

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Contents

Figures

Tables

Acronyms

BOD	biochemical oxygen demand
CBOD5	carbonaceous biochemical oxygen demand
CCR	California Code of Regulation
CDPH	California Department of Public Health
CEC	California Energy Commission
CFU	colony forming unit
CII	commercial, industrial and institutional
COC	cycles of concentration
COD	chemical oxygen demand
CT	combustion turbine
CWA	Clean Water Act
DC	direct current
DEH	San Diego County Department of Environmental Health
DDW	Division of Drinking Water
DI	deionized
DO	dissolved oxygen
DPR	direct potable reuse
EDI	electro-deionization
EDR	electrodialysis reversal
EMWD	Eastern Municipal Water District
EPA	Environmental Protection Agency
F.A.C.	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
GE	General Electric
gpm	gallons per minute
HES	high efficiency softening
HRSG	heat recovery steam generator
IEEC	Inland Empire Energy Center
IPR	indirect potable reuse
IWR	industrial water reuse
IX	ion exchange
LEED	Leadership in Energy and Environmental Design
MF	microfiltration
MGD	million gallons per day
µg/L	microgram per liter
mJ/cm	millijoule per centimeter
MPN	most probable number
µS/cm	microsiemens per centimeter

NJDEP	New Jersey Department of Environmental Protection
NPDES	National Pollutant Discharge Elimination System
NTU	nephelomeric turbidity unit
PAC	Project Advisory Committee
RAC	Research Advisory Committee
RO	reverse osmosis
RW	recycled or reclaimed water
RWQCB	Regional Water Quality Control Board
SCADA	supervisory control and data acquisition
SCVWD	Santa Clara Valley Water District
SDCWA	San Diego County Water Authority
SWRCB	State Water Resources Control Board
TCEQ	Texas Commission on Environmental Quality
TDS	total dissolved solids
TSS	total suspended solids
UV	ultraviolet
WBMWD	West Basin Municipal Water District
WCTI	Water Conservation Technologies International
WRRF	WateReuse Research Foundation

Foreword

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

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

- Defining and addressing emerging contaminants, including chemicals and pathogens
- Determining effective and efficient treatment technologies to create 'fit for purpose' water
- Understanding public perceptions and increasing acceptance of water reuse
- Enhancing management practices related to direct and indirect potable reuse
- Managing concentrate resulting from desalination and potable reuse operations
- Demonstrating the feasibility and safety of direct potable reuse

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

This specific project, *Evaluation of Historical Reuse Applications and Summary of Technical/ Regulatory Issues and Related Solutions for Industrial Reuse Projects* (WRRF-12-03), seeks to help recycled water agencies and potential industrial recycled water customers bridge the gap toward the successful implementation of industrial reuse projects.

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This project was funded by the WateReuse Research Foundation in cooperation with sponsorship from San Diego County Water Authority and Santa Clara Valley Water District.

This work was inspired originally by a 2012 panel discussion among "pioneers" who had implemented water reuse at their companies' industrial facilities. The take-away from that event and others like it was, "It shouldn't be this difficult." The members of the Industrial Water Reuse Committee within the WateReuse Research Foundation came to the same conclusion. Their tireless efforts helped to garner support and sponsors for WRRF-12-03, the research grant under which this work has been produced. Thank you to the sponsoring organizations, in-kind contributors, and project champions. In addition, sincere thanks go to the individuals who candidly shared their experiences with the research team. The courage to describe the miscues, misunderstandings, faulty assumptions, and other "gotchas" that affected their projects is of tremendous benefit to the cause of water sustainability.

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Executive Summary

Fresh water resources and their availability in the future are threatened by changing climatological conditions, increasing population growth, potential contamination, recent droughts, and other external factors. Several states have adopted or are considering regulations that mandate the use of recycled water for nonpotable uses in locations where it is readily available and in close proximity to potential users. Initially, recycled water was targeted at irrigation and groundwater replenishment. However, the use of recycled water for nonpotable industrial water reuse is growing as end users discover the cost effectiveness of this resource and its suitability for use in most industrial applications.

Despite the growing interest among the industrial community to adopt recycled water as a supply source and the enthusiastic desire among agencies to sell recycled water to industrial customers, there appears to be a disconnect between the two parties, which has slowed the widespread adoption among the industrial community of this available water resource. Based on the experience of the co-investigators and the data collected during the course of this study, several potential barriers to entry were unearthed. These include a general lack of understanding by potential industrial customers of the regulations governing recycled water use and the length of time often necessary to navigate and complete the regulatory review and permitting process. Among agencies is the lack of understanding regarding the speed at which business moves and the pragmatic decision process that determines whether customers will move forward with an industrial reuse project. Furthermore, there are points of departure, goals, and drivers among the agencies and end users that often diverge.

Despite the seeming disparity, there are multitudes of agencies and industrial customers who have learned to bridge the gap toward successful implementation of industrial reuse projects. The goal of this study is to help both agencies and potential industrial customers learn to speak the same language and navigate beyond the seeming barriers to entry so that successful industrial reuse projects using municipal supplies can be realized. This study leverages the experiences, lessons learned, and advice of existing agencies and industrial customers who have successfully navigated the process to successful project implementation. Furthermore, the expertise and experience of the co-principal investigators in the areas of industrial recycled water retrofit projects and communication methodologies are merged to present usable documents that will guide agencies and potential industrial customers out of the fog.

This report summarizes the data generated during the research phase of the study, but the primary project objective includes the development of a separate graphically driven Model Template document and Project Charter, which will provide both recycled water agencies and industrial end users with the tools necessary to develop and implement industrial water reuse projects successfully. The Model Template and Project Charter are included in the same download packet as this report.

Chapter 1

Introduction and Background

1.1. Introduction

Fresh water resources and their availability in the future are threatened by changing climatological conditions, increasing population growth, potential contamination, and other external factors. As supplies dwindle, the cost of fresh water continues on an upward spiral with availability for nonpotable (non-drinking) water uses steadily decreasing. Several states have adopted or are considering regulations that mandate the use of recycled water for nonpotable uses in locations where it is readily available and in close proximity to potential users.

In today's highly competitive commercial, industrial, and institutional markets, businesses must make wise use of available water resources. Increasingly, the most forward-thinking companies are partnering with local utilities to reduce their demands for energy and fresh water, both to save costs and to improve the long-term sustainability of their businesses coupled with water conservation. Over the past several decades, the use of recycled or reclaimed water, derived from highly treated wastewater effluent, has continued to gain popularity as an effective way to reduce the demand for precious fresh water resources for nonpotable purposes. By converting to recycled water, commercial, industrial, and institutional customers can secure a drought-proof water supply that protects fresh water for drinking water purposes when fresh water supply shortages loom.

Despite potential regulations requiring use of recycled water and their increasing popularity in certain locales, potential industrial customers and water recycling utilities often find implementation of recycled water reuse projects to be fraught with challenges. The challenges stem from a myriad of issues that ultimately can be boiled down to lapses in communication regarding requirements specific to recycled water use and failures of providers and users to understand the drivers, goals, and motivations of each respective group. As awareness of these challenges began to grow among industry leaders, practitioners, and champions of industrial water reuse, it became apparent that further study was necessary to understand the issues and provide solutions to mitigate the challenges.

This report was developed to provide insight regarding the common issues and barriers to recycled water implementation at potential industrial reuse customer sites. This study is based on the experiences of the co-principal investigators and data gathered through research of available literature, interviews of recycled water agencies and existing industrial customers, and development of several case studies for representative existing industrial water reuse projects. Although this report provides useful information regarding the data generated during the research phase of the report, the primary project objective included developing a separate graphically driven "model template" document that provides both recycled water agencies and industrial end users with the tools necessary to develop and implement industrial water reuse projects successfully. (The model template document is included in the same download packet as this report).

1.2. Recycled Water Background

Recycled or reclaimed water by definition refers to water derived from sewage that has been treated at a wastewater treatment facility to very high-quality standard in accordance with state and federal requirements. Recycled water is not drinkable but is suitable for beneficial and controlled uses that do not require drinking water quality. Beneficial uses may include landscape and turf irrigation, agricultural irrigation, geothermal energy production, natural habitat restoration, recreational impoundments, groundwater recharge, stream augmentation, and seawater intrusion prevention. In addition to these benefits, recycled water can be used for various commercial and industrial related processes. Examples of these processes will be discussed herein.

For several decades, recycled water has been used in the United States. In 1912, the first small urban reuse system began with the irrigation of Golden Gate Park in San Francisco (California Recycled Water Task Force, 2003). Although steady progress has been made to promote the safe recycling and reuse of water, there are still challenges that must be addressed including institutional and social barriers to widespread implementation, regulatory approaches and their effectiveness, public acceptance, competing water and energy needs, and socioeconomic factors.

Early developments in the field of water reuse and recycling stem from the historical practice of land application for the disposal of wastewater. With the beginning of sewerage systems for urban sanitation in the nineteenth century, domestic wastewater has been used at “sewage farms” across the United States. The purpose of these sewage farms was the effective removal of treated sanitary wastes from population centers to prevent the spread of disease, and incidental use was made of the treated water for crop production or other beneficial uses. During the twentieth century, the growing need for reliable water coupled with environmental concerns about discharge of wastewater into ecosystems and increasing costs and energy requirements of wastewater treatment has spurred progress in water recycling and reuse.

One of the earliest cases of industrial reuse in the United States was the use of chlorinated wastewater effluent for steel processing at the Bethlehem Steel Company in Baltimore, MD, which was practiced from 1942 until the company ceased operations in the late 1990s. In the 1960s planned urban water reuse systems were developed in response to rapid urbanization in California, Colorado, and Florida.

Today, industrial water reuse is gaining traction in many industrial segments. Primary uses of recycled water for industrial reuse can be found in commercial, institutional, and industrial businesses that use open recirculating cooling towers to remove heat from various processes. More recently, recycled water has found its way into an increasing number of industrial uses ranging from textiles manufacturing and commercial laundering to high-purity applications involving nonpotable ultra-pure water for low- and high-pressure boiler feed systems, and other industrial nonpotable processes. As recycled water providers and potential industrial customers continue to gain greater understanding of the water quality challenges and available treatment technologies, varying regulatory requirements, and implementation timelines and costs, the adoption of recycled water into newer industrial applications continues to grow.

Chapter 2

Overview of Regulatory Considerations

2.1. Regulatory Considerations for Industrial Reuse

Use of recycled water for industrial applications, such as cooling and process water, involves several sets of regulatory requirements. The following sections provide an overview of the federal and state regulations that govern industrial recycled water use. With regard to state regulations, this chapter is not exhaustive; therefore, the reader is cautioned to verify specific recycled water requirements, regulations, and guidelines within the specific state where the proposed industrial reuse project resides.

2.2. Federal Requirements

The Clean Water Act (CWA) requires that all discharges of pollutants to surface waters (streams, rivers, lakes, bays, and oceans) must be authorized by a permit issued under the National Pollutant Discharge Elimination System (NPDES) program. Under the CWA, the EPA has the authority to implement the NPDES program. The EPA may authorize states to implement all or parts of the national program. Once approved, a state would gain the authority to issue permits and administer the program. In the absence of state assumption of NPDES authority, the EPA operates the NPDES program by direct implementation. Because recycled water continues to be treated as municipal wastewater, it must meet secondary biological treatment standards at a minimum. Beyond this basic level of treatment, there are no other federal requirements specifically relating to recycled water or the industrial use of such water.

2.3. State Requirements

Some states have regulations, guidelines, or neither. Regulations refer to actual rules that have been enacted and are enforceable by government agencies. Generally, guidelines are not enforceable but can be used in developing a reuse program or for exercise of agency discretion. Examples of states that have regulations for industrial reuse activities are discussed in the sections that follow.

State requirements typically consider the probable degree of public exposure to recycled water. In addition to federal secondary standards, states may require more stringent standards regarding the treatment level of the recycled water, monitoring requirements, and prevention of cross connections with potable water sources. Generally, treatment of recycled water is established to control microbial pathogens; therefore, states usually establish limits on fecal or total coliform bacteria and may require that the wastewater be filtered and/or disinfected before it can be reused as recycled water. The following subsections provide an overview of regulatory requirements for the states of California, Florida, New Jersey, and Texas as a basis of comparison. The reader should verify regulatory requirements within his or her specific state of residence by checking with the state's department of environmental quality or similar regulatory body governing water and wastewater treatment. Where no state regulations are available, one of the example state regulations cited herein may be considered for use.

2.3.1. California

Regulations for recycled water are defined in Title 22 (Social Security), Division 4 (Environmental Health), Chapter 3 (Water Recycling Criteria) of the California Code of Regulations (CCR). On July 1, 2014, the authority, duties, powers, purposes, functions, responsibilities, and jurisdiction for enforcement of drinking water and recycled water regulations was transferred from the California Department of Public Health (CDPH) to the State Water Resources Control Board (SWRCB), Division of Drinking Water (DDW).

In the case of industrial and commercial applications, California allows the use of recycled water for cooling and process water applications. Separate requirements apply to cooling systems that either create mist or do not create mist. Cooling towers create a mist or vapor plume; therefore, use for cooling tower makeup would follow the requirements for uses that create mist. Recycled water used for cooling tower applications must be treated to California's "disinfected tertiary" standards, which represent the highest level of regulated recycled water quality within the state. The recycled water must be sampled daily for total coliform bacteria and continuously for turbidity. Cooling towers that use recycled water for makeup must employ drift eliminators to minimize mist and must treat the recirculating cooling water system with chlorine or other biocide to control microbial activity.

California defines four different types of recycled water quality. Each type undergoes a different level of treatment to satisfy end-use requirements. The description of each type of recycled water is provided as follows:

1. **Disinfected tertiary recycled water:** Disinfected tertiary recycled water is defined as filtered and subsequently disinfected wastewater that meets the following requirements:

   (a) The filtered wastewater has been disinfected by either

      1. A chlorine disinfection process following filtration that provides a chlorine residual/contact time value of not less than the 450 mg min/L at all times with a modal contact time of at least 90 min, based on peak dry weather design flow.

      2. A disinfection process that, when combined with the filtration process, has been demonstrated to inactivate and/or remove 99.999% of plaque forming units of F-specific bacteriophage MS2, or polio virus, in the wastewater. A virus that is at least as resistant to disinfection as polio virus may be used for purposes of demonstration.

      3. The median concentration of total coliform bacteria measured in the disinfected effluent does not exceed a most probable number (MPN) of 2.2/100 mL using the bacteriological results of the last seven days for which analyses have been completed and the number of total coliform bacteria does not exceed an MPN of 23/100 mL in more than one sample in any 30-day period. No sample shall exceed an MPN of 240 total coliform bacteria per 100 mL.

   (b) In addition, the filtered wastewater must be oxidized and passed through natural undisturbed soils or a bed of filter media pursuant to the following:

1. At a rate that does not exceed 5 gpm/ sq ft of surface area in mono, dual, or mixed gravity, upflow or pressure filtration systems, or does not exceed 2 gpm/ sq ft of surface area in traveling bridge automatic backwash filters

2. So that the turbidity of the filtered wastewater does not exceed any of the following:

    (a) An average of 2 nephelometric turbidity units (NTU) within a 24-h period.

    (b) 5 NTU more than 5% of the time within a 24-h period

    (c) 10 NTU at any time.

2. **Disinfected secondary-2.2 recycled water:** Disinfected secondary-2.2 recycled water is defined as recycled water that has been oxidized and disinfected so that the median concentration of total coliform bacteria in the disinfected effluent does not exceed a MPN of 2.2/100 mL using the bacteriological results of the last seven days for which analyses have been completed, and the number of total coliform bacteria does not exceed an MPN of 23 per 100 milliliters in more than one sample in any 30 day period.

3. **Disinfected secondary-23 recycled water:** Disinfected secondary-23 recycled water is defined as recycled water that has been oxidized and disinfected so that the median concentration of total coliform bacteria in the disinfected effluent does not exceed a MPN of 23/100 mL using the bacteriological results of the last seven days for which analyses have been completed, and the number of total coliform bacteria does not exceed an MPN of 240/100 mL in more than one sample in any 30-day period.

4. **Undisinfected secondary recycled water**: Undisinfected secondary recycled water is oxidized wastewater. Oxidized wastewater is wastewater in which the organic matter has been stabilized, is nonputrescible, and contains dissolved oxygen. Each state provides regulations and guidelines for the type of the recycled water and its nonpotable direct use for various applications.

The following section describes an overview of regulatory considerations.

In high-population areas where businesses and industries are most likely to be located, the majority of California water recycling agencies produce and distribute recycled water meeting the highest quality in accordance with the disinfected tertiary standard.

