



Resource Guide to Effective Utility Management and Lean

*Improving Performance and Addressing Key
Management Priorities at Water-Sector Utilities*

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Disclaimer

Appendix C of this Resource Guide contains case studies of several utilities' experiences implementing EUM and Lean; these case studies have been thoroughly reviewed and approved by the utilities. Representatives of EPA have reviewed and approved this document, but this does not necessarily constitute EPA endorsement of the observations or recommendations presented in Appendix C.



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Preface

Water and wastewater utilities are critical to the environmental, economic, and social well being of our nation's communities, as they work to ensure that the public continues to enjoy the benefits of clean and safe water. These utilities are facing unprecedented challenges, many of which have been exacerbated by the economic downturn, including:

- Aging infrastructure that needs more intensive repair and replacement
- Continuing regulatory challenges, including the need to often balance priorities among multiple compliance endpoints
- Workforce challenges, including an aging workforce and difficulties in recruiting and retaining qualified staff
- Uncertainty about future federal funding
- Competing local priorities and the dwindling resource base in many communities.

To help address these challenges, utilities have made a concerted effort over the past several years to improve the management, overall efficiency, and sustainability of their operations. In this regard, there are numerous systems, tools, and programs that can help utilities improve their efficiency and performance in many areas of operations. However, utility managers often express concern about the lack of a common utility management *framework* that can provide utilities of all sizes with a series of outcomes to pursue that will help them improve all aspects of their operations, while still providing the flexibility for them to use a variety of existing management tools and techniques to achieve their goals.

In 2007, based on recommendations from leading water and wastewater utility managers, EPA and six water-sector associations signed a historic agreement to promote effective utility management (EUM) based on a series of Attributes of Effectively Managed Utilities and Keys to Management Success. These Attributes describe the kinds of outcomes that all utilities, regardless of size, should strive for to manage their operations and infrastructure most effectively, while the Keys provide the organizational structure and systems to achieve successful outcomes. In 2008, these same collaborating organizations published



the *Effective Utility Management Primer for Water and Wastewater Utilities*, which is available at: www.watereum.org. The EUM Primer provides utilities with a simple step-by-step process to assess their operations based on the EUM Attributes and chart a course for making systematic changes to improve and measure performance based on utility priorities. The EUM Primer has been well accepted and provides a solid foundation for utilities to assess and improve the management of their operations and infrastructure. EUM—and the Attributes and Keys to Management Success it encompasses—are critical to the sustainability of water-sector utilities.

Effective planning is also critical to the effective management of a utility and its infrastructure. In recognition of this, in February 2012, the Office of Water at EPA published *Planning for Sustainability: A Handbook for Water and Wastewater Utilities*. The Handbook provides information about ways in which utilities can build sustainability considerations and other techniques into their planning processes to help them make the right infrastructure choices for their communities and ensure that this infrastructure is effectively managed over its full life cycle. Copies of the Handbook are available at: <http://water.epa.gov/infrastructure/sustain/upload/EPA-s-Planning-for-Sustainability-Handbook.pdf>.

While the EUM Attributes focus on outcomes water-sector utilities should strive to achieve, there also is a need to demonstrate how other well-accepted tools can help utilities, improve efficiency, reduce waste in their operations, and promote utility sustainability. One set of tools involves the use of Lean techniques. Lean involves a powerful set of specific practices that can help utilities achieve the outcomes embodied in the EUM Attributes. Accordingly, EPA has developed this *Resource Guide to Effective Utility Management and Lean* based on input and examples from several utilities involved in both EUM and Lean. In simple terms, the EUM Attributes express *what* utilities should seek to achieve and Lean tools outline *how* to work towards those attributes, or outcomes. This Resource Guide is intended to be a bridging document that explains how these two important and complementary approaches can be used by utilities to reduce waste and improve overall efficiency and effectiveness.





Executive Summary

This *Resource Guide to Effective Utility Management and Lean* explains how water-sector utilities can use these two important and complementary approaches to reduce waste throughout their operations, while continuing to improve utility products and services for customers.

- **Effective Utility Management (EUM)** is a framework that helps water-sector utilities assess their strengths and weaknesses, set priorities, and identify *what outcomes* they want to achieve. The EUM Framework consists of 10 Attributes of Effectively Managed Utilities, Five Keys to Management Success, and an EUM Self-Assessment Tool.
- **Lean** is a business improvement approach focused on eliminating non-value added activity or “waste” using practical, implementation-based methods; it is often combined with **Six Sigma**, a set of statistical tools designed to eliminate defects and variation. Lean and Six Sigma provide the “*how to*” tools, helping utilities achieve the outcomes.

Benefits of EUM and Lean

There are three key reasons for using EUM and Lean together:

1. **Address key management priorities:** EUM is a simple and compelling way for water-sector utilities to identify improvement priorities based on the EUM Attributes; this framework provides a roadmap for success, while Lean provides structured tools for implementation.
2. **Deliver financial and operational results, improve customer service, and reduce risk:** Water-sector utilities have used Lean and Six Sigma to save millions of dollars, improve product quality, enhance customer service, improve morale, and reduce environmental and safety risks.
3. **Enhance continual improvement efforts:** Lean offers a range of powerful, yet simple methods for engaging employees in continual improvement efforts—a key foundation for EUM success.



Water-Sector Utility EUM and Lean Experience

Water-sector utilities have applied Lean and Six Sigma methods to all types of organizational processes, ranging from administrative processes like budgeting to core operational processes like treatment plant operations and sewer system repairs. Highlights of utility EUM and Lean experience include:

- **Charleston Water System** in South Carolina used Lean and Six Sigma methods to enhance financial viability, operational optimization, and water resource adequacy in a wastewater collection inflow and infiltration project that saved \$1.3 million per year in operations and maintenance costs and increased treatment capacity by 2.62 million gallons per day.
- **Clean Water Services** in Oregon invested in Lean and Six Sigma because it needed proven, data-driven improvement tools to advance its resource-recovery vision. The utility's Bio-P project is expected to enhance operational optimization, financial viability, and community sustainability by saving \$250,000 in chemical costs per year and increasing struvite recovery by 20 percent.
- The **City of Palm Bay Utilities Department** in Florida improved financial viability and operational optimization using Six Sigma techniques to facilitate a 40 percent reduction in energy costs at its water and wastewater treatment plants from the base year 2008 projected through 2012.
- The **City of Pompano Beach Utilities** in Florida used Six Sigma to study the low participation in its residential water reuse connections program. Using Six Sigma, the utility developed a new reuse program, improving water resource adequacy and community sustainability by increasing use of reuse water, saving a projected 92.4 million gallons of water between 2011 and 2013.

Lean Methods and Effective Utility Management Connections

Although Lean originated in manufacturing, it is now used across a wide variety of industries. Lean and Six Sigma methods that are highly relevant to water-sector utilities include the following.

Method	Definition	Connection to EUM Attributes
Standard Work	Documentation of the best way to perform a task, often incorporating pictures to make it easy to follow	Product Quality, Operational Optimization, Customer Satisfaction, Operational Resiliency, and Infrastructure Stability
5S (or 5S+Safety)	A 5-step process to develop and maintain a clean, neat, safe, and orderly work area; a sixth "S" can be added for Safety	Operational Resiliency, Operational Optimization, and Employee and Leadership Development
Lean Event (e.g., kaizen event)	A 2-5 day period when a cross-functional team of employees analyzes and improves a process	Operational Optimization, Customer Satisfaction, and Financial Viability
Total Productive Maintenance	A method that engages all workers in maximizing the effectiveness of equipment, with the goal of preventing breakdowns, accidents, and other losses	Infrastructure Stability and Operational Resiliency
Six Sigma	An improvement approach and set of statistical tools designed to eliminate defects and variation	Product Quality, Operational Optimization, Financial Viability, and Customer Satisfaction



Lean tools, as well as the EUM Self Assessment, can be used by utilities of all types and sizes, and scaled depending on the project size. For example, water and wastewater utilities have used Lean in projects ranging from organizing workstations and improving the efficiency of inventory and supply processes, to optimizing treatment plant processes. Lean relies on simple concepts, low-cost solutions, and employee creativity to yield large performance gains without significant resource investments.

Steps for Getting Started with EUM and Lean

There are five key steps water-sector utilities can take to start improving utility performance and management with EUM and Lean:

1. Conduct an EUM Self Assessment to determine improvement priorities.
2. Engage leadership.
3. Learn more about Lean.
4. Find technical assistance.
5. Conduct EUM and Lean improvement projects.

EUM and Lean implementation typically goes through phases—ranging from learning about Lean tools and conducting small ad hoc projects to a transformative phase where EUM and Lean become “the way we work,” and continual improvement is everyone’s job. Keys to long-term success include leadership; strategic business planning; organizational approaches that integrate process-improvement methods, communications, and training; measurement; and a continual improvement management framework. Lean, in particular, enhances organizational approaches, performance measurement, and continual improvement systems. This facilitates a higher level of effectiveness, provides objectivity and transparency to decision-making, and supports overall utility sustainability.

The process of becoming a lean and effectively managed utility offers opportunities for near-term, low-intensity gains with the prospect for longer-term, sustained improvements. This Resource Guide is designed to help water-sector utilities learn more about EUM and Lean and to equip them to get started on an improvement journey of their own.



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Chapter 1: Why Lean is Important for Water-Sector Effective Utility Management

Purpose of This Resource Guide

In support of effective utility management (EUM), more and more water-sector utilities are successfully using an improvement approach and collection of powerful tools known as “Lean” or “Lean Six Sigma” to improve their operations and management. “Lean” is an improvement approach focused on eliminating non-value added activity or waste, while “Six Sigma” is an improvement approach often combined with Lean that uses statistical methods to improve quality and reduce variation (see box below). Lean and Six Sigma methods have enabled water-sector utilities to save millions of dollars, avoid customer rate increases, improve product quality, enhance customer service, reduce energy costs and environmental pollution, and improve employee morale—all of which are important outcomes consistent with EUM Attributes.

IN THIS CHAPTER

- Purpose of this Resource Guide
- Benefits of using Lean to achieve EUM outcomes
- Organization of this Resource Guide

EUM provides a roadmap for utility improvement efforts, while Lean provides tools to help achieve the EUM Attributes. EPA believes that EUM and Lean are highly complementary. This *Resource Guide* is intended to be a bridging document that shows water and wastewater utility managers how EUM and Lean can work together to deliver better results. It introduces EUM and Lean concepts and methods, provides guidance on how to get started with EUM and Lean improvement efforts, and describes other resources for utilities that would like to learn more. (**Note:** Unless we refer to particular methods, we use the term “Lean” in this Resource Guide to refer generically to both Lean and Six Sigma approaches.)



