

2022

## **Cost-Saving Strategies for Municipal Wastewater Treatment Plant Managers**

Rosalie Rivera  
*Walden University*

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# Walden University

College of Management and Technology

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Rosalie Rivera

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Walden University  
2022

Abstract

Cost-Saving Strategies for Municipal Wastewater Treatment Plant Managers

by

Rosalie Rivera

MS, Columbia Southern University, 2018

BS, Columbia Southern University, 2015

Doctoral Study Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Business Administration

Walden University

July 2022

## Abstract

Wastewater treatment plant (WWTP) managers deal with increased costs while facing declining budgets to meet treated water standards. Biological disinfection processes comprise 65% of a typical WWTP's energy use and are of significant concern to WWTP managers. Grounded in the resource-based view theory and Six Sigma DMAIC approach as the conceptual framework, the purpose of this qualitative embedded single case study was to explore strategies WWTP managers use to lower water disinfection costs. Data were collected using semistructured interviews with four plant managers of the same organization in the central region municipalities of Florida who successfully implemented strategies to lower costs in wastewater disinfection. Data were collected using semi-structured interviews and organizational policies, and financial documents. Four key themes emerged from the three-phase thematic analysis (a) managers' role in lowering cost, (b) automation with continuous monitoring, (c) improvement and control, and (d) communication. A key recommendation is for WWTP managers to analyze and document used strategy methods to help future researchers and practitioners understand which parts of the methodology best suit their wastewater disinfection to benefit the service-receiving public and environmental sectors. The implications for positive social change include the opportunity for enhancing WWTP managers' use of strategy to reduce costs in water disinfection further and improve the relationship between WWTP managers and customers by lowering tax rates.

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## Dedication

I dedicate this doctoral study to my loving and selfless husband, Hector Luis Rivera-Rivera; I am forever grateful. My daughter, Naomi Alisha Chavez, and fur-grandbaby, DeeDee, for your positivity and encouragement. I also dedicate this doctoral study to my parents, Ramon Ruiz, and Ramona Sepulveda; we made it! To my sisters, Griselle Tamayo and Sally Ruiz, and my brothers, Raymond Ruiz, and Javier Ruiz, who all cheered me on to push further in my scholastic endeavors, thank you for your love and emotional support. To my extended family, especially Aida, Juanita, Don Ramon, Christopher, and Christian, you have each helped me grow spiritually, whether it be from kindness or patience; thank you. To my university sisters, Jennifer, Wanda, Carmen, and Denise, my sincerest appreciation for your supply of laughter, friendship, and motivation.

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## Section 1: Foundation of the Study

The purpose of this qualitative embedded single case study was to explore the successful strategies that some wastewater treatment plant (WWTP) managers use to lower the cost of water disinfection processes. In the past two decades, wastewater treatment demands have significantly increased, causing WWTP managers to customize solutions that save operational costs. An increase in demands for WWTP services arises from a steady increase in population and increasingly stringent federal regulations for water quality (Sun et al., 2019). Between the 2010 Census (U.S. Census Bureau, 2011) and the 2020 Census (U.S. Census Bureau, 2020), the population for the state of Florida increased from just over 18.8 million to 21.48 million. The approximately 2.68 million (13%) increase to Florida's population equates to further water and wastewater infrastructure demands associated with the daily use and consumption of water. When the amount of treated wastewater increases, so do WWTPs' operational costs because treating wastewater is energy intensive (Xue et al., 2019).

### **Background of the Problem**

Wastewater disinfection is an important, energy-intensive, and costly process in WWTPs. WWTP managers use wastewater disinfection processes to supply the public and environment safe and healthy water. WWTP manager responsibilities include maintaining water quality to meet federal and state regulations (American Society of Civil Engineers [ASCE], 2021). WWTP managers seek funding based on operational needs and receive a mix of funding sources from their local government. A comparison of funding between the years 2013 and 2020 of the Environmental Protection Agency

(EPA) yearly Clean Water State Revolving Fund (CWSRF) program allocations indicated that the state of Florida is not provided with funding to reflect the increase in water and wastewater demands by the growing Floridian population. The importance of exploring how WWTP managers successfully strategize to lower costs in wastewater disinfection processes while facing a lack of funding may help other plants to do the same.

### **Problem Statement**

WWTP managers deal with increased cost while facing declining budgets to meet treated water standards (Xue et al., 2019, p. 1). Wastewater biological disinfection processes make up 65% of a typical WWTP's energy use (Arden et al., 2019, p. 4). The general business problem is that some plant managers lack strategies that provide cost savings to meet budget constraints. The specific business problem is that some WWTP industry managers lack strategies to lower the cost of water disinfection processes.

### **Purpose Statement**

The purpose of this qualitative embedded single case study was to explore the strategies that some WWTP managers use to lower the cost of water disinfection processes. The targeted population consisted of four plant managers of the same organization in the central region municipalities of Florida who had successfully addressed annual budget reduction from the CWSRF program (EPA, 2020). The implications for positive social change include the potential to provide people and the ecosystem with safer and healthier water. For WWTP managers, the implications for positive social change involve the potential for increased social health of the public from

budget savings while also continuing to meet strict environmental water treatment standards and regulations.

### **Nature of the Study**

Researchers may use qualitative, quantitative, or the mixed methods for conducting a study. Researchers use qualitative methodology to study participants' meanings by collecting verbal, textual, and visual data from participants in a natural setting (Saunders et al., 2019). Researchers use the qualitative method to focus on the data obtained through open-ended questions or conversational communication to explore what participants think and why they think so (Saunders et al., 2019). Given the uniqueness of each WWTP managers' operating conditions and because human experience cannot be expressed in numbers or explained by examining variables' characteristics or relationships for analytic generalizations (Yin, 2018), the quantitative method did not align with my study's purpose. Moreover, difficulty in analyzing or comparing intangibles such as human subjective experience (Yin, 2018) would make combining the qualitative and quantitative dimensions of a mixed-methods approach inappropriate for the research. Therefore, the qualitative research method was most appropriate for this study.

Case study, ethnography, and phenomenology are three research design options for a qualitative study (Yin, 2018). In case studies, researchers conduct an in-depth investigation of unclear boundaries between context and a contemporary phenomenon in a real-world context (Yin, 2018). A researcher's use of case study design entails coding and assigning themes from participant responses from semistructured interviews while

holistically analyzing persons, events, decisions, and policies (Yin, 2018). A single case study design was appropriate, as WWTPs are dissimilar in scale and treatment operations, making it difficult to conduct an in-depth exploration of the site-specific phenomenon. An embedded single case study design refers to embedded subunits within a single case (Yin, 2018). WWTP managers' use of strategy is dependent on the geographical location and size of the plant, as well as the type of influent intake. Therefore, a multiple case study for this research would not have provided a comparable contrast to explore “like” cost-saving strategies due to the diversity among WWTPs. Ethnography applies to the study of a culture (Yin, 2018). For this reason, ethnography was not appropriate to the intent of this study. Based on the underpinnings of a phenomenological research design where the focus is on the participants' recollection and interpretation of personal lived experiences, a phenomenological design was not appropriate (Saunders et al., 2019). Therefore, a single embedded case study design was the most appropriate design for this research.

### **Research Question**

What strategies do some WWTP managers use to lower the cost of water disinfection processes?

### **Interview Questions**

Warm-up question: What is your responsibility for lowering the cost of water disinfection processes?

1. How did you recognize a need to improve strategies in water disinfection processes and record those strategies?

2. What current strategies do you use to successfully reduce high energy consuming processes?
3. How have you determined the relative effectiveness of different strategies for lowering the cost of water disinfection processes?
4. What were the key barriers to implementing the successful strategies for lowering the cost of water disinfection processes?
5. How did you address the key barriers to implementing the successful strategies for lowering the cost of water disinfection processes?
6. What more can you tell me about the strategies for successfully lowering costs in water disinfection processes?

### **Conceptual Framework**

The composite conceptual framework for this research was Barney's (1986) resource-based view (RBV) theory and Harry's (1998) extension to Six Sigma techniques and tools. Barney developed the RBV theory to explore links between a firm's internal characteristics and performance. The key constructs of the theory are the manager's attention to internal resources to (a) identify unique assets and (b) control strategic resources (Barney, 1986). Barney stated that researchers' use of the RBV theory helps them to explore conditions under which a firm's physical, human, and organizational resources may develop as a competitive advantage.

As described by Harry (1998), Six Sigma's DMAIC provides a process and tools for managers using the strategy of defining, measuring, analyzing, improving, and controlling (DMAIC) performance improvement projects. Furthermore, Caiado et al.

(2019) described using DMAIC for exploring water disinfection processes. Krovvidi et al. (2019) argued that DMAIC steps of Six Sigma methodology help to improve process costs in water treatment. I expected the composite conceptual framework of RBV and Six Sigma to enable identification and understanding of WWTP managers' use of cost-lowering strategies.

### **Operational Definitions**

*DMAIC*: Acronym for the process improvement approach of five stages or phases of Six Sigma representing the words *define*, *measure*, *analyze*, *improve*, and *control* and used for reducing cost and improving quality (Soundararajan & Janardhan, 2019).

*Resource-based view (RBV)*: The term first used by Wernerfelt (1984), who stated that a company is a large assortment of resources with tangible and intangible assets.

*Six Sigma*: Business methodology approach to a business strategy used to reduce the variability of the process through the effective use of tools and statistical techniques (Kaswan & Rathi, 2020).

*Wastewater treatment plant (WWTP)*: Industrial system that treats sewage water, resulting in cleaner and safer water suitable for reuse and return to the environment (Cao & Yang, 2020).

### **Assumptions, Limitations, and Delimitations**

#### **Assumptions**

I made assumptions to carry out this study. Assumptions are true but unverified facts presumed throughout a researcher's study (Theofanidis & Fountouki, 2019). I assumed that strategies exist for WWTPs to use and reduce costs in wastewater

disinfection processes. I assumed that the RBV theory and the Six Sigma DMAIC conceptual model constructs supported the research question. For the interview, I assumed that a semistructured interview format would encourage the participants to reply with sufficient information to explain in detail and that the data would be helpful in answering the research question. I also assumed that participants fully understood interview questions and provided truthful and accurate responses. A researcher depends on quality data to achieve quality research (Silverman, 2020). As the researcher, I assumed that I created lines of questioning while attempting to reduce assumptions about participant or interviewer roles and allow for participant leadership in the conversation, as explained in Azzarri and Baker (2020). Unlike closed-ended questions, open-ended questions are helpful to the researcher's understanding of an interviewee's perspective and interpretation of events, experiences, and opinions (Silverman, 2020). I assumed that I could interpret the interviewees' responses while mitigating bias and assumptions.

To mitigate bias, I used member checking to allow for the accuracy of respondent data. The use of member checking allows for the correction of any misunderstanding. The researcher may use triangulation as the method to contribute to the validity of collected data sources and findings (Farquhar et al., 2020). The use of triangulation is helpful in mitigating differences in interpretations of participant responses.

### **Limitations**

I addressed limitations in my study. Limitations are potential weaknesses or restrictions in a study beyond the researcher's control (Theofanidis & Fountouki, 2019). All studies have limitations, and researchers should avoid making unfair assumptions,

overgeneralizations, or conclusions (Theofanidis & Fountouki, 2019). The first limitation or restriction presented in this study was the method used to select participants. All participants were WWTP managers from the same plant of the same region and were more likely to provide similar response information rather than opposing information. There may have been some bias among the managers, who might have preferred to provide information on positive outcomes versus lessons learned or failures to avoid internal retribution. Methodological triangulation helped offset bias in participant responses. Another limitation was the manager's inability to remember strategy techniques due to a change in job responsibilities or a recent change in job location. Participant distrust of the interviewer during the research process was a limitation. Although there was no way to guarantee confidentiality, all reasonable measures, such as use of pseudonyms, helped to maintain participant confidentiality. As the researcher, I provided each participant with an explanation of pseudonym use to maintain confidentiality before conducting data collection and conducting interviews. Consideration for limitations to the study included social distancing because of the COVID-19 pandemic.

### **Delimitations**

I addressed delimitations while conducting my study. Delimitations are actions or boundaries that researchers choose to address study limitations (Theofanidis & Fountouki, 2019). One delimiter was the selected participants' work experience, which was expected to be over 1 month. I chose to focus on WWTP managers' use of cost-saving strategies because of the increasing need for them to provide quality treated water

in the face of decreased federal and state funding. The research process involved asking open-ended research questions about cost-saving strategies to four managers of a single WWTP county in central Florida's municipal area. I did not interview all WWTP managers in Florida to capture a focused view of WWTP facilities in the central municipality. This approach provided more timely and manageable study completion. Available technology and tools such as audio recording were available to substitute face-to-face interviews with audio only phone approaches, as there were no personal guarantees that face-to-face interviews could protect participants from exposure to COVID-19.

### **Significance of the Study**

#### **Contribution to Business Practice**

In this qualitative embedded single case study, I explored managers' success strategies to lower cost in wastewater disinfection. For this study, I explored the wastewater utility manager's strategies to reduce the cost of energy-consuming processes limited in wastewater program funding. The research may benefit the implications of general social change by promoting organizational sustainability through enhanced employee use of strategy during work performance.