2.3.2. Florida

The Florida Department of Environmental Protection developed regulations for using recycled water. These regulations are located in Chapters 62-600 and 62-610 of the Florida Administrative Code (F.A.C.), “Reuse of Recycled Water and Land Application.”

Florida allows the use of recycled water for cooling water systems and process water. Recycled water must be treated to secondary treatment levels and must include filtration and high-level disinfection. The recycled water should not contain more than 5 mg/L of suspended solids before the application of the disinfectant. Monitoring is required for *Giardia* and *Cryptosporidium* every two years. A 300-ft setback distance should be provided from the cooling tower that receives recycled water to the site property line. The cooling tower should be designed and operated to minimize aerosol drift to areas beyond the site property line that are accessible to the public.

2.3.3. New Jersey

The New Jersey Department of Environmental Protection (NJDEP) does not have specific regulations for using recycled water. However, the agency has published a technical manual for recycled water for beneficial reuse. The industrial beneficial reuse involves the use of recycled water for cooling water and/or washing operations. The uniqueness of each industrial reuse application makes it impossible to establish specific treatment standards for this general category of reuse.

Prior to implementation, all industrial reuse systems require a case-by-case review by the department. Other requirements include submission of standard operations procedures that ensure proper material handling and a user/supplier agreement annual usage report. Worker contact with recycled water must be limited to individuals who have received specialized training to deal with the recycled water systems.

NJDEP has identified four main categories of recycled water for beneficial reuse and the specific requirements for each with the level of recycled water treatment. Minimum level of treatment includes secondary treatment followed by filtration and disinfection. Following are the four primary categories with the recycled water quality requirements:

1. **Type I–Public Access Systems:** Public access systems involve the use of recycled water where public exposure is likely, thereby necessitating the highest degree of treatment. Where chlorine is used for disinfection, a total chlorine residual of at least 1.0 mg/L shall be maintained for a minimum of 15 min at peak hourly flow. Where ultraviolet (UV) disinfection is used, a design UV dose of 100 mJ/cm^2 under maximum daily flow must be used. The use of alternative methods of disinfection, such as ozone, may satisfy the high-level treatment requirements of public access reuse water. Fecal coliform concentrations shall not exceed 14 CFU/100 mL at any given time. Fecal coliform concentrations must also meet a weekly median value of 2.2 CFU/100 mL. Total suspended solids (TSS) shall not exceed 5.0 mg/L before disinfection. Continuous monitoring for turbidity before disinfection is required.

2. **Type II–Restricted Access and Non-edible Crop Systems:** Restricted access and non-edible crops reuse involves the use recycled water where public exposure is controlled; therefore, treatment requirements may not be as demanding as in a public access reuse systems. These systems do not include the irrigation of edible crops. Total nitrogen concentrations shall not exceed 10 mg/L. The department may impose a total nitrogen concentration limitation greater than 10 mg/L if the permittee can demonstrate that a higher concentration is protective of the environment. The treatment facility shall establish a written standard operating procedure that ensures all effluent that is used for beneficial reuse has satisfactorily met the disinfection requirements. For restricted access applications, the fecal coliform concentration shall not exceed a monthly geometric mean value of 200 CFU/100 mL or a weekly geometric mean value of 400 CFU/100 mL.

3. **Type III–Agricultural Edible Crop Systems**: This use of recycled water involves the irrigation of edible crops. The same high-level treatment requirements associated with public access uses also apply to reuse for edible crops.

4. **Type IV–Industrial Systems, Maintenance Operations, and Construction:** Industrial reuse involves the use of recycled water in industrial applications such as cooling water and/or process water operations. The uniqueness of each industrial reuse application makes difficult the establishment of specific treatment standards for this general category of reuse. Prior to implementation, all industrial reuse systems require a case-by-case review by the department. Some applications, such as the reuse of effluent for noncontact cooling water, may require very little, if any, changes to the level of treatment the wastewater is already receiving at the wastewater treatment plant.

2.3.4. Texas

The Texas Commission on Environmental Quality developed regulations for using recycled water. These regulations are Title 30 Texas Administrative Code Chapter 210 – Use of Recycled Water. The water must meet standards for BOD_5 and fecal coliform. Sampling must be conducted once per week. There are special requirements for use of recycled water for industrial applications such as cooling towers, which produce significant aerosols adjacent to public access areas.

There are two types of recycled water use in the state of Texas; Type I and Type II.

1. Type I recycled water use includes irrigation or other uses in areas where the public may be present during the time when irrigation takes place or other uses where the public may come in contact with the recycled water. For Type I use, recycled water on a 30-day average shall have a quality of:

    (a) BOD, or CBOD – 5 mg/L;

    (b) Turbidity – 3 NTU;

    (c) Fecal coliform 20 CFU/100 mL geometric mean and 75 CFU/100 mL in any grab sample

2. Type II recycled water use includes irrigation and other uses in areas where the public is not present during the time when irrigation activities occurs or other uses where the public would not come in contact with the recycled water. For Type II use, recycled water on a 30-day average shall have a quality of:

    (a) For a system other than pond system:

        1. BOD – 20 mg/L or CBOD – 15 mg/L;

        2. Fecal coliform – 200 CFU/100 mL geometric mean and 800 CFU/100 mL in any grab sample

    (b) For a pond system:

        1. BOD – 30 mg/L

        2. Fecal coliform – 200 CFU/100 mL geometric mean and 800 CFU/100 mL in any grab sample

2.4. Consideration of Regulations for Industrial Reuse

On the basis of the overviews provided for federal and example state regulatory requirements, the following general requirements can be expected, regardless of the locale of the proposed industrial reuse system. Regulatory requirements generally address generic water quality, monitoring, and reporting needs but may not address water quality necessary for the specific industrial process. Industrial process treatment considerations are discussed further in Chapter 3.

2.4.1. Open Recirculating Cooling Systems

Generally, open recirculating cooling systems have the potential for producing fine droplets or a mist that may become windblown. These systems generally require the highest treatment level of recycled water available including oxidation, filtration, and disinfection. Additional requirements are preventing drift from reaching the public and generally include requirements for installing a high-efficiency drift eliminator, as well as minimizing the potential for drift to enter a building's ventilation intake system.

2.4.2. Closed Recirculating Cooling Systems

Closed recirculating, or once-through, cooling systems generally are not affected by the potential for producing mist. As a result, the minimum required treatment level of the recycled water is generally disinfected secondary.

2.4.3. Process and Wash Water

Industrial systems using recycled water for in-plant process and wash water use generally will require a minimum secondary level of treatment including oxidation and disinfection. Each specific industrial process use of recycled water must consider other nonregulatory water quality requirements. These considerations are discussed in Chapter 3.

2.4.4. Cross-Connection Control

Industrial sites utilizing recycled water for certain processes generally also include potable water and nonpotable in-plant water that is derived from a potable water source. Most states have strict cross-connection control requirements that prevent the interconnection of recycled water and potable water sources. This is necessary to protect the potable water source and prevent the potential for contamination. Cross-connection control programs generally require the use of a suitable air gap for the potable source where a recycled water source is present to the same process. In some states, backflow prevention devices may not be considered suitable for cross-connection control from a pressurized recycled water source.

Additional requirements may include regulating agency inspection of the potable and recycled water pipeline during construction prior to backfilling of buried pipeline and prior to the closing of walls and vaults for exposed pipelines.

2.4.5. Plan Review and Approval

Nearly all industrial reuse projects will require the preparation of engineering drawings prepared by a registered professional engineer and submission of the drawings and related specifications and/or an engineering report to the reviewing agency. The review may be performed by multiple agencies, including the local recycled water provider, as well as the county and/or state agency responsible for environmental protection. The review process can be lengthy depending on the complexity of the industrial reuse project. Perspective industrial reuse customers must be prepared to include additional time in the project implementation schedule to complete required agency plans review and receive agency approvals. Agency reviews can be as short as 30 days but may exceed several months. A review period of 60 to 90 days should be expected.

2.4.6. Signage and Markings

All agencies, regardless of locale, will require special signage for buildings, enclosures, and systems that use recycled water. At a minimum, signage requirements will be dictated by local, state, federal, and/or international building codes. State and local agencies may have strict signage and marking requirements for recycled water that may include color and materials for piping, marking, and labeling of piping and equipment, and signs posted at specific locations warning of recycled water use. Guidelines and specifications generally are available from each agency having jurisdiction.

2.4.7. Professional Guidance

Because of the potential complexity of the regulatory process, industrial reuse customers and recycled water purveyors should consider the use of professions having specific experience with the design and permitting of industrial reuse projects. This expertise will help avoid potential pitfalls and will assist with navigating specific local and state recycled water requirements for industrial reuse projects.

Chapter 3

Recycled Water Quality Considerations and Treatment Alternatives

3.1. Agencies Recycled Water Quality at a Glance

Understanding the quality of available recycled water is key to any planned implementation of recycled water for commercial and/or industrial uses. Federal and state regulations typically govern specific quality requirements that are necessary for the protection of public health. However, recycled water, like other sources of water, may contain other physical qualities and constituents that must be quantified and reviewed by the proposed end user to determine whether supplemental onsite treatment is necessary. It is important to note that all purveyors of recycled water will meet and exceed the quality requirements set forth by their governing state and federal regulations; however, the water quality will be highly variable from one agency to the next. Each potential end user, or his or her designated water quality/water treatment specialist, must review the specific agency's recycled water data and identify those physical and chemical constituents that may impact or limit use of recycled water within each specific commercial or industrial process.

Water quality data from a sample of various recycled water agencies in various states is provided on the tables that follow. Table 1 summarizes the varying water quality among several recycled water agencies in that state. Table 2 provides water quality summaries for agencies located in the states of Arizona, Colorado, Florida, and Texas. Each list contains the water quality constituents that are of greatest concern to the commercial and industrial end users.

3.2. Recycled Water Quality Parameters Issues

All water, regardless of its source contains various constituents at different concentrations. Some constituents can be very beneficial for the proposed use, whereas others may require supplemental water treatment processes and/or chemical treatment to mitigate their potential effect. Knowledge and understanding of the specific recycled water quality are needed to assure successful use of recycled water for industrial applications such as cooling water and process water. However, recycled water also has some unique characteristics that significantly influence its use as a source of water for cooling water system applications. The constituents that will be of greatest concern to the end user are briefly discussed here.

1. **Ammonia:** Ammonia is a nutrient for many microorganisms and, therefore, may promote increased microbiological activity and biofilm growth in cooling and process water systems such as heat exchangers and cooling tower fill. In addition, ammonia is extremely corrosive to copper and copper alloys used in many piping systems, valves, cooling water systems, and other processes. For those systems containing copper or copper alloys, ammonia either must be removed or a suitable chemical treatment applied to protect the copper and copper alloy surfaces.

Table 3.1. Recycled Water Quality for Select California Agencies

Parameter	Symbol	Unit	Recycled Water Provider						
			EBMUD San Ramon Valley (2010)	IRWD Michelson WRP (2008)	San Diego North City WRP (2013)	San Jose/ Santa Clara South Bay WRP (2012)	San Ramon Valley RWP	West Basin MWD[2]	
								Nitrified (2009)	CRWRF RO (2009)
pH	pH	S.U.	7.43	6.8	6.88	8.3	7.35	—	—
Electrical Conductivity	EC	µS/ cm	1265	1092	1370	1180	1327	< 1350	< 50
Alkalinity	$CaCO_3$	mg/L	293	147	86	158	278	< 300	—
Hardness	$CaCO_3$	mg/L	—	—	—	—	244	—	< 0.3
Total Dissolved Solids	TDS	mg/L	658	675	781	755	660	—	< 35
Calcium	Ca	mg/L	49	46	57	—	48	< 100	< 1.0
Magnesium	Mg	mg/L	32	23.5	28.3	—	30	< 30	< 1.0
Potassium	K	mg/L	25	18.2	15.9	—	23	< 20	—
Sodium	Na	mg/L	139	146	163	140	150	—	—
Sulfate	SO_4	mg/L	105	142	145	124	97	< 600	—
Chloride	Cl	mg/L	158	146	239	148	159	< 450	—
Iron	Fe	mg/L	—	0.054	0.088	0.1	—	< 1.0	—
Manganese	Mn	mg/L	—	0.013	0.071	0.02	—	—	—
Zinc	Zn	mg/L	—	0.047	0.025	0.06	—	—	—
Boron	B	mg/L	—	0.43	0.3	0.48	0.47	—	—
Ammonia-Nitrogen	NH_3-N	mg/L	—	0.19	ND	—	—	< 1.6	< 4
Nitrate	NO_3	mg/L	5.3	34.1	59.9	20.2	5.8	—	—
Total Nitrogen	N	mg/L	—	9.8	15.3	—	—	—	—
Phosphorus	P	mg/L	—	3	0.63	—	—	< 5	—
Silica[1]	SiO_2	mg/L	21.3	—	12	—	19.4	< 35	< 1.0

Notes:

1. Although not reported in some water quality analyses provided by the various California Water Reclamation Facilities above, silica is known to be naturally present in most California recycled water effluent.

2. West Basin Municipal Water District is unique in that it provides five levels of recycled "designer" water, four of which are used for industrial reuse applications. Values shown are taken from the 2009 WBMWD Capital Implementation Master Plan for Recycled Water Systems for either maximums or targets depending on the treatment facility and end user.

Table 3.2. Recycled Water Quality for Select Agencies in Arizona, Colorado, Florida, and Texas

Parameter	Symbol	Unit	Recycled Water Provider					
			Arizona	Colorado	Florida			Texas
			Tucson Water RW (2013)	Denver Water RW (No date)	Dunedin RW (2011)	Melbourne D.B. Lee RW (2012)	Tampa RW (2012)	Austin Water Walnut WRP (2007-2009)
pH	pH	S.U.	7.5	—	7.9	7.3	7.11	6.7
Electrical Conductivity	EC	µS/ cm	1237	360–1250	1270	—	1771	—
Alkalinity	$CaCO_3$	mg/L	221	50–150	—	—	—	35
Hardness	$CaCO_3$	mg/L	292	—	—	—	—	—
Total Dissolved Solids	TDS	mg/L	752	—	760	—	1,158	469
Calcium	Ca	mg/L	88	40–70	—	—	—	38
Magnesium	Mg	mg/L	18	5–20	—	—	—	17
Potassium	K	mg/L	—	10–20	—	—	14.8	—
Sodium	Na	mg/L	142	90–200	130	126	297	77
Sulfate	SO_4	mg/L	155	80–250	59	94.1	436	91
Chloride	Cl	mg/L	147	65–170	200	152	213	91
Iron	Fe	mg/L	—	0.05–0.6	—	0.043	0.048	—
Manganese	Mn	mg/L	—	0.003–0.08	0.019	0.0071	—	20
Zinc	Zn	mg/L	—		0.003	0.035	—	38
Boron	B	mg/L	0.27	0.2–0.4	—	—	—	—
Ammonia-Nitrogen	NH_3-N	mg/L	10.5	0.0–0.4	—	—	0.08	0.28
Nitrate	NO_3	mg/L	16	—	—	7.76	5.93	89
Total Nitrogen	N	mg/L	14.6	—	—	—	1.12	—
Phosphorus	P	mg/L	1.2	0.04–0.4	—	—	2.1	7.8
Silica	SiO_2	mg/L	—	—	—	—	—	11

2. **Phosphate:** Phosphate at concentrations of 4.0 mg/L or less and with pH in the range of 7.0–7.5 can provide corrosion protection with use of a chemical based dispersant. Phosphate at higher concentration can be combined with calcium to form calcium phosphate scaling. In addition, phosphate can provide nutrients for microorganism growth resulting in biofilm formation.

3. **Oxygen demand:** Oxygen demand and organic carbon concentrations, as indicated by COD/BOD and TOC are a concern, primarily because they reflect the organic content and the associated demand for oxidizing biocides used to obtain effective biological and biofilm control in the process system.

4. **Nitrite and nitrate:** The presence of nitrite and nitrate in recycled water provides a source of nutrients for microorganisms resulting in biological activity in the cooling water and process water systems. As a result, the demand for oxidizing and nonoxidizing biocides for microbiological control may be increased significantly.

5. **Heavy metals:** Heavy metals, such as iron, manganese, copper, and others, can form deposits and cause localized corrosion, which can result in a rapid failure of cooling water or process water systems. In addition, iron can react with phosphate to form iron phosphate foulants.