Is It Lean? Is It Six Sigma? Or Lean Six Sigma?

- “**Lean**” is an improvement approach focused on eliminating waste or non-value added activity. It was developed by Toyota based on the principles of Henry Ford. Many Lean methods are simple, visual, and can be implemented quickly.
- “**Six Sigma**” is an improvement approach focused on improving quality by eliminating variation. It was developed by Motorola and popularized by GE. Six Sigma uses statistical methods and in general requires more training than Lean.
- “**Lean Six Sigma**” refers to a combination of Lean and Six Sigma. Some organizations choose to use either Lean or Six Sigma as an overarching initiative, even if they use both types of tools. Whatever it is called—Lean, Six Sigma, Lean Six Sigma, business process improvement, or something else—the important thing is to pick the right tool for the problem at hand.

Benefits of Using Lean to Achieve Effective Utility Management Outcomes

As a utility manager, you are continually exposed to a myriad of management systems, improvement initiatives, and tools. It can be difficult to sort through what will be most useful for your utility and what will work over the long term. EUM is a proven framework, and Lean provides established tools that can work together to improve utility performance and management. There are three key reasons to use Lean and EUM together:

- Address key management priorities
- Deliver financial and operational results, improve customer service, and reduce risks
- Enhance continual improvement efforts

Address Key Management Priorities

As described in the Preface, EUM is a simple and compelling way for water-sector utilities to identify priorities for their improvement efforts based on a series of 10 Attributes (or outcomes) and five Keys to Management Success. The *Effective Utility Management Primer for Water and Wastewater Utilities* provides a framework to help utilities assess their performance based on the Attributes and set

Palm Bay, Florida: Lean and Six Sigma and Effective Utility Management

- Palm Bay Utilities views effective utility management and the utility’s environmental management system (EMS) as key to its success.
- After prioritizing its improvement efforts, Palm Bay used Lean and Six Sigma to reduce energy costs in its water and wastewater treatment plant operations by 34 percent from 2008 to 2011.
- Palm Bay engages employees in a process improvement program that uses Lean methods like 5S+S (5S plus Safety); the program had 70 percent participation and 127 process improvements in 18 months.
- Collectively, the utility’s improvement efforts saved \$1.15 million in FY 2011, and helped the utility to improve its municipal bond ratings in 2009 (Standard and Poor’s) and 2010 (Moody’s).

Source: Dan Roberts, “Environmental management Systems (EMSs): A Key to Financial Viability, Environmental Excellence – and Worthy of Regulatory Incentives,” PEER Center website, www.peercenter.net/ewebeditpro/items/O73F24974.pdf.



priorities to guide utility improvement efforts.¹ An increasing number of water-sector utilities are embracing EUM, with many utilities successfully using the Primer and its self-assessment tool to set priorities and enhance performance.²

Lean supports the EUM Attributes with a set of practical tools for process and performance improvement—it is, essentially, an effective low-cost implementation tool for addressing key management priorities based on the attributes.

Deliver Financial and Operational Results, Improve Customer Service, and Reduce Risks

Lean uses a variety of tools—many of them simple and visual—to deliver improvements within the context of the EUM Attributes. Private and public organizations from diverse industries have had unparalleled success using these tools to reduce costs, increase process speed, decrease errors, and enhance customer service. Water and wastewater utilities have derived impressive operational and administrative improvements from Lean, as the examples on the next page illustrate.

“The Utilities Department’s establishment of a certified ISO Environmental Management System coupled with the use of Lean and Six Sigma tools has led to the utilities’ improved and maintained bond ratings even in a severe economic downturn.”

– Dan Roberts, Director, Utilities Department, City of Palm Bay, Florida

Lean works by engaging employees in process improvement, focusing on performance metrics, emphasizing practical action, and, above all else, eliminating non-value added activity or “waste” from processes wherever possible. These wastes include wasted time, wasted resources, and unnecessary complexity. Utilities implement Lean to:

- Achieve better financial and operational results
- Enhance customer service
- Produce quality products and services
- Optimize operational and administrative processes
- Reduce risks and errors
- Improve staff morale and engage employees

¹ The Effective Utility Management Primer and other resources are available at www.watereum.org.

² For example, see the Effective Utility Management case studies available at www.watereum.org/resources.



Operational Improvements at Water and Wastewater Utilities from Lean and Six Sigma

JEA of Northeast Florida: JEA—an electric, water, and wastewater utility serving five counties in Northeast Florida—conducted over 580 process improvement projects through its Green Lean Six Sigma Initiative between 2000 and 2010. Highlights of JEA’s Lean and Six Sigma results include:

- Improved financial viability and customer satisfaction by saving \$579 million over 10 years and avoiding rate increases of \$20 per month on average.
- Improved product quality and community sustainability by reducing nitrogen discharges to the St. John’s River by 74 tons per year, allowing the utility to meet its regulatory compliance deadline without investing in additional treatment technology.
- Improved product quality and optimized operations by reducing sanitary sewer overflows from 43 per month in 2002 to 2.5 per month in 2009–10.
- Achieved operational optimization and operational resiliency by reducing recordable safety violations from maintenance trucks to zero for over four years.

Austin Water Utility, Texas: The Austin Water Utility has used Lean to improve its operations since 2009. The utility has conducted several Lean process improvement events as well as encouraged employees to eliminate inefficiencies and wastes through immediate actions, which the utility calls “fix-it-here/fix-it-now” improvements. Highlights of Austin Water Utility’s Lean results include:

- Improved financial viability by saving over \$2 million from Lean events and activities.
- Improved operational optimization and customer satisfaction by reducing time to respond to customer requests for water main repairs by 10 percent.
- Improved operational optimization and customer satisfaction by minimizing time spent repairing water mains by 25 percent, with an average repair time of 5.4 hours.

Renewable Water Resources (ReWa), South Carolina: ReWa used Lean methods, including visual dashboards of key performance indicators, to make improvements in many areas of its operations, including pretreatment compliance, biosolids management, methane-fueled combined heat and power generation, and budgeting processes.

- These efforts have improved financial viability and aided operational optimization by saving as much as \$232,000 per year in solids management and chemical usage, saving over 200 hours per year in planning and travel time, improving preventative maintenance, and providing more accurate data for budgeting and construction projects, among other benefits.

Sources: U.S. EPA, “Lean Six Sigma and Environment Case Study: JEA,” www.epa.gov/lean/studies/jea.pdf; Austin Water Utilities webinar on ASQ Government Division website, http://asq.org/gov/0002C2/video/division-government/2009-06-26_11-00-why_lean_succeeds_both_in_private_and_public_sectors.html?shl=100609; Randy Boyette, Chuck Scholpp, and Gabi Miles, “Enabling Lean Water Operations: Transforming Data into Information is Critical for Driving Efficiency for Renewable Water Resources (ReWa),” Paper presented at Utility Management Conference, 31 January 2012.

EUM and Lean offers a powerful way for water-sector utilities to take their improvement programs to the next level, face the ever-increasing resource, infrastructure, and regulatory challenges, and, in the words of best-selling business author Jim Collins, move from “good to great.”



Enhance Continual Improvement Efforts

Lean employs a rapid “Plan-Do-Check-Act” management framework that is identical to one of the Keys to Management Success in the EUM Primer (Continual Improvement Management Framework). Lean can be a powerful vehicle for engaging employees.

For example, it is typically implemented in “events” lasting 2-5 days where cross-functional teams analyze a process, identify solutions, and make immediate process changes. These events empower employees to make changes that will make their jobs easier and save the utility time and resources. In this way, Lean can be very effective in supporting other utility management improvement efforts, including environmental, safety, and quality management systems.

By emphasizing simple concepts such as eliminating waste, visual controls, and teamwork, Lean makes it easy for all employees to be involved in continual improvement efforts. One of the key benefits of Lean to employees is that it makes their jobs easier—it eliminates the non-value-added parts of processes (waiting time, unnecessary process steps, rework, duplicate forms, time spent looking for supplies or parts, etc.) and then gives employees more time to focus on their core responsibilities and priorities. Several utilities have integrated Lean methods into their continual improvement efforts to achieve impressive results. For example, employee teams at **JEA** in Florida and **Irving, Texas Water Utilities** used Lean events and the five-step 5S method to improve the layout and organization of maintenance and repair trucks. For both utilities, this improved customer service by increasing work crew efficiency. At JEA, the improvements reduced water maintenance crew ticket completion time by an average of 30 percent, and allowed 479 additional jobs to be completed per year.³ (See box for more on the City of Irving’s efforts.)

Lean and EUM do not need to be complicated, and they can be implemented without a lot of staff or resources. Lean can be as simple as getting a team together to identify and eliminate the waste in a process or work area, while a group of managers can conduct an EUM self-assessment in a single meeting to set improvement priorities. Both EUM and Lean can be used by utilities of all sizes and can be tailored to the specific needs of your utility. Lean methods apply to all types of processes—from administrative processes like customer billing to core water and wastewater utility operational processes including treatment plant operations and water and sewer system repairs.

What Is Lean Like in Practice? (Irving, Texas Truck Maintenance Project)

- Irving, Texas Water Utilities used a Lean event and methods such as 5S to reconfigure the layout of maintenance trucks. (Watch a video at: www.sixthsigma.com/2009/09/irving-texas-utility-uses-lean-six.htm)
- The truck upgrades are estimated to save 45 minutes in administrative work and 1.5 hours per work order per day.
- Overall, the City of Irving has saved \$30 million from Lean and Six Sigma since 2006.

Sources: See article linked above; City savings noted in this 2012 American City and County podcast: <http://americacityandcounty.com/administration/lean-six-sigma>

³ A case study of JEA’s Lean and Six Sigma efforts is available on EPA’s website at: www.epa.gov/lean/studies/jea.pdf.



Organization of This Resource Guide

The remainder of this Resource Guide is organized as follows.

- **Chapter 2** presents overview information about EUM, Lean, and the connections between Lean and EUM.
- **Chapter 3** describes how Lean works by profiling Lean methods and how they relate to water-sector utilities.
- **Chapter 4** provides guidance on how utilities should get started with improving their performance with Lean and EUM.
- **Appendices** include a glossary, annotated list of resources, and additional case studies.

“Lean is the set of tools that every manager needs to achieve operational excellence and to stimulate innovation in their organizations. It is a pragmatic approach to achieving continual improvement.”

– Diane Taniguchi-Dennis, Deputy General Manager, Clean Water Services, Oregon





Chapter 2: Overview of Lean and Effective Utility Management

What Is Effective Utility Management?