The American Society of Civil Engineers (ASCE, 2021) indicated that no federal funding could be used to pay for operations and maintenance (O&M) of WWTPs. This requirement causes WWTP managers to spend half of the total annual expenditures on the O&M sector. Stakeholders, such as ratepayers, are burdened with covering funding shortfalls with tax rate increases (ASCE, 2021). Wastewater treatment plants continue to

experience inadequate funding as a result of tax rate increases and stakeholders' unwillingness to invest in wastewater infrastructures. The World Health Organization (WHO) and the International Water Association (IWA) indicated that WWTP plant managers may benefit in the process cost savings by improving processes in water treatment (WHO & IWA, 2018) while still producing improvement of treated wastewater.

### **Implications for Social Change**

There are several potential social change benefits from decreasing the cost of water disinfection processes. The positive social implications of this study may contribute to promoting treated water quality for the health of receiving ecosystems and communities. Other implications of this study are the potential to improve the relationship between WWTP managers and customers with the lowering of tax rates. Further implications for social change involve the potential to improve the relationship between WWTP managers and customers.

### **A Review of the Professional and Academic Literature**

The purpose of this qualitative single case study was to explore managers' success strategies to lower cost in wastewater disinfection. The literature review is described as a process requiring the researcher to scour the field of study for insight in defining the purposefulness of the research (Muraliraj et al., 2018). For this literature review, a description of the conceptual framework addresses the RBV VRIN approach and the Six Sigma DMAIC tools to develop mitigation strategies. I explain the use of other approaches and theories in other studies. I also analyze research on the background to

lowering cost in wastewater disinfection processes, the results for wastewater treatment organizations, and the nature of strategic approaches. In this literature review, I present the lack of research on WWTP manager successes in addressing lowering costs in wastewater disinfection processes to justify the need for this study.

The collection of literature for this study has two major components, each with two subsections. The first component focuses on using the RBV theory to analyze the business implementation of Six Sigma. The first major component continues with the RBV theory and its history. Two subsections then follow the RBV theory component: the value (V), rare (R), inimitable (I), and nonsubstitutable (N) model and its updated version of the value (V), rare (R), inimitable (I), and organizational processes (O) model (Barney, 1995; Kaukab et al., 2020) and an explanation of choices between two of the competitive analyses for the RBV theory. The second major component focuses on Six Sigma with an explanation of Six Sigma's history. The Six Sigma history component is followed by two subsections addressing the DMAIC approach and the DMADV approach. After these two Six Sigma subsections, an explanation of the two approaches and their respective phases is provided. Literature based on the cons of Six Sigma completes the discussion on the two approaches.

To collect research literature for the study, I searched for peer-reviewed academic articles and books using (a) Google Scholar, (b) Business Source Complete, (c) Science Direct, (d) CrossRef, and (e) ProQuest. Most of the sources, with the exception of some of the books, were accessible online through the Walden University Library. Government sources, which permit public access, such as the 2010 Census (U.S. Census Bureau,

2011), the 2020 Census (U.S. Census Bureau, 2020), and the Florida Department of Environmental Protection Agency (FDEPA) official website, provided additional access to research literature. For this literature review, I identified a total of 86 referenced articles. Of these articles, 85% were published within 1 to 5 years of my anticipated graduation date (see Table 1). Keywords and phrases relevant to access scholarly articles were (a) *wastewater treatment*, (b) *management*, (c) *resource-based view theory*, and (d) *Six Sigma DMAIC*. For each major component, an explanation of other like or rival theories is presented with reasoning for not choosing these alternate theories or approaches for the study.

**Table 1**

*Summarization of References in the Literature Review*

Description	Number of references	Percentage of references
Gov't/Peer-reviewed 2018–2021	73	85%
Gov't/Peer-reviewed 2017 & older	13	15%
Total references	86	100%

**Resource-Based View Theory to Analyze Implementation of Six Sigma**

The general business problem is that some plant managers lack strategies to provide cost savings to meet budget constraints. The specific business problem is that some WWTP industry managers lack strategies to lower the cost of water disinfection processes. The research approaches that I used helped in exploring WWTP organizations' implementation of Six Sigma or a combined use of Six Sigma with RBV “like” perspectives. The purpose of this qualitative embedded single case study was to explore the strategies that some WWTP managers use to lower the cost of water disinfection

processes. Incorporating complementary theories or other levels of analysis to the RBV theory helps a researcher to seek or explain research outcomes (Miller, 2019). I used a composite of the RBV theory and Six Sigma DMAIC approach to create a framework within which to study the participants' responses regarding the strategies that WWTP managers use for successful cost lowering in wastewater disinfection processes.

The nature of the study was based on the internal business problem of the firm. The RBV theory is useful to researchers interested in analyzing project success through Six Sigma implementation. Through the lens of the RBV theory, one examines resources such as human capital and organizational capital (Ali et al., 2020; Barney, 1991). The researcher may examine the organization's valuable, rare, inimitable, and organizational structure (VRIO) with nonsubstitutable resources (Chatzoglou et al., 2018; Kaukab et al., 2020) as the firm's unique resources. From this view, the composite of the RBV theory and Six Sigma five-phase DMAIC approach is most appropriate to the focus of the study for the WWTP managers' perspective on strategies to lower costs in water disinfection processes.

The approach for this study involved combining the underpinnings of the RBV theory with the Six Sigma DMAIC approach. Denzin and Lincoln (2018) suggested that researchers provide information on the nature of a case by informing the reader of its historical background. A case may also be compared to other cases or from participant-provided information. The interpretive philosophy is typically associated with qualitative research (Denzin & Lincoln, 2018). The participants' expressed and socially constructed meanings are analyzed to understand how WWTP managers use strategies to lower costs

in water disinfection processes. Saunders et al. (2019) provided the theoretical and conceptual framework for qualitative research studies are the researcher's use of analytical procedures to seek relationships among participant meaning and collected data. García-Alcaraz et al. (2018) stated that successful implementation of Six Sigma requires integrating management as a resource. I used an embedded case study research design to explore strategies that one group of wastewater treatment managers use to lower the cost of their water disinfection processes.

### **Resource-Based View Theory**

The RBV theory is helpful in research that involves Six Sigma. Hudnurkar et al. (2019) used RBV and Six Sigma to help them examine successful or deficient Six Sigma project implementation. Hudnurkar et al. proposed that Six Sigma projects could sustain a quality advantage when possessing a combination of tangible and tacit resources. In Barney (1991), the term *resources* referred to organizational capital and human knowledge of Six Sigma implementation. In contrast to Barney's definition of a resource is Burvill et al.'s (2018) definition of a resource as something that provides strengths or weaknesses based on how the resource is used. Six Sigma project capability is a composite of both tangible and intangible resources or the project's successful capability. Dionysus and Arifin (2020) classified resources as tangible and intangible. In this study, WWTP managers were the tangible resource who possessed intangible knowledge of strategy in disinfection processes.

## History of Resource-Based View Theory

Although Penrose published her original contributions to the discussion of RBV in 1959 (Penrose, 1995), the term RBV was first coined by Wernerfelt (1984). The strategic idea of the RBV is that a firm's analysis of people skills and capabilities provides a more accurate expectation over conducting a competitive environment analysis to sustain greater economic performance (Barney, 1986). Wernerfelt (2016) acknowledged Barney's extension to RBV as a theory. Barney's extension to the RBV theory was a later paper contributing to the assumption of differences in firms. Barney (1986) suggested that for the RBV theory, firms should leverage what they are good at doing. Wernerfelt argued that his personal contributions to the RBV were not generalizations from Penrose but inspired by Porter's 1980 five-forces analysis. Barney (1986) introduced the RBV theory as an extension to Penrose's discussion of the theory of the growth of the firm (TGF).

This study was also based on later contributive works of the RBV theory made by Barney (1991). Jay Barney is the father of the modern RBV theory of the firm. Barney expanded upon the RBV theory by building on Wernerfelt's (1984) *resource bundling* and later views of strategic formulation models with firm resources as the key concept of sustainable competitive advantage. A composite of Barney's (1986, 1991) RBV theory, Harry's (1998), and Harry et al.'s (2010) Six Sigma techniques and tools were the underlying conceptual frameworks used to underpin this study. Barney (1991) first introduced the VRIN model as value (V), rare (R), inimitable (I), and organization (O) in

organizational processes. Houé and Murphy (2018) reinforced that a VRIO analysis helps researchers question whether an organization can manage to benefit from its resources.

The VRIO acronym switched to VRIN as Barney (1995) examined links between firm resources and sustained competitive advantage. In contrast to the VRIO analysis is the adopted VRIN model, which reflects a better version of characteristics of competitive resources as the strategic factor in organizational processes. A resource or capability that meets all four requirements of the VRIN analysis can bring a sustained competitive advantage (Houé & Murphy, 2018).

### **Rival and Similar Resource-Based Theories**

Assumptions of the RBV theory imply that there can be differences among firms that allow some of them to sustain competitive advantage (Barney, 1995). The tenets of the RBV emphasize strategic choice, charging the firm's management with the essential tasks of identifying, developing, and deploying key resources to maximize returns. The RBV of competitive advantage is meant to examine links between internal characteristics and performance (Barney, 1986, 1991). The RBV theory of competitive advantage contrasts with Porter's (1980) five-forces model. Researchers use the five-forces model to analyze opportunities and threats between a firm and its competitors. The contrast between the five-forces model and the RBV provides the rationale for why the RBV theory was a suitable match for the conceptual framework of this study.

A similar theory is the natural resource-based view (NRBV). The NRBV theory is similar to the RBV theory because for the NRBV theory, the organization's physical resources are developed as a competitive advantage (Albertini, 2019). However, the

NRBV does not concentrate on human capital as part of an organization's resources to provide a competitive advantage as it does in the RBV theory. Managers use the NRBV theory as a proactive environmental strategy towards a competitive advantage. They equate cost savings by minimizing end-of-pipe pollution. In NRBV, pollution is a product of inadequate, inefficient, and ineffective manufacturing processes (Albertini, 2019). Managers of NRBV strategies lend themselves to developing a firm's resources and environmental capabilities. The NRBV theory is a repackaged version of the RBV theory. A researcher may use the NRBV for a composite conceptual framework seeking solutions to the firm's environmental issues. A similar study approach used the RBV in conjunction with stakeholder theory to examine strategy-based approaches to lowering cost in water treatment from an environmental regulation perspective (Liao & Tsai, 2019). Other studies have approached the topic from a political view of commitment and policy or standard uncertainty (Liao & Tsai, 2019; Liu et al., 2018; Maditati et al., 2018; Maktabifard et al., 2018).

The theory of work adjustment is a rival theory to the RBV theory. Dawis et al. (1968) created the theory of work adjustment that describes an expected employee work adjustment or change of skillsets result from changes in work requirements. Brown and Washburn (2020) conducted a study focused on human capital as an industry effort that positively impacted the water resource industry for Kansas City. Like the RBV theory, the theory of work adjustment may converge with another theory and highlight the researchers' view of a business-focused problem.

Human capital, among other organizational resources, may benefit an organization's success. The human capital theory was combined with the theory of work adjustment in the study conducted by Brown and Washburn (2020), which helped explain why investing in worker education and skillset knowledge could benefit the organization and society. The theoretical framework in the study focused on the education and skillset knowledge of human capital to create positive organizational change. Brown and Washburn's (2020) use of human capital theory to study a water facility was not specific to the phenomenon of how managers use strategies to lower water disinfection costs.

### **Six Sigma DMAIC**

Six Sigma is a set of techniques and tools for process improvement. Initially, manufacturing industries featured Six Sigma as a quality control effort (Krovvidi et al., 2019). Six Sigma is now known as a common improvement tool used to help optimize service sector processes. In their case study, Soundararajan and Janardhan (2019) examined small to medium-sized organizational use of the Six Sigma DMAIC approach and found that it reduced costs. Similarly, Krovvidi et al. (2019) supported the Six Sigma DMAIC method as a successful tool in minimizing the costs of wastewater disinfection processes.

The Six Sigma DMAIC methodology is a problem-solving approach for improving a product, service, or process (Harry et al., 2010). Discussion of the Six Sigma five-phase DMAIC method for this study is meant to be viewed as a problem-solving approach for process improvement made by WWTP managers who need site-specific strategies to lower the cost of water disinfection processes. It is from several recent peer-

reviewed research articles (Avilés et al., 2019, 2020a, 2020b; Bailey et al., 2020; Farrukh et al., 2020; Guo et al., 2019; Li et al., 2019; Singh & Kansal, 2018; Sun et al., 2019; Xue et al., 2019) where the problem of cost lowering for identified energy-intensive water disinfection processes presents itself. Lazaroiu et al. (2020) argued that research should be conducted for WWTP to analyze optimization in process costs. Many published articles are from various works based on WWTPs and their approaches to WWTP issues concerning their global location. From the total of collected articles, I identified only a few peer-reviewed articles published in the United States that discussed similar examinations associated with the subject of the study. Other articles have approached the cost-lowering problem from theories such as life-cycle assessment (LCA) or life-cycle cost (LCC) assessment, as seen in Xue et al. (2019), and control strategy, as seen in Avilés et al. (2019). Few of the peer-reviewed articles contained discussion of RBV theory, the Six Sigma DMAIC approach, or the composite use of the two as a conceptual framework.