6. **Total dissolved solids (TDS):** Recycled water has a higher concentration of TDS comparing to potable water. Specifically, chloride and sulfate ions are the primary concern. Chloride and sulfate are aggressive to metals and can significantly increase their corrosion rates. Whereas metal corrosion cannot be eliminated regardless of the water source, a proper chemical or alternative treatment program can mitigate corrosion by significantly slowing down the process.

3.3. Industrial Reuse Applications at a Glance

There has been a dramatic shift in the momentum for industrial water reuse, as more and more companies actively seek out options from their water providers. A summary of industrial reuse applications, water quality required, treatment processes, and cost impact comparisons are provided in Table 3.3. An overview of treatment technologies are discussed in the following sections.

Industrial reuse applications can be classified as cooling water systems, boiler systems, and process water. Cooling and boiler systems are used widely in industries, such as refineries, petrochemical plants, power plants, and similar commercial and institutional applications, which have a high demand for nonpotable water consumption. Industrial process water reuse applications include, but are not limited to, carpet and textile manufacturing, commercial laundry, nonfood process rinse, and high-technology manufacturing. Each application would determine the level of additional treatment and water quality requirements necessary to appropriately use recycled water.

In the carpet and textile industry, finishing raw fabrics is a basic operation that requires water for weaving mills, kiering, and bleaching operations. Recycled water, with the addition of chemical conditioning and dissolved solids removal, can provide a source of water for these operations. Some of these facilities have their own water recycling treatment capabilities to recover the wastewater generated from the various unit operations and reuse it within the process. The goal is to use the higher quality recycled water in critical processes that need it and then reuse the recycled water for those processes that require lesser quality water.

High-technology manufacturing uses high purity water for their process. Use of recycled water for this type of industrial reuse requires additional treatment. The additional treatment can be incorporated into the existing water treatment system to condition and pretreat the recycled water prior to use.

Cooling water systems are widely used in industrial, commercial, and institutional applications to remove heat from a process. Cooling water systems require a water treatment program to control corrosion, scale formation, and biological activities. Conventionally, chemical inhibitors and biocides are used as part of the water treatment program. However, newer, proven alternative green technologies have come to market within the past decade that can reduce chemical consumption significantly and reduce make-up water demand. Use of recycled water for cooling water systems requires adjustment or change in the water treatment program and adjustment to operating parameters to control the system from corrosion, scale formation, and biological activities successfully.

Boiler systems are mainly used for heating water or producing steam for various applications. In high-pressure boiler systems, feed water requires both physical and chemical treatment to control corrosion and scaling in the system. Physical treatment of high-pressure boiler systems includes removal of minerals from the feed water to produce high-purity water using reverse osmosis (RO) membrane systems, electrodialysis reversal (EDR) systems, or ion exchange (IX) systems. Use of recycled water as a source for boiler feed make-up water requires additional pretreatment system (i.e., filtration system) upstream of the RO, EDR, or IX systems to prevent fouling of these systems and condition the recycled water prior to use for high-pressure boiler applications. In low-pressure boiler system applications, a pretreatment filtration system followed by an IX softening system are required to condition recycled water for use as a low-pressure boiler feed water with subsequent addition of chemical to control corrosion.

Table 3.3 provides a summary of typical industrial reuse applications that can benefit from using recycled water along with the typical treatment program that may be necessary preconditioning of the water for its successful use.

3.4. Overview of Treatment Technologies

Use of recycled water for industrial and commercial reuse may require adjustment to chemical treatment programs, addition of physical unit processes, or combinations of both to provide the required water quality for industrial applications such as cooling make-up water, boiler feed water, and process water systems. Although not always necessary, traditional practice has shown that chemical treatment programs should be employed to control corrosion, deposition, and microbiological growths. Newer, proven alternative technologies are also available for specific use in cooling tower applications. These technologies employ the use of softening systems to remove scale forming constituents, such as calcium and magnesium, coupled with high-cycle operation and silica-based corrosion control programs. Physical treatment systems typically are used to reduce or remove dissolved solids from recycled water for high-purity water applications such as boiler systems and high-technology manufacturing processes.

Table 4.3 provides a matrix of typical treatment processes based on the example industrial reuse application and typical recycled water quality desired. The typical treatment processes provided in the matrix are not exhaustive but are intended to show general trends in industrial applications.

Table 3.3. Industrial Recycled Water Reuse Application and Treatment Matrix

Quality Level	Typical Application	Typical Recycled Water Quality Required	Typical Treatment Process	Additional Treatment Regiment	Cost Impact Relative to Conversion from Potable	
					Capital Cost	O&M Costs
1	Carpet/Textile Manufacturer Commercial Laundry Nonfood Process Rinse	Tertiary Disinfected TDS < 1500 mg/L	Adjustment to Chemical Treatment Program	Not Required	Low-Moderate	Low-Moderate
2	Cooling Tower System	TDS < 1200 mg/L Total Hardness < 500 mg/L as $CaCO_3$ Ortho-Phosphate < 3 mg/L as PO_4 Total Suspended Solids < 2 mg/L Ammonia < 2 mg/L as NH_3	Adjustment to Chemical Treatment Program	Generally Not Required. *Nitrification may be necessary to remove high levels of ammonia*	Low–Moderate	Moderate
			Alternative Natural Chemistry Treatment Program	Not Required	Moderate	Low
3	High-technology Manufacturer Low-pressure Boiler System	TDS < 60 mg/L Total Hardness < 0.3 mg/L	Reverse Osmosis (RO) System followed by Ion Exchange Demineralization	Filtration Pretreatment	High	High
			Electrodialysis Reversal (EDR) followed by Ion Exchange Demineralization	Filtration Pretreatment	High	High
4	High-pressure Boiler System	TDS < 5 mg/L Total Hardness < 0.03 mg/L	Reverse Osmosis (RO) followed by Ion Exchange Demineralization	Filtration Pretreatment	High	High

			Electrodialysis Reversal (EDR) followed by Ion Exchange Demineralization	Filtration Pretreatment	High	High

The following subsections provide additional discussion for the typical chemical, alternative, and physical treatment process summarized in Table 4.3 for industrial reuse of recycled water.

3.4.1. Chemical Treatment

Chemical treatment programs include a variety of chemicals used for controlling corrosion, scale formation, and biological activities in cooling water and process water systems. Each chemical type and its use are further described as follows:

1. **Corrosion Control:** Corrosion is an electrochemical reaction in which metals are oxidized by transferring electrons from an anodic site to a cathodic site. Cathodic inhibitors reduce the amount of cathodic surface available and anodic inhibitors reduce the amount of anodic surface available. Sometimes both types of inhibitors are needed to prevent corrosion. Phosphates, zinc salts, molybdates, and polysilicates are typical mild steel corrosion inhibitors, whereas organic nitrogen-based compounds (azoles) are copper alloy corrosion inhibitors.

2. **Scale Formation Control:** Several different types of scale deposits can be formed, necessitating various approaches for control as follows:

   - Scale control inhibitors focus on either solubilizing agents to prevent scale from precipitating or crystal modifiers to alter the nature of precipitate to prevent adhesion to surfaces.

   - Dispersants and surfactants are charged molecules that adsorb suspended solids and cause a mutual repulsion, which keeps solids as smaller particles to prevent scale formation.

   - Acid, phosphonates, and water-soluble polymers are typical mineral scale inhibitors.

3. **Microbiological Control:** The hydroxyl radicals, hydrogen peroxide, bromine, and chlorine are oxidizing biocides that control microbiological growth. Oxidizing biocides irreversibly oxidize protein groups, resulting in loss of normal enzyme activity and death. Non-oxidizing biocides are also available such as isothiazolin, glutaraldehyde, quarternay ammonium compounds, and organo-sulfurs. Best practices may involve alternating biocide types to provide the most effective microbial control.

3.4.2. Alternative Cooling Water Treatment

Alternative cooling water treatment technologies refer to newer, nontraditional water treatment programs developed specifically for cooling water treatment applications using recycled water as the source of make-up water. Optimal and efficient use of recycled water in cooling water systems requires that an appropriate treatment technology be implemented. One of the successful alternative technologies proven for use in cooling water treatment systems uses a patented "green" technology. The technology does not use conventional chemicals for corrosion, scale, and biological control in the open recirculating cooling water systems. Rather, this technology is unique in that it uses the natural minerals present in recycled water to provide corrosion, scale, and biological control within the cooling water system at elevated cycles of concentration. Increasing the cycle of concentration in the cooling water system significantly decreases operational costs by reducing the make-up water requirements, chemicals consumption, and blow-down to waste. As a result, this green technology qualifies for additional Leadership in Energy and Environmental Design (LEED) credits for water efficiency and technology.

The proven alternative treatment process uses multimedia filtration followed by high-efficiency softening (HES). The filtration process is used to prevent fouling of the softener resins and reduce the suspended solids concentration in the cooling water as the cycle of concentration is increased. The HES system removes scale forming cations, such as calcium and magnesium, from the recycled water. The HES system uses strong-acid cation exchange resins designed to operate with low salt usage for regeneration compared to conventional ion exchange softening systems.

After softening of the recycled water, the remaining natural chemistry in the source water used beneficially by the process includes silica, alkalinity, and total dissolved solids, which perform productive roles when concentrated in the cooling water system. Simple evaporative concentration of these source water minerals results in the polymerization of silica to amorphous polysilicates that provide exceptional corrosion inhibition of metal surfaces at saturation concentration. Excess silica in the cooling water will form soluble and meta-stable silica colloids that do not form heat transfer inhibiting deposits, because low-solubility scales that result from calcium and magnesium have been removed by the softening process. Increasing the cycle of concentration in the cooling water results in elevated concentrations of total dissolved solids (TDS) and alkalinity and increases the pH level, which help to provide a second natural chemistry benefit. High TDS and pH are prohibitive to biological activity; therefore, the cooling water becomes naturally biostatic at high cycles of concentration. This biostatic chemistry is a natural process that mitigates pathogen risk and endocrine chemistry contaminant issues. However, maintaining a biocide onsite is a requirement of most state regulations regarding recycled water use in cooling towers.

3.4.3. Physical Treatment Processes

Selection of physical treatment processes depends on the water quality requirements for commercial and industrial reuse applications. One of the main applications includes producing high-purity recycled water for boiler systems and high-technology manufacturing processes. The following physical treatment systems are viable for producing high-purity recycled water:

3.4.3.1. Reverse Osmosis (RO) Membrane System

Reverse osmosis (RO) membrane processes typically are applied for the removal of dissolved constituents, including both inorganic and organic compounds. RO is a process in which the mass transfer of ions through membranes is controlled. Consequently, these processes can remove salts, hardness, synthetic organic compounds, and disinfection byproducts precursors, among others. However, dissolved gases, such as hydrogen sulfide and carbon dioxide, can pass through RO membranes. RO is a membrane separation process in which the water from a pressurized solution is separated from the solutes (dissolved materials) by flowing through a permeable membrane.

In practice, the RO feed water is pumped into a closed vessel where it is pressurized against the membranes. As a portion of the water (permeate) passes through the membranes, the remaining feed water increases in salt content. At the same time, a portion of this feed water (concentrate or brine) is discharged without passing through the membranes. Without this controlled discharge, the pressurized feed water would continue to increase in salt concentration, creating such problems as precipitation of supersaturated salts and increased osmotic pressure across the membranes.

Pretreatment is important in RO systems, because the feed water must pass through very narrow passages during the process. Therefore, suspended solids must be removed and the water pre-treated so that mineral precipitation or microorganism growth does not occur on the membranes. Typically, pretreatment consists of filtration and addition of chemicals to inhibit precipitation.

3.4.3.2. Electrodialysis Reversal System (EDR)

Electrodialysis reversal (EDR) is an electrochemical separation process, which allows selective passage of ions, or charged species, in a solution. Only anions, or negatively charged ions, can pass through an anion exchange membrane, whereas cation exchange membranes transport positively charged ions, or cations. Ions are transferred through ion exchange membranes by means of direct current (DC) voltage and are removed from the feed water as the current drives the ions through the membranes to demineralize the process stream.

EDR systems use membrane stacks with electrical stages. Each electrical stage also has two corresponding hydraulic stages. Water passes through each electrical stage twice to provide greater residence time for ion transfer. Essentially, an electrical stage is composed of one cathode and one anode separated by a series of cationic and anionic membranes and spacers. EDR systems reduce the fouling tendencies of the water by periodically reversing the polarity of the electrodes. This change in polarity causes scale to disassociate from the membranes.

3.4.3.3. Ion Exchange System (IX)

Ion exchange (IX) systems are used to remove selective charged dissolved substances from the water. Ion exchange is the reversible interchange of ions between a resin and a liquid in which there is no permanent change in the structure of the resin. Both dissolved cations and anions can be removed by the IX processes. There are two types of IX resins: cation exchange resins and anion exchange resins. Cation exchange resins are widely used to remove scale-forming cations, such as calcium and magnesium, from the source water. In this process, cations are exchanged for sodium or hydrogen ions in the resin. Anion exchange resins are used to exchange anions in the water with hydroxide or chloride ions. The demineralization operation can be a sequential cation–anion process (single beds or layered beds) or an intimate mixture of cation and anion resins (mixed beds).

IX resins consist of an organic polymer chemically bonded to an acidic or basic functional group. Most ion exchange polymers are polymerized polystyrene cross linked with divinylbenzene (DVB). Cation resins are created by attaching negatively charged functional groups to the copolymer structure. Anion resins are functionalized by attaching chemical groups with positive charges to the copolymer.

Chapter 4

Interviews and Case Studies

4.1. Interviews and Case Studies Introduction

A major task of this project involved conducting interviews with several recycled water agencies and existing industrial reuse customers. Interview forms were prepared and sent to prospective interviewees in advance of in-person meetings or telephone interviews. This allowed respondents time to gather information in preparation for the interviews. Where possible, interviews were conducted with a matching agency and customer. These interviews proved invaluable, as participants provided their own experiences and salient responses to questions regarding an interrelated industrial reuse project.

Several agency interviews did not include a specific industrial reuse project with a matching customer but were general in the specific agency's overall experience implementing successful industrial reuse projects. The interviews yielded a cross section of agency experience levels, including one particular agency, the Eastern Municipal Water District (EMWD), whose first foray into the industrial reuse arena involved the supply of 7.0 mgd of recycled water to a major inland natural gas-fired power supplier, the Inland Empire Energy Center (IEEC). Other agency interviews included City of Austin Water and City of San Diego Recycled Water Programs.

In addition to the interviews, several industrial reuse customers provided information for the development of case studies for their respective facilities that have implemented recycled water use for specific processes. The case studies generally involve a range of facility types that use recycled water primarily for cooling water and high-quality boiler make-up systems. The cross section of industries range from small- to medium-sized biopharmaceutical, global defense/aerospace, and premium data center companies, with larger industrial facilities represented by a power plant and petroleum refinery. The case studies provided herein include the Amylin Pharmaceuticals, BAE Systems, Internap, Inland Empire Energy Center, and Tesoro Carson Refinery.

4.2. Interviews

4.2.1. City of Austin Water–Agency

City of Austin Water has developed a robust and reliable recycled water supply and distribution system serving a variety of commercial, industrial, and institutional (CII) customers. Austin Water has significant experience working with this type of customer base with successful implementation of numerous commercial and industrial reuse projects. Austin Water's recycled water is one-quarter to one-third of the cost of potable drinking water, thereby making it an attractive option for CII customers. Austin Water strategically developed its recycled water distribution system based on the prioritization of projects recommended from its recycled water master plan.

Austin Water actively communicates with prospective CII customers to generate interest in replacing potable water with recycled water for nonpotable uses. Austin Water approached BAE

Systems with this concept while planning the extension of a new 36-in. diameter recycled water main into the area. This interview was centered specifically on Austin Water's experience with successfully implementing an industrial reuse project with BAE Systems. Even though BAE Systems did not participate in a formal interview, BAE graciously supplied information for completion of a case study for its facility (see Section 4.3.2).

4.2.1.1. Project Description, Parameters, Scope, Objectives, and Expected Outcomes

The BAE Systems project was developed as a result of a recycled water master plan, prepared by Austin Water, for the expansion and extension of its recycled water distribution system. Austin Water's Walnut Creek Water Reclamation Plant is located close to the BAE Systems property. Austin Water requested easements from BAE Systems for recycled water main extension, and BAE Systems approached Austin Water to negotiate connection to the proposed project. Ultimately, the project included the construction of 6-in. and 8-in. recycled water mains onto the BAE Systems site from a new 36-in. recycled water transmission main. Once BAE Systems became committed to receiving recycled water, the City of Austin refined the design development based on current and future needs of BAE Systems. Austin Water's objectives were to increase recycled water use and to expand future use by planning for future, adjacent customers.