As mentioned earlier, EUM is a framework developed by EPA and six national water-sector associations that helps utilities to assess their operations, set priorities, and chart a path for improving their performance. EUM for water-sector utilities improves utility products and services, increases community support, and ensures a strong and viable utility into the future. The *Effective Utility Management Primer for Water and Wastewater Utilities* has three main components:⁴

- **Ten Attributes of Effectively Managed Water Utilities (EUM Attributes):** The EUM Attributes describe outcomes all utilities should strive to achieve, provide a clear set of reference points, and are intended to help utilities maintain a balanced focus on important operational areas.
- **Keys to Management Success:** The five Keys to Management Success are proven approaches to help utilities maximize their resources and improve performance.
- **Where-to-Begin Self-Assessment Tool:** This self-assessment tool is a step-by-step utility-tailored guide to help utility

IN THIS CHAPTER

- What is effective utility management?
- What is Lean?
- Connections between Lean and effective utility management

Ten Attributes of Effectively Managed Water-sector Utilities

1. Product Quality
2. Customer Satisfaction
3. Employee and Leadership Development
4. Operational Optimization
5. Financial Viability
6. Infrastructure Viability
7. Operational Resiliency
8. Community Sustainability
9. Water Resource Adequacy
10. Stakeholder Understanding and Support

⁴ The Effective Utility Management Primer and other resources are available on the Water EUM website, www.watereum.org.



managers assess their performance across the EUM Attributes and identify where to begin improvement efforts.

Many water-sector utilities have found that the Primer makes a significant contribution to their improvement efforts and serves as benchmarking reference point. The EUM framework allows utilities to develop a clear understanding of their strengths, identify opportunities for improvement, and balance between internal and external priorities. Many utilities have incorporated the EUM Attributes into their strategic-planning efforts or used them to initiate a strategic-planning process. **Columbus Water Works** in Georgia, for example, used the Primer as a framework for workshops to review its long-term strategic plan. **Gwinnett County Utilities** in Georgia used the Primer to review its priorities and incorporated the 10 attributes into the countywide balanced scorecard process-improvement tool. For more information, resources, and case studies on EUM, see the *Water EUM: Effective Utility Management* website (www.watereum.org).

What Is Lean?

Lean refers to an improvement approach and set of methods that seek to eliminate non-value-added activity or “waste.” Waste in this context refers to any inefficiency in resource use and deployment (often the mnemonic “DOWNTIME” is used to identify Lean wastes; see table below). While Lean methods emerged in a manufacturing context, they are designed for use in a wide variety of contexts and have now been widely embraced by numerous sectors, including water-sector utilities. For example, water-sector utilities have used Lean tools to streamline internal human resource processes, organize and load repair trucks more efficiently, and reduce variation and optimize the process for biological excess phosphorus removal.

Metropolitan Sewer District of Greater Cincinnati, Ohio

- The Cincinnati MSD formed cross-functional, interdivisional teams to analyze its financial processes using Lean.
- The utility developed better work methods; eliminated redundant payments, paperwork, and approvals; and, as a result, reduced processing time (touch time) by 26 percent and total lead time by 38 percent.
- Permit and sampling fees paid by industrial wastewater users was also reduced from five payments a year to one—freeing up millions of dollars in increased cash flow and greatly reducing the administrative burden.

Source: TechSolve Case Study, www.techsolve.org.



Table 1: Process Wastes Eliminated by Lean

Waste	Examples
Defects	Errors, mistakes, and rework (e.g., change orders, billing errors)
Overproduction	Processing too soon or too much (e.g., multiple forms with same information, processing orders ahead)
Waiting	Employees or customers waiting (e.g., customers waiting to be served, system or equipment downtime)
Non-utilized or under-utilized resources/talent	Employees not leveraged to their own potential (e.g., staff not cross trained, unused employee suggestions)
Transportation	Movement of items more than required (e.g., multiple document handoffs, inefficient layout of collection and distribution systems)
Inventory	Holding more inventory (chemicals, office supplies, email, etc.) than required
Motion	Movement of people or machinery that does not add value (e.g., wasted time & motion trying to find tools)
Excess Processing	Doing more “work” or processing than is required (e.g., data re-entry, multiple approvals, cumbersome processes, unused reports)

Lean is implemented in short “bursts” of activity (e.g., 2-5 day events) and emphasizes actions that can take place and show results relatively quickly.⁵ By eliminating wasted time and resources, Lean allows utilities to redirect efforts to higher-priority activities related to their core mission. In many ways, Lean is “common sense uncommonly applied.” Key Lean principles include:

- Focus on the customer
- Reduce the complexity of processes
- Use metrics and visual controls to provide rapid feedback to improve real-time decision-making
- Involve employees in continual improvement and problem-solving activities
- Use a whole-systems perspective that seeks to optimize processes across multiple goals.

“Lean forces you in a deliberate and logical way to evaluate a process. You have to walk through step-by-step and evaluate areas that are wasteful and refine them. Lean shows you how to do things better, more quickly, and more efficiently.”

– Gwendolyn Ruff, Vice President, Strategic Planning and Employee Services, Columbus Water Works, Georgia

⁵ Sometimes Lean events are called kaizen “blitz” events for this reason; *kaizen* refers to continual improvement.



Lean and “Jargon”

Within the process-improvement world, it is easy to get lost in terminology. There are a myriad of tools, philosophies, and terms, and it can be difficult to track which are useful and which are just the latest “flavor of the month.” However, Lean does not need to be complicated. Lean tools are just structured approaches for simplifying processes and reducing wastes. When you hear of an organization or agency being “leaned,” what it is really doing is becoming more efficient. Once leaned, an organization can focus its time, resources, and staff on its most important priorities.

Connections Between Lean and Effective Utility Management

The EUM Attributes help water-sector utilities assess their operations and identify *what outcomes* they want to achieve. Lean methods can provide the *how to help utilities achieve the outcomes*. Many water-sector utilities have found that Lean is a way for them to take their internal strategies to a new level. For example, the EUM Attributes can be used as a benchmark to ensure that utilities strategies are on task with priorities. Lean can help a utility stay focused, quantify improvements, and become more efficient. The table below illustrates connections between the EUM Attributes and Lean methods.

Table 2: Effective Utility Management Attributes and Lean Connections

Effective Utility Management Attributes	Lean Connections
<p>Product Quality</p> <ul style="list-style-type: none"> • Complies with regulatory and reliability requirements. • Consistent with customer, public health, and ecological needs. 	<ul style="list-style-type: none"> • Lean methods reduce errors and rework in processes, thereby improving product quality and customer service. • Lean also supports improvements in product quality and environmental outcomes through root-cause analysis.
<p>Customer Satisfaction</p> <ul style="list-style-type: none"> • Provides reliable, responsive, and affordable services. • Receives timely customer feedback. • Responsive to customer needs and emergencies. 	<ul style="list-style-type: none"> • Lean can help identify ways to reduce inefficiencies and allow workers to better serve customers. • Lean efforts can help identify and implement ways to decrease time to perform utility services (e.g., service calls) and reduce costs that affect customer rates.
<p>Employee and Leadership Development</p> <ul style="list-style-type: none"> • Recruits and retains competent workforce. • Collaborative organization dedicated to continual learning and improvement. • Employee institutional knowledge retained and improved. • Opportunities for professional and leadership development. • Integrated and well-coordinated senior leadership team. 	<ul style="list-style-type: none"> • Lean methods encourage the engagement of all levels of employees in Lean events and waste-elimination activities. Training is also integrated into Lean methods, such as training on the first day of Lean events. • Lean focuses heavily on developing the problem-solving and leadership capacity of its employees. • Lean tools such as policy deployment can support strategic planning by linking organizational objectives with employee performance metrics and job responsibilities.



Effective Utility Management Attributes	Lean Connections
<p>Operational Optimization</p> <ul style="list-style-type: none"> • Ongoing performance improvements. • Minimizes resource use and loss from day-to-day operations. • Awareness and timely adoption of operational and technology improvements. 	<ul style="list-style-type: none"> • Lean has various tools for identifying sources of variation and inefficiency in the use of resources and time and implementation tools for optimizing performance. • The tools range in sophistication, but many are simple, visual, and can be implemented across utilities on many types of processes (administrative, maintenance, utility services, production and treatment processes, etc.).
<p>Financial Viability</p> <ul style="list-style-type: none"> • Understands full life-cycle cost of utility. • Effective balance between long-term debt, asset values, operations and maintenance expenditures, and operating revenues. • Predictable and adequate rates. 	<ul style="list-style-type: none"> • One of the most frequently cited benefits achieved from Lean events is cost savings. • Cost savings and avoidance are realized from process changes allowing utilities to avoid investing in costly new controls and increasing machinery and process efficiency.
<p>Infrastructure Stability</p> <ul style="list-style-type: none"> • Understands the condition and costs associated with critical infrastructure assets. • Maintains and enhances assets over the long-term at the lowest possible life-cycle cost and acceptable risk. • Repair efforts are coordinated within the community to minimize disruptions. 	<ul style="list-style-type: none"> • Lean methods can help utilities increase the capacity of existing systems, thereby reducing the pressure or need for additional infrastructure investments. • Lean tools help operators understand the operational and maintenance performance, capacity, and costs of infrastructure assets. This enables the optimization of existing capacity (and in this way can be a strong tool in support of utility asset management programs).
<p>Operational Resiliency</p> <ul style="list-style-type: none"> • Staff work together to anticipate, mitigate, and avoid problems. • Proactively establishes tolerance levels and effectively manages risks (including legal, regulatory, financial, environmental, safety, security, and natural disaster-related). 	<ul style="list-style-type: none"> • Lean supports a neat, orderly workplace that minimizes safety hazards, compliance problems, and risks. • Lean establishes and advances a culture of pro-actively identifying and addressing potential safety problems. • Lean promotes increased efficiency and reduction of waste through a variety of methods, including Lean events, 5S, standard work, and visual controls.
<p>Community Sustainability</p> <ul style="list-style-type: none"> • Attentive to impacts on community and watershed health and welfare. • Operations enhance natural environment. • Efficiently use water and energy resources; promote economic vitality; and engender overall community improvement. • Maintain and enhance ecological and community sustainability including pollution prevention, watershed, and source water protection. 	<ul style="list-style-type: none"> • Community sustainability encompasses a wide range of activities, all of which Lean can address directly or are often experienced as ancillary benefits to a Lean event. • Lean can help utilities develop tools to eliminate non-value added activities and allow utilities to focus on “mission critical” work. • Lean can also promote efficient use of water, chemicals, and energy by reducing over-processing and other wastes. • In tandem with activities to promote financial viability, utilities can use Lean methods to address the needs of specific customer groups, such as disadvantaged households.