Modern quality management approaches involve project quality initiatives such as Six Sigma. Project management uses the Six Sigma approach to improve the quality of service (Project Management Institute [PMI], 2021). The Six Sigma DMAIC is a five-phase methodology for problem solving, process improvement, product improvement, or service improvement (Harry et al., 2010). Six Sigma will hold a different meaning across individual job roles of an organization. For example, Harry et al. (2010) explained Six Sigma as an implemented strategic business initiative for those at the executive level. In contrast, Six Sigma is a tactic for improving operational effectiveness and efficiency for

those at the operations level. The implementation of Six Sigma at the process level is used to decrease defects and costs (Harry et al., 2010). This implementation of Six Sigma in processes distinguishes Six Sigma from total quality management.

### **Six Sigma Rival and Similar Approaches**

Six Sigma may be confused with total quality management (TQM); however, they are not synonymous. Six Sigma and TQM are both recognized as continuous improvement (CI) initiatives that improve the quality of product outcomes and services in project management (PMI, 2021). Antony and Gupta (2019) perceived that many advancing organizations implemented different process improvement initiatives, such as Six Sigma, to tackle negative processes and quality-related issues. Six Sigma is performed horizontally and vertically in a business. In contrast, TQM is limited to general quality improvements of a product (Harry et al., 2010). Organizations will use Six Sigma as a top-down business imperative versus TQM, a bottom-up quality program. Harry et al. (2010) explained that TQM is underpinned by improving organizational performance. In contrast, Six Sigma is concerned with improvements in operations and quality for process improvements. Quality management was once the main management tool within organizations (Muraliraj et al., 2018). Six Sigma is now the common quality management and process improvement tool.

Unlike the DMAIC approach, the define (D), measure (M), analyze (A), design (D), and verify (V), the DMADV approach is for new processes, plants, and products. For this study, the use of Six Sigma tools by WWTP managers was for current processes and not intended to explore new plant processes. The DMAIC approach is appropriate to

this study. Eloka-Eboka et al. (2018) explained implementing Six Sigma DMADV is meant for the beginning of project design and meant as a means of optimization. For instance, in their study involving new approaches to decrease capital costs and improve energy consumption for wastewater treatment, Eloka-Eboka et al. made use of the DMADV approach. Six Sigma is a valuable and integrative tool in organizational cost reduction strategies (Takao et al., 2017). Although the Six Sigma method emerged as part of the U.S. manufacturing industry (Krovvidi et al., 2019; Takao et al., 2017), it can be used in small and medium-sized enterprises such as wastewater treatment plants which provide a service of processes such as wastewater disinfection.

Prashar (2020) provided an excellent example of Six Sigma DMAIC to examine continuous improvement involving lowering costs for energy-intensive water treatment in the pharmaceutical industry. The study Prashar (2020) conducted was relevant, demonstrating Six Sigma DMAIC as a continuous improvement (CI) method which helped to reduce costs. In process industries where valuable and rare resources such as water are continuously flowing, Prashar (2020) noted Six Sigma DMAIC as a proven approach to enhance lowering costs. The following paragraphs break the various applicable tools for the Six Sigma DMAIC phases as seen from a resource perspective. It is important to note not all Six Sigma tools apply to a qualitative framework.

### **Define Phase**

In the define phase, the organization will identify actual process problems. Project managers use a business case to pinpoint financial success factors, project objectives and considers how they affect project stakeholders (PMI, 2021). Once identified, the project

objectives become specific to the business case study conducted with a proven successful approach such as Six Sigma DMAIC. There are several tools to choose from when managers conduct the define phase of the five-step DMAIC method. Two examples of the defining phase tools are the customer's voice and process mapping (Harry et al., 2010; PMI, 2021). In the define phase, managers may choose to use the voice of the customer (VOC) and process mapping tools.

### ***Voice of the Customer***

Customer concerns drive project management to meet customer satisfaction. Voice of the customer (VOC) is a planning technique applicable to organizations providing services and new product results based on the customers' needs (PMI, 2021). Managers use the VOC to annotate the needs of the customer. Techniques for obtaining VOC are interviews, focus groups, surveys, complaints, acknowledgments, and market research. The customers of the water treatment facility are the plant managers. Voice of the customer applies to the wastewater industry because plants must meet customer expectations. In a case study research conducted by Krovvidi et al. (2019), the authors support Six Sigma as a common tool implemented in the water treatment service sector to improve process costs. Frequently use of tools such as process mapping, supplier (S), inputs (I), process (P), outputs (O), and customers (C) diagrams, and Pareto diagrams under the DMAIC method (Farrukh et al., 2020) are helpful to WWTPs who seek to lower costs in wastewater disinfection processes.

### ***Process Mapping***

Managers use the process map to define a detailed graphical representation of activities and steps represented by flowchart symbols (Harry et al., 2010; PMI, 2021). Similarly, the PMI (2021) provides flowcharts are referred to as process flows or process flow diagrams when used to represent steps in a process. Use of process maps, process flows, or process flow diagrams may help show decision points in the overall order of operations. These data representation techniques are also helpful for process improvement, identifying defects in quality, and opportunities to include quality checks (PMI, 2021). Brown (2019) compared process mapping as a similar tool to the suppliers, inputs, process, output, and customer (SIPOC) analyzing tool.

### ***SIPOC***

There is more than one method of process mapping. Managers may use SIPOC as a high-level process map, to specify the steps of a delivered product or service. Some managers will use a SIPOC to diagram processes or services from the customer's viewpoint (Harry et al., 2010). The point of a SIPOC is to help the organization discover customer needs and wants so the provided product or service can attempt to satisfy the customer's requirements. For instance, manager's use of SIPOC helped to optimize the lowering of process costs of a water treatment plant by providing an 18% cost savings (Krovvidi et al., 2019). The measure phase of Six Sigma follows the completion of process mapping.

## **Measure Phase**

Wastewater treatment plant managers diagram steps that come before, during, and after a process to easily highlight improvement areas. The Six Sigma SIPOC applies to analyzing inputs, outputs, and procedures. This action helps to develop a solution to challenges (Brown, 2019). As a Six Sigma DMAIC tool, SIPOC is easy to understand and quick to implement. Brown maintained SIPOC as easy to use by any person, team, or department. The SIPOC requires a mere understanding of each letter of the acronym's significance to cover macro views down to the micro-examination of tasks for a process. For example, the implementation of SIPOC may begin by looking into the larger system, aligning processes to bring forth relationships by their importance to determine the priority of improvements.

Organizing qualitative data allows for better decision-making conducted by the researcher. Qualitative data organization involves graphing the data, creating pie charts, bar graphs, and Pareto analysis with the Lorenz curve (Harry et al., 2010). The use of frequency tables and graphs allows one to display qualitative data in an organized manner. For frequency tables, Harry et al. (2010) explained one might obtain information from a dataset to organize qualitative facts into a frequency table. One categorizes nominal data down the first column of a table and respective frequencies for each data set down in a second column. In a third column, one may calculate the relative frequency to provide a fourth column and display the associated frequency percentage.

The Pareto analysis with a Lorenz curve is a Six Sigma DMAIC tool for better decision-making. Harry et al. (2010) defined a Pareto chart as a bar graph for qualitative

data. The arranged bars in a Pareto graph present in order of relative frequencies, from tallest to shortest. This histogram display draws attention to the significant frequencies needed for analysis (Harry et al., 2010). Harry et al. explained more than one Pareto diagram based on the same relative frequencies is helpful to show a before and after process improvement. Unlike a histogram, the bars of a Pareto graph touch one another and have no spacing in between. This tool provides for further communication between team members and management. One may use Pareto analysis to help determine if improvement efforts are successful.

Once creating the Pareto graph, the manager can use a Lorenz curve, a cumulative sum line, to show the total data percentage. Analyzing the Lorenz curve of a Pareto chart permits one to identify where 80% of the potential problems exist. The 80/20 rule represents where 80% of the problems occur at 20% of the time (Harry et al., 2010). This 80/20 principle, or "Vital Few" and "Trivial Many," is the business rule (Harry et al., 2010, p. 220). The Pareto analysis is based on the principle that process optimization is achievable. For example, in Krovvidi et al. (2019), the Lorenz curve helped the authors to recognize the important processes to focus on. For the same frequency results, one can use graphing. Graphing qualitative data means using a pie chart, bar graph (histogram), or both to draw attention to the difference between categories (Harry et al., 2010). For this study, the manager use of Six Sigma DMAIC tools with qualitative measurement may provide a display of relative frequencies.

## **Analyze Phase**

The analyze phase is for developing solutions. In process industries, the current state of a process is analyzed by the corresponding measure in performance. In the analyze phase, the formation of ideas helps solve process problems (Meeuwse, 2018). Krovvidi et al. (2019) provided that analyzing data are helpful to provide the most significant impacts on process improvement. For instance, in Krovvidi et al.'s case study, a Pareto chart of cost head helped to identify which areas would provide the organization the most results in cost improvement. An alternate tool to the Pareto analysis is the fishbone diagram [synonymous with the Ishikawa diagram and cause-and-effect diagram] and the failure mode and effect analysis (FMEA) diagram.

During the qualitative analysis of organizational processes in the analyze phase, the fishbone diagram and the FMEA are appropriate. Fishbone diagrams are synonymous with cause-and-effect diagrams as they allow for a breakdown of effects and track back to a root cause. Takao et al. (2017) viewed FMEA as a Six Sigma tool designed to reduce variability and cost in processes while also helping process owners to combat failure, identify opportunities, and apply corrective actions. Other researchers identify the FMEA and cause-and-effect tools as frequently used for process improvement (Farrukh et al., 2020; Iyede et al., 2018; and Soundararajan & Janardhan, 2019). From these Six Sigma tools, one can conclude their effectiveness to organizations implementing them for process improvement and lowering costs.

### **Improve Phase**

The improvement phase sums up the primary goal of Six Sigma. Six Sigma is a continual improvement initiative meant to improve the quality of project management and results (PMI, 2021). Managers use idea sourcing as a tool during the improvement phase to review and capture all stakeholder's contributing ideas that are helpful to organizational growth (Harry et al., 2010). The PMI provides Six Sigma as a modern improvement approach to meet stakeholder requirements. According to Harry et al., stakeholders are the organizations' holders such as customers, employees, suppliers, competitors, owners, regulators, and the community, making them essential to help organize and improve processes. In the improvement phase of their study, Krovvidi et al. (2019) addressed the most significant cost driver identified during the analysis phase. In addressing the largest cost driver of chemical costs, water treatment costs were improved.

### **Control Phase**

The control phase is the fifth of the DMAIC phases. In the control phase, the organization seeks to sustain process improvements. This phase marks the control steps to ensure continuous effort in process improvement. This phase involves documenting process improvements. Examples of documenting process improvements are process models. The process model entails Plan, Do, Check, and Act (PDCA). The PDCA cycle is recognized within the PMI (2021) project management body of knowledge (PMBOK) as a continual trend, much like other initiatives such as TQM, Six Sigma, and Lean Six Sigma. Within the PDCA cycle, any activities or resources are verified at each stage to confirm if requirements are met (Gupta, 2006). For instance, Antony and Gupta (2019)

provided that when management continued to allocate increasing amounts of resources without consistent monitoring and control as one of the top ten reasons for failure of project improvement. Projects seek to sustain and stabilize overall improvements in the control phase (Antony et al., 2018). This project manager concern is presented in several peer-reviewed papers such as: Antony et al. (2018); Antony et al. (2019); Avilés et al. (2019, 2020a, 2020b), and Snee and Hoerl (2020).

Six Sigma works well and compliments standards from the International Standardization Organization (ISO). For example, the ISO 9000 standard, when compared to Six Sigma, is similar in conceptual design. There are quantitative and qualitative ISO standards to compliment Six Sigma implementation. From the findings of the study, the participants' organization did not make use of ISO 9000 and 9001 standards because they are voluntary. The ISO 9000 and 9001 standards, however, are most comparable to Six Sigma qualitative tools. Organization use of initiatives such as the ISO 9001 standards help them to identify process improvement and require managements' commitment in the control phase (Gupta, 2006). Energy-intensive utilities, such as U.S. wastewater plants, can improve their energy efficiency. Compared to other wastewater utility companies who have successfully implemented ISO standards, as seen in Voltz and Grischek (2018), the U.S. wastewater utilities may benefit from considering ISO standards with Six Sigma implementation. Voltz and Grischek argued that the U.S. wastewater utilities needed to reach 81% more in annual savings in comparison to German WWTPs already using ISO standards as well as the Six Sigma tool. As of 2016, only forty-seven U.S.-based wastewater utilities companies have adopted the ISO

standards (Voltz & Grischek, 2018). A study conducted by Albertini (2019) also reported ISO 50001 metric energy management standards with the potential for 39% in energy-saving.

### **Role of Wastewater Treatment Plant Operators**

Florida state operators are required to follow a stringent licensing process before operating in a domestic WWTP (FDEPA, 2020). Operator licensure is renewed every two years, and workers must possess a valid and active license to work. Each class of domestic WWTP license requires operators to meet education and work experience qualifications. Additionally, operators must maintain continuous education training from an approved facility (FDEPA, 2020). Garner (2019) informed that the Water Environment Federation created the Wastewater Treatment Plant Operator certification like the FDEPA.

Industry credentials are standards set to outline minimal candidate competence in each class. As the role of a water treatment plant operator becomes more advanced, so must the operators' training become more advanced. In the United States, from 1970 to 2000, individual states were responsible for issuing either certifications or licenses for drinking water or wastewater operators (Garner, 2019).