4.2.1.2. Water Provider Drivers

Austin Water notes that its drivers for pursuing CII projects and more specifically the BAE Systems project included the following:

- Conservation of its potable water sources for potable consumption.
- Policy directive through its Recycled Water Master Plan to increase recycled water use.
- Desire to encourage large potable water users having non-potable uses to switch to recycled water as source.
- Prioritize prospective customers located within close proximity of existing or proposed recycled water distribution facilities.

4.2.1.3. Project Primary and Salient Technical Issues and Challenges

Austin Water notes from its experience several salient technical issues that needed to be addressed for the BAE Systems and other similar projects:

- Austin Water experienced initial issues with the construction and extension of recycled water main to BAE Systems property owing to lack of experience and lack of quality of the contractor performing the work. Austin notes that contractors experienced with municipal infrastructure construction (especially recycled water projects) provide better quality of work and that inexperienced contractors should be avoided.
- Water quality issues related to BAE Systems' use of Austin Water's recycled water needed to be addressed. Austin Water assisted BAE Systems by researching and finding an alternative pretreatment technology provider capable of handling typical recycled water quality with little to no additive chemical use and engaging the provider to assist BAE Systems with cooling-tower-related pretreatment requirements.
- City of Austin has very stringent cross-connection control requirements that affect recycled water connection requirements. These stringent requirements added to project difficulty in meeting the cross-connection control requirements.

4.2.1.4. *Agency Recycled Water Quality Aspects*

Austin Water provides two levels of recycled water in accordance with Texas Commission for Environmental Quality (TCEQ) requirements: Recycled Water Type 1 and Type 2. Larger treatment plants provide both Type 1 and Type 2.

- Type 1 required WQ:

  BOD_5 or $CBOD_5 \leq 5$ mg/L
  Turbidity ≤ 3 NTU;
  Fecal coliform ≤ 20 CFU/100mL
  Enterococci ≤ 4 CFU/100mL

- Type 2 required WQ:

  $BOD_5 \leq 20$ mg/L or $CBOD_5 \leq 15$ mg/L
  Fecal coliform ≤ 200 CFU/100mL
  Enterococci ≤ 35 CFU/100mL

Austin Water notes little variation in water quality with good consistency of the recycled water throughout the season. However, Austin Water noted that phosphorus can be an issue for some users and that turbidity may increase periodically at one of its treatment plants.

4.2.1.5. *Project Execution Aspects*

Austin Water notes the following that impacted the project execution the schedule, and/or the project costs.

- Contractor inexperience and lack of quality during construction resulted in delay in overall project schedule.
- At initial start-up of BAE Systems cooling towers on recycled water, BAE Systems experienced scaling issues as a result of the previous condition of the cooling towers prior to changing to recycled water and use of the alternative treatment system provider. BAE Systems incurred cost to descale the cooling towers to allow appropriate operation of the alternative pretreatment and use of recycled water. BAE Systems asked for a city-sponsored rebate to offset the cooling tower descaling cost.
- Project implementation requires the timely preparation of detailed drawings, payment of recycled permit and review fees, and the performance of inspections. Cross-connection control review is required and can be cumbersome as the City of Austin has very strict requirements. Plumbing permits must be obtained. It is important to understand these requirements and build them into the timeline of the project schedule.

4.2.1.6. *Project Success Factors*

Austin Water attributes the following factors from an agency perspective as being integral to the success of the BAE Systems' industrial reuse project.

- Communication between agency and end user was noted as a primary key to project success. Communication requires both parties understanding one another's needs and planning for them in advance (i.e., water quality requirements for customer's use, regulatory and technical requirements, project-related issues and resolutions, and operational follow-ups after project implementation).

- Collaboration between agency and end user during design to finalize Austin Water mains and meter locations was needed. This collaboration effort allowed Austin Water to install connections for future use by BAE Systems' planned future site expansion and use of recycled water.
- Experience of the design engineer is essential. Austin Water noted that specific recycled water design experience by the end users' consultant is highly recommended. Typically, experienced consultants will know and understand regulatory and design requirements for proper recycled water implementation and will make the overall process smoother.
- Experience of the end user and city staff are key to project success. Agencies must be willing to work with new CII end users at the project outset to provide end users with an understanding of recycled water use requirements and training.
- Proactive project management helps both parties to identify potential issues and plan corrective action in advance.

4.2.1.7. Project Hindsight and Advice to Others

Austin Water notes in hindsight the importance of paying greater attention to contractor selection and to understanding its customer's connections requirements in advance. Because of the City of Austin's stringent cross-connection control requirements, additional drawings were required to detail the customer's connections. Austin Water also notes the requirement to understand its customer's water quality needs so that necessary customer onsite pretreatment can be planned and designed in advance.

To agencies seeking to implement industrial reuse projects, Austin Water recommends providing customer care and understanding customer needs. Attracting potential CII customers requires active marketing and direct (face-to-face) interaction.

4.2.2. Eastern Municipal Water District–Agency

Eastern Municipal Water District (EMWD) serves an area encompassing nearly 555 sq mi and a population of approximately 758,000. In addition to providing potable water deliveries and sanitary collection and treatment services, EMWD produces approximately 46 mgd of recycled water from five water reclamation plants. Historically, EMWD has produced secondary disinfected and tertiary disinfected recycled water primarily to a gravity-based agricultural distribution system; therefore, EMWD had no prior experience with commercial, industrial, or institutional (CII) customers until it was approached by the Inland Empire Energy Center (IEEC). IEEC was planning to fast-track construction of a new 800 megawatt (MW), state-of-the-art, natural gas-fired, combined cycle gas-turbine power plant requiring a peak recycled water supply of 5000 gpm or 7.2 mgd.

This interview discusses the implementation of the IEEC project from EMWD's perspective. IEEC also participated in a formal interview (see Section 4.2.3) and provided additional information for developing a case study (see Section 4.3.3)

4.2.2.1. Project Description, Parameters, Scope, Objectives, and Expected Outcomes

When the Recycled Water Division of EMWD was informed in 2006 of the need to supply recycled water to IEEC, the supply agreement between EMWD and IEEC was already in place, having been negotiated and prepared at a much higher level within the organization but without technical involvement. Unfortunately, the original supply agreement did not address the necessary technical and regulatory recycled water requirements beyond the capacity needs of the end user. Therefore, this project to supply up to 7.2 mgd of recycled water to IEEC became one in which both EMWD and IEEC technical and design staff were thrust into a steep learning curve on all fronts. This new, ambitious, first project of its type for EMWD necessitated development of regular and frequent communication, trust, and relationship building among project participants ultimately to provide a successful large industrial reuse project.

Project goals from the standpoint of the EMWD Recycled Water Division were as follows:

- Complete expansion of the EMWD recycled water distribution system from a traditional gravity agricultural supply to a pressurized system as required to accommodate the IEEC project.
- Address current EMWD water quality issues to establish a suitable recycled water supply for IEEC use.
- Address regulatory (local and DDW) recycled water and cross-connection control requirements for recycled water use and local waste disposal requirements.
- Address other technical issues such as adding an EMWD Supervisory Control and Data Acquisition (SCADA) node.
- Develop relationship and trust between EMWD and IEEC to ease an otherwise difficult project start.
- Develop more robust recycled water design standards that address complexities of commercial, industrial, and institutional (CII) recycled water use.

4.2.2.2. Water Provider Drivers

EMWD notes that its drivers related to this IEEC project and future CII projects include the following:

- Enhance existing reclamation facility treatment and distribution capabilities to address water quality and pressurized supply needs. The IEEC project prompted EMWD to accelerate its goal of moving to a pressurized distribution system and addressing water quality concerns of supplying quality tertiary disinfected recycled water to attract high-value customers.
- Price elasticity was a goal that EMWD had been planning to attract high-value CII customers willing to pay a higher cost for tertiary disinfected recycled water, as opposed to its existing large base of agricultural customers who paid extremely low rates for both secondary disinfected and tertiary disinfected recycled water. Attracting high-value customers would better enable EMWD to recover its cost of producing recycled water.
- Consistent use was a goal for EMWD. Agricultural recycled water demand is seasonal with peaks during warmer months and little demand during winter months. EMWD was

searching for customers who could provide a lower peak-driven base load on its reclamation facilities and recycled water distribution.

4.2.2.3. Project Primary and Salient Technical Issues and Challenges

EMWD notes from its experience several salient technical issues that needed to be addressed for the IEEC project:

- IEEC redundancy water supply requirements necessitated that a dual feed system of recycled water and standby potable water be provided to the facility. The redundant system was necessary to assure that cooling towers and boiler feed systems would never be without a water source.
- Lack of coordination between management and technical staff during the project negotiation phase led to the negotiated agreement not having appropriate technical and regulatory requirements. These requirements had to be communicated to IEEC after the fact, which caused initial project coordination issues.
- Lack of communication initially with IEEC during project design phase occurred when IEEC began moving forward expeditiously with design before understanding all of the technical and regulatory requirements governing the design. IEEC knew regulatory requirements for power plants but not for recycled water use and implementation, which necessitated training and communication sessions to get everyone up to speed. EMWD was also new to recycled water requirements as they relate to CII projects and had no formal guidelines in place. EMWD called on a well-known retired regulator to assist them and IEEC with training, which was beneficial to all.
- IEEC needed a rate of flow control system to be provided to help control flow to its feed supply. EMWD provided a mechanically operated valve to control opening and closing speeds on the recycled water supply source.
- At the time of the interview, the recycled water service connection design did not meet IEEC capacity requirements. EMWD was working proactively with IEEC to resolve the issue through improvements that were expected to be complete by the winter of 2013–2014.

4.2.2.4. Agency Recycled Water Quality Aspects

EMWD provides two levels of recycled water in accordance with California Title 22: secondary disinfected and tertiary disinfected. EMWD has open reservoirs for storage of recycled water. Algal blooms may cause issues during certain times of the year and impacts water quality. Copper-sulfate for algal control cannot be used by EMWD, because it impacts feed water quality to IEEC (i.e., increase in sulfate can lead to calcium-sulfate scaling). EMWD has supplied a filtration system to IEEC to address TSS/algae issue in the recycled water feed. EMWD also added a flushing connection at the end of the conveyance pipeline near the IEEC connection point.

4.2.2.5. Project Execution Aspects

EMWD notes the following that affected project execution, impacted schedule, and/or affected project costs.

- Project experienced a slow start due to lack of internal communication at EMWD during the high-level agreement negotiation with IEEC. This led to technical and regulatory requirements not being contained in the agreement. These requirements were later communicated by EMWD technical staff which led to initial project delays.

- Timelines and understanding of regulatory approvals were not realistically set at outset of the project. EMWD brought in a recycled water and cross-connection control specialist to help provide training and communicate recycled water regulatory requirements to the EMWD/IEEC team.

4.2.2.6. Project Success Factors

EMWD attributes the following factors from an agency perspective as being integral to the ultimate success of the IEEC industrial reuse project:

- Personnel at IEEC during later design and operational phases of the project have been great to work with. Communication efforts between EMWD and IEEC at staff levels sped up response times as the project progressed. Both parties implemented nonthreatening, proactive, solution-oriented communication. Rather than focusing on project negatives and assigning blame, both parties focused on solutions and worked together to achieve them.
- The customer's desire and commitment to use recycled water assisted in the successful establishment and commitment to the project schedule, funding, and regulatory requirements necessary to implement the project.
- When the IEEC facility became operational, EMWD notes that IEEC staff was helpful in providing community tours of facilities.

4.2.2.7. Project Hindsight and Advice to Others

In hindsight EMWD wishes it had known the following from the outset of the project:

- Protocols and details for a sophisticated industrial end user and having the necessary details and requirements in place up front. EMWD did not have suitable recycled water standards in place for industrial type uses, because it was primarily a supplier of recycled water to the agricultural industry. The IEEC project helped EMWD understand the need for industrial project standards, which it now has in place for future projects.
- Regulatory requirements and coordination for projects of this type. This type of industrial user (i.e., power plant) was new to DDW (regulatory agency for recycled water) and to EMWD. Therefore, understanding how to best implement and apply regulatory requirements posed a challenge as each party gained experience of how potable water, recycled water, and other nonpotable (i.e., backflow protected industrial water) would be used in-plant and protected against cross contamination.
- Complete understanding of the project from an end user perspective. EMWD understands the importance of understanding other nonrecycled water use state and federal regulations and permitting requirements that may govern industrial projects of this type. EMWD acknowledges the need to engage an industry professional to help understand both the end user and agency regulatory picture.

EMWD notes that it is important for potential industrial reuse customers to understand local, state, and federal regulatory agency requirements and timelines for permitting, implementation and use of recycled water. It is also important that both agencies and end users understand the level of service (O&M, treatment, etc.) required to use recycled water on the customer's end.

To agencies seeking to implement industrial reuse projects, EMWD recommends acquiring as much information ahead of time to understand end user and agency recycled water requirements. EMWD notes that a Model Template (such as the one developed under this WateReuse Research Foundation project) would have been useful for EMWD and the end user to get up to speed.

4.2.3. Inland Empire Energy Center (IEEC)–Large Industrial Customer

The Inland Empire Energy Center, LLC (IEEC), is a state-of-the-art, natural gas-fired, 800 MW combined cycle, gas-turbine power plant that is financed, owned, and operated by GE Energy. California regulatory requirements dictated the use of recycled water for nonpotable uses where it is available and reasonably priced. Specifically, the California Energy Commission (CEC) adoption order required the use of recycled water for the IEEC project. Construction of the IEEC was completed in 2008, and the facility was brought online using recycled water supplied by the Eastern Municipal Water District (EMWD).

This interview discusses the implementation of the IEEC project from IEEC's perspective. EMWD also participated in a formal interview regarding this project (see Section 4.2.2). A case study of the IEEC project is discussed in Section 4.3.3.

4.2.3.1. Project Description, Parameters, Scope, Objectives, and Expected Outcomes

The IEEC project included the application for use of California Title 22 tertiary disinfected recycled water for process make-up to the facility's large cooling towers and boiler feed systems. The recycled water used as make-up to the cooling towers is chemically treated to allow operation at approximately 4.5 COC. Recycled water used as boiler feed make-up undergoes additional onsite treatment consisting microfiltration (MF) pretreatment followed by reverse osmosis (RO) treatment and deionization. Peak recycled water use at IEEC is about 5000 gpm (7.2 mgd). IEEC notes that its goals were simple: find and apply for use of a suitable recycled water supply to meet the recycled water use requirement mandated by the California Energy Commission (CEC) for this project.

4.2.3.2. Water User Drivers

IEEC notes that its drivers related to this project include the following:

- **Cost–Benefit:** IEEC was concerned about finding a suitable recycled water supply that would also be cost effective and provide a reasonable payback period as compared to a potable water supply source.
- **Regulatory compliance:** The CEC adoption order for this project required the use of California Title 22 recycled water where available. Since recycled water was available through EMWD and located proximally to the proposed IEEC site, the project was required to implement recycled water as a condition of its approval.

4.2.3.3. Project Primary and Salient Technical Issues and Challenges

IEEC notes several salient technical issues that needed to be addressed for this project:

- **Dual plumbed separation criteria:** Because of the complexity of the plant and portions of its piping systems requiring potable water derived sources, a modified cross-connection control testing methodology became necessary. This modified methodology required communication and understanding of the project type by DDW and its willingness to learn how IEEC (a power producer) operates. The DDW regional office and the recycled water agency (EMWD) did not have prior experience implementing CA Title 22 regulatory requirements for this type of facility.

- Air gap requirements. Cross connection between potable water and recycled water sources is prohibited. Suitable means of supplying potable water as a back-up to processes that are also fed by recycled water require that the potable water source be protected by an air gap.
- Back flow prevention. Because the IEEC plant is very complex and was under construction, DDW did not have the opportunity to review and inspect portions of the piping construction (separation requirements and backflow/cross-connection prevention). Therefore, cross-connection testing was modified to verify that no cross connections existed between recycled water and potable-derived industrial in-plant water piping.

4.2.3.4. Project Execution Aspects

IEEC notes the following, which impacted project execution, schedule, and/or project costs.

- **Permit application process undefined with regard to content and scope**. The regional DDW office having jurisdiction over this project did not have experience with permitting recycled use in a power plant; therefore, no specific submittal requirements were developed. IEEC prepared a system summary and submitted a color-coded drawing package to facilitate the permit review process with DDW.
- Late definition of construction inspection and witnessing requirements impacted the schedule.
- Process configuration comprehension by authorities having jurisdiction required additional time during review and permitting. A power plant contains much greater complexity than the typical irrigation system or dual-plumbed commercial building; therefore, the reviewing agencies needed to be brought up to speed on this type of complex facility.