Effective Utility Management Attributes	Lean Connections
<p>Water Resource Adequacy</p> <ul style="list-style-type: none"> • Ensures water availability through long-term resource supply and demand analysis, conservation, and public education. • Manages operations to provide for long-term aquifer and surface water sustainability and replenishment. 	<ul style="list-style-type: none"> • Lean methods can help utilities conduct process-optimization exercises that either focus on conservation or include conservation as an ancillary benefit that comes with increased efficiency and reduction of waste.
<p>Stakeholder Understanding and Support</p> <ul style="list-style-type: none"> • Engenders understanding and support from oversight bodies, community and watershed interests, and regulatory bodies for service levels, rate structures, operating budgets, capital improvement programs, and risk management decisions. • Actively involves stakeholders in the decisions that will affect them. 	<ul style="list-style-type: none"> • Lean is focused on meeting customer needs, and often involves customers and/or stakeholders in Lean events (e.g., Lean events often include up to a third of participants from outside the process or organization). • Involving those who are affected by a process in Lean efforts can provide a valuable perspective and engender greater understanding and support.

With EUM as the framework for charting improvement priorities, water-sector utilities can use practical Lean implementation tools to achieve the goals of the EUM Attributes. The next chapter discusses a range of specific Lean tools and how they relate to water-sector utilities.





Chapter 3: How Lean Works: Lean and Six Sigma Methods, Utility Applications, and Effective Utility Management

Introduction to Lean and Six Sigma Methods

Lean provides proven, implementation-based methods for making significant operational improvements at utilities and engaging employees in continual improvement efforts. The EUM Attributes and a utility's strategic plan sets the direction and goals for utility improvement efforts, while Lean and Six Sigma methods offer "how to" techniques to make implementation happen and deliver results. These methods can make it easier for employees to:

- Identify waste and inefficiency
- Determine the root causes of problems
- Make changes that improve product and service quality, reduce time and costs, and enhance customer satisfaction

IN THIS CHAPTER

- Introduction to Lean and Six Sigma methods
- Key Lean and Six Sigma methods relevant to water-sector utilities
 1. Standard work
 2. 5S (or 5S+Safety)
 3. Lean Events
 4. Total Productive Maintenance (TPM)
 5. Six Sigma
- Finding Lean methods to meet your effective utility management goals

The Toyota Production System, upon which the term "Lean" was coined, relies on a variety of methods to support the philosophy of "kaizen," or continuous improvement.⁶ While some of these Lean methods are more applicable for manufacturing contexts, many methods have proven highly useful for water and wastewater utilities. These methods include the five-step "5S" method for cleaning and organizing workspaces, standard work for formalizing efficient work practices, and Lean kaizen events for making rapid improvements to a process in a 2-5 day period. Along with formal methods, Lean also encourages employees to find "waste" and improvement opportunities in their everyday work, promoting a culture of continual improvement. For complex problems, the statistical tools of "Six Sigma," an improvement

⁶ Kaizen is a combination of two Japanese words that loosely translated means to take apart and make better.



approach developed by Motorola, provide a structured system for eliminating variation and defects. Many organizations combine Lean and Six Sigma toolboxes as “Lean Six Sigma,” or use the overall umbrella of “Lean” or an organization-specific name for the process improvement program.

Lean and Six Sigma concepts and tools apply across all types of water-sector utility processes and operations. This includes utility plant operations and maintenance processes, service delivery processes, transactional and office processes, and physical space improvements. Lean and Six Sigma process improvements help utilities with key EUM Attributes including operational optimization, financial viability, customer satisfaction, infrastructure stability, and operational resiliency.

“The EUM Self Assessment is a good tool for prioritizing your utility’s goals and initiatives – but it only makes a difference if you then take action. That’s where Lean fits in.”

– Ed McCormick, Manager, Wastewater Engineering, East Bay Municipal Utility District, California

Tips from Water-Sector Utilities —How to Talk About Lean and Six Sigma

- Staff may be turned off by Lean and Six Sigma terms; address this by informing staff about the nature of improvement efforts at the outset of the process. Adapt the terminology if needed.
- A communication strategy can be key to getting staff buy-in. Explain what you are doing and what you hope to achieve—get staff invested in the project and the outcomes.
- It takes communication—from start to finish and top to bottom—and lots of “boots on the ground” time to make change happen.

Key Lean and Six Sigma Methods Relevant to Water-Sector Utilities

To illustrate the range of ways that utilities can use Lean and Six Sigma methods to make improvements in the EUM Attributes, we’ve selected and profiled several commonly used methods that are highly relevant to water-sector utilities. Table 3 below provides an overview of these methods, with information on their improvement focus and example applications. The methods range from those that apply to individual tasks (standard work) or workspaces (5S) to those that address complex problems involving multiple variables (Six Sigma). While these are not all the methods utilities may use to work towards the EUM Attributes, they cover a spectrum of water-sector utility applications and include the most commonly implemented Lean methods. Each of these methods is also further described below.



Table 3: Overview of Lean and Six Sigma Methods and Their Applications

Method	Goal and Focus of Improvement	Examples
Standard Work	Document the best way to perform a task/operation to make it easy to work efficiently and effectively	Step-by-step and visual documentation of processes for operating facility equipment, emergency response processes, compliance monitoring, job performance standards
5S (or 5S+Safety)	Improve the organization, cleanliness, safety, and efficiency of work areas	Maintenance and repair truck layout, organization of chemical supplies, desk organization
Lean Event (e.g., Kaizen Event)	Eliminate inefficiency and non-value added activity (waste) in repeatable processes in a short time period	Reducing time to respond to service delivery calls or back-ups; improving billing, contracting, or hiring processes
Total Productive Maintenance (TPM)	Integrate effective maintenance practices into all employees' work to minimize breakdowns, accidents, and other losses	Wastewater treatment plant operator practices, such as drying operations in the solids handling area; monitoring, inspecting, and adjusting pumps, motors, generators, air compressors, and other plant equipment
Six Sigma	Eliminate variation or defects in processes or address complex problems using statistical analysis	Optimizing plant digester operations, identifying root causes of effluent variations or sanitary sewer overflows, optimizing the use of chemical disinfectants

Lean and Six Sigma Method Profiles

In the method profiles below, we define each of these five key methods and describe how they are implemented, why they are useful for EUM, and water-sector utility examples.

Standard Work

Definition: *Standard work is a documentation of the best way (as currently known) to perform an operation; it is also known as standard operating procedures. Lean standard work often incorporates pictures, color-coding, and/or other visual controls to make it easy to follow.*

Implementation Process: Organizations develop standard work to document the proper way to perform an operation or task and make it easy for workers to do the task correctly. (Standard work can be created for an entire process, or it can document the specific steps for each part of the process, such as standard work for operating a piece of equipment.) Lean teams may produce standard work through a process-improvement project (e.g., a Lean event could create a new report template) or through other means. In Lean, standard work serves a key role in the continual improvement process; once standard work is documented, employees can use that as the starting point for further improvement efforts. Standard work can also make it easier for new employees to efficiently undertake their new duties. Standard work often includes process maps or flow charts, diagrams,



reference tables, and/or other visuals to make it easy for employees to follow the correct procedures. Developing the standard work with the people who actually use it, evaluating it “in the field,” improving the documented practices over time, and reviewing it in regular audits are some best practices for standard work.

Why the Method is

Useful for EUM:

Standard work makes it easier for employees to work in an effective, efficient, safe, and compliant way. Consistent practices minimize errors and other problems. Standard work also eliminates reliance on “tribal knowledge,” and makes utilities more resilient and flexible to address utility needs even if key staff leave or are missing. Standard work can be applied to all utility planning, operations, and maintenance activities, so it supports many EUM Attributes, including product quality, operational optimization, customer satisfaction, operational resiliency, and infrastructure stability.

Example Water-Sector Utility Applications:

- **Union Sanitary District** in California has dozens of employee-developed standard operating procedures that cover plant operations and maintenance, collection services, and safety practices. These are very important for product quality and operational optimization. Often when employees develop standard work documentation, they find that they may not have been doing something as uniformly as they believed or that they had been doing something incorrectly or inefficiently.
 - During one project to standardize procedures, for example, Union Sanitary District found it had been discarding Bio-Cell filters for the aeration blowers long before they were due for replacement.
 - While they were developing the first plant procedure module, utility employees discovered that incorrect gauges had been installed to measure head loss across the filters and that a practice had evolved to replace the filters based solely on a visual observation that the filters were dirty.
 - Once the gauges were replaced, the utility was able to accurately measure head loss and use the data to determine when a filter change was needed.
 - With these improvements to change and standardize its filter-replacement process, Union Sanitary District was able to save thousands of dollars.
- In its efforts to improve a disinfection process, **Charleston Water Services** established guides, standard operating procedures, and task instructions for calibrating instruments, monitoring processes, and adjusting chemical dosages. The utility has over 2,000 standard operating procedures and an organization-wide expectation or culture of using and developing standard procedures. These standard procedures enhanced operational optimization, as they helped reduce variation and costs in the process. (See the case study in Appendix C.)



- The **City of Palm Bay** has used standardized 10-paragraph templates for standard operating procedures to promote consistency, replicability, interoperability, and quality control throughout the organization. This template supports document and operational control standards of the City’s environmental management system. Palm Bay Utilities has also developed a standard form for documenting process-improvement activities to support its employee and leadership development efforts. (See the case study in Appendix C.)

5S or 5S+Safety

Definition: 5S is a five-step process to develop and maintain a clean, neat, safe, and orderly work area.

Implementation Process: 5S is implemented in the following five steps:

1. Sort (organize tools and materials, retaining only what is essential)
2. Set in order (arrange and label items in an order that maximizes workflow)
3. Shine (regularly straighten and tidy workspaces and restore items to their place)
4. Standardize (use consistent organization for workspaces, and perform the same procedures for maintaining the first three Ss)
5. Sustain (maintain and review standards to ensure they continue to be implemented)

Some organizations (including **Palm Bay Utilities**) add a 6th “S” for safety (eliminate workplace safety hazards and maintain a safe work environment), making it 5S+Safety.

Depending on the scale of the project, a 5S project can be conducted in as little time as a day or less, by a team or by an individual. Once an area has been organized and cleaned according the 5S principles, employees then maintain it as part of daily 5S activities and periodic 5S audits.

Why the Method is

Useful for EUM:

5S is particularly effective for improving the efficiency and organization of equipment, materials, and work areas. Well-organized and uncluttered work areas reduce safety hazards and accidents, and make spills and leaks easy to detect and fix. 5S is very helpful for inventory control, and helps utilities avoid accumulation of off-spec materials. With 5S, workers also spend less time looking for tools and can focus more time on important tasks. Key EUM Attributes that 5S supports include operational resiliency and operational optimization. It is also a very effective tool for employee



engagement because of its hands-on, practical focus and easily recognizable results so can support employee and leadership development.