These educational and training requirements allow the WWTP managers to demonstrate competence. Managers, especially those responsible for the formulation and implementation of strategic decisions (top managers), should bear in mind that organizational structure plays a pivotal role in achieving superior performance. Though it is necessary for top management to get involved and committed, leadership at all levels

needs to demonstrate successful implementation of process improvement in projects. Management plays a crucial role in process improvement projects selection and goal setting (Antony & Gupta, 2019).

Managers making strategic decisions help enhance the use of resources. Sangwan et al. (2018) listed people as a resource required for product delivery. Managers are an important part of the organizational structure and help to enhance the use of valuable, rare, inimitable, and nonsubstitutable resources (Chatzoglou et al., 2018). Managers who have a successful organizational structure should be aware of the requirements set by the structure of their organization. Burvill et al. (2018) argued that managers who first focused on RBV found it to be helpful in understanding their own capabilities. Chatzoglou et al. (2018) provided that understanding organizational requirements enhance the use of resources and implementation of business strategies based on rapid and constant changes in their work environment. From Chatzoglou et al.'s view, strategy decisions must be aligned with existing processes, so process strengths are enhanced and weaknesses are avoided.

In an organization that implements Six Sigma, Green and Black Belts work together to utilize various tools and methods to lead projects to process improvement (Kregel & Coners, 2018). Yellow, Green, and Black are three levels designated to identify leaders with specific Six Sigma training (Fernandes et al., 2019). Decision making differs among the Six Sigma belts during project process improvement. For example, in Prashar (2020), the project leader trained as a Six Sigma Black Belt led a

team of workers through a Six Sigma DMAIC approach to counter the adverse impact of energy-intensive water processes of a pharmaceutical plant.

Chatzoglou et al. (2018) explained organizational structure is an indirect but important resource. The authors concluded that competitive advantage resulted from an organizational structure where employees can build sustainable competitive organizational advantage, which may indirectly contribute to developing competitive advantages. A work culture open to change is where employees are encouraged by managers (Chatzoglou et al., 2018) and essential in the WWTP industry where change is constant and strategic decision making is a skillset by those managing it. Master Black Belts (MBB) also lead Six Sigma projects as they have experience in various Six Sigma projects (Antony et al., 2018). Black Belts and Champions are less experienced than MBBs. Champions select team members and the good projects that benefit from Six Sigma continuous improvement. Black Belts commonly lead project management and are considered the change agents as they possess technical proficiency in Six Sigma tools. Green Belts and Yellow Belts are typically involved part-time in continuous project improvement.

### **Role of Wastewater Treatment Plants**

Public and environmental health are dependent on WWTP's consistent improvement of water quality. Wastewater treatment plant processes protect the environment and human health (Jones et al., 2021; Shoushtarian & Negahban-Azar, 2020; Wang et al., 2018). Wastewater treatment plant processes reduce and neutralize harmful bacteria before returning to different water bodies, such as lakes and rivers

(ASCE, 2021; Kõrgmaa et al., 2019; Shoushtarian & Negahban-Azar, 2020). Treated wastewater demands are expected to grow in the next two decades. The ACSE (2021) argued that by the year 2032, the United States can expect a 23% nationwide population growth. With an increase in population comes an increase in the amount of wastewater generated from the daily use and consumption by the population receiving treated water (Fendrich et al., 2018; Garrido-Cardenas et al., 2019; Simon-Varhelyi et al., 2020).

Wastewater treatment plant (WWTP) performance depends on various technical, non-technical, and human factors (Kõrgmaa et al., 2019). Simon-Varhelyi et al. (2020) conducted their study on management strategy to lower cost in Romania's WWTPs. In their study, Simon-Varhelyi et al. noted other studies on WWTPs focused more on wastewater treatment associated to energy consumption or environmental considerations. However, few studies within this recent decade have discussed what strategies WWTP managers use to lower costs in wastewater disinfection processes.

### **Challenges of Wastewater Treatment Plants**

As the demand for daily wastewater treatment increases, so does the costs in energy intensive plant processes. Federal wastewater regulations make WWTP water quality compliance costly (Chakraborti, 2020). Municipal WWTP discharges meet limits on concentration and quantity of pollutants to lower energy consumption and operating cost (Chakraborti, 2020; Guo et al., 2019). WWTP managers must ensure all water treatment processes maintain water quality to meet federal and state regulations (ASCE, 2021). These water treatment processes include water disinfection the public and environment depend upon to remain safe.

WWTP managers seek funding based on operational needs. Most of their funding comes from local government, and the rest of their funding comes from a mix of sources. Local governments receive funding from the federal government and then provide funds to each county based on the application qualifications of the requesting plant. Knopman et al. (2018) argued the importance of understanding where help and funding resources from state and local governments need improvement in the struggling of infrastructure systems of WWTPs among the counties (ASCE, 2021). Wastewater treatment plant managers in Florida play an important role in water reclamation to offset increases in process demands caused by population growth and higher standards on water quality (ASCE, 2021). For example, Guo et al. (2019) indicated that strategies to save energy and costs in municipal WWTP disinfection processes helped meet discharge standards. This study focuses on WWTP managers of municipal (domestic) wastewater treatment facilities in the central Florida area.

### **Wastewater Treatment Plant Financing**

Not all WWTPs follow the same design for wastewater management. Brooks et al. (2019) explained that although there are similarities among plants in water disinfection goals, disinfecting processes may differ in strategy due to the amount or type of wastewater treated. Most states have various sources for water quality funding (Petersen-Perlman et al., 2018). The federal, state, and local governments share water resource management responsibilities (He et al., 2020) but do not all manage each state's wastewater processes. The Environmental Protection Agency (EPA) focuses on sewage management (Brooks et al., 2019), but because plants function differently (Chakraborti,

2020), some plants operate under state management. For example, some plant managers run decentralized onsite processes, while others run centralized offsite processes (Bakshi et al., 2021). Decentralized (onsite) WWTP sewage management is the regulatory responsibility of the state in which they operate. Onsite plants are the regulatory responsibility of their local government (Brooks et al., 2019). Brooks et al. explained the difference in regulatory responsibilities created a lack of consensus on wastewater management policy.

Sharing lessons learned among water resource management utilities is helpful to economic development and sustainable development goals. For instance, a New Jersey (N.J.) WWTPs' approach to cost savings, a public-private partnership (PPP), allowed the utility managers to achieve energy neutrality by installing a second anaerobic digester and converting produced methane into WWTP energy (Rodriguez et al., 2020). By becoming energy neutral, WWTPs may sustain themselves without negatively affecting taxpayers by lowering costs in wastewater disinfection processes.

As a global example of sharing lessons learned, He et al. (2020) provided a comparison study of water policy resource management between China and the United States. The authors revealed that water resource management provided policy and approach recommendations could benefit other WWTPs worldwide. Seifert et al. (2019) supported a similar view of lessons learned, where the authors informed of information exchange as necessary to align organizational activities for sustainability in WWTPs. Wastewater treatment plants are energy-demanding utilities that provide quality water as a service to receiving communities. The WWTP industry faces many challenges, such as

energy consumption (Sun et al., 2019). Better solutions can be provided (Sun et al., 2019), hence the need for WWTPs to implement a Six Sigma DMAIC approach.

Specific operational practices between WWTPs are diverse (Brooks et al., 2019). For instance, there are differences in each WWTPs disinfection goals, use of processes and type of wastewater treated (Brooks et al., 2019). There are even differences in the application of specific operational practices. From Brook et al.'s point of view, similar firms cannot achieve similar operational effectiveness (Hudnurkar et al., 2019). The use of the RBV is helpful to understand site-specific Six Sigma project capabilities and impact each projects' success in lowering costs in disinfection processes. Use of the RBV allows for an understanding of how deficiencies in Six Sigma project capability impact its success (Hudnurkar et al., 2019) and is controlled by the WWTP manager of a project.

The environmental finance center network compiled by Florida provides funding and wastewater funding sources (Environmental Finance Center Network [EFCN], 2020). Organizations such as the FDEPA, U.S. EPA, USDA Rural Development, Florida Department of Economic Opportunity, the National Rural Water Association, CoBank, Suwanee River Water Management District, Live Oak Bank, Army Corp of Engineers, and the Economic Development Administration (EDA) are each available to wastewater managers on individual requirements based on purpose or use of funds. Plant managers must understand the criteria for qualification, then how and when to apply to obtain funding. Each funding organization falls under government, nonprofit, or for-profit categories.

The Florida Department of Environmental Protection (FDEPA) provides access to the Clean Water State Revolving Fund Loan Program (CWSRF). WWTP managers submit a request for inclusion (RFI) and compete for funding depending on the type of CWSRF loan requested. The different types of loans are for planning, design, or for construction (EFCN, 2020). All requests are placed on a priority list for consideration. Examples for the WWTP need of this low-interest type loan are for construction of new wastewater, treatment, and rehabilitation or upgrade of systems (EFCN, 2020). The U. S. Environmental Protection Agency (EPA) is associated with the Water Infrastructure Finance and Innovation Act (WIFIA) (EPA, 2020). For WWTP managers, this federal credit program is applied for in two phases that include negotiating low but flexible fixed-interest rate loans; however, it is available to small communities with a minimum population of less than 25,000. Like the CWSRF, the WIFIA loan is subject to application approval (EFCN, 2020; FDEPA, 2020). In contrast to the CWSRF, the WIFIA has an annual deadline for submittal rather than a 45-day submittal requirement.

Many of the funding organizations do not offer loans unless it is to assist low income or qualifying non-profit applicants. Respectively these funding organizations are the USDA Rural Development which provides a Water and Waste Disposal predevelopment planning grant, and the Water and Waste Disposal revolving fund. Other funding sources such as the Florida Department of Economic Opportunities provide the Florida small cities community development Block Grant Program requires applicants to attend public hearings and meet national objectives (EFCN, 2020). The National Rural Water Association provides the NRWA revolving fund. The NWRA provides funds

through the Rural Water Loan Fund (RWLF); however, the funds are for small water and wastewater utilities (EFCN, 2020). The RWLF is meant as a short-term loan with low-cost utilities, small capital projects, or pre-construction costs for large projects.

South Florida Water Management District, Suwanee River Water Management District, Army Corp of Engineers, Live Oak Bank, and CoBank provide a cooperative funding program, regional initiative valuing environmental resources (RIVER) cooperative funding, Section 595 Water Resource Development Act, rural water and wastewater lending, and water environmental programs, respectively (EFCN, 2020). The bank entities provide rural wastewater long-term fixed rate loans while the government entities help county governments, municipalities, and district applicants. All the funding organizations mentioned in this study vary in the application process and submittal dates. From these findings, WWTP managers are challenged constantly to compete with other utilities for funding.

### **Transition**

Section 1 included the introduction of the research topic and commenced with a discussion of the background of the problem and the relationship with the current business climate. Section 1 justified a need for research to explore the strategies used by some WWTP managers to lower costs of water disinfection processes. Lowering costs in disinfection processes is essential in the face of declining budgets to meet treated water standards. Further details in this section included an introduction to the research method, research design, and rationale for the selection and alignment to the research objectives. The purpose of this qualitative single case study was to explore how WWTP managers

lowering costs is essential due to increases in cost to meet treated water standards resulting from increased population growth and unmatched funding. The literature review section involved in-depth discussion about the challenges of cost saving strategies for wastewater disinfection processes, which is related to the purpose of the study. A critical review of the literature included considering the resource-based view theory and the Six Sigma DMAIC method, which supported the conceptual framework chosen for the study. In Section 1, the discussion covered examples of previous researchers who have used the resource-based view theory and the Six Sigma DMAIC method served as the underpinnings and justification to the theoretical lens to the study.

Section 2 contains a restatement of the purpose statement and its relation to the business problem. The discussion included (a) a description of the researcher's role in the data collection process; (b) a discussion of the strategies related to the participants; (c) the identification of the research method and design; (d) an explanation of the population, sampling, and ethical research process; (e) presentation of data collection instruments, techniques, and analysis; and (f) an outline of the measures taken to ensure reliability and validity.

## Section 2: The Project

Section 2 begins with the purpose statement to connect with all the components of the study and includes (a) the role of the researcher as the primary instrument of the study, (b) study participant relationship and involvement, and (c) a detailed discussion of the research method and design compared to other research options. This section also includes details of the population and sampling; the ethical approach to the study; data collection, organization, and analysis techniques; and research credibility, transferability, dependability, and confirmability.

### **Purpose Statement**

The purpose of this qualitative embedded single case study was to explore the strategies that some WWTP managers use to lower the cost of water disinfection processes. The targeted population consisted of four plant managers of the same organization in the central region municipalities of Florida who had successfully addressed annual budget reduction from the CWSRF program (FDEPA, 2020). The implications for positive social change include the potential to provide people and the ecosystem with safer and healthier water. For WWTP managers, the implications for positive social change are the potential to strengthen relationships between the WWTP industry and its customers due to budget savings while continuing to meet strict environmental water treatment standards and regulations.

### **Role of the Researcher**

For this qualitative embedded single case study, I was the primary data collection instrument. The concept of the researcher as the instrument is the researcher's self-

realization in a qualitative study (Fusch et al., 2018). Denzin and Lincoln (2018) explained that among various research instruments, the researcher is the instrument. Azzarri and Baker (2020) and Wa-Mbaleka (2020) further maintained that the researcher's role is that of an instrument in many qualitative research data collection methods.