4.2.3.5. Project Success Factors

IEEC attributes the following factors from an *agency perspective* as being integral to the ultimate success of the industrial reuse project.

- Perseverance by IEEC and EMWD staff to work together and see the project through to its completion
- Cooperation and support of EMWD staff during construction and maintenance of continued communication during operation
- Cooperation and support of the regulating and permitting agencies during design and construction

IEEC notes that communications during the project were good overall but that there was no defined communication process or standards. Therefore, there was a perception among IEEC that all parties involved in the project were "feeling their way" through it.

4.2.3.6. Project Hindsight and Advice to Others

In hindsight IEEC staff wishes it had known the specific requirements from a regulatory and permitting standpoint necessary to implement recycled water use for a project of this type. Furthermore, it wishes that the communication, review and submittal processes had been more defined.

To industrial users seeking to implement industrial reuse projects, IEEC recommends defining the specific project implementation requirements and deliverables before breaking ground on an industrial reuse project.

4.2.4. City of San Diego–Agency

The City of San Diego encompasses an area of approximately 372 sq mi with a population in 2013 of about 1,356,000. In addition to providing potable water deliveries and sanitary collection and treatment services, the City of San Diego provides a recycled water treatment capacity of 30 mgd at its North City Water Reclamation Plant (NCWRP) and 15 mgd at its South Bay Water Reclamation Plant (SBWRP). A large portion of the City's recycled water customers use the water for landscape irrigation, although the city also supplies recycled water to commercial, industrial, and institutional (CII) clients. The city reviews all applications for recycled water use in conjunction with the San Diego County Department of Environmental Health (DEH). Dual-plumbed facilities, which include CII customers, require the submittal of plans and an engineering report for review by the city, DEH, and the regional state DDW.

This interview discusses the city's general experience with industrial recycled water implementation but does not reference any specific project. A case study for Amylin Pharmaceuticals, an industrial customer receiving recycled water from the City of San Diego, is provided in Section 4.3.1.

4.2.4.1. Project Description, Parameters, Scope, Objectives, and Expected Outcomes

> The city's primary goal for encouraging implementation of industrial reuse projects is to maximize use of recycled water to lower the amount of imported water that is used regionally, as well as to reduce treated wastewater discharge to the Pacific Ocean. This goal is further highlighted by the city's desire to create a reliable local supply of water to the region.

4.2.4.2. Water Provider Drivers

The city notes that its drivers related to the production and supply of recycled include the following:

- Reduce ocean discharge, which was an initial driver that has led to the methodology whereby the city can continue to meet conditions of renewable waiver that allows the city's Point Loma Wastewater Treatment to discharge highly processed primary treated wastewater to the Pacific Ocean.

- In January 2004, the San Diego City Council authorized a comprehensive evaluation of all viable options to maximize the usage of recycled water. The study also included analysis and research on the health effects of reuse options and a public participation process. The reuse study's stakeholders identified reservoir augmentation at the city's San

Vicente Reservoir to be the preferred strategy. In October 2007, the San Diego City Council also recognized reservoir augmentation/indirect potable reuse (IPR), as the preferred alternative. The city council adopted the Water Purification Demonstration Project final report in 2013 and directed staff to complete the next steps associated with planning a full scale IPR facility.

- Nonpotable recycled water system expansion is limited to completion of the Hwy 56 corridor pipelines (Phase II of the 2005 RW Master Plan) and connection to "infill customers" and potential recycled water use sites in close proximity to the existing RW pipelines.

These drivers point to the city's desire to maximize recycled water production at its existing facilities and maximize use among a variety of landscape irrigation and irrigation customers, as well as local supply augmentation through IPR and eventually direct potable reuse (DPR). Industrial reuse is a part of the overall picture to maximize use.

4.2.4.3. Project Primary and Salient Technical Issues and Challenges

The City of San Diego notes the following salient technical issues that it desires to address for all industrial reuse projects:

- San Diego is concerned about water quality from the end-user perspective. The city provides disinfected tertiary recycled water that meets or exceeds California Title 22 requirements by providing total dissolve solids (TDS) below 1000 ppm (Note: Regional Water Quality Control Board [RWQCB] permit allows up to 1200 ppm TDS) and other primary constituent parameters. Its staff continuously monitors the water quality within the recycled water distribution system and reports water quality constituents of interest monthly for industrial and irrigation customers on its Web site: http://www.sandiego.gov/water/recycled/quality.shtm.

- End users who require water quality that exceeds Title 22, disinfected tertiary level treatment, are responsible to provide onsite pretreatment.

4.2.4.4. Agency Recycled Water Quality Aspects

The City of San Diego provides tertiary disinfected recycled water in accordance with California Title 22 requirements. Water quality is includes constituents of interest to industrial and irrigation customers is posted monthly at http://www.sandiego.gov/water/recycled/quality.shtml.

The city notes that seasonal water quality parameters may change depending on the potable source water (i.e., use of imported Colorado water results in higher TDS than imported state project water). State delta smelt environment issues impacts the amount of state project water that can be pumped south to Southern California, often requiring a greater percentage of Colorado River water and drought conservation measures.

4.2.4.5. Project Execution Aspects

The City of San Diego notes the following, which impact project execution, schedule, and/or project costs.

- End users' consultant or staff member should be a registered professional engineer (PE) having recycled water system engineering expertise in Title 22 Engineering Report, plans, specialization in using recycled water. Identification of CA Title 22 requirements for use of recycled water are noted as important.

- San Diego has developed a Web site for recycled water submittal requirements and city's rules and regulations for recycled water use, with links to county and state resources (http://www.sandiego.gov/water/recycled/index.shtml). The city notes that prospective end users need to understand recycled water regulations and permitting requirements, coordination of regulatory oversight, and inspection.

- Simultaneous submittals are recommended to the city and county jointly to expedite reviews. When the city and county plan review is satisfied, construction can move forward.

- The city and county both are responsible for inspections during construction and cross-connection control testing.

4.2.4.6. Project Success Factors

The City of San Diego notes the following factors that will lead to successful implementation of industrial reuse projects:

- The city will perform site assessments (free of charge to the customer) to understand the customer's site in advance of the submittal process. Generally, the site assessment will include the assigned plan reviewer and inspector.

- Inspection and plan review service are performed in-house within the city's Recycled Water Department, which provides seamless coordination between plan review and inspection staff during preconstruction and construction.

- Site supervisor training has been provided through the city since 2008 and is offered every other month to meet state-mandated user site requirements. This half-day course is designed to provide recycled water users in the state of California with the necessary information required to become fluent in the operational practices of recycled water. Course objectives include:
  1. Roles and responsibilities of a site supervisor at a recycled water use site
  2. Identification of potential and direct cross connections and learning appropriate preventative measures
  3. Practice of appropriate techniques for the safe and efficient use of recycled water, with site supervisor retraining every five years or when new client personnel is assigned

- The end user needs a good consultant or designer familiar with recycled water regulatory, permitting, and design requirements.

The city notes that potential poor communication issues can be mitigated by meeting with the customer in advance, having preconstruction meetings, and performing site walks, pre-shutdown tests, and construction meetings. The city reiterates the importance of having engineering and regulatory knowledgeable people on the customer's end. The city is considering the implementation of a post-connection survey to acquire feedback on the recycled water retrofit process to access the quality of customer service provided.

4.2.4.7. Project Hindsight and Advice to Others

The City of San Diego recommends that prospective industrial customers contact the recycled water supply agency ahead of time to discuss the project and gain understanding of recycled water requirements. Thus, establish communication with the agency as early as possible.

4.3. Case Studies

4.3.1. Amylin Pharmaceuticals–Pharmaceutical Company with Small Cooling Tower

Amylin Pharmaceuticals Inc. (Amylin), located in the "Golden Triangle" area of the City of San Diego, had previously undertaken a separate retrofit projects to connect another property to recycled water for nonpotable irrigation use and cooling tower use. On the basis of Amylin's previous experience with recycled water use and the savings realized over the use of potable water, Amylin desired to retrofit two additional facilities located nearby. This case study describes the recent recycled water retrofit and alternative cooling tower treatment project at Amylin's facilities at 9360 and 9390 Towne Centre Drive in San Diego, CA. The case study focus on the alternative cooling tower treatment technology employed at the 9390 location. This alternative treatment technology significantly reduces recycled water make-up demand and chemical use, and decreases the operational issues that typically affect cooling towers using a traditional chemical treatment program with recycled water.

4.3.1.1. Primary Project Goals

- Reduce water costs
- Implement an alternative pretreatment technology
- Support ISO 14000 recertification

4.3.1.2. Key Project Benefits

- Reduced overall potable water use to the site by converting to recycled water from potable water
- Pretreatment technology reduced make-up water consumption, reduced chemical consumption, and associated costs
- Eliminated scale formation and reduced corrosion resulting in extended time between chiller inspections (from annual to every three years)

4.3.1.3. Project Description

Amylin implemented recycled water retrofit projects at 9360 and 9390 Towne Centre Drive in San Diego, CA, in January 2011. Recycled water retrofit engineering plans were prepared by Amylin's engineer, pursuant to the City of San Diego (city), San Diego County Department of Environmental Health (DEH), and State Water Resources Control Board Division of Drinking

Water (DDW) requirements. The retrofits at 9360 included conversion of the irrigation system and a large, decorative reflecting pond with recycled water use. The retrofits at 9390 included conversion of the irrigation system and cooling tower system make-up water to recycled water. Because of the cooling tower conversion at 9390, RBF Consulting prepared a separate Title 22 Engineering Report for review and approval by DEH and DDW. Construction permitting and approvals were received by early July 2011, and construction of the project commenced immediately thereafter. Project construction was completed by mid-August and cross-connection tests performed by late August/early September 2011. Approval for release of the recycled water meters was received in late October 2011. Recycled water meter installation and start-up occurred on November 3, 2011.

4.3.1.4. Recycled Water Quality

The recycled water feed to the Amylin facility is provided from the City of San Diego's North City Water Reclamation Plant (NCWRP) in accordance with California Title 22 disinfected tertiary requirements. The city of San Diego regularly uploads its recycled water quality results to the Internet monthly for use by its customers. Most recent water quality data for the NCWRP shows the following important constituents of concern to Amylin: TDS-781 mg/L, calcium-57 mg/L, magnesium–28.3 mg/L, sulfate–145 mg/L, chloride–239 mg/L, nitrate–59.9 mg/L (as NO_3), and phosphorus–0.63 mg/L (as P).

Amylin uses recycled water for irrigation and for make-up water feed to its cooling towers. Cooling tower water chemistry and treatment must be selected to minimize or control sparingly soluble salts to prevent scale formation, control aggressive water that may lead to corrosion, and control nutrients to prevent and inhibit microbial activity.

4.3.1.5. Process Description (Recycled Water Use and Process Modifications)

The cooling tower at Amylin Pharmaceuticals is of the counter-current induced draft type, two cells, variable speed fans, and having a design cooling capacity of 600 tons. The tower construction is galvanized steel upper with a stainless steel basin. Make-up water feed is controlled by pilot- activated float valves. Two make-up water feed sources are provided to each tower cell: recycled water (primary) and potable water (emergency only). The recycled water feed uses a newer alternative treatment technology patented by Water Conservation Technologies International (WCTI). The WCTI process employs a high-efficiency, strong-acid cation exchange system to remove scale-forming cations, such as calcium and magnesium, from the make-up water. The remaining natural chemistry in the softened source water (silica, alkalinity, and TDS) is then used beneficially by increasing their concentrations within the cooling tower.

This was accomplished at Amylin by increasing the cycles of concentration (COC) within the cooling tower from 3.5 (typical of recycled water with chemical treatment) to greater than 50 COC. The tower has been operating between 50 to 75 COC since August 2012, following ramp-up of the process. The increase in cycles of concentration resulted in an instantaneous make-up water reduction of approximately 30%. The increased silica concentration in the tower forms natural corrosion inhibition of metal surfaces. Because of the removal of calcium and magnesium hardness in the softening process, low-solubility salts, such as calcium carbonate, magnesium sulfate, and calcium silicate, can no longer form, which reduces scaling potential significantly. Furthermore, operation at high cycles of concentration increases TDS, alkalinity and pH. The high TDS and pH create a naturally biostatic environment that eliminates biological activity. The results of this alternative treatment system are reduced water use (owing to decreased tower blow-down) and significantly decreased chemical use. Because of specific California Title 22 requirements, a disinfectant feed system is maintained but is used only during the ramp-up period until the tower control chemistry is established. In case of interruption of the recycled water feed because of planned utility maintenance, scale inhibitor and corrosion control feed systems are maintained for temporary use with the emergency potable water make-up system.

4.3.1.6. Water Savings Results and Other Project Benefits

The conversion to recycled water replaced almost 39 acre-ft of annual potable water use (10.5 acre-ft from landscape and irrigation, plus 28.1 acre-ft from cooling tower use), saving approximately $65,000 per year. In addition, because of efficiencies gained by the use of an alternative treatment technology for the make-up water feed to the cooling towers, the overall use of make-up water is reduced by about 30%.

4.3.17. Project Implementation Issues

Primary issues encountered during the project implementation process included the following:

- Somewhat lengthy plan review periods for permitting through the City and County Health Departments. Amylin's engineering consultant worked to mitigate lengthy reviews by maintaining regular and consistent communication with reviewing agencies, including facilitating plan deliveries among the review agencies.

- Following receipt of plan approvals and construction permits, Amylin noted that field inspection tended to be inconsistent, sometimes deviating from the approved plans, which resulted in additional costs to Amylin. This issue was somewhat mitigated by site meetings with Amylin, the consulting engineer, and city review and inspection personnel to address concerns. It must be noted that actual field conditions (i.e., existing utility infrastructure not located where shown on record drawings, differing subsurface conditions, etc.) may require augmentation during construction and should be anticipated.

- Coordination of cross-connection testing and facility shutdowns must be planned well in advance. Cross-connection testing to verify that no connections exist between the onsite potable and recycled water systems is a key component to finalizing approvals for recycled water meter installation and supply of recycled water to the facility. Coordinating a suitable schedule for all required parties requires advanced planning and sufficient float in the implementation schedule in case testing must be rescheduled.

- Amylin's cooling towers and recirculation piping were highly scaled from the prior operation, and faulty isolation valves were discovered during the start-up of the alternative treatment system. Normally, the leaking system valves are masked by low-cycle operation; however, high-cycle operation quickly exposed their location. Amylin operations staff replaced leaking and malfunction system valves. The alternative treatment process will also dissolve and remove scale buildup; however, the extent of the scale extended the ramp-up period and limited COC to less than 20 for a period of several months. Once the majority of scale and hardness were removed from the system, the alternative treatment system then ramped up quickly to between 50 to 75 COC. Total ramp-up time was about 8 months, as precleaning of the cooling towers prior to treatment implementation did not occur.

4.3.1.8. Project Successes

- Significant water savings were gained from the conversion from potable water to recycled water. The City of San Diego recycled water purchase cost is currently approximately 20% of the potable water cost. In addition, implementation of the alternative treatment technology for this project reduced overall cooling tower make-up water use by about 25%, resulting in additional savings. Once the system ramp-up was complete, chemical use was reduced significantly. Total annual savings of up to $65,000 are expected. Owing to overall savings, payback for the entire project (engineering, construction, and treatment procurement) is expected to be less than one and a half years.
- Amylin performed its annual teardown and chiller inspection in early 2013. The new treatment process on recycled water resulted in no scale or corrosion being found. The inspection report recommended extending periods between teardown and inspections from annually to once every three years. Amylin reported that this year's inspection report was the best experienced at any of its facilities and is elated with both recycled water use and its new treatment program.
- Increased communication among Amylin, the city, and the county following initial inspection issues noted earlier resulted in successful project implementation.

4.3.1.9. Lessons Learned

- Unforeseen field conditions can and will occur and should be expected. Plan for these events by allocating additional project budget and allowing sufficient float in the schedule.
- Maintain regular and consistent communication with review and regulating agencies during all aspects of the project from design through construction, testing, startup, and follow-up inspections.
- When implementing new treatment technologies, include budget for precleaning of systems that are moderately to heavily scaled. Ensure that all system valves, make-up water floats, and blow-down valves are in proper working order. High-cycle operation will quickly expose these issues and lengthen ramp-up time if not taken care of in advance.