Example Water-Sector Utility Applications:

- **JEA and Irving Water Utilities** both used the 5S method to improve the efficiency and organization of materials stored on maintenance trucks. Teams of employees evaluated the issues with the trucks, and brainstormed and implemented solutions that would make their jobs easier, safer, and more ergonomically correct, as well as reduce the time to perform the work. Improvements included eliminating unnecessary materials, standardizing the materials stored on trucks, adding labels and inventory sheets, and other changes. The results for these efforts, affecting EUM Attributes including operational optimization, customer satisfaction, and operational resiliency, are noted in Chapter 1. (Photos from the JEA 5S truck project are in Figure 1; the full case study is available at <http://www.epa.gov/lean/environment/studies/jea.pdf>.)

Figure 1: 5S Before and After Photos



Before 5S: Tools Piled Together



After 5S: Tools Sorted, Organized, and Stored in Labeled Compartments on the Water Maintenance Truck



Lean Event

Definition: Lean events are 2-5 day periods when a cross-functional team of employees analyzes and improves a process. Two common types of Lean events are value-stream mapping events and kaizen events. **Value-stream mapping events** focus on prioritizing future improvement projects and generally have a larger scope, such as all activities in a service process or product line,⁷ while **kaizen events** focus on identifying and implementing process changes.

- Implementation Process:** Along with ongoing improvement activities, Lean is implemented in short bursts of activity known as “events.” There are three phases to Lean events:
1. Planning and preparation, which includes forming the team, identifying roles and responsibilities, scoping the event and developing the charter, making logistical arrangements, and pre-event data collection;
 2. The Lean event, in which a cross-functional team of about 6-15 people analyze and map the current process, brainstorm solutions and develop a new “future state” process map, start making process changes, develop a plan for implementing the new process, and hold a report-out presentation; and
 3. Implementation and follow-up, in which the organization implements the new process based on the process changes identified in the event.

Both kaizen events and value-stream mapping events include process mapping, although the emphasis of the events varies (see Figures 2-4 below). In value stream mapping events, the focus is on identifying large sources of inefficiency and future improvement projects. Value stream mapping events will often name specific problems or projects that can be targets of kaizen events. Kaizen events are used to both implement and plan specific changes to improve a process (e.g., develop standard work for a process, implement 5S in an area, etc.). The goal is to begin implementation of the new process the Monday after the event. Sometimes organizations use a combined approach of doing value-stream mapping in kaizen events to gain a big-picture understanding of the process, but also identify and work on specific implementation actions. Appendix D includes a Lean event charter template.

A key emphasis of Lean events is on real-time measurement of process data to inform improvement efforts. In Lean events, the primary focus is on calculating time spent in the current process, and then estimating the

⁷ A “value stream” refers to all activities involved in producing a product or delivering a service to a customer, from start to finish.



benefits (e.g., dollars, time, etc.) from the improvement projects. Using standard work to document the new process changes and devoting systematic attention to follow-up (e.g., weekly standup team meetings) helps ensure that teams meet their Lean implementation goals.

Figure 2: 5-day Kaizen Event Agenda Outline

Day 1	Day 2	Day 3	Day 4	Day 5
<p>Training Day Begin mapping and measuring current work process</p>	<p>Discovery Day Measure and analyze current work process</p>	<p>Do Day Create and map new process</p>	<p>Do, Re-Do, Document Day Finalize new process design, estimate benefits, develop action plan</p>	<p>Celebration Day Present results and celebrate</p>

Figure 3: 3-day Value Stream Mapping Event Agenda Outline

Day 1	Day 2	Day 3
<p>Training & Current State Map Value stream mapping training; map & analyze the current state of the process</p>	<p>Future State Map & Implementation Plan Map a desired future state for the process; develop an implementation plan</p>	<p>Celebration Day Present results and celebrate</p>

Why the Method is

Useful for EUM:

Lean events allow rapid action to make progress on EUM Attribute areas identified through a utility’s strategic plan, the EUM Self Assessment, or other means. They are a vehicle for using a variety of problem-solving tools (including process mapping, root-cause analysis, and direct observation and measurement) and engaging employee creativity to improve processes in a short period. Chief among the gains from Lean events are operational optimization, customer satisfaction, and financial viability, as Lean events focus on eliminating inefficient use of time and resources (e.g., unneeded process steps, rework, waiting time, process complexity, etc.) to meet customer needs.



Total Productive Maintenance (TPM)

Definition: *TPM is a method that engages all workers in maximizing the effectiveness of equipment, with the goal of preventing breakdowns, accidents, and other losses. Like utility asset management initiatives, which aim to optimize the life of assets, TPM emphasizes preventative maintenance and inspection practices along with predictive maintenance. However, TPM also integrates maintenance and problem-solving activities into the responsibilities of every operator, rather than reserving them solely for maintenance staff.*⁸

Implementation Process: When implementing TPM, organizations typically focus on four areas: (1) efficient equipment; (2) effective maintenance; (3) “mistake-proofing” equipment, or the application of fail-safe techniques to make errors impossible or easy to spot and correct;⁹ and (4) safety management. To ensure efficient equipment, operators work to prevent six major types of losses: breakdown losses, set-up and adjustment losses, stoppage losses, speed losses, quality defect losses, and equipment and capital defect losses. For example, a stoppage or speed loss could be a stopped or slowly operating pump, and a quality defect loss at a wastewater treatment plant could be solids composition inconsistent with the intended disposition method (e.g., overly smelly solids intended for land application). The metric for evaluating equipment performance is overall equipment effectiveness (OEE), which depends on the availability and performance of the equipment and the quality of the output.

TPM trains operators and maintenance/electrical technicians to integrate autonomous maintenance (including inspections, simple repairs, parts replacement, lubrication, etc.) and safety management into their daily work. Finally, modifying equipment to incorporate “mistake-proofing” devices facilitates effective equipment operations. Operators and maintenance/electrical technicians need to know what the equipment is supposed to do and its capabilities, how the systems work, and be able to determine whether it is the system or the equipment that needs attention. TPM is implemented on an ongoing basis, although specific TPM projects (e.g., analyzing equipment losses and implementing improvements) can be addressed through Lean events.

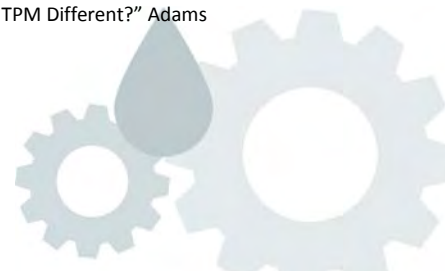
Why the Method is

Useful for EUM:

TPM helps water-sector utilities optimize the use of their assets. Mistake-proofing equipment and the preventative and corrective maintenance activities of operators encouraged by TPM can ensure equipment operates

⁸ For more information on how TPM and asset management compare, see Terry Wiseman, Vesta Partners, “How is TPM Different?” Adams Business Media, 2000, http://vestapartners.com/worxcms_files/HowIsTPMDifferent.pdf (accessed 26 June 2012).

⁹ The Japanese term for mistake-proofing is *poka-yoke*.



as intended, prevent failures or breakdowns, and extend the useful life of assets. By involving every operator in TPM inspection, cleaning, maintenance, and problem-solving activities, the benefits from improved asset management are multiplied. Key relevant EUM Attributes include infrastructure stability and operational resiliency.

Example Water-Sector Utility Applications:

- India's first and only private urban infrastructure utility, **Jamshedpur Utilities and Services Company (JUSCO)**, has used TPM since 2004 to improve the efficiency and effectiveness of its water and wastewater management operations. In a press release, the company reported "immensely" benefiting from the TPM methodology in reducing breakdowns, minimizing losses, reducing customer complaints, and improving process efficiencies.¹⁰ JUSCO won a 2008 TPM Excellence Award by the Japan Institute of Plant Management for these operational optimization and customer satisfaction improvement efforts, and it was the first Indian utility to win a High Commendation Award from Global Water Intelligence.¹¹

Six Sigma

Definition: *Six Sigma is an improvement approach and set of statistical tools designed to eliminate defects and variation. The term "Six Sigma" refers to the concept of eliminating defects to the level of six standard deviations, or 3.4 defects per million. When combined with Lean tools, the methodology is often called "Lean Six Sigma."*

Implementation Process: Six Sigma projects are implemented through a five-phase process known as Define-Measure-Analyze-Improve-Control, or DMAIC:

1. In the Define phase, the Six Sigma project team defines the problem statement.
2. In the Measure phase, the team gathers information about the process and identifies problem areas.
3. In the Analyze phase, the team analyzes the root causes of quality problems, using qualitative and quantitative analytical tools such as "fishbone" root-cause analysis diagrams, Pareto charts, and Failure Mode Effects Analysis.
4. In the Improve phase, the team implements changes to improve the process and conduct statistical assessments to verify the results.
5. In the Control phase, the team institutionalizes the process changes and monitors implementation over time.

¹⁰ Tata Group, "JUSCO Conferred TPM Excellence Award – 2008 by Japan Institute of Plant Maintenance," Press release, 29 Jan 2009, <http://www.tata.com/company/releases/inside.aspx?artid=1XJfT6TNVjs> (accessed 18 June 2012).

¹¹ Gayatri Kamath, "The Business of Urbanity: Jusco, India's First and Only Private Sector Comprehensive Urban Infrastructure Services Provider, Is Winning Contracts All Over India, and Awards and Accolades from around the World," Tata Group website, Jan 2010, www.tata.com/company/articles/inside.aspx?artid=r4XuV0Eak5Q (accessed 24 May 2012).



Individuals trained in Six Sigma (or Lean and Six Sigma) methods are called “green belts” or “black belts” indicating their level of training and experience, with black belts having more experience. Several templates for Six Sigma projects are included in Appendix D, including a Plan-Do-Check-Act worksheet version of the Six Sigma process, a root-cause analysis “fishbone” diagram, and a SIPOC (Suppliers-Inputs-Process-Outputs-Customers) process definition sheet.

Why the Method is

Useful for EUM:

Like Lean events, Six Sigma can be applied to a range of utility processes and operations; however, the statistical tools of Six Sigma are most appropriate for addressing complex problems related to operational optimization and product quality. The Six Sigma tools and the DMAIC framework help utilities pinpoint and address root causes of errors or variation, and then systematically optimize operations and improve product quality (e.g., consistency of plant outputs). Six Sigma projects can support several EUM Attributes, including product quality, operational optimization, financial viability, and customer satisfaction.