Even in an organized study, conflict of morals and values can arise (Karagiozis, 2018). My training and education in health, safety, and environmental (HSE) management provided me, at a minimum, with an entry-level knowledge base about wastewater treatment. I had no present or past employment relationship or work connections to the wastewater industry or its professionals.

The role of the researcher consists of gathering and analyzing data. Gathering case study data requires the researcher to design a field protocol and to collect and report findings fairly. Kaliber (2019) stated that the researcher may use a reflectivist approach, as it is an essential part of mitigating interviewer influence over an interviewee and avoiding ethical issues. The researcher's role involves use of the reflexive approach, which is meant to help them to remain self-aware of their biases (Saunders et al., 2019; Thurairajah, 2019). To address research ethical considerations, I completed training on the Belmont Report and its principles (Appendix E).

The Belmont Report (National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research [NCPHSBBR], 1979) explains the tenets of research ethics by which all researchers abide. These tenets are (a) respect for a person's privacy, (b) beneficence, and (c) justice regarding the treatment of the study participant

or participants. To begin, only participants who provided informed consent participated in the embedded single case study. After consenting, participants were informed of the nature of the study, which was (a) voluntary, (b) designed to minimize exposure to breaches of confidentiality, and (c) designed to protect identity with the use of pseudonyms so that none of the participants would be vulnerable to workplace retribution from the study findings (Yin, 2018). I ensured that participants were engaged in a trusting atmosphere and that my tone and language were not portrayed as judgmental. I safeguarded all participant information on encrypted and password-protected computer files.

Yin (2018) pointed out that a researcher puts together a real-world data collection plan before collecting case study data. The Belmont Report upholds a formal protocol with set objective procedures designed by the researcher and formally reviewed to evaluate the efficacy and safety of research participants (NCPHSBBR, 1979). To mitigate recognized biases, I completed training with the Bristow and Saunders reflexive tool, Heightening Your Awareness of Your Research Philosophy (HARP; as seen in Saunders et al., 2019). The use of this tool helped me to pinpoint personal biases, values, and ideologies. Additionally, I refined my research philosophy to minimize biases that might affect the interpretation of findings for the study. I realized that by remaining self-aware of my biases, I would be less likely to affect or shape the analysis in research findings. Yin (2018) stated that researchers must understand what their biases are prior to collecting data. Kaliber (2019) emphasized that the role of the researcher requires an openness to learning, attentive observation, and a self-critical approach. I had no

professional or private relationship with the participants of the study. My decision to use a protocol was necessary because although unforeseen issues might have arisen in the data collection environment, the protocol still served as a way of providing reliability of the case study. Ethics are important in all research studies. The interview protocol is provided in Appendix A.

### **Participants**

The identified population was WWTP managers who had successfully used strategies to lower the cost of water disinfection processes. There are many levels of wastewater certification, but all certifications have a requirement to aid in cost savings. Time in position of more than 1 month had little relevance to the study, as all managers are employed with the understanding that they are prepared to conduct cost-saving strategies. Likewise, working in wastewater treatment processes does not mean that a WWTP manager is using strategies to lower the cost of water disinfection processes.

For this study, I focused on WWTP managers in the central municipal area of Florida who had demonstrated successful strategies in wastewater cost savings. My strategy for gaining access to participants included emailing or conducting telephone contact after identifying the appropriate participant organization. Saunders et al. (2019) encouraged incremental access as a method of establishing credibility to gain entry to a desired organization. The domestic wastewater plants' contact information is accessible online to the public. Another option was to contact participants using professional media such as LinkedIn or the Project Management Institute (PMI) website, where I am a current member. Upon contact with the participant organization, I obtained a letter of

cooperation (see Appendix G). Once the letter of cooperation was provided, the university Institutional Review Board (IRB) granted permission to continue with the study. I used the partner organization's provided list of employees to email a consent form (Appendix C) to each possible participant. The interested participants responded only with "I consent," as indicated on the form instructions.

## **Research Method and Design**

### **Research Method**

The research approach selected for this study was the qualitative method. Researchers' use of qualitative research methods allows a focus on participant attitudes and behaviors (Denzin & Lincoln, 2018). Researchers use the qualitative research method to develop theories based on thematic patterns of participant responses and then draw conclusions (Saunders et al., 2019). I chose a qualitative method based on the research questions and the likelihood of gathering data due to the flexibility of the qualitative method. This flexibility allows for qualitative data to come in many forms, such as archival and documentary research, secondary data, video, audio, or a combination of these, which may be used to answer the research question (Saunders et al., 2019).

Contrasting research approaches for this study were the experimental methods that researchers use to test hypotheses in quantitative and mixed-methods studies (Saunders et al., 2019). Unlike the qualitative research method, the quantitative research method focuses on analyzing data to determine and test hypotheses (Saunders et al., 2019). The nature of the study focused on a contemporary organizational phenomenon.

The phenomenon was examined from participant responses to open-ended *how* and *why* questions. I chose the qualitative method as the ideal approach for the study.

### **Research Design**

Case study, phenomenology, narrative, and ethnography each provide different qualitative designs (Saunders et al., 2019; Yin, 2018). For this study, I chose an embedded single-case study as the research design of inquiry. There are two different subcomponents in case study design. These contrasting designs are orthodox and emergent (Saunders et al., 2019). In emergent cases, the researcher allows the focus of the study to emerge while engaged in the research setting. For orthodox cases, the researcher conducts a literature review first before conducting data collection, analysis, interpretation, and reporting (Saunders et al., 2019).

The researcher uses archival records and documentation when conducting a case study. Ethnography is described as a research strategy used to focus on description and interpretation through firsthand field study (Saunders et al., 2019). There are three strategies for ethnography. These contrasting strategies are critical, realist, and emergent ethnography (van Manen, 2017a, 2017b). Researchers' use of critical ethnography in qualitative research involves questioning how things are or present themselves and adopting a supportive role to foster social change. Realist ethnography involves a third-person view or narration of the observed situation.

Narrative design is used in studies where the researcher intends to explore the life and history of an individual. Phenomenology is a qualitative design that researchers use to interpret lived experiences without bias and to gain meaningful insight into a

phenomenon (Pathiranage et al., 2020; van Manen, 2019; van Manen & van Manen, 2021). Phenomenological interview designs are typical for mixed-methods qualitative research designs. Fusch et al. (2018) commented that phenomenological studies are challenging and difficult for novice researchers to understand, and students are discouraged from using them. Phenomenology, ethnographic, and narrative designs were not suitable for this study based on their approaches to the research focus (Moser & Korstjens, 2018). In doctoral studies where exploring strategies help to establish the effectiveness and enhancement of an organization, a case study design is suitable (Pathiranage et al., 2020).

### **Population and Sampling**

A case study design was used for this study. I used Saunders et al. (2019) as guidance to decide on an appropriate nonprobability sampling size. Saunders et al. suggested that researchers use nonprobability sampling to focus on a sample size to answer the research questions of an explored phenomenon. Saunders et al. also reasoned that the case or cases of a case study are not considered sampling units and cannot be part of a statistical generalization. According to Moser and Korstjens (2018), a sample plan is appropriate when the setting and participants are sufficient for the researchers' full understanding of the studied phenomenon. Saunders et al. summarized the differences between homogenous and heterogenous group sample sizes to provide researcher guidance. This study consisted of a purposive sample of a homogenous group of four participants of the same subgroup of a population from similar organizational occupations and skillsets in WWTP management.

There are various other sample strategies in qualitative research. Phenomenology, and ethnography differ in sampling (Moser & Korstjens, 2018; Wood et al., 2020). Criterion sampling is the sampling technique for phenomenology. In phenomenology, the researcher examines individual experiences between participants who share the same phenomenon under study (Saunders et al., 2019). Researchers use purposive sampling as the main strategy in ethnography. Researchers' use of purposive sampling allows them to reveal and interpret culture from the perspective represented by knowledgeable key informants (Moser & Korstjens, 2018). The technique decision for sample size selection in this study was based on Saunders et al.'s (2019) discussion of nonprobability sampling. Saunders et al. confirmed that no rules apply to sample size for nonprobability sampling in case study; rather, there is a logical relationship between the sample selection technique and the purpose and focus of the research.

### **Ethical Research**

As a responsible researcher conducting a study involving human participants, I worked according to the Ethical Principles and Guidelines for the Protection of Human Subjects (NCPHSBBR, 1979). This study's protocol included the necessary ethical and relevant principles and applications as required in practice and research seen in the final Belmont Report published (NCPHSBBR, 1979). The objective of the informed consent protocol was to consider any element of research activity, and the protocol included respect, protection, and fairness to all participants (as referenced in NCPHSBBR, 1979). Consenting research participants had the right to decline or withdraw during researcher data collection (Saunders et al., 2019). After I have secured the data for 5 years, all hard

and paper copies and electronic versions will be destroyed, shredded, or permanently erased to protect participant and participating organization confidentiality.

### **Data Collection Instruments**

As the researcher, I was the primary data collection instrument. Researchers actively collect, manage, and present collected data (Azzarri & Baker, 2020). The data collection process involved semistructured interviews and archival documents. The protocol delineated that process. Researchers develop interview guidelines as part of their data collection instruments (Azzarri & Baker, 2020). Member checking enhances reliability and validity. See Appendix A for the interview protocol. This protocol provides steps and descriptions of the interview process. Scholarly peer-reviewed or seminal sources provided support to the following claims.

### **Data Collection Technique**

The data collection sources for this qualitative embedded single case study included semistructured interviews of prescreened participants. All participants were qualified professionals with experience in wastewater treatment and whose job description required them to provide or apply strategies to lower costs in water disinfection processes. Researchers use research interviews to collect primary data (Saunders et al., 2019). Time management was essential and provided participants respect and consideration of interview duration. This action helped to increase the likelihood of participants being willing to voluntarily consent. Setting aside the appropriate day and time for interviews provided alternative planning in case of logistical issues such as unforeseen participant cancellation due to work schedule, illness, and media issues.

Considering the unique challenges due to COVID-19, social distancing was considered, and collecting face-to-face interview data was avoided. Technologies such as Skype or Zoom are suitable alternatives and were provided as alternative considerations for participant safety. Lobe et al. (2020) described investigation options due to social distancing mandates for researchers affected by changes required in face-to-face investigations for research needs. New and unique challenges in social distancing introduced the need for accessible, controlled, and privacy-featured platforms in Skype and Zoom. These platforms provide researchers and participants with an additional safe option to conduct interviews besides socially distancing in traditional face-to-face interviews (Lobe et al., 2020). This planning was important, especially in the unforeseen event that interviews may require succinct interviews until saturation is reached (Saunders et al., 2019). Furthermore, a one-on-one interview approach encouraged rapport and trust with participants.

Setting aside enough time minimizes stress for both the interviewer and the interviewee. Interview options and methods in qualitative research are (a) face to face, (b) telephone (voice only), (c) Skype, and (d) Zoom video conferencing (Archibald et al., 2019; Saunders et al., 2019). Video recording would have added an unnecessary risk to the study and was not used. The purpose of the interview remained the same based on the participants' choice of medium, telephone (voice only). Telephone interviews tend to be shorter than face-to-face interviews, implying less rapport between those involved (Saunders et al., 2019). For this study, no issues of researcher–participant rapport were experienced. Telephone interviews tend to involve cues and a tendency for the researcher

to repeat themselves for clarity from issues such as poor phone reception or connection. After each telephone interview, member-checking allowed for clarification of any potential miscommunication between parties. Saunders et al. (2019) explained that in phone interviews, researchers tend to concentrate on listening and provide less verbal acknowledgment versus the visual and verbal cues of acknowledgment typically seen in face-to-face interviews.

Synchronous internet mediated interviews with Skype or Zoom are user friendly, cost-effective, and provide security options (Archibald et al., 2019). The technique to collect data was a telephone [voice only] audio recorded interview for each participant. Appendix A provides an abridged interview protocol and lists steps on how the interview steps occurred. Appendix A includes consideration for timely return of completed data interpretation and interview member checking to the participant for review.

### **Data Organization Technique**

All original or draft files are treated with confidentiality, properly labeled, and kept secure. These files also include any recordings, re-recordings, hard copies, backups, and anonymized versions. Pseudonyms or high levels of generalizations are provided as identifiers to conceal participant names, location, or names of organizations. Applying unique identifiers allows for referencing purposes while protecting confidentiality (Archibald et al., 2019). Versions of data that hold the legends revealing participant or organization identities are kept in a separate location with high level of confidentiality and protected from unauthorized access (Saunders et al., 2019). Systems for keeping track of data are noted in the protocol. All raw data are secured for a minimum of five

years. After five years, all hard copies will be shredded, all electronic versions will be permanently erased, and all other materials destroyed accordingly.

### **Data Analysis**

Data analysis is when a researcher generates meaning from collected documents and participant interview responses to explain a studied phenomenon. Lochmiller (2021) defined thematic analysis as a technique involving the qualitative researchers' use of identifying the recurring patterns in key statements and themes. The researcher captures patterns, assigns categories, themes, and groups data to compare information sources (Saldaña, 2021). Rumman and Alheet (2019) indicated the goal of data analysis was to answer the research question. Data analysis requires thematic analysis. I used the Lochmiller (2021) three-phase approach to thematic analysis from qualitative data for this study. The three phases are the setup phase, analysis phase, and interpretation phase.