4.3.2. BAE Systems–Defense/Aerospace/Security Company with Medium Cooling Tower

BAE Systems is a global defense, aerospace, and security company that employs more than 88,000 people worldwide. BAE Systems, Austin site, operates two chilled water plants with two open recirculating cooling towers at each plant. Because of a multiyear, record setting drought, BAE Systems was faced with a need to reduce potable water consumption at the plants. The chilled water plants have historically used 70–75% of the total campus potable water consumption. During this period, the City of Austin's water department (Austin Water) contacted BAE Systems to request permission to install a new reclaimed water pipeline through the campus as part of Austin Water's reclaimed water system expansion. Upon learning of the potential benefits of using reclaimed water to reduce potable water consumption, BAE Systems contacted Austin Water to request a hookup to the new pipeline. During the retrofit process, BAE Systems discovered that a significant change in its cooling tower chemical water treatment approach would be necessary and would potentially result in unacceptable treatment costs. Partnering with Austin Water, an alternative cooling tower water treatment program was identified to reduce treatment costs by reducing make-up water consumption, blow-down, and chemical use. This case study focuses on using reclaimed water in open recirculating cooling towers and the use of an alternative treatment program that reduces make-up demand significantly, reduces blow-down and chemical usage, and, as a result, reduces operating costs at the plants.

4.3.2.1. Primary Project Goals

- Reduce potable water consumption
- Implement an alternative pretreatment technology
- Reduce operating costs

4.3.2.2. Key Project Benefits

- Conversion to reclaimed water from potable water
- Reduced overall potable water use to the site
- Reduced make-up water consumption with pretreatment technology, as well as reduced chemical consumption, blow-down, and cost

4.3.2.3. Project Description

In summer 2010, Austin Water and BAE Systems mutually agreed to the construction of a new 8-in. reclaimed water line through the BAE Systems campus. This new reclaimed water pipeline was part of Austin Water's master plan for reclaimed water extension to the area. The new 8-in. pipeline was a lateral connection to a new 36-in. transmission main extension from Austin Water's nearby Walnut Creek Water Reclamation Plant. During preliminary design of the reclaimed water extension project, BAE Systems approached Austin Water to become the first new customer along the pipeline extension project. Austin Water revised its design to include two taps for use by BAE Systems.

Parallel with the design effort, Austin Water and BAE Systems began the easement acquisition process. Following several planning and negotiation discussions, Austin Water agreed to provide additional taps as part of the design of the 8-in. pipeline for future irrigation use by BAE Systems. Pipeline design and easement acquisition work continued through 2010. The project was issued for bid in spring 2011. Follow bid evaluation, reviews and approvals, Austin Water began construction of the reclaimed water system expansion in early 2012. Concurrently, BAE Systems received authorization to proceed with its portion of the retrofit project, which included tapping of the new main and installation of new reclaimed water feed lines to each of the two chiller plants.

During this time, a review of the water treatment program took place, and it was discovered that changing from potable water to reclaimed water would greatly increase the chemical treatment cost because of differences in the quality of the reclaimed water. Austin Water assisted BAE Systems in finding a suitable alternative treatment program that would work well with reclaimed water and keep operating costs close to existing potable water treatment costs. After exhaustive research, an alternative treatment program was adopted and equipment ordered and installed. Installation of the Austin Water reclaimed water pipeline, the BAE Systems feed pipelines, and the water treatment equipment was substantially complete by December 2012. Reclaimed water use began in January 2013.

4.3.2.4. Process Description (Reclaimed Water Use and Process Modifications)

The cooling towers included as part of this reclaimed water retrofit are two 700 ton stainless steel Evapco, counter-flow, single cell units with variable speed fans, and two 500 ton fiberglass Marley, counter-flow, single cell units with variable speed fans.

The reclaimed water feed uses an alternative treatment technology patented by Water Conservation Technologies International (WCTI). The WCTI treatment process employs a filtration system (used only to remove any excess suspended solids from reclaimed water), followed by a high-efficiency, strong-acid cation exchange system to remove scale-forming cations, such as calcium and magnesium, from the make-up water. The concentration of the remaining chemicals already present in the cooling water has a beneficial effect on reducing corrosion and biofouling in the cooling tower. This was accomplished at BAE Systems by increasing the cycles of concentration (COC) within the cooling towers from approximately 5 to 42 COC at one plant and 50 COC at the other. As of the date of this case study, the process continues to ramp up. The COC target is 80 and is expected to be achieved at the end of the ramp-up period. The increase in cycles of concentration resulted in an instantaneous make-up water reduction of approximately 30%. The increased silica concentration in the tower forms natural corrosion inhibition of metal surfaces. Scaling is eliminated by the removal and elimination of low-solubility salts that normally would result from calcium and magnesium. Furthermore, the high cycles of concentration increase TDS, alkalinity, and pH. The high TDS and pH create a naturally biostatic environment that minimizes biological activity. The results of this alternative treatment system are reduced water use, whether using potable or reclaimed water (because of decreased tower blow-down) and significantly decreased chemical use.

4.3.2.5. Water Savings Results and Other Project Benefits

The drought conditions in central Texas make water conservation extremely important. By converting from potable to reclaimed water, the savings in potable water is estimated to be 10 million gallons per year. At the 6-month point since startup, the estimate is holding. In addition, the difference in cost between potable and reclaimed water, the reduced make-up demand, the very significant reduction in blow-down volume, and the savings in chemicals should total to approximately $65,000 per year in savings.

4.3.2.6. Project Implementation Issues

The BAE Systems cooling tower retrofit was the first application within the Austin Water system to use reclaimed water in cooling towers. As a result, the appropriate procedures for processing and permitting this type of installation and operation were not yet established. Therefore, this project represented a test case for both BAE Systems and Austin Water. To ensure the success of the project, BAE Systems and Austin Water worked together as partners and collaborated to develop the necessary procedures and work through them with excellent results.

The drastic change in water quality and the necessary change in water treatment requirements was somewhat of a surprise; however, the outcome proved to be outstanding as BAE Systems achieved its goals and reduced its operating costs by using the noted alternative treatment program.

The transition to the new alternative treatment process also presented an issue that BAE Systems had not considered. Its existing cooling towers contained large amounts of scale and debris that were not removed prior to adopting the treatment process. The alternative WCTI treatment process requires low hardness in the cooling tower to ramp up the process to the required control ranges. The WCTI process cannot be ramped up if large amounts of scale forming deposits are present in the system and the soft water produced from the cationic exchange units continue to dissolve existing scale over time. However, the volume of existing scale present in the towers would have necessitated a long period to mitigate fully. Therefore, BAE Systems replaced the scaled fill. In addition to aiding the WCTI ramp-up process, the removal of the excess scale and new fill has resulted in increased delta T across the tower, increasing overall cooling tower efficiency.

4.3.2.7. Project Successes

- Saved 10 MG of potable water per year
- Reduced chemical use and storage on campus
- Saved approximately $65,000 per year

4.3.2.8. Lessons Learned

- Project success required collaboration and teaming between BAE Systems and Austin Water to achieve the desired results for both parties.
- Reclaimed water can be applied to various industry uses but may require a learning curve to establish appropriate procedures for implementation and permitting.
- Adopting reclaimed water as source of make-up water to a cooling tower requires an understanding of the water quality and modification of the existing water or adoption of a new treatment technology to address the water chemistry.
- Any treatment technology requires that highly scaled systems be cleaned to restore operational efficiency. Treatment control ranges should be monitored regularly to verify proper treatment and prevent scale formation.

4.3.3. Inland Empire Energy Center (IEEC) – Large Power Plant with Cooling Towers and Boiler System

Inland Empire Energy Center, LLC (IEEC), is a state-of-the-art, natural gas-fired, 800 MW combined cycle, gas-turbine power plant financed, owned, and operated by GE Energy. Calpine Power Services managed plant construction and currently markets the plant’s output and fuel management under an agreement with GE. California regulatory requirements dictate the use of recycled water for nonpotable uses where it is available and reasonably priced. Specifically, the California Energy Commission (CEC) adoption order required the use of recycled water for the IEEC project. Construction of IEEC was completed in 2008, and the facility was brought online using recycled water supplied by the Eastern Municipal Water District (EMWD). This case study discusses the challenges and success of implementing a large-scale industrial reuse project between an agency and end user both new to using recycled water for industrial purposes.

4.3.3.1. Primary Project Goals

- Comply with California Energy Commission regulations to use recycled water for cooling towers and boiler make-up.
- Obtain cost–benefit of using lower cost recycled water supply.
- Conserve potable water resources in California by using recycled water supply.

4.3.3.2. Key Project Benefits

- Resource conservation by implementing recycled water use
- Reduced overall potable water use to the site
- Implementation of newer high-efficiency combined cycle gas-turbine technology (first implementation in the United States)
- Provide additional power source to Southern California region

4.3.3.3. Project Description

Inland Empire Energy Center project owners petitioned the CEC for a new natural gas-fired power generating facility proposed for the Perris/Menifee area of Riverside County, CA. Use of recycled water for the proposed facility became a part of the CEC’s certification of the project, which was issued on December 22, 2003. Because of GE’s desire to implement use of its latest, most advanced, high-efficiency gas turbine technology, the project owners requested and received a project certification amendment from the CEC in 2005.

During the project certification process, the project owners began high-level negotiations with EMWD upper management for the supply of approximately 7.0 mgd of recycled water to IEEC. Until this time, EMWD primarily supplied recycled water only for irrigation purposes and was in the midst of facility modernization and expansion of its treatment and distribution facilities. Furthermore, EMWD was inexperienced with commercial, industrial, and institutional (CII) reuse; therefore, no design standards or guidelines were in place that could assist EMWD staff and the project proponents with technical preplanning for the proposed IEEC project. The resulting agreement between IEEC and EMWD established the volume and supply requirements but did not include detailed technical and regulatory requirements generally necessary for non-irrigation CII use of recycled water.

In 2006 the IEEC project was in full design development by the project owners when EMWD recycled water program technical staff were alerted to the project by upper management. EMWD technical staff engaged the services of a knowledgeable recycled water industry consultant to assist in the process of coordination, technical information dissemination, and training of project personnel for both the agency and end user. Communication among IEEC and EMWD technical staff members became critical during the design phase to ensure technical and regulatory compliance requirements were being met. EMWD began facility improvements to address potential water quality concerns and ensure adequacy of the distribution system necessary to supply up to 7.0 mgd of California Title 22 disinfected tertiary quality recycled water to IEEC.

Power plants typically require distribution of nonpotable or “industrial water” throughout portions of the plant facility. The source of industrial water generally is derived from backflow-protected potable water. Use of recycled water requires strict compliance to cross-connection control regulations and verification that no cross connections exist within the facility between potable and recycled water sources. The regional state and local regulatory staff was generally unfamiliar with an industrial reuse project of this size and scale; therefore, plan approvals for the recycled water connection to IEEC required coordination, extended plan reviews, site visits, and meetings among all project technical participants. Ultimately, the level of communication and desire among all project participants to engage in problem solving resulted in successful implementation of recycled water use and critical supply of electrical energy from IEEC.

4.3.3.4. Recycled Water Quality

The recycled water feed to the IEEC facility is provided from EMWD via the Moreno Valley Regional Recycled Water Facility (MVRWRF), Perris Valley Regional Recycled Water Facility (PVRWRF), and Temecula Valley Regional Recycled Water Facility (TVRWRF). The majority of the recycled water provided to IEEC is supplied from the PVRWF, which is located closest to the power plant site. Recent water quality data for the PVRWF show the following important constituents of concern to IEEC: TDS–660 mg/L, calcium–65 mg/L, magnesium–15 mg/L, sulfate–90 mg/L, chloride–215 mg/L, nitrate–45 mg/L (as NO_3), and phosphorus–0.93 mg/L (as P).

In addition, EMWD notes that it uses large, open reservoirs for storage of recycled water prior to distribution. The open reservoirs periodically cause an increase in suspended solids because of wind-blown debris and algae. To assist IEEC in managing suspended solids spikes, EMWD furnished a new automatic backwashing filter battery system to IEEC.

IEEC uses recycled water for make-up water feed to its cooling towers and boiler systems. Although the EMWD recycled water is in full compliance with California Title 22 water quality requirements, IEEC is required to provide additional pretreatment prior to its use.

4.3.3.5. Process Description (Recycled Water Use and Process Modifications)

IEEC is an 800 MW natural gas-fired power plant that employs the latest in advanced combined-cycle turbine technology. The plant uses two 400 MW GE S107H systems, each of which is comprised of a steam turbine and gas turbine configured on a common shaft that drives a single generator. Each steam turbine has a dedicated eight-cell cooling tower with common water basin, pump pits, circulating water pumps, and circulating water piping. At 100% load, the two cooling towers evaporate water at a rate of 3588 gpm. The cooling towers currently operate at about 4.5 cycles of concentration, which results in a blow-down rate of 1025 gpm and a total make-up water requirement of 4613 gpm. Approximately 203 gpm of additional recycled water is sent through membrane-based treatment to provide demineralized water to the combustion turbines (CTs) and heat recovery steam generators (HRSGs). In addition, 26 gpm of recycled water is used for onsite landscape irrigation. Therefore, the total recycled water demand for the IEEC facility at 100% load is approximately 4842 gpm, or 7.0 mgd.

EWMD delivers recycled water from the MVRWRF, PVRWRF, and TVRWRF via the 48-in. diameter McLaughlin Road recycled water pipeline, which connects the 18-in. through 24-in. pipeline approximately 0.2 mi to the IEEC site. Upon entering the site, the recycled water is pretreated by an automatic backwashing filtration system supplied by EMWD to IEEC and then stored onsite. From storage, recycled water is provided to the cooling towers, demineralized water treatment system, and irrigation. Additional treatment is provided as follows:

- Make-up water to the cooling towers is primarily filtered recycled water. Chemical treatment is provided to address issues of scale prevention, corrosion control, and biological activity mitigation.
- Make-up water to the CTs and HRSGs receives additional treatment comprised of microfiltration (MF) followed by two-pass reverse osmosis (RO), electro-deionization (EDI), and ultraviolet (UV) disinfection. The MF/RO/EDI/UV process results in approximately 131 gpm to the CTs and HRSGs. The MF backwash (10 gpm) is

discharged sewer, whereas the RO and EDI reject and HRSG blow-down streams (138 gpm) are reused to supplement make-up feed to the cooling towers.

4.3.3.6. Water Savings Results and Other Project Benefits

Based on data supplied in the 2005 CEC Certification Amendment, annual potable water savings resulting from the industrial reuse of recycled water ranges from 4180 to 4842 acre-ft per year (1.36 to 1.58 billion gallons per year).

4.3.3.7. Project Implementation Issues

Primary issues encountered during the project implementation process include the following:

- The initial supply agreement between IEEC and EMWD did not include the necessary technical and regulatory language to address recycled water use. This led to gaps in the design requirements and IEEC's understanding of those initial requirements necessary to meet the strict technical and regulatory requirements for implementing recycled water use.
- EMWD was the primarily a supplier of recycled water for agricultural users. It had only recently begun the process of converting from a gravity-fed supply system to a pressurized supply system having greater capacity. The IEEC project came about during a time when EMWD had not yet established design criteria and standards for industrial recycled water retrofit projects. Therefore, the lack of this information coupled with the recycled water system conversion, which was in process, and the size and type of industrial customer all combined to produce a very difficult and challenging project for both the EMWD and IEEC technical staff.
- EMWD and regional state and local recycled water regulatory agencies did not have prior experience with large-scale recycled water use in a power plant. Furthermore, IEEC did not have recycled water use regulatory knowledge. This led to steep learning curves for both the agency and end user in developing and implementing typical recycled water standards and cross-connection controls for this type of large industrial user.

4.3.3.8. Project Successes

- Communication efforts by both the agencies and end user (once technical staff became involved in the project) led to greater awareness and understanding of the project needs, as well as the technical and regulatory requirements. Both the agency and the end user worked together to implement nonthreatening, proactive, solution-oriented communication.
- The agency notes that the end user's commitment to use recycled water helped with prompt addressing of schedule and funding necessary to implement the project.
- Use of lower cost, high-quality recycled water resulted in the saving of local potable water resources for the area's potable water needs.

4.3.3.9. Lessons Learned

- High-level discussions between agencies and industrial end users must include technical and regulatory requirements in the supply agreements up front.

- Regular and consistent communication must be maintained at all times during project planning, design, implementation, and operation. Both agencies and end users must be committed to the implementation process.
- Agencies and end users must understand each other's needs and processes. Agencies need to learn the process requirements of the industrial end user and how recycled water will be used at the end user's facility. Industrial end users need to learn and understand the technical and regulatory requirements necessary for using recycled water at their facilities. Encourage the use of knowledgeable persons (engineers, consultants, technical staff, etc.) who are familiar with the requirements for recycled water use.