Example Water-Sector Applications:

- **JEA** used Six Sigma to analyze the root causes of variations in wastewater treatment plant discharges of nitrogen to the St. Johns River and develop a solution to reduce peak discharges. Through data analysis, the team discovered that when a nearby fish-processing facility halted its discharge of fish by-products to the collection system each weekend, the treatment plant microbes would die, and nitrogen levels would spike. The team brainstormed and developed a solution for feeding the microbes over the weekend by using a byproduct from the production of biodiesel. JEA implemented the changes, and they improved discharge (product) quality and enhanced financial viability by reducing 74 tons of nitrogen discharges annually and by allowing JEA to meet new regulatory requirements without investing in costly new treatment technology. (For the full case study, see EPA’s website at www.epa.gov/lean/environment/studies/jea.pdf.)
- **Charleston Water Services** used Six Sigma methods to reduce variation in its disinfection process and meet regulatory requirements. The improvements the utility identified optimized operations and contributed to financial viability by reducing chemical costs by \$50,000 per year and labor costs by \$50,000 per year. The utility has trained all department directors and assistant department directors on Lean and Six Sigma. (See the case study in Appendix C.)
- In a Six Sigma DMAIC process, **Pompano Beach Utilities** studied the residential water reuse connection process to understand the reasons for the low rate of customer participation and develop strategies to improve connection rates. The utility used analytic tools including a Critical-to-Customer analysis to categorize issues identified by customers, process mapping to better understand the process and map out a new future process, and time-series data plots to track performance over time and address issues when they arise. The new program has improved water resource adequacy and community sustainability by increasing customer



utilization of reuse water, resulting in an estimated **92.4 million gallons** of water saved in 2011–13 (if all planned connections are accomplished). (See the case study in Appendix C.)

Lean & Six Sigma Templates in Appendix D

- Lean Event Charter
- Six Sigma Plan-Do-Check-Act Project Worksheet
- Root Cause Analysis “Fishbone” Diagram
- SIPOC (Suppliers-Inputs-Process-Outputs-Customers) Process Definition Sheet
- Process Improvement Form

Finding Lean Methods to Meet Your Effective Utility Management Goals

There is no “one size fits all” approach to implementing Lean at your utility. The key is to find tools and approaches that will support the EUM Attributes your utility has identified as priorities and to implement the tools in a way that will work for your organizational culture and needs. It is also important to remember that tools are only one aspect of Lean implementation—engaging people in Lean thinking and continuous improvement is often more important to success than the specific tools used. Many organizations avoid specific Lean and Six Sigma terminology and/or develop new names for the tools, for example, but they still adopt the problem-solving approaches from the Lean methods. The Lean and Six Sigma methods profiled here represent some of the methods that are most relevant for water-sector utilities, but many other Lean and Six Sigma tools can also support improvements in EUM Attributes. For more information on Lean and Six Sigma, see the resources in Appendix B. The next chapter discusses how to get started with implementing Lean and EUM improvements at your utility.



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Chapter 4: Starting the Effective Utility Management and Lean Journey

Steps for Getting Started with EUM and Lean

Getting started with EUM and Lean is not hard. There are several simple steps you can take to learn more and then systematically improve your utility's performance and management.

1. Conduct an EUM Self Assessment to Determine Improvement Priorities

To begin your utility's EUM improvement efforts, it is useful to have a clear picture of your utility's most important priorities for change. The EUM Self Assessment Tool, contained in the *Effective Utility Management Primer for Water and Wastewater Utilities*, presents a simple five-step process for identifying which EUM Attributes (or outcomes) to focus on and then developing an improvement plan. With this EUM Self Assessment, your utility will:

- Candidly assess current conditions
- Rank the importance of each of the 10 EUM Attributes to your utility
- Graph the attributes to determine the importance and level of achievement
- Choose attributes to focus on
- Develop and implement an improvement plan

Doing the EUM Self Assessment can help you better delineate your utility's top priorities and reveal whether you have overlooked any important areas. It also may be useful to involve others outside the

IN THIS CHAPTER

- Steps for getting started with EUM and Lean:
 1. Conduct an EUM Self Assessment to Determine Improvement Priorities
 2. Engage Leadership
 3. Learn More about Lean
 4. Find Technical Assistance
 5. Conduct EUM and Lean Improvement Projects
- Facilitating long-term success with EUM and Lean
- Concluding thoughts



Leaders also play an important role in supporting the use of Lean methods to achieve the utility’s goals and progress on EUM Attributes. Specific ways that leaders can enhance EUM and Lean efforts include:

- Articulate EUM goals and the value of Lean process-improvement efforts.
- Participate in EUM and Lean efforts (e.g., EUM Self Assessment, Lean events, etc.).
- Allocate staff resources for EUM and Lean improvement efforts.
- Provide visible support for EUM and Lean improvement efforts (e.g., communicate the value of the efforts in writing, meetings, and other communications).
- Remove barriers to improvement that may arise during implementation.
- Monitor the progress of EUM and Lean improvement efforts, hold people accountable for meeting goals, and celebrate successes.
- Provide means to obtain needed technical and equipment resources for improvement efforts.

The People Who Make the Difference for EUM and Lean – Tips from Water-Sector Utilities

- **Leaders:** If leadership doesn’t buy in, then it won’t happen. You need management support for time to work on projects.
- **Champions:** Designate someone as the “champion” of improvement efforts. The champion is responsible for organizing events and holding staff accountable for improvement efforts.
- **Facilitators:** Establish a core group of highly trained people who can lead or facilitate improvement efforts.
- **Team Members:**
 - Be careful how you select your team—consider their personalities and skills. Choose people who will produce outcomes.
 - Involve a cross-section of your organization—from front-line workers and maintenance staff to mid- and upper-level managers.

3. Learn More about Lean

While it is not necessary to do extensive training before launching a Lean initiative, it is helpful to become more familiar with Lean methods to understand how to best use them to meet your utility’s EUM goals. (Due to its reliance on statistics, Six Sigma requires more expertise than other methods.)

Key Resources for Getting Started with EUM and Lean

- *Effective Utility Management: A Primer for Water and Wastewater Utilities* (includes EUM Self-Assessment), www.watereum.org/resources/interactive-primer
- *Lean in Government Starter Kit: How to Plan and Implement Successful Lean Initiatives at Environmental Agencies, Version 3.0*, (includes downloadable resources), www.epa.gov/lean/government/starterkit

See Appendix B of this Resource Guide for additional resources on EUM and Lean.



Water-sector utilities have used a variety of strategies for learning more about Lean concepts and methods, including:

- Reading Lean and Six Sigma books, articles, and on-line resources (See Appendix B for an annotated list of resources)
- Learning from other utilities' efforts
- Participating in formal training (classroom, on-site, and/or on-line)
- "Learning by doing" through implementation of Lean methods, including any training received as part of Lean events.

Tips from Water-Sector Utilities for Getting Started with EUM and Lean

Where to Start and What Tools to Use

- Lean can be as easy as understanding waste. You can start at many places; it depends on the readiness of the organization.
- When considering improvement efforts, be sure to address the culture of your organization and what you want to change. For example, is the goal of the improvement effort to save money, to become a more innovative organization, or simply to find ways to improve?
- Use the tools that are most meaningful to your employees and that connect to the strategy of the utility.
- You can adjust the tools; you don't have to do everything "by the book."

Lean training courses range in depth and length from short webinars on specialized topics to multi-week Lean and/or Six Sigma certification programs, which generally require participants to complete an improvement project. Individuals trained on Six Sigma (or Lean and Six Sigma) methods are often classified similar to martial arts "belts," with "black belts"

being able to lead more advanced improvement projects than "green belts." It is not necessary to have advanced Lean or Six Sigma training or certification, but over the longer term, utilities may wish to develop greater in-house capability to lead improvement projects. One of the easiest and best ways to learn about Lean is to observe it firsthand by participating in Lean events at your utility or other organizations. Small utilities may want to partner on training and information exchange to reduce costs. There is no shortage of Lean training providers or training options. The table below describes different types of training providers.

"Lean can help utilities build internal capabilities to make improvements rather than spending a lot of resources on consultants."

*- Donna Wies, Quality Program Coordinator,
Union Sanitary District, California*



Table 4: Lean Training Providers

Type	Description and Examples
Educational institutions	<p>University business schools and community colleges often offer courses on Lean and Six Sigma. Examples of university Lean programs include:*</p> <ul style="list-style-type: none"> • Georgia State University (Lean Six Sigma training and certification), http://robinson.gsu.edu/execed/programs/sixsigma.html • Kent State University (Lean Six Sigma training and certification), www.kent.edu/leansixsigma • North Carolina State University Industrial Extension (Lean and Six Sigma classes, on-site training, and consulting support), www.ies.ncsu.edu • San Diego State University (Lean certification program), www.ces.sdsu.edu/Pages/Engine.aspx?id=717 • Villanova University (on-line Six Sigma certification program), www.villanovau.com/online-certificates/six-sigma.aspx
Manufacturing Extension Partnership (MEP) Centers	<p>The National Institute of Standards and Technology (NIST) has a network of non-profit MEP centers that provide Lean consulting and training. To find a center, see:</p> <ul style="list-style-type: none"> • www.nist.gov/mep/find-your-local-center.cfm
Non-profit organizations	<p>Several non-profit organizations promote learning on Lean, Six Sigma, and related process-improvement methods, through webinars, conferences, training courses, and on-line discussion forums. Examples include:*</p> <ul style="list-style-type: none"> • Lean Enterprise Institute (offers webinars, training, conferences, articles, discussion forums, etc.), www.lean.org • American Society for Quality (ASQ) Government Division (offers webinars, conferences, and articles), http://asq.org/gov • Learners TV (offers free training videos on Lean and Six Sigma), www.learnerstv.com/Free-Management-video-lecture-courses.htm • Industry Week (offers webinars, on-line training, and articles), www.industryweek.com/webcasts • Association for Manufacturing Excellence (AME), Society of Manufacturing Engineers (SME), Shingo Prize for Operational Excellence, and ASQ's Lean Certification Program, www.sme.org/lean-certification.aspx
Private consulting firms	<p>Most private Lean consulting firms offer Lean training. Training may be provided separately or along with support for Lean/Six Sigma projects.</p>
Other options	<ul style="list-style-type: none"> • Businesses implementing Lean in your community may be willing to allow observers to participate in Lean events or training sessions at their facilities. • An increasing number of federal, state, and local government agencies have Lean programs and may offer training courses and/or have downloadable resources on agency websites.¹²

*Note: This is not an exhaustive list.