#### **Phase 1—Setup Phase**

In the setup phase, the researcher sets up the collected research data for analysis. Yin (2018) defined qualitative analysis as the examination and categorization of data for evidence-based results. Researchers use a computer assisted qualitative data analysis software (CAQDAS) package for the inventorying, organizing, and filing datasets (Lochmiller, 2021). During transcription, the researcher removes identifiable references from audio files. The application of pseudonyms provides confidentiality for the participants' organization of the study. The researchers' use of Microsoft Word or Adobe PDF file format protect and store any uploaded handwritten conversions or paper-based field notes. Use of a password protected NVivo program allows the researcher to track,

describe, and date data files. Recorded interviews have the length of the conversation and the pseudonym of participants involved. A researcher organizes datasets with the end goal of conducting a smoother analytic process (Lochmiller, 2021). In thematic analysis, one assumes the researcher can fully develop a coding scheme (Lochmiller, 2021).

Thematic analysis helps the researcher to make visible the elements come together and build on each other for successful qualitative analysis (Braun & Clarke, 2021). After collection and analysis of each data set, I anticipated the use of a simple descriptive coding scheme to organize and make comparisons of interviewed participant perspectives. From the use of simple descriptive coding, I may identify and generate robust descriptive codes to allow for more in-depth comparison and contrast of datasets.

### **Phase 2—Analysis Phase**

In the analysis phase, the researcher becomes familiar with the recorded and transcribed data by reading and re-reading participant responses. The researcher becomes familiar with participant ideas, concepts, or experiences from recorded and transcribed responses of the participant interview (Lochmiller, 2021). I reviewed and attempted to recognize the recorded ideas, concepts, observations, or experiences described by the research participants. Use of the CAQDAS memo function allows the researcher to package and to make notes about the participants and data shaping the close of the interviews (Lochmiller, 2021). I noted specific words, phrases, or participant recollections, which address the research questions for analysis. Descriptive questions help the researcher to familiarize and find patterns in the dataset while avoiding assumptions to participants' perspectives or ideas (Lochmiller, 2021). I repeated the

process of reviewing and coding the collected data until meaningful themes no longer presented in my analysis.

### **Phase 3—Interpretation Phase**

In the third phase, the researcher finds category connections and disconnections to produce themes. The interpretive phase describes the researcher's intentional analytic work to review, define, and label themes (Lochmiller, 2021). Lochmiller (2021) specified the importance of the researcher to remain transparent in the process and to acknowledge there exist no rules to this decision-making process. The researcher structures theme findings with use of examples from the dataset. Use of examples from the dataset helps the researcher to assign categories, confirm and support themes. Lochmiller (2021) commented, the researcher allows for enough categories to sustain themes so the reader understands how the themes address the research question.

### **Triangulation**

Triangulation is a characteristic of the case study research design (Smith, 2018). The purpose of triangulation is to enhance the credibility of the study. Yin (2018) referred to triangulation as the multiple application to theoretical and methodological approaches of the same phenomenon. A researcher will use various data from credible sources to provide thick, rich, and contextual descriptions (Smith, 2018). A researcher will use triangulation as an approach to mitigate bias and reach data saturation through multiple sources of data (Fusch et al., 2018). For this study, I used methodological triangulation to focus on key themes and the conceptual framework. Denzin and Lincoln

(2018) and Pathiranage et al. (2020) explained that in methodological triangulation, two or more methods of converging data provide data validity.

For triangulation in a case study design, I used interviewing and document analysis as the strategy of inquiry. Yin (2018) stated case studies rely on document analysis, interviewing, and observation. I analyzed and collected participant data from the responses of semistructured interviews to compose a thematic analysis. Researchers may use thematic analysis as a general approach to analyzing qualitative data (Saunders et al., 2019). The use of thematic analysis provides opportunity for topic discovery through coding documents and is an effective tool to obtain trustworthiness while offering different insights into emerging topics of the study (Wood et al., 2020). Relationships and thematic patterns between different qualitative data help to maintain credibility, dependability, and confirmability of the data.

Transcripts were analyzed immediately after each interview. Careful revisiting of recorded interviews allows the researcher to search for meaning and patterns. Moving back and forth between data collection and data analysis helps the researcher to gather rich data (Moser & Korstjens, 2018). Transcripts are transcribed verbatim and include any verbal pauses and tone of voice. Also, nonverbal data such as coughing and clearing of the throat are fully transcribed to reflect the interview discussion in its entirety (Moser & Korstjens, 2018). Researchers may use the NVivo data analysis software program, Microsoft word documents, and Microsoft Excel spreadsheets to help them organize, sort, and analyze qualitative data (Azzarri & Baker, 2020; Kaliber, 2019; Pathiranage et al., 2020; Wood et al., 2020).

## **Reliability and Validity**

Reliability and validity are terms appropriate in positivist research criteria.

Quantitative research is associated with positivist research inquiry where researchers use terms such as internal validity, external validity, reliability, and objectivity. Lincoln and Guba (1988) explained scholars in naturalistic research use terms such as dependability, credibility, transferability, and confirmability as inquiry terms equivalent to reliability and validity.

Case study paradigms and criteria differ between quantitative and qualitative research. The quantitative case study design is known as a conventional or traditional paradigm. In contrast, the qualitative case study design is an emergent or naturalistic paradigm (Lincoln & Guba, 1988). The traditional paradigm is the oldest and commonly linked to positivist research inquiry. The naturalistic paradigm is newer and widely related to constructivist or social constructivist research inquiry. This newer paradigm is more common in research associated with social sciences. Lincoln and Guba (1988) explained findings are products of the participants' natural language when collecting data in the naturalistic paradigm. The naturalistic paradigm suits this study because part of the data collection entails capturing participant perceptions and present findings.

### **Dependability**

Dependability refers to data stability throughout the generation of a study (Ellis, 2019). In qualitative research dependability is parallel to reliability (Lincoln & Guba, 1988; Saunders et al., 2019). Researchers will focus on recording dependable data and information to provide others the ability to evaluate and understand the research content.

Dependability serves as an additional criterion in the validation of a researcher's study. Validation requires techniques such as triangulation and member checking to establish research quality (Saunders et al., 2019). As part of the criteria to evaluate dependability, Fusch et al. (2018) discussed the importance of triangulation.

Dependability adds to the depth of data collection findings as rich data also allows for data saturation in qualitative research. Moser and Korstjens (2018) stated sample size determines data saturation and is different between ethnographic, and phenomenological design. In case study research, knowing when one has reached data saturation is different from other methods. For this study, the data collection necessary to reach saturation may begin with population and sampling. Saunders et al. (2019) defined data saturation as the inability to reach newer insights after data collection is performed. It is the merging of associated data findings, such as sources and methods, which provide validity in case study research (Farquhar et al., 2020). Yin (2018) states that for case study researchers, data saturation has no clear cutoff point. The functional elements of inquiry are participant observation, field notes, interview transcripts, literature review, and narrative inquiry. Data collection then is considered enough when reinforced with (a) evidence verified from a minimum of two sources and based on the main topics of the study, and (b) includes rival explanations (Yin, 2018). The researchers' use of data saturation helps to ensure and reinforce decisions making. This process is done by locating, reading, and synthesizing relevant scholarly peer-reviewed articles or seminal work to support synthesis.

## **Credibility**

Credibility is what the researcher strives for by customizing case study descriptions and contrasting them to rival explanations (Yin, 2018). To avoid bias, had the findings from the case study revealed a more favorable design than the original (as understood in Yin, 2018), the study design would have been adjusted. Trust and rapport must be built between the researcher and the participants to maintain credibility.

Archibald et al. (2019) indicated that nonvisual mediums such as telephone interviews formed less rapport with participants. Before our initial introduction to one another, I carefully planned and later gained access to study participants with the support from upper management before conducting interviews to acquire participant trust. This tactic was essential to collect data. Checking data, analysis, and data interpretation with the participants helped explain the studied phenomenon. As the researcher, my reflexivity helped to minimize any personal preconceived biases about the research. Social constructivism and positivism are two possible but contrasting views in research. Positivism exists outside of the social world with properties measured through objective methods. The guiding principles for a social constructivist exist internally and are created socially with properties measured through subjective methods. The objective for this study is to explore strategies that some WWTP managers use to lower the cost in water disinfection processes. For this reason, the social constructivist approach was most appropriate for the study.

Understanding research philosophy and approaches are concerned with the way a researcher collects data to answer a research question. Researchers who can understand

and explain their choice of approach and techniques in data collection are able to better plan research related questions (Saunders et al., 2019). I began by developing knowledge of how my personal beliefs and assumptions (research philosophy) shape the understanding of research assumptions. These assumptions are epistemological (of human knowledge), ontological (of realities), and axiological (of how personal values influence the research). Researchers with consistent and well-planned sets of assumptions provide credibility to the research related questions (Saunders et al., 2019). As intended, I supported the choice of an appropriate research method, strategy, data collection, and analysis procedures from this plan. This self-awareness helped to develop the reflexivity needed before beginning the research. Ontological, epistemological, and axiological are three common assumption types (Pathiranage et al., 2020) that make up the philosophical underpinnings of business and management research (Saunders et al., 2019). Throughout the study, the researcher exercises their reflexivity among the assumptions and their opposing viewpoints. The two opposing viewpoints for each assumption are objectivism and subjectivism (Saunders et al., 2019). Furthermore, recording and challenging the participants' social constructions allowed for abbreviated data analysis (Saunders et al., 2019). Reaching data saturation helped assure the transferability, confirmability, and credibility of the findings.

### **Transferability**

Transferability refers to the extent to which a research study's findings are applicable to other settings (Saunders et al., 2019). For this study, documenting of followed protocol procedures allows other researchers interested in exploring similar

phenomena to replicate the work (Yin, 2018). Saunders et al. (2019) explained that replication is not always possible to reflect socially constructed participant interpretation of a specific location and the time of the completed qualitative research. For a qualitative study, a thorough representation of the research design helps others to conduct a similar study.

Based on an interview approach for the embedded single case study, participants work in the same plant. This cross-section approach allowed for data collection to represent the sample of others working in the same WWTP setting. For this study, I considered that research could encompass several settings for the large organization with treatment sites across the cities served by the same WWTP facility to produce valuable findings.

### **Confirmability**

As part of the research interview protocol, I used methodological triangulation, conduct semistructured interviews, and conducted member checking. Sharing interview summaries with participants ensured the credibility, transferability, dependability, and confirmability of collected data and results. Additional considerations for increasing reliability were developing a case study database and maintaining a chain of custody.

Yin (2018) proposed a case study tactic of using multiple sources of evidence and case study report reviews by key informants. Data triangulation strengthens study findings with the development of converging evidence (Yin, 2018). In case study research, maintaining a chain of custody increases the confirmability of case study data information.

### **Transition and Summary**

In Section 2, the details represented a restatement of the purpose statement and its relationship to the existing business problem. The discussion included a (a) description of the researcher's role in the data collection; (b) discussion of the strategies of relationship with participants, (c) identifies the research method and design, (d) explanation of the population, sampling, and ethical research process; (e) presentation of data collection instrument, technique, and analysis; and (f) outlining of the measures to ensure credibility, transferability, confirmability, and data saturation. Section 3 details include: (a) an introduction, (b) a presentation of the study findings, (c) an application of the discoveries of the study to the industry professional's practice, (d) the implications for: social change, (e) for future actions, (f) recommendations for further study, and (g) final reflections and conclusions.

### Section 3: Application to Professional Practice and Implications for Change

#### **Introduction**

The purpose of this qualitative embedded single-case study was to explore the strategies that some WWTP managers used to reduce costs in water disinfection processes. The data came from manager interviews, as well as manager and company documentation at one WWTP location in Florida. The findings showed strategies that the managers used to lower costs in water disinfection processes. I conducted semistructured interviews with four department managers of a municipal WWTP plant located in Central Florida to answer the research question. The selected participants were WWTP managers who possessed experience in successfully using strategies to reduce costs in wastewater disinfection processes. The interview data coupled with the WWTP managers' organizational documents contributed to achieving methodological triangulation and data saturation. The data collection process helped to successfully answer the research question: What strategies do some WWTP managers use to lower the cost of water disinfection processes?

After each interview, I conducted member checking to ensure understanding of participant responses. Each interview audio file from Zoom was uploaded to my personal computer. The audio files and notes taken were uploaded into NVivo software for transcription and labeled respectively with P1 through P4 for confidentiality. The NVivo software allowed for the organization of audio and transcript files. The transcript files allowed me to analyze the context, create codes, assign themes, and review to ensure the accuracy of my analysis. The following section contains the findings, application to

professional practice, implications for social change, recommendations for action, and recommendations for future research. I end this study with my reflections and research study conclusions.

### **Presentation of the Findings**

The research question for this qualitative embedded single case study was the following: What strategies do some WWTP managers use to lower the cost of water disinfection processes? The data collection process included semistructured interviews with four WWTP managers who met the participant criterion of a minimum of 18 years of age, 1 month of work experience in WWTP operations, and successful application of strategies to lower costs in water disinfection processes. Conducting individual semistructured interviews with each participant provided information on successful strategies that they used to lower costs in wastewater disinfection processes.