4.3.4. Internap—Data Center with Medium Cooling Towers

Internap, located in Santa Clara, CA, is a premium power-rich data center employing state-of–the-art technology to provide high-density power with high-efficiency cooling options for data storage solutions having redundancy for 100% data protection. To ensure maximum uptime and data storage reliability, the site is provided with dual substation power feeds, onsite N+1 emergency power generation (4.5 MW), and uninterrupted power system battery backup. In addition to being a premium data storage provider, Internap incorporates "green" design philosophy into its facilities to reduce greenhouse emissions and minimize its impact on the environment. Internap employed this philosophy when it undertook the operation of its new 27,000 sq ft Santa Clara Data Center with two 1100 tons cooling towers and employed the use of recycled water as its make-up water source. Furthermore, Internap installed a make-up water pretreatment technology (WCTI) to eliminate chemical use and cooling towers blow-down. This represented a 40% saving on cost of water from South Bay Water Reclamation and average water saving of 5000 to 10,000 gpd. By using recycled water, Internap is able to free up an average of 76,300 gallons of drinking water per day and nearly 28 million gallons per year.

4.3.4.1. Primary Project Goals

- Reduce water and sewer costs
- Implement an alternative pretreatment technology
- Discontinue use of hazardous chemicals in cooling towers
- Increase green footprint

4.3.4.2. Key Project Benefits

- Increase the company's green footprint
- Use pretreatment technology to reduce potable water consumption and eliminate all chemical use to site
- Eliminate scale formation and control corrosion, as well as reduce time between inspections

4.3.4.3. Project Description

Internap implemented the use of recycled water for its cooling towers on the basis of availability of recycled water from South Bay Water Reclamation within the vicinity of its data center. (It should be noted that Internap moved into a facility previously connected to a recycled water system installed for landscape irrigation.) Internap proceeded with a recycled water retrofit project and provided connection to its cooling towers following certification of the facility to use recycled water. Internap selected the alternative cooling water treatment technology provided by WCTI based on a vetting process that tested the process on an existing tower. The vetting process included operation of the alternative technology for a period of two years. This cooling tower was equipped with a corrosion coupon rack, and the results showed good corrosion control on carbon steel and copper with no scaling or biological activity in the cooling water system. On the basis of these observations, Internap moved forward with the alternative treatment program. Implementation of the WCTI treatment system required replacing existing software equipment with a much larger system having much tighter controls and automatic e-mail notifications to the operation office. The payback of the complete system was less than 6 months.

4.3.4.4. Recycled Water Quality

The source of recycled water used at Internap is from South Bay Water Reclamation, which meets Title 22 requirements for disinfected tertiary recycled water.

4.3.4.5. Process Description (Recycled Water Use and Process Modifications)

The cooling towers at Internap are the counter-current induced draft type, two cells, having a design cooling capacity of 1100 tons each. The recycled water feed to the cooling towers uses a newer alternative treatment technology patented by Water Conservation Technologies International (WCTI). The WCTI process employs a high-efficiency, strong-acid cation exchange system to remove scale-forming cations, such as calcium and magnesium, from the make-up water. The concentration of the remaining chemicals already present in the cooling water has a beneficial effect on reducing corrosion and biofouling in the cooling tower. The increased silica concentration in the tower forms natural corrosion inhibition of metal surfaces. Scaling is eliminated by the removal and elimination of low-solubility salts that normally would result from calcium and magnesium. Furthermore, the high cycles of concentration increase TDS, alkalinity, and pH. The high TDS and pH create a naturally biostatic environment that eliminates biological activity. The results of this alternative treatment system are reduced water use (owing to decreased tower blow-down) and eliminated chemical use.

4.3.4.6. Water Savings Results and Other Project Benefits

The conversion of the Internap cooling towers to recycled water replaced an average of 8.4 acre-ft of annual potable water use, saving approximately 40% on water costs. In addition, because of efficiencies gained by the use of an alternative treatment technology for the make-up water feed to the cooling towers, the overall use of make-up water was reduced significantly.

4.3.4.7. Project Successes

- Saving more than 8.4 acre-ft of potable water
- Saving 40% on water cost
- Implementing new green cooling water treatment technology
- Eliminating hazardous chemicals use in the cooling towers and storage onsite

4.3.5. Tesoro Carson Refinery—Large Petroleum Refinery with Cooling Towers, Low and High Pressure Boiler System

The Tesoro Los Angeles Refinery – Carson Operations, located in Carson, CA, is a premier supplier of clean transportation fuels for the Los Angeles basin. The refinery supplies approximately 25% of the Los Angeles gasoline supply and provides about 20% of the jet fuel used at Los Angeles International Airport.

4.3.5.1. Primary Project Goals

- Protect the business from potential shortages in potable water
- Reduce pumping of onsite wells
- Create a synergy opportunity that benefits both the business and the community

4.3.5.2. Key Project Benefits

- Shifting of about 30% of the refineries water supply to recycled water
- Reducing risk of water-related production cuts, which protects the Los Angeles fuel supply
- Using RO technology to make boiler water treatment operations simpler and safer
- Providing more consistent quality of water supply, which benefits the cooling tower treatment systems

4.3.5.3. Project Description

Historically, the refinery relied on onsite, privately owned wells to supply water to the refining operation. Today, the majority of these wells are no longer in service because of salt-water intrusion. Rather than increase its dependence on potable water, the refinery staff made a strategic decision to use recycled water.

The refinery implemented its first recycled water project in 2000 by using recycled water in cooling towers. The primary driver was to insulate itself from potential potable water curtailments. The refinery expanded its recycled water use in 2006 by converting the entire boiler feed water supply to recycled water.

That investment proved to be highly beneficial in 2010 when Southern California faced the first water supply allocation in the history of the Metropolitan Water District of Southern California. The allocation in Southern California was because of, in part, drought conditions but also to what was called a "regulatory drought" in which pumping restrictions from the Sacramento–San Joaquin delta caused water to be in short supply for users up and down the state. Water-intensive industries, such as oil refining, were not required to cut back, but interest was piqued regarding what could turn out to be longer term supply variability.

Consistent water *quality* and reliable water *quantity* (i.e., uninterrupted service) are the two most critical components for oil refinery water use operations. The refinery maintains a backup potable water supply system for this reason.

4.3.5.4. Recycled Water Quality

The source of recycled water used at the refinery is from West Basin Municipal Water District, Title 22 disinfected tertiary recycled water, distributed from Edward C. Little Water Recycling Facility in El Segundo. The supplied Title 22 recycled water is nitrified at the Carson Water Reclamation Facility (CRWRF or Carson Facility). This water has a high concentration of iron and phosphate because of upstream treatment processes, which may limit the cycle of concentration in the cooling water systems. This effect is reduced by blending treated reverse osmosis (RO) water with the nitrified recycled water supply.

4.3.5.5. Process Description (Recycled Water Use and Process Modifications)

The recycled water used at the refinery is further treated by West Basin Municipal Water District at the CRWRF. The CWRF takes Title 22 water as feed and uses microfiltration and RO to produce 4.5 mgd of first-pass RO product. The microfiltration backwash is sent to a Biofor nitrification process to produce 0.8 mgd of nitrified water. The RO and nitrified water are conveyed in separate pipes approximately 1 mi to the Tesoro Refinery.

At the refinery, Tesoro processes the first-pass RO from CRWCRF in another RO plant to produce second-pass RO water. The second RO treatment is needed to achieve the necessary boiler feed water (BFW) purity and which also acts as a backup system. The water treatment tank features a break tank upstream of the RO train. In the event of loss of first-pass RO water from West Basin, the refinery can feed potable water to the tank, and after making some operational changes, can still produce BFW. All of the refinery boilers run on recycled water.

About half of the RO water is used for BFW production. The remaining RO water is combined with the nitrified water. This recycled water blend is used for cooling tower make-up. To run recycled water, a separate “purple pipe” piping system was built in the refinery. At each cooling tower a new control valve and air gap was installed. The air gap prevents backflow of recycled water into the potable supply.

4.3.5.6. Water Savings Results and Other Project Benefits

Currently 30% of the Tesoro Refinery’s water supply is met with the recycled water with plans to increase this percentage to 55% by 2017. The major economic benefit of using West Basin recycled water is reduced treatment costs at the refinery, especially for BFW.

4.3.5.7. Project Implementation Issues

- **Reliability:** Because the make-up water supply to refinery boilers cannot be interrupted at any time, Tesoro has built-in city water backup supplies to supplement recycled water if it is not available for any reason. If the feed water to the onsite RO system is changed from first-pass RO water to city water, the operational characteristics of the unit must be adjusted to maintain sufficient quality. There are redundancies built into this system at several points with “city” water ready injection points to ensure 100% reliability.
- **Regulation:** Because there is a mixture of potable and recycled water used at the facility, there must be air gaps present to prevent a backflow situation if the potable system goes down for any reason. The air gaps are required by the State Water Resources Control Board Division of Drinking Water (DDW); check valves or block valves are not deemed sufficient. The installation of multiple air gaps throughout the facility and the need to

meet other mandatory regulations is costly though necessary to enable recycled water use.

- **Water quality:** Water that is treated with RO is corrosive by nature, so a separate noncarbon steel pipeline distribution system was built inside the refinery to accommodate the use of this water. In addition, the Title 22 stream coming from West Basin's ECLWRF in El Segundo is nitrified at the Carson facility. This water is high in iron and phosphates because of an upstream treatment processes and may limit the number of cycles the water can be used in the cooling towers.
- **Chemical treatment programs:** These programs need to be adjusted when switching from the city water supply to a predominantly recycled supply, especially in cooling towers. The water quality from the Carson Regional Facility generally is of very consistent quality, especially compared to city water, which can change seasonally or when the blend of imported water sources change. However, sudden quality changes can occur with recycled water. Good communication between the recycled plant operator and the refinery operators is critical to minimize the impacts of these changes.

4.3.5.8. Project Successes

- Saved 30% of the refinery water supply using recycled water with goal of achieving 55% by 2017
- Practiced good communication between the recycled water provider and refinery operation staff
- Regulatory permitting knowledge was acquired for the proper implementation of cross-connection controls, as well as other requirements that must be factored into the design of the project early on. Understand the specific regulatory requirements **and factor in the cost to implement those requirements**

4.3.5.9. Lessons Learned

- Permitting and regulatory requirements
- Adjustment to water treatment program; when switching from potable water to recycled water, the change in water chemistry will necessitate a change in the current treatment program or adoption of a new treatment program
- Water quality requirements and additional onsite treatment for each process application; the use of RO treatment systems results in a water that is corrosive to ferrous-based pipelines and equipment. Verify the constituents in the recycled water, provide appropriate treatment for the process, and use suitable materials. Understanding the water quality will be key to successful implementation of an industrial reuse project

Chapter 5

Communication Issues Impacting Industrial Reuse Projects

5.1. Communications Introduction

Although water providers and retailers and their industrial customers share common geography, they operate in very different worlds. The demands on privately owned and publicly traded companies can be diametrically opposed to those of public agencies and regulatory bodies. Although the differences can be challenging and complex, they are not insurmountable. Effective communication is key to bridging the gaps between these different worlds to help providers and customers achieve their shared goal: efficient industrial use of recycled water.

5.2. Emerging Themes

Through surveys, white paper reviews, conference panels, and interviews with participants in successfully completed industrial water reuse (IWR) projects, a small number of consistent themes and issues emerged as contributing factors to miscommunication between water providers and their customers:

1. Project drivers and objectives
2. Views of time and money
3. Metrics and measures of success
4. Decision-making processes and styles
5. Regulatory landscape
6. Language and terminology

The list has been dubbed "points of departure" in consideration that the terms and concepts mean different things to customers and providers, respectively. Note that these reflect perceptions held by each group for the other and are, therefore, not necessarily true in every case. Nevertheless, recognizing the differences and working to clarify them early on minimizes disconnects, erroneous assumptions, and other risks to project success. The points of departure are summarized in Table 5.1 and explored in more detail in the subsections to follow.

5.2.1. Drivers for Water Customers

There has been a dramatic shift in the momentum for industrial water reuse, as more and more companies actively seek out options from their water providers. This is in stark contrast to the "early days" when the job of promoting recycled water fell exclusively to providers. Although outreach efforts are still needed, many providers now find customers "beating a path to their door" for access to recycled water.

Table 5.1. Organizational and Cultural Differences at a Glance

Points of Departure	Water Customer	Water Provider
Drivers and Objectives	Primarily to achieve one or more of the following: supply security, cost – benefit, compliance, social responsibility	Primarily to achieve one or more of the following: source conservation, policy initiatives, range of water quality, diversification, minimal wastewater disposal costs
Views of Time and Money	Time *is* money. Things generally happen faster in the private sector, particularly once the project has penciled out; single source funding and minimal approval process for relatively low-cost projects; likely to be frustrated by slow response times and absence of aggressive cost control	Used to several rounds of public hearings and regulatory approvals; deal with multiple sources of funding that require more time to secure; may have a “pass through” mindset regarding cost increases affecting the customer versus “not-to-exceed” approach
Metrics and Measures of Success	Looks for payback of 6–12 months from small capital projects; seeks cost savings, operational benefits, reliability, and other goals related to project drivers	Views infrastructure payback in range of 5–10 years; social and environmental benefits often take precedence to cost savings; focus on minimizing customer complaints
Decision-making Processes and Styles	Localized authority; ready funding can be pulled from established accounts; involvement of plant maintenance and operations personnel who may be directly affected	Used to planning, negotiating, and decision making as extremely lengthy processes, owing to numerous rounds of discussions and public input that are required by law; subject to remote decision making by nonparticipants
Regulatory Landscape	Understanding of regulatory issues and processes is greater in highly regulated industries (e.g., oil and gas, petrochemical, power supply); less so in relatively unregulated sectors (e.g., data centers, logistics)	High level of sophistication based on repeated engagement with multiple levels of government, sensitivity to dynamics of policy legislation and knowledge of interpersonal networks
Terminology	Don’t speak “acre-feet”; likely to use “volume and flow” terms that reflect their industries (gallons, barrels, “gallons per chicken”); typically have a “plant operator” mindset that affords opportunity for alignment with providers’ treatment plant and engineering personnel	Steeped in technical and engineering language of public water systems; some “bureau-speak” (e.g., vague generalities over specific examples); can find common ground via the “plant operator” mindset that exists within treatment facilities versus agency management and administration

Note: The previous list does not imply absolutes; each project and group of stakeholders is unique; the aim here is to provide a few generalizations that can help build awareness of the different perspectives that participants bring to the discussion.

Of course, this dynamic varies from region to region as a consequence of the availability of potable water, its quality and cost. In general, however, industrial users who are considering applications for recycled water do so for four primary reasons:

1. **Security supply:** Water shortages or drought poses an operational risk to plants and facilities that require large amounts of water to maintain production, whether for cooling or processing and production.

2. **Cost–Benefit:** Recycled water offers potential cost savings over use of fresh water, depending on the economics.

3. **Compliance:** Regulatory requirements in many areas stipulate industrial use of recycled water as a condition for new plant construction.

4. **Social responsibility:** Corporations that have added sustainability, green initiatives, and environmental responsibility to their mission, vision, and value statements to look at water use as part of the formal strategy for achieving their goals in these areas.

Figure 5.1 offers a conceptual illustration of these drivers and three secondary factors–water quality, technology and water quantity–that can come into play in formulating the customer business case for industrial water reuse. It is likely that several drivers will be “in the mix,” as depicted by the adjustable sliders and knobs. Each customer will have different priorities among the set of drivers and secondary factors. Through understanding the customer’s business case as a reflection of their drivers, priorities and concerns, water providers establish a foundation for effective communication and, ultimately, project success.

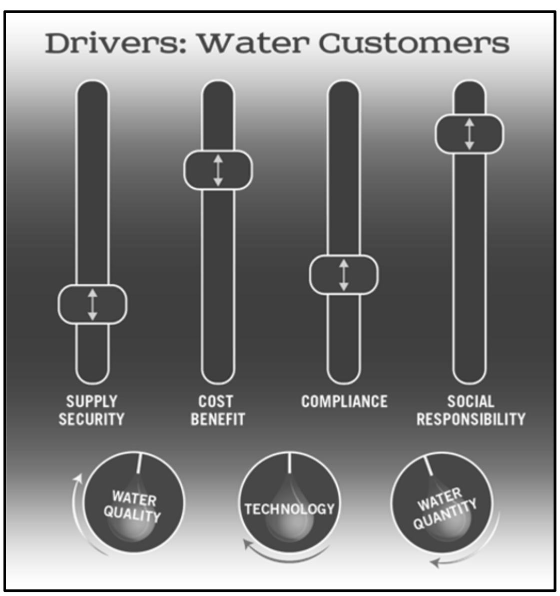

Figure 5.1. Drivers: Water customers

5.2.2. Drivers for Water Providers

As noted in the introduction, customers and providers have a powerful common interest in industrial water reuse; yet, their reasons are not the same. In general, water providers are pursuing industrial applications of recycled water for a separate set of four primary reasons:

1. **Source conservation:** Fresh water supplies are under increasing pressure in many areas of the country as a function of extended drought, development and population growth, changes in water quality, source water availability, and other factors.