¹² For lists of government agency Lean websites, see the Quality and Productivity Improvement Center's Lean Government website, <http://leangovcenter.com/govweb.htm>, and/or the Lean Government Wikipedia article, http://en.wikipedia.org/wiki/Lean_Government (accessed 17 June 2012).



4. Find Technical Assistance

Most utilities find it helpful to have technical assistance when beginning a Lean and EUM improvement initiative. This technical assistance can come from in-house resources—if you have staff trained in Lean and/or Six Sigma methods and familiar with their application in utility contexts—or from outside organizations. All Lean events are led by a Lean facilitator, who guides the project team throughout the Lean process, helping to scope events, facilitate activities and discussions during the events, and advise on follow-up activities. Skilled facilitation is important to the success of Lean efforts, and external consultant support can help utilities to generate positive results rapidly. Some utilities, such as **Pompano Beach Utilities**, have also found that consultant support can help them conduct the EUM Self Assessment more quickly and thoroughly than they would have without it.

Tips for Successful EUM and Lean Implementation and Follow-up from Water-Sector Utilities

Deployment, Implementation, and Follow Up

- Don't forget to consider how you will roll out improvement efforts. Anticipate potential barriers, how to deploy and make improvements “stick,” and any resistance from staff.
- Clearly identify staff expectations, roles, and responsibilities for getting the work done, especially after Lean events end.
- Ensure staff are well versed in improvement efforts and are on board with any changes being made.
- Reward staff for improvement efforts.

Measuring and Evaluating Progress

- To show measurable improvement, you need a baseline. A baseline also helps identify areas to target and provides data that can be useful in making decisions about where to focus improvement efforts. Without a baseline or metrics, you cannot know what success looks like.
- Benchmarking can be a useful way to measure your progress externally. Pick benchmarking partners who are better than you are.
- There may be some trial and error and disappointment, but you need to give people a chance.
- It's all about results. When you start seeing results, then management buys in, and then it becomes part of the culture.

If you choose to pursue external support for Lean facilitation, there are numerous technical assistance providers that facilitate Lean events, including private consultants and non-profit organizations, such as the national network of Manufacturing Extension Partnership centers.¹³ When evaluating a potential Lean facilitator, consider the facilitator's past experience, areas of expertise (e.g., supporting Lean in utility or government contexts), price, references, and availability. Costs of experienced Lean facilitators can range from approximately \$2,000 to \$3,400 per day. Talk to your utility peers about their

¹³ For a directory of local MEP centers, see www.nist.gov/mep/find-your-local-center.cfm.



experiences with Lean facilitators to identify recommendations. After initial Lean projects, identify individuals who might be interested in becoming trained Lean facilitators (or Lean and Six Sigma black belts), so that you can decrease your reliance on external support and build internal capacity for change.

5. Conduct EUM and Lean Improvement Projects

Common advice from public sector Lean practitioners to agencies considering Lean is to “Just Do It.” While this is simplistic, there is value in this perspective of pilot testing Lean to see how it works at your utility before deciding to invest heavily in training or launch a larger improvement initiative. There is no single path to implementing Lean. The most important consideration is to do what makes sense

“To continually improve, people need to know *what to do, why they are doing it, when the tasks are due, where the resources are, and how to accomplish their part of the mission.*”

– Richard Bickerstaff, Strategic Business System Manager, Charleston Water System, South Carolina

for your organization’s goals and culture. Lean methods can be implemented at many scales to address many types of problems. Consider starting with a few discrete projects that can generate “quick wins and then build up to address more challenging or complex problems. Lean kaizen events and the 5S method are good tools for engaging employees in hands-on continual improvement activities. It’s also important to avoid scoping your initial projects too large (be realistic about what you can accomplish in an event), in order to be able to make concrete progress and generate results.

As you embark on Lean improvement projects, be sure to evaluate your success based on the EUM Attributes your utility identified as priorities in its EUM Self Assessment. If you are falling short of your objectives and targets, consider initiating one or more Lean or Six Sigma projects to address problem areas and further improve performance. Be sure that you also devote adequate time and attention to the implementation phase of current and past projects (the period after Lean events or the “Control” phase in Six Sigma)—often this is where process-improvement projects run into problems.

Facilitating Long-Term Success with EUM and Lean

EUM and Lean can both be described in terms of a journey or transformation. The EUM Attributes and Lean principles, such as elimination of inefficiency and waste, represent endpoints that utilities strive to achieve through improvement activities. EUM and Lean implementation can go through several phases, such as the following:

- **Learning and improving phase**, when teams learn the Lean tools and make progress through ad hoc projects based on the EUM Self Assessment
- **Optimizing phase**, when managers apply Lean more strategically and systematically to meet EUM and other goals



- **Transforming phase**, when EUM and Lean become “the way we work,” and continual improvement is everyone’s job

Over time with EUM and Lean implementation, more staff become engaged and knowledgeable and there is less need for external support. The EUM and Lean journey can vary substantially based on utility conditions, context, and organizational support. For some utilities, the move from selective use of Lean tools on EUM-improvement projects to adopting a comprehensive continual improvement culture can happen relatively quickly, while other utilities may obtain sufficient success while remaining in an ad-hoc, project-specific mode of implementation.

Introducing EUM and Lean does not mean that you should abandon the improvement efforts that your utility has already been doing. Rather, it is

important to integrate EUM and Lean into your utility management improvement efforts so that employees see them as building from previous efforts and linking to your organization’s culture. EUM and Lean provide an established improvement framework and practical implementation tools for taking your utility improvement efforts to the next level and producing more impressive results. By maintaining connections to other utility management initiatives (such as an environmental management system), you’ll reduce employees’ sense of initiative fatigue and make it easier to incorporate any new concepts and tools. You may wish to adapt the Lean and Six Sigma terminology (e.g., avoid Japanese words) or implementation practices (e.g., adapt the structure of Lean events) to make it better fit with your organizational culture.

Ultimately, success with EUM, and with Lean as a supporting implementation methodology, depends on the five Keys to Management Success articulated in the *Effective Utility Management Primer*. Lean supports all of the Keys; however, the practical application of Lean and Six Sigma methods, combined with the communications and training to make sure those methods are effectively integrated into the culture of the organization, relate specifically to the “Organizational Approaches” Key (see Figure 6).

“We used EUM to develop our strategic plan and recently used Lean techniques to optimize our backflow program. We were so impressed with the outcome as far as better use of staff time and increase in productivity that we have trained three people in our department in Lean techniques. We expect this will become part of our culture.”

*– Tyler Richards, Deputy Director,
Operations and Environmental Services,
Gwinnett County Water Resources,
Georgia*



Figure 6: Keys to Management Success with Effective Utility Management and Lean

- **Leadership:** The involvement and commitment of leadership in utility EUM improvement efforts is the most important factor in long-term success. See the section on “Engage Leadership” above for ideas on how leaders can support EUM and Lean implementation efforts.
- **Strategic Business Planning:** Strategic planning allows a utility to establish goals, objectives, and strategies, and identify specific implementation steps that will move it toward its vision. Utilities can use Lean and Six Sigma tools in these implementation steps.
- **Organizational Approaches:** Although Lean relates to most of the Keys, it is particularly helpful for providing implementation-based strategies and tools for the “organizational approaches” Key to support EUM. Three aspects of a Lean organizational approach are important:
 1. **Lean Methods:** Lean is both a toolbox and a continual improvement process. Lean methods actively engage employees in process-improvement activities and incorporate visual, simple solutions that make it easier for employees to detect and fix problems.
 2. **Communications:** For any change initiative, an effective communications strategy can make the difference between something that falters and something that takes root and grows. Especially during early stages of implementation, people may have many questions and misconceptions about Lean and what it means for their work.
 3. **Training:** Training and capacity building are important for developing and sustaining process-improvement programs, such as EUM and Lean. Training on continuous improvement tools is critical to the successful implementation of a Lean culture. See the section on “Learn about Lean” above for guidance on training options to consider.



- **Measurement:** Performance measurement is critical for continual improvement efforts—it allows utilities to identify problem areas, evaluate solutions, and monitor progress towards the EUM Attributes. Lean and Six Sigma methods also depend on data for their success; Lean methods emphasize real-time data collection to assist with decision-making, visual displays of data, and evaluating potential process improvements based on analysis of process data.

- **Continual Improvement**

Management Framework: Lean and Six Sigma approaches are

both modeled after Dr. W. Edwards Deming’s “Plan-Do-Check-Act” continual improvement cycle. Both Lean, with its focus on eliminating waste, and Six Sigma, with its focus on reducing variability, provide structured processes for working towards utility goals and EUM Attributes. They are also highly compatible with environmental management systems (EMSs) based on ISO 14001 or comparable approaches.¹⁴ For example, **Palm Bay Utilities** uses its ISO 14001 EMS as the overarching framework for all its utility management efforts including EUM and Lean (see the case study in Appendix C for more information).

Lean and Continual Improvement: Clean Water Services, Oregon

- Clean Water Services encourages employees to eliminate different types of waste in processes they work on, using the Lean wastes in the acronym “DOWNTIME” (Defects, Overproduction, Waiting, Non-utilized people, Transportation, Inventory, Motion, Excess processing) as a guide.
- The utility has found this to be an effective tool to support continual improvement, as it makes it easy for workers to collaboratively identify improvement opportunities.
- For example, using Lean methods, a team identified improvements to the budgeting process that would reduce staff time from 279 to 87 hours (69 percent reduction).

¹⁴ Public Entity EMS Resource (PEER) Centers located throughout the United States are available to assist public entities with establishing EMSs and developing mature continuous improvement management frameworks. For more information about PEER Centers and resources, see <http://www.peercenter.net>.



What Does It Take To Establish A Full-Scale EUM and Lean Initiative At A Utility?