Each interview lasted no more than 60 minutes and was conducted via telephone. Each phone interview was recorded with the Zoom audio conferencing platform. The scheduled interviews accommodated each participant's chosen day and time. I used an interview protocol (see Appendix A) as a guide for conducting each interview. To ensure the correct interpretation of participant responses, I conducted individual participant member checking. After the fourth interview, no new themes emerged from this analysis, and I concluded that data saturation was reached. For the methodological triangulation process, I reviewed organizational documents such as organizational policies, annual budget reports, and comprehensive annual reports of the WWTP associated with the participant organization. I uploaded the transcribed interview data, notes, and company

documents into NVivo. The data were compiled to identify emerging themes, to analyze themes, to remove unconnected themes, and to check themes for patterns against interview data and company documents. I assigned a pseudonym to each participant (P1 to P4) in place of the participant's name to maintain the confidentiality of the participants' and their organization's data. In using the RBV theory as a lens to view the Six Sigma DMAIC approach to the participants' and organization's data, the following themes emerged: (a) managers' role in lowering disinfection cost, (b) automation with continuous monitoring, (c) improvement and control, and (d) communication, which helped to extend the knowledge from the peer-reviewed studies identified within the literature review.

### **Theme 1: Managers' Role in Lowering Cost**

All participants emphasized the general plant responsibility to ensure efficiency in wastewater disinfection processes while optimizing wastewater disinfection costs. P1 discussed how utilities "look to optimize while minimizing costs" as they were "held to a high level of disinfection standards." P1 shared his perspective on the WWTP managers' strategy to optimize disinfection costs as "operating an efficient utility that includes disinfection processes." P2 voiced "always looking for ways to save on disinfection costs" and described using the "least amount of equipment and chemicals" while maintaining set requirements. Similarly, P3 described "doing a better job" so as not to "waste chemicals, money, stuff like that." P4 mentioned an "always conscious" use of funding from taxpayer money in "the most efficient and effective way." Regulatory requirements work to set limits on the use of chlorine for disinfection. P1 indicated

staying “close to that required level” as the “primary method to optimizing disinfection costs.”

### ***Connection to the Conceptual Framework***

All participants conducted decision making as a problem-solving approach based on gathered field data before adjusting utility wastewater disinfection processes. Participants' decision to adjust disinfection processes was for wastewater disinfection efficiency and to lower costs. The correct problem-solving framework must be chosen and is used to guide a team step by step through a problem-solving process (Snee & Hoerl, 2020). Because problem-solving is an ongoing event, it is a continuous process and reflects the improvement and control phases of the Six Sigma DMAIC approach. Snee and Hoerl (2020) argued that the DMAIC tools are appropriate but not enough to strategize solutions properly. WWTP managers, who are the organization's resources, use the SCADA high-quality data system to ensure that water disinfection processes meet predetermined standards and regulations, making the application of SCADA a successful strategy tool.

### ***Connection to the Literature***

From the literature, waste and energy management are relevant to WWTPs because efficient management can reduce costs (Seifert et al., 2019). Urban wastewater utilities strive to improve their economic performance from challenges in dwindling resources, growing urban populations, strict water quality criteria, and constraining financial burdens (Xue et al., 2019). Avilés et al. (2019) noted that a start-to-finish approach to WWTP energy efficiency helped with optimization and cost minimization.

WWTPs focus on operational environmental performance and customer satisfaction, the laws regulating them, and their financial savings (Seifert et al., 2019). Snee and Hoerl (2020) argued that the practice of placing too much focus on problem-solving tools rather than on aspects of problem-solving is an issue. Problem-solving means finding a solution to a problem (Seifert et al., 2019). Participant decision-making actions align with the first two phases (i.e., the define and measure phases) of the Six Sigma DMAIC approach (Soundararajan & Janardhan, 2019). WWTP processes are adopted continuously to meet demanding quality standards, making proactive management sometimes difficult (Seifert et al., 2019).

## **Theme 2: Automation With Continuous Monitoring**

All participants mentioned that automation helped create a reliable method to monitor and measure the use of resources. P4 based the primary means of lowering cost on “continuous monitoring” of residual chemical requirements for treated water. P1 and P2 discussed providing close, continuous monitoring for chemical residuals in treated water by monitoring required dosage levels. All participants favorably viewed their SCADA training.

The participants conveyed that combined use of training for the SCADA system and the system itself, with continuous monitoring and lab results, vastly improved their ability to benchmark progress. P1 described SCADA as the “primary method to monitor and measure the use of energy and chemicals.” Additionally, the organization’s use of the SCADA system added lab data results to minimize delays in wastewater disinfection processes. Participants P2, P3, and P4 were vocal about how the automated SCADA

system provided trending that allows for adjustments and reduces chemical waste in disinfection processes. All participants viewed this change as having a positive impact on the disinfection processes.

Each participant stressed that training played an essential role in the efficiency of WWTP management. P4 viewed “preplanning and clearly understanding the process” as part of the strategy for successfully lowering the costs in water disinfection processes. P3 mentioned “training on SCADA to best view where we don’t have waste of the disinfection process.” Employee SCADA system training helped to minimize process energy and chemical waste.

#### ***Connection to the Conceptual Framework***

Training in Six Sigma and selection of strategy were identified as two leading critical success factors for organizations (Muraliraj et al., 2018). The implementation of a DMAIC-based framework to improve a process industry’s environment is discussed and supported in Prashar (2020), where employee training is part of activities in process standardization. In addition, management involvement and commitment are helpful factors in implementing Six Sigma concepts (Soundararajan & Janardhan, 2019).

#### ***Connection to the Literature***

The literature focuses on human resources in an organization’s economic success and sustainability. Wastewater utility managers strive to improve environmental and economic performance (Xue et al., 2019). Digital representations such as SCADA systems contain different components and interact with human resources to help monitor and optimize control strategies that help to achieve performance goals (Sun et al., 2019).

SCADA stores automated consumption records (Avilés et al., 2019). Management choices in chemical dosages and electricity consumption are significant to human health, environmental health, and lowering plant costs (Sun et al., 2019; Xue et al., 2019). Minimizing operational costs is aided by documenting and recording the energy consumption of disinfection processes.

### **Theme 3: Improvement and Control**

All participants recognized a need to improve strategies in water disinfection processes. P1 recognized a need for improvement from “the whole utility applying to any chemical addition, power use, etcetera.” P1, P2, and P3 mentioned SCADA as part of their control system. P1 viewed the SCADA system as necessary and commented, “we need this level of control.” P2 recognized a need for strategy improvement from recorded lab results and data spreadsheets, while P3 commented on knowledge of “Department of Environmental Protection (DEP) rules and regulations.” P4 vocalized an “always conscious” approach to using funds from taxpayer money in an “efficient and effective way.” P1 viewed process optimization as considering the entire treatment process and not solely “specific to disinfection.”

Experience plays an integral part in a manager’s ability to create improvement or control in WWTP processes. P1 indicated that he had been working in the utility for a year and a half but possessed “historical work in the consulting engineering field.” P2 stated that he had worked for the present utility for “6 years” and had progressed in responsibilities from the operator to lead operator and eventually into a management role. P1 and P3 each possessed over 30 years of WWTP management experience. P3 described

strategy use from analyzed process data as going “far back” and conveyed that his experience helped him to recognize the concern for chlorine use from the end-user and the organization’s cost standpoint.

### ***Connection to the Conceptual Framework***

Cost reduction, as discussed in the literature, includes effective cost reduction referring to the Six Sigma DMAIC phases. In addition, proactive management includes reducing the use of material and energy consumption for cost savings (Seifert et al., 2019). Although the WWTP managers never mentioned training in the Six Sigma DMAIC approach or the use of Six Sigma to approach cost saving, many of the strategies incorporated a resource-based view and some semblance of the DMAIC approach.

### ***Connection to the Literature***

The control phase includes inspecting and ensuring parameters for matched specified values (Soundararajan & Janardhan, 2019). Energy demands of the WWTP are dependent on the volume of wastewater treated. The amount treated varies daily, monthly, and yearly dependent on end-user activities (Lazaroiu et al., 2020). Real-time control (RTC) with SCADA was discussed in Sun et al. (2020), where increases in urbanization and scarcity of water prompted a need for WWTP managers to maintain efficiency in wastewater treatment. Improving efficiency and energy use are current trends in WWTP management (Avilés et al., 2019).

Many resources such as materials, energy, money, water, and people are required to produce and deliver a process (Sangwan et al., 2018). The WWTP managers follow the objective of producing treated water to satisfy customer demands. Managers of WWTPs

are recouping savings and generating profits with innovative designs due to increased trends in growing urban environments, as indicated in the 2021 infrastructure report card (ASCE, 2021).

#### **Theme 4: Communication**

The participants viewed communication as an integral part of lowering costs in water disinfection. Discussion between managers to choose alternative approaches in disinfection processes occurs within the WWTP. Workers may choose to meet and brainstorm while considering materials, DEP regulations, and cost. P2 noted occasional collaboration with contractors to conduct associated DEP plant upgrades. P3 expressed that operational constraints were countered when “all operators use the same strategy and are on the same page.” P1 expressed that operators integrated communication from their automated system as part of their additional strategy, while P4 explained that an ongoing process of communication between experienced operators to counter proper control in disinfection processes was necessary. Factors in decision making were based on experience and trends identified in the spreadsheets created through the SCADA system.

#### ***Connection to the Conceptual Framework***

The Six Sigma DMAIC approach provides tools that are useful in decision making. Rexeisen et al. (2018) discussed the challenges and opportunities for Six Sigma initiatives that could be encouraged and supported. Harry et al. (2010) emphasized that different DMAIC tools helped further communication between team members and management. The formal or informal brainstorming sessions between WWTP managers

closely resemble focused brainstorming, a means of formulating new ideas, as seen in Harry et al. (2010). Brainstorming sessions may occur at any of the DMAIC phases.

### ***Connection to the Literature***

According to the literature, learning through the sharing and synthesis of knowledge during the execution of a specific practice, as seen in Antony et al. (2018), supports communication between persons or groups as it enables learning. For any phase of the Six Sigma DMAIC approach, preparation tools such as fishbone diagrams or cause-and-effect diagrams help in conducting brainstorming sessions. Brainstorming sessions help participants collect relevant data while identifying potential causes (Bhat et al., 2021).

The WWTPs' City Plan 2030 projected treatment, capacity, surplus, and inventory data are publicly available online. These organization-specific data helped in methodological triangulation from credible sources of data. The annual budget report data provided thick and rich context, supporting the findings and answering the research question. WWTP managers can communicate growing demands in wastewater flow trends documented within the annual budget report. Between 2010 and 2020, the WWTP managers experienced an upward trend in wastewater influent. Influent increased from 6.87 million gallons daily (MGD) to 7.33 MGD and is projected to increase by approximately 0.22 to 0.24 MGD every 5 years until 2030.

Additionally, the compared data between the years 2010 and 2020 annual budget reports helped to confirm the credibility and dependability of the context of increased wastewater disinfection demands discussed in the study's findings. The data shown are

specific to the population growth of the researched organizations' geographical location. The population increased by 4,917 people between the years 2010 and 2020. The future population count is projected to increase by approximately 2,000 residents. The latest fiscal year annual report indicated a \$7.5 million decrease or 14.5% decrease while operating costs increased by 3% or \$552,669. The 2021 annual budget showed a mere \$70,000 difference compared to the 2017 annual budget report. These data support the contextual wastewater demand, population growth, and budget decline findings within the study's literature review and use of peer-reviewed sources. Fusch et al. (2018) supported the use of methodological triangulation as an approach to mitigate bias and reach data saturation through multiple sources of data.

### **Applications to Professional Practice**

The findings and results of this study are beneficial to WWTP managers' use of strategy to lower costs in water disinfection processes. Barney (1991) argued that managers are indeed relevant to an organization's economic performance. Barney explained that managers are the valuable, rare, hard to imitate, and irreplaceable resource of an organization since managers or a managerial team are those who can understand and describe the economic performance potential of their organization is capable of being. Furthermore, in Six Sigma, as defined in Harry and Crawford (2005), a manager is a person with formal influence to exercise operational control over resources.

This research applies to WWTP utilities' use of strategy to lower costs in wastewater processes. The study findings revealed the following themes: (a) managers' role in lowering cost, (b) automation with continuous monitoring, (c) improvement with

control, and (d) communication. The managers who work at a WWTP utility shared their perspectives on using successful strategies to lower the cost of water disinfection processes. Other managers of water treatment utilities could use these strategies to improve the reduction of costs in water disinfection processes.

### **Implications for Social Change**

The findings of this study may contribute to positive social change by providing organization sustainability through enhanced employee use of strategy. Managers for WWTP utilities already meeting budget constraints may benefit in their use of approaches to reduce costs in water disinfection processes. Wastewater treatment plants are becoming increasingly important in North America, where the population grows steadily and demands more use of WWTP processes. In addition, the public requires healthy and safely treated water for personal and recreational use. Properly disinfected water is becoming a valuable and rare resource due to increased public demand and use. The study revealed strategies to lower costs in wastewater disinfection. The results of this study can benefit WWTP managers to implement successful strategies that may reduce water disinfection costs while facing budget constraints. Another benefit is the continued positive effects on the safety and health of the serviced communities and the surrounding environment.