2. **Policy initiatives:** Legislation and regulatory requirements to promote use of recycled water have been implemented by state or local governments, regulatory agencies, service districts, and other institutions.

3. **Quality range:** Providers' treatment facilities may have limitations in terms of the quality of the source water available for recycled water production, that is, the level of certain constituents may limit use of the water or require some level of pretreatment be provided to ensure the water is of a quality suitable for its intended purpose.

4. **Diversification:** Providers may consider recycled water supply capability and IWR projects as additions to their "portfolio" of products, services, and revenue streams, as well as a desire to derive more ROI from infrastructure and sunk costs.

Figure 5.2 depicts these primary drivers and secondary factors that go into formulating the business case for providers developing industrial water reuse projects in their service areas. As with the customer equation, it is likely that several drivers will be "in the mix," as depicted by the adjustable sliders and knobs. A comparison of the provider's drivers and the customer's drivers can be helpful in revealing any potential direct conflicts or areas of misalignment. In scenarios with additional stakeholders (e.g., municipal water retailer/wholesaler), there may be value in identifying any additional drivers that may impact the project.

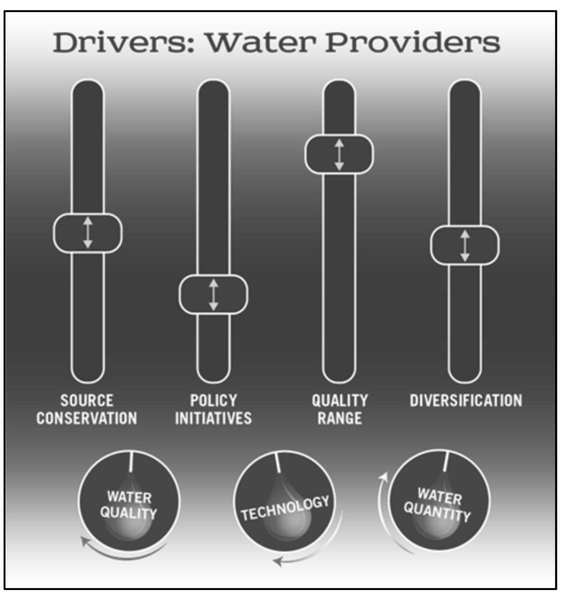

Figure 5.2. Drivers: Recycled water provider

A deeper look into the seemingly disparate drivers reveals an underlying set of common interests, as depicted in Table 5.2.

Table 5.2. Summary of Industry Drivers, Utility Drivers, and Resultant Common Themes

Industry Driver	Common Theme	Utility Driver
Supply Security	***Reliable Water Supply***	Diversification
Cost–Benefit	***Cost Reduction***	Range of Quality
Compliance	***Environmental Compliance***	Source of Conservation
Social Responsibility	***Community Benefit***	Policy Initiative

Within these underlying themes exists the possibility of a higher degree of collaboration, as water customers and water providers mutually recognize even greater shared interests in expanded use of recycled water.

5.3. Points of Departure

"Point of departure," as used in the context of this report, refers to the starting point of an idea, metric, view, driver, goal, or opinion that is expressed or implied by recycled water providers and/or industrial reuse customers. Often, the points of departure reveal disparities between the providers and existing or potential customers. Common points of departure for this study were previously identified in Table 5.1 and are discussed in detail in the following subsections.

5.3.1. Views of Time and Money

Among respondents, *time* was one of the most significant points of departure. Once a customer's organization was convinced recycled water was a good deal, they wanted it to be a "done deal." Most expected that the typical timelines they experienced with their own small-to-medium capital projects would apply to the proposed reuse implementation process. In one case study involving a pipeline extension to bring recycled water into a plant cooling system, the customer's expectation was six months. Ultimately, the project took 18 months to complete, which according to the company's project sponsor, was "six months too long."

From a postmortem perspective, 12 months was a reasonable duration for the project. The learning points here are two-fold: the need for providers to educate customers and better manage their expectations from the outset, and providers having an opportunity to bring their response times more in line with private sector expectations and, as the saying goes, operate at the *speed of business.*

The organizational culture of government institutions and public service agencies have long traditions of moving cautiously, and many volumes have been written about reasons and remedies. For purposes of this document, that is all water under the bridge. The meaningful ideas to remember from this research are these:

> If water providers truly want an exponential increase in recycled water use by industrial customers, they will have to revisit and revamp their existing project planning processes, approvals, and execution to bring a more timely response to businesses

> requests for delivery of recycled water. At the same time, business customers must come to understand that many regulatory reviews and approvals are outside the agencies' jurisdiction and sphere of influence. The result will be project delays that are, in many cases, unavoidable.

The second half of this "point of departure" is money. To a large extent, "time *is* money" in the private sector. In analyzing the use of recycled water, customers will consider such time and value factors as potential lost revenue from plant shutdown or business interruption and more. If they will be bringing money to the project, they will consider borrowing costs, ROI, lost opportunity cost from delays, and other factors. Also, if they are contributing to the budget, they want to see the same level of cost control applied to the budget as they use internally. For providers, this means managing the project to minimize "pass-through" to the customer.

Another difference is the dynamics of money. The larger the business, the faster and easier it is to find and access the financing when a project has been deemed desirable. Often, there are existing budgets from which to draw; if not, the process for funding approval is typically a matter of weeks or months.

This stands in stark contrast to public funding models that apply to the majority of water providers. Typically, agencies are constrained by annual operating budgets that have been cobbled together from property tax forecasts, revenue from permits and fees, and anticipated billings to the rate payer base. To respond to a customer request for recycled water, providers may need to draw from multiple sources of funding at the federal, state, and local levels. Each "pot of money" has its own application or administrative requirements, multiple approval loops, and signoffs. This is, perhaps, a primary reason that projects in the public sector have longer timelines than equivalent projects in the private sector. This fact needs to be part of the shared understanding that project stakeholders create at the outset of an IWR project.

5.3.2. Metrics and Measures of Success

This point of departure is, in some ways, an extension of the previous one, Views of Time and Money. In the private sector, decision makers expect a relatively fast payback (6–12 months) from small capital projects. This can be from a combination of performance measures, e.g., lower costs for water, increased plant run time, reduced maintenance and better reliability, and other quantifiable benefits. There may be nonmonetary measures if one of the project drivers includes a "green," or environmentally friendly, corporate social responsibility commitment.

Although providers focus on delivering a customer's desired business results, there may be a separate set of success measures that providers can achieve at the same time. These include mission-driven objectives, such as fresh water conservation and other environmental benefits, or expanding infrastructure now to hook up future customers for recycled water.

All parties should have the opportunity to set forth their respective needs and measures of success upfront to ensure that any potential project they pursue together represents a win–win solution.

5.3.3. Decision-making Processes and Styles

Many barriers and failures to communicate originate from differences in the ways organizations make decisions. The length of time it takes, number of people involved, chain of command–these and more factors impact the speed of decision making. As a rule of thumb, industrial operating plants have a degree of autonomy when it comes to doing what is best for the asset. As long as they are achieving their revenue targets, plant management teams typically have the authority to approve projects and allocate funds for plant upgrades and expansions. They will rely on plant maintenance staff, technical experts, and operations personnel to validate a business case and make a recommendation.

There is a very different scenario, however, among water providers. The professional community is required to maintain an open and transparent process as it pertains to planning, negotiating, and finalizing projects and decisions. This is a consequence of the numerous rounds of discussions and public input that are required by law. The larger and more bureaucratic the organization, the more detailed and involved the decision making tends to be. In cases that include multiple public agency stakeholders (e.g., provider/wholesaler, municipality/retailer, conservation districts, EPA, or others), consensus building, turf battles, conflicting agendas, and other factors can come into play. At best, these will delay the process and test customers' patience; at worst, they could stop a viable project from moving forward into reality.

5.3.4. Regulatory Landscape

The most critical legislative barrier to industrial water reuse (in fact, all types of reuse) is the level of treatment required in various states for the recycled water to be reused. Beyond cooling applications, the use of reclaimed or recycled water as an input to industrial production requires secondary and tertiary treatment at a minimum. Many companies prefer to keep using freshwater instead of investing in the treatment infrastructure and technology. Around the country, water reuse proponents have undertaken an increasing number of efforts to reshape policy legislation and remove barriers at the state level. In California, for example, planning of new developments must include designated percentages of water from renewable and/or recycled sources before freshwater sources can be accessed.

IWR projects that fall within acceptable reuse criteria will still face regulatory hurdles. Some customers will be better prepared than others to understand the regulatory process, depending largely on their type of industry. The more highly regulated the industry (e.g., oil and gas, petrochemical, power production, food processing), the more a customer's team can provide support and manage internal expectations around permitting and compliance issues. Customers in relatively unregulated sectors (e.g., data centers, logistics) are at a disadvantage.

This is where providers have the opportunity to add significant value to the project. Technical professionals and even managers generally have a high level of sophistication in dealing with multiple levels of government. More important, they have connections, such as informal personal networks that they can use to move projects off of one desk and onto the next, making slow but steady progress toward meeting all applicable requirements. They also have the means to tap into legal channels (i.e., internal legal representation or through professional associations) that can assist in providing regulatory review and recourse on regulatory matters. It is also worth noting that providers and customers can sometimes find common cause in their frustration with a third-party regulator (e.g., a local health department). This actually may present an opportunity for them to work together if they each provide their best effort toward resolving the regulatory issues.

5.3.5. Terminology

Somewhat surprisingly, this point of departure is the least divergent of the group. Project contributors from the customer side and from the provider side often share an "operations mentality" that comes from working in a plant and keeping it running. Whether their experience is in an industrial facility or a water treatment plant, they still value the same things, e.g., efficiency, reliability, productivity, and cost management.

That said, few people outside the water community understand the term “acre-ft.” Typically, customers will use the terms for volume and flow rates that reflect their industries (e.g., gallons per min, barrels per day). The best approach is for all participants to define terms early and apply them consistently throughout a project. Beyond that, the same caveats apply as they would to any group steeped in technical and engineering jargon: keep it simple.

5.4. Best Practices

In addition to the communications barriers and points of departure that emerged from this research effort, participants provided several lessons learned from their experiences. They also indicated that IWR projects could benefit from a range of best practices widely used in capital project management. Following is a brief overview of applicable lessons and recommended best practices.

1. **Engage the right people at the right time:** Knowledge, experience, and effective communication are inextricably linked to project success. The surest way to provide this foundation is by harnessing the collective wisdom of all of the people who will be contributing to the project over the course of its lifecycle. A partial list would include representatives from the customer’s maintenance, operations, procurement, and safety departments, along with process engineers and key managers; on the provider side, these people are project discipline leads, environmental engineers, permitting specialists; and third parties include treatment technology consultants, municipal health departments, other regulatory agencies, and building and construction divisions.

2. **Hold a kick-off meeting and write a project charter:** This involves bringing the expanded group of experts together with the core team in a facilitated workshop; the output of the event is a detailed project charter that serves as a repository of key assumptions and details about the project objectives, approach, risks, responsibilities and much more. A sample Project Charter document is included in the same download packet as this report..

3. **Assign a project integrator:** In addition to having a project manager in the conventional sense of the term, projects with multiple stakeholders and permitting and oversight bodies should identify a single point contact to serve as the nexus for communications among these diverse groups; this prevents communication disconnection and provides for continuity and coordination; the integrator is the designated “process owner” for all facets of compliance. Generally, the most appropriate person for this role will be found within the water provider organization. In certain cases, that resource could be a highly experienced person from the customer organization or a third-party resource with the necessary high-level expertise.

4. **Implement IWR projects using a shared framework:** The WateReuse Research Foundation will be publishing a recommended “template” for water providers and their industrial water customers to use in planning and executing projects in a streamlined, collaborative approach designed to ensure project success.

5. **Foster awareness of and appreciation for respective drivers, motivations, and points of view:** Providers and customers who recognize each other’s cultural differences and commit to over-communicating can turn their “points of departure” into opportunities for shared understanding.

6. **Support after completion:** The completion of a successful IWR project is not the end of the relationship between providers and customers; it is the beginning of a new, more proactive shared path, dedicated to continuous improvement and stewardship of water resources. There is the potential for agencies to benefit from a long-term relationship with industry beyond water, into energy conservation, demand management, and others.

5.5. Messaging Platform

Being accurately heard and clearly understood is the bottom-line goal of every effort to communicate. One tool used toward that goal is a messaging platform. It serves as a reference or repository for how the members of an organization can consistently address key audiences on the issues that most concern those audiences. Although core messages can be used verbatim, they typically are reworded as appropriate to better suit the specific communication channel being used, e.g., print, correspondence, meetings or group presentations, Web site, or others. Table 5.3 and Table 5.4, which follows, provides an initial messaging platform to address key issues that have been surfaced as points of departure between water customers and water providers regarding industrial water reuse. Typically, the platform will evolve over time as the audiences become more familiar with one another and develop a shared understanding of one another's perspectives.

Table 5.3. Messaging Platform: Recycled Water Providers to IWR Customers

Topic	Messaging *from* Water Providers *to* Water Customers
Industrial Water Reuse	Use of recycled water is a globally proven solution with documented benefits to industrial facilities that need to improve supply security, cost reduction, regulatory compliance, and social responsibility impacts.
Water Quality Concerns	Industrial use of recycled water is a technically mature field in which guaranteed water quality is no longer a significant barrier to implementation. Treatment technology and application expertise are widely available to support successful integration of recycled water into a growing number of industrial processes.
Cost and ROI Considerations	Nationwide experience indicates payback of industrial reuse projects to be in the range of 6–12 months, based on median scope and complexity. This range factors in the combination of upfront costs, cost savings versus freshwater, operational benefits, incentives, reliability, and other project objectives and, naturally, will vary with each case.
What to Expect	As water providers, we have a wealth of knowledge and experience that we can bring to the process to help industrial customers benefit from water reuse. As public entities, however, we operate within an environment that has some marked differences and constraints compared with the private sector. Although we will make every effort to bring transparency and urgency to the task of supplying your facility with recycled water, the process is likely to be less straightforward and more involved than some are used to. We commit to managing your expectations and the process itself to make it as efficient and cost effective as possible.
Regulatory Issues	Water projects are subject to a level of regulatory scrutiny that may differ from that applied to your industry. If yours is a highly regulated industry (e.g., oil and gas, petrochemical, power), we will rely on your assistance; if your industry is relatively unregulated, we have the expertise to navigate the water-related issues on your behalf.

Table 5.4. Messaging Platform: IWR Customers to Recycled Water Providers

Topic	Messaging *from* Water Customers *to* Water Providers
Industrial Water Reuse	(Interested) We want to know more about the potential for using recycled water in our production facilities. We need you, as our water provider, to help us make the right recommendation to our management and decision makers, as well as plant personnel. (Committed) We have been charged by our company to start capturing the advantages and benefits of recycled water in our industrial facility and need the prompt response from our water provider. How soon can we get this done?
Water Quality Concerns	We are concerned that recycled water is not high enough quality for use in our facility and process, or that it will compromise our systems and equipment over time. How do we make that determination? What technology options are there to consider?
Cost / ROI Considerations	Every project we propose to our management must have a reasonable ROI to be approved. What are the parameters of other or typical projects that we can use when putting together our business case?
What to Expect	We have a wealth of knowledge and experience about our plant and process facilities to contribute to the planning and executing the right recycled water solution for our businesses. In the private sector, we typically have a "get 'er done" mindset when it comes to small projects. This translates to making decisions locally and fairly quickly once the business case or project request has been approved. We will need our provider's help managing not only our expectations but also those of senior management if time frames or response times differ significantly from what we are used to in our industry.
Regulatory Issues	(Low-level regulation) Our facilities are subject to very little regulation, so we are not familiar with the issues and agencies that are involved in water reuse. We need the assistance of water providers knowledgeable with the mechanics of that process. (High-level regulation) We are in an industry that is subject to a wide range of regulation and, therefore, have a sophisticated understanding of the processes and participants. That experience and expertise will be important for integrating a water reuse project with our existing operations.

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