### **Recommendations for Action**

Managers can apply strategies to increase the likeliness of cost-saving in WWTP disinfection processes. Recommendations for action may be helpful for managers of WWTP utilities to reduce resource use such as energy or chemicals that provide value to

these utilities' continued enhancement and sustainability. Recommendations are: (a) WWTP manager's consideration for the use of Six Sigma or Six Sigma-like strategy approaches (b) utility manager consideration for the use and application of a SCADA system or a similar automated system useful to the specific needs of the WWTP, and (c) utility manager focus on resource-based view to help lower costs in water disinfection.

### **Management Use of Six Sigma or Six-Sigma-Like Approaches**

Recognizing resources helps managers to reinforce improvement initiatives. Managers may use water technologies and smart water quality sensors to monitor their resources (ASCE, 2021). Wastewater utility managers may improve their use of strategy using Six Sigma or Six Sigma-like approaches through learning and development but require continued support from top management. Antony and Gupta (2019) argued that resources such as management must be involved in all phases, such as goal setting, resource allocation, process monitoring, and process control.

### **Adapting Automated Systems to Plant Needs**

Using more structured methods such as specific performance metrics helps the efficiency of processes (Ali et al., 2020). An organization's implementation of Six Sigma follows the concept of the resource-based view (Ali et al., 2020). Each phase of the DMAIC cycle requires decision-making activities dependent upon data from various functional units (Antony et al., 2018); the SCADA system provides such data. The problem-solving approach in DMAIC helps decision-makers rationalize as they improve organizational routines and processes (Antony et al., 2018).

### **Manager Focus on Resource-Based View**

Continuous focus is essential to the stabilization of process improvement. Management's resource-based view helps them consider the resources at hand and focus on selecting appropriate tools to address problems. Antony and Gupta (2019) argued that management's ineffective focus or lack of involvement on supervision of resources contributed to failure in process improvement. Managers should focus on each phase of organizational resource allocation, monitoring, and control, which can attribute to successful process improvement.

### **Recommendations for Further Research**

The underpinnings of this qualitative embedded single-case study aimed to explore strategies that WWTP managers use to lower costs in water disinfection processes. For this study, four WWTP managers from one wastewater utility were interviewed to provide perspectives on strategies for lowering costs in wastewater disinfection processes. A recommendation for an area of future research would be to use a qualitative or quantitative case study design in other geographic locations of the United States. Researchers can add to the body of knowledge by acquiring more utility-specific data on the use of strategy and approaches to lower costs in water disinfection processes. Future researchers could understand this WWTP phenomenon by using the quantitative study to examine relationships between the constructs of lowering cost in water disinfection using strategy proactively versus reactively. I recommend conducting similar research in different types of water disinfection industries. Similar research may help researchers further explore how managers can consider using various social media

platform tools to promote in the depth and breadth of applying strategy involving cost reduction in water disinfection processes.

### **Reflections**

This doctoral journey has been a positive experience as it has allowed me to contribute to original research within the field of this study. It has been a path of self-discovery and potential. As a novice researcher, I learned about grit, perseverance, and reflexivity while conducting the study. I reflected on the beginning of this doctoral journey when my bias was that some WWTP managers lacked strategies to lower the costs of disinfection processes. I have since then gained new perceptions and understanding from these data that helped answer the research question. The Walden University College of Management and Technology Doctor of Business Administration program challenged me in finally fulfilling a lifelong dream of completing a doctoral degree. I used reliable and defensible data to mitigate my biases while remaining reflexive to avoid my personal views or beliefs.

Additionally, I strictly adhered to the interview protocols and refrained from comments or verbal cues to ensure participants' responses were not influenced or prompted. From the findings of this study, WWTP managers may decide to implement and administer strategy approach programs on various media platforms to share successes and lessons learned in industry information. Very often, the journey was challenging but never impossible. Most importantly, I will continue serving and being of service to others in my field with this terminal degree. The doctoral journey has been one of my longest

and most challenging endeavors, and from it, I am more prepared to conduct further research and explore other business-related challenges.

During the pandemic, I was thankful for the technologies that helped overcome the challenges of conducting interviews and collecting data due to requirements for social distancing caused by the new and ongoing pandemic involving COVID 19 and its variants. The participants were professional, respectful, and cared to share their perspectives and knowledge, which made the interview process a pleasant and learning experience. The doctoral journey was a challenging experience that enabled me to improve my research and writing skills. At the conclusion of this research study, I understood the need for more exploration of successful WWTP strategies with a particular focus on those within the United States. There is a lack of current peer-reviewed or published research on how U.S.-based plant and utility managers can share their successes in the use of strategy to lower costs in wastewater disinfection processes.

### **Conclusion**

Wastewater treatment plant disinfection processes continue to increase in demand from a steady increase in population and a need to maintain water quality requirements. Florida's growing population equates to further water and wastewater infrastructure demands associated with the daily use and consumption of water. The increase in the amount of treated wastewater causes an increase in energy-intensive WWTP disinfection processes. The outcome of this study revealed the participants were successful in continued lowering of costs in water disinfection processes with the use of a resource-based view and Six Sigma DMAIC-like approaches. The main conclusion that can be

drawn from this case study are as follows: The human capital resources (WWTP managers) use and apply a continuous automated system with continuous employee monitoring to facilitate cost reduction in disinfection processes. Problem-solving should not be looked upon as a process but as an event (Snee & Hoerl, 2020). The use of a site-specific SCADA system helped employees hone into needed adjustments to resource use in water disinfection processes, but workers continued to communicate and focus on meeting or exceeding standards and regulations for the processes from start to finish.

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## Appendix A: Semistructured Interview Protocol

<b>Semistructured Interview Protocol</b>	
<b>Step</b>	<b>Description</b>
<b>Selecting Participants</b>	Researcher will make email or phone contact with human resources of the organization to obtain consent, and permission to approach participants. Organization's HR will provide participant email or contact information.
<b>Explaining the Research Study and Objectives</b>	Researcher will email a letter of introduction (Appendix B) to each potential participant.
<b>Informed Consent Form</b>	Researcher will email each participant and request a "I consent" reply once the participant chooses to participate.
<b>Setting Time and Place for Interview</b>	Researcher will agree with the participant on the date, time, and location of the interview.
<b>Thank Participants, Start Interview</b>	Researcher will ask interview open-ended questions (Appendix D)
<b>Recording the Interview</b>	Researcher will record each interview using a digital voice recorder as video recording is not permitted. Researcher will email and thank participants after the interview session.
<b>Transcribing the Interview</b>	Researcher will transcribe, code, and theme the interviews within 72 hours of the session.
<b>Member Checking</b>	Researcher will email or phone call each participant to ensure results findings are accurate (Appendix D).
<b>Final Study</b>	Researcher will offer interested participants a 1-2-page summary of the research findings by email.

## Appendix B: Introduction Letter

You are invited to participate in an interview session for my doctoral research study titled "Cost Saving Strategies for Municipal Wastewater Treatment Plant Managers." If you agree to participate in this study, you will be asked six open-ended questions during the interview. Member-checking will be conducted after the interview to seek clarification or additional information, which should last between 30 to 45 minutes. The purpose of this qualitative single case study is to determine the successful strategies WWTP managers use to lower the cost of water disinfection processes. Your in-depth responses to the interview questions would significantly contribute to my research findings. Once this study is approved by Walden University, and upon your request, you will be provided an electronic copy of my dissertation manuscript if you provided a valid email address. The interview session will be audio recorded. Data collected from the interview session will only be used for this study. Your identity, the organizations' identity, and your responses to the interview questions will remain confidential. If you are willing to participate in this study, please authorize the attached Informed Consent Form, and return it to me via email at [rosalie.rivera@waldenu.edu](mailto:rosalie.rivera@waldenu.edu) or by hand. After I receive the authorized form, I will contact you to schedule an interview. Please feel free to contact me by email at [rosalie.rivera@waldenu.edu](mailto:rosalie.rivera@waldenu.edu) if you have any questions or concerns about participating in this study.

All the best,

Rosalie Rivera, Doctoral Student, Walden University

Dr. Edgar A. Jordan, Committee Chair

## Appendix C: Interview Template

### **Opening**

Ms. /Mrs. /Mr. [volunteer/participant name]. I appreciate your decision to volunteer and participate in this interview. The purpose of this study is to explore how those who manage wastewater treatment plants successfully use strategy to lower cost in water disinfection processes. I would like to begin by asking questions about yourself, your wastewater management experience, and your involvement in implementing a cost savings framework in wastewater disinfection. All information shared in this interview is confidential. I will ensure your identity and the organization's identity remain confidential. At any time, you do not feel comfortable answering a question, you may request to skip it. Once I receive a consent form with your response of "I consent," I will contact you via email or phone to set up an interview that will last 45 to 60 minutes. I will be audio recording the interview and taking notes. Is this process all right with you? Do you have any questions for me or any concerns before we begin?

#### Appendix D: Interview Questions

Warm-up Question: What is your responsibility for lowering the cost of water disinfection processes?

1. How did you recognize a need to improve strategies in water disinfection processes and record those strategies?
2. What current strategies do you use to successfully reduce high energy consuming processes?
3. How have you determined the relative effectiveness of different strategies for lowering the cost of water disinfection processes?
4. What were the key barriers to implementing the successful strategies for lowering the cost of water disinfection processes?
5. How did you address the key barriers to implementing the successful strategies for lowering the cost of water disinfection processes?
6. What more can you tell me about the strategies for successfully lowering costs in water disinfection processes?

Appendix E: Training Module Certificate



Completion Date 03-Oct-2020  
Expiration Date N/A  
Record ID 38790726

This is to certify that:

**Rosalie Rivera**

Has completed the following CITI Program course:

**Student's**  
(Curriculum Group)  
**Doctoral Student Researchers**  
(Course Learner Group)  
**1 - Basic Course**  
(Stage)

Under requirements set by:

**Walden University**

Not valid for renewal of certification through CME.



Collaborative Institutional Training Initiative

Verify at [www.citiprogram.org/verify?w86a1c253-89dc-4695-9588-6972a332ee57-38790726](http://www.citiprogram.org/verify?w86a1c253-89dc-4695-9588-6972a332ee57-38790726)

## Appendix F: Email Request for Partner Organization Letter of Cooperation

Dear [Name]:

My name is Rosalie Rivera. I am a doctoral student at Walden University, pursuing a Doctor of Business Administration (DBA) degree. I am conducting a research study about wastewater treatment plant managers who use strategies to reduce cost in wastewater disinfection processes. The research collected from this study will be used to explore the strategies to reduce costs in wastewater disinfection processes.

To ensure participants are eligible to participate in this study, they must meet the following conditions:

- a) Be over 18 years old
- b) Have at minimum one month experience working in a wastewater treatment plant environment
- c) Have experience with use of strategies to reduce costs in wastewater disinfection processes

The requirement for participants is to meet with me for approximately 45-60 minutes via phone or at a location of your choice to answer various questions about their experiences with strategies to reduce costs in wastewater disinfection processes.

I assure you that participant identity and your organization's identity will be confidential and not be disclosed within the research study. As a participant in my research study, I will provide individual participants a summary of the research findings upon completion and publication. The research study may be useful and provide information that may be incorporated into your business practices and operations to reduce costs in wastewater disinfection processes.

I would like to schedule a date and time to speak to you by phone, in person, or by video conference to explain the research study or to answer questions that you may have about your potential participation in my study.

Please provide me with your availability by replying to this email. If you are interested in participating in this study, and have taken time to consider participating, please contact me at [rosalie.rivera@waldenu.edu](mailto:rosalie.rivera@waldenu.edu). If you are not interested in participating, please let me know.

I look forward to hearing from you.

Thank you,  
Rosalie Rivera  
Walden University Doctorate (DBA) Candidate

## Appendix G: Letter of Cooperation From Participant Organization



January 6, 2022  
 Attention Walden University IRB:

Please note that Ms. Rosalie Rivera, a Walden University doctoral candidate, has the permission of the City of [redacted] to conduct research at our Regional Wastewater Reclamation Facility for her study, "Cost Saving Strategies for Municipal Wastewater Treatment Plant Managers". We understand Ms. Rivera's plan is to:

- Contact only volunteers who have agreed to become participants after they have provided an "I consent" response on the informed consent form. From the consent form we understand that each participant will participate in an individual, confidential, and audio recorded interview through either a face-to-face meeting or using the zoom platform (45-60 minutes).
- We understand that selected participants will take part in the interview and will be asked to share company documents or policies related to how those who manage wastewater treatment plants successfully use strategy to lower costs in water disinfection processes.
- It is understood that participants will partake in a member-checking session to verify the answers from your interview (30-45 minutes).

Our human resources office will provide de-identified information regarding employee availability for use in her research. Ms. Rivera's research activities will be finished by January 30, 2022.

Ms. Rivera has agreed not to enter any of our facilities unless invited to do so. We expect the interview process will not interfere with the flow of employee scheduled work tasks. Employees will be allowed time from their work duties to complete the individual interviews. Ms. Rivera has provided to my office a copy of the Walden University IRB-approval, which we understand necessitates this letter of cooperation. It is understood that participants meeting the preestablished criteria will be emailed, and those agreeing to participate will simply send a response of "I consent" at the bottom of the informed consent to [rosalie.rivera@waldenu.edu](mailto:rosalie.rivera@waldenu.edu). It is our understanding that Ms. Rivera will provide each participant individual research results and findings once her study is finalized and approved.

If there are any questions, please contact my office.

Signed,

[redacted signature]

[redacted name]

City of [redacted]  
 Division Director Water, Wastewater & Reuse