Water-sector utilities involved in the development of this EUM and Lean Resource Guide identified five factors to consider when incorporating and establishing a full-scale EUM and Lean initiative:

- **Organizational Readiness:** Before launching a full-scale EUM and Lean initiative, it is critical to know whether your utility is ready for the type of investment involved. For example, is there leadership support? Do you have the appropriate management structure to support the effort? It may make sense to “test the waters” with several EUM and Lean projects in select areas before investing heavily in outside training or external facilitation support.
- **Training:** A successful EUM and Lean initiative will require some training. Training for managers can help them understand how Lean and Six Sigma can be used to improve their processes. Training is also useful for people who will be participating in improvement projects, with much more extensive training needed for Six Sigma than for Lean methods. If the utility chooses to build internal capacity to lead improvement projects, then it may choose to pay for Lean facilitator training or Lean and Six Sigma “black belt” level training.
- **Time:** Attending training and conducting improvement projects both take time, and that is time that would otherwise be used for other utility activities. Lean events typically occur over a 2-5 day period (plus prep and follow-up time), while Six Sigma projects are implemented over a much longer period (e.g., a few months to a year).
- **Cost:** Along with staff time for improvement activities, utilities should consider costs for training and technical assistance. For example, Clean Water Services has spent \$40,000 on training for 16 staff, including two staff who will be “black belt” level and several who will be “green belt” level. Unless utilities develop internal capacity for Lean facilitation, they may want to hire consultants to facilitate events. Lean facilitators typically charge \$12,000–\$25,000 for a five-day Lean event, depending on the consultant and the scope of the services.
- **Return on Investment:** Water-sector utilities and many other industries have seen unparalleled performance gains with Lean and Six Sigma methods. Clean Water Services expects to save hundreds of thousands of dollars from its Business Process Improvement Center of Excellence and its investment in Lean and Six Sigma training. JEA invested heavily in its Lean and Six Sigma program, with eight full-time “black belt” staff and 24 directors and vice presidents trained as black belts, but the program saved \$579 million in 10 years.*

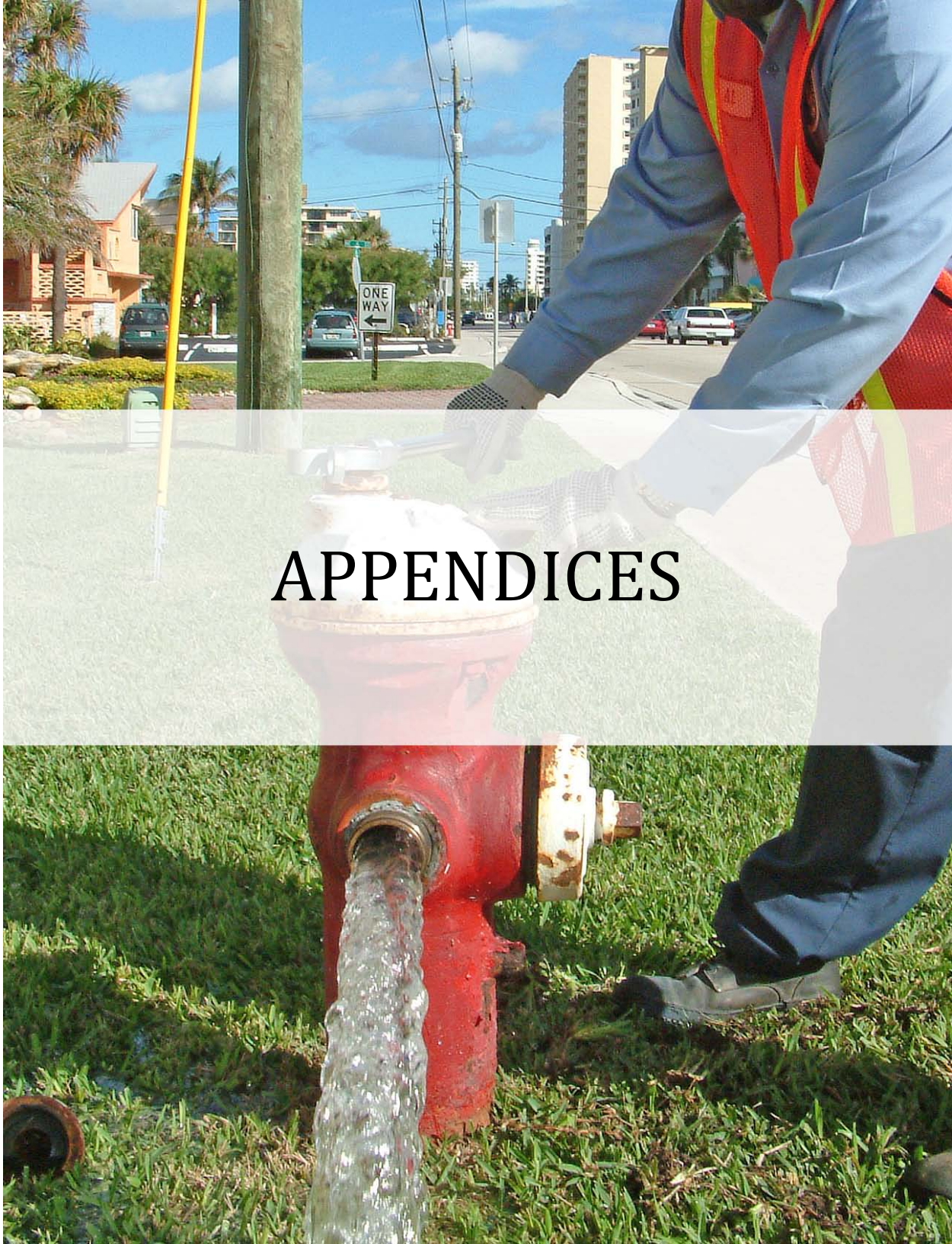
*For more information, the JEA case study is available at www.epa.gov/lean/environment/studies/jea.pdf. The Clean Water Services case study is in Appendix C.



Concluding Thoughts

We hope that this EUM and Lean Resource Guide has been helpful to you as you learn how EUM and Lean can support your utility's improvement goals. The process of becoming a lean and effectively managed utility offers opportunities for near-term, low-intensity gains with the prospect for longer-term, sustained improvements with greater deployment of Lean methods to achieve EUM outcomes. We wish you success in your EUM and Lean journey.





APPENDICES



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Appendix A: Glossary

Definitions of Effective Utility Management and Lean Terms¹⁵

5S, 5S+S, or 6S A method used to create and maintain a clean, orderly, and safe work environment. 6S or 5S+S (5S+Safety) is based upon the five pillars (5S) of the visual workplace in the Toyota Production System, plus a pillar for safety. The six pillars are: Sort, Set in order, Shine, Standardize, Sustain, and Safety.

A

Attribute A characteristic or outcome of a utility that indicates effective performance.

Asset management The systematic planning and control of a physical resource throughout its economic life.

Autonomous maintenance A component of Total Productive Maintenance that involves operators in step-by-step activities to ensure optimum conditions of machine operation.

B

Black belt A leader who has passed an advanced level of training in Six Sigma (or Lean Six Sigma). Responsible for implementing Six Sigma projects at his or her company.

C

Cause-and-Effect Diagram (Fishbone Diagram) A technique for brainstorming and categorizing the causes and effects of problems. Often a common set of potential reasons for problems are identified as the branches in the diagram—man, methods, materials, machines, measurement, and environment (5M+E). Also known as a *fishbone diagram* or an *Ishikawa diagram* (after its originator, Karoru Ishikawa).

Critical-to-Quality (CTQ) A classification of key process output issues relevant to meeting customer needs. These issues are often depicted in a tree diagram.

D

Define-Measure-Analyze-Improve-Control (DMAIC) The DMAIC process is used to guide implementation of Six Sigma statistical tools and to identify process wastes and variation.

DOWNTIME DOWNTIME is a mnemonic that refers to the eight wastes targeted by Lean: Defects, Overproduction, Waiting, Non-utilized employee resources, Transportation, Inventory, Motion, and Excess processing.

E

Effective Utility Management (EUM) Management that improves products and services, increases community support, and ensures a strong and viable utility into the future.

¹⁵ Definition sources include: Productivity Press Development Team, *LeanSpeak: The Productivity Business Improvement Directory*, Productivity Press, 2002; Forrest W. Breyfogle III, *Implementing Six Sigma: Smarter Solutions Using Statistical Methods*, John Wiley & Sons, 1999; and U.S. EPA, *Effective Utility Management: A Primer for Water and Wastewater Utilities*, 2008.



F

Failure Mode Effect Analysis (FMEA) A technique used to identify and analyze the causes of failures in processes or products. FMEA includes examining root causes of failures and identifying corrective actions to address problems.

G

Green belt A team leader who has passed the first level of training in Six Sigma (or Lean Six Sigma) and who can apply this learning to lead improvement teams in his or her regular job. A green belt is less advanced than a black belt.

K

Kaizen Composed of the Japanese *kai* meaning “to take apart” and *zen* meaning “to make good,” kaizen is the incremental and continual improvement of activities to create more value and less non-value-adding waste.

Kaizen event A planned and structured event lasting 1-5 days that enables a team to improve a process or business area. Kaizen events aim for focused identification of root causes of problems and quick implementation of solutions.

L

Lean An improvement approach and set of methods focused on the systematic elimination of non-value added activity or waste. James Womack and Daniel Jones coined the term “Lean” to describe the Toyota Production System.

Lean event A short period, typically 1 to 5 days, when a team of employees work together to implement Lean methods. Two common types of Lean events are value stream mapping events and kaizen events.

Lean Six Sigma The combination of Lean and Six Sigma improvement methodologies.

M

Mistake proofing Technologies and procedures designed to prevent errors and equipment malfunction. Also called a *poka-yoke*.

O

Overall Equipment Effectiveness (OEE) The measure of a piece of equipment’s actual contribution as a percentage of its potential to add value to the value stream. Overall equipment effectiveness = availability x performance x quality rate x 100.

P

Pareto Chart This bar graph separates and displays the “critical few” from the “trivial many” causes of a problem. The chart arranges bars from left to right in descending order of importance and shows the cumulative percentage of each.

Plan-Do-Check-Act A cycle that represents four steps used in many improvement activities. It encompasses planning, doing, observing results, adjusting, and then repeating.



S

SIPOC (Suppliers Inputs Process Outputs Customers)	A SIPOC chart is a tool that allows users to understand the high-level flow of inputs and outputs in a process. The relevant components of the process are organized in columns for suppliers, inputs, process, outputs, and customers.
Six Sigma	Six Sigma is an improvement approach and a set of statistical methods used to identify and reduce variation in products and processes. Motorola developed the terminology Six Sigma.
Standard Work	An agreed upon and documented set of work procedures for performing a given task or operation in the best way currently known. It can also be thought of as an optimal combination of people, materials, and machines to ensure the process works efficiently and effectively.

T

Total Productive Maintenance (TPM)	A Lean method that focuses on optimizing the effectiveness of equipment and involves all employees in preventative and corrective maintenance activities.
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V

Value stream	All the activities (both value-added and non-value added) required to produce a product or deliver a service to the customer, from order to delivery, and from raw materials into the hands of the customer.
Value stream mapping	The identification of all the specific activities (material and information flow) occurring along the value stream for a particular product or service, usually represented pictorially in a value stream map.
Visual controls	The control of the workplace by the visual regulation of operations, performance goals, and tool and parts placement so that a process or system can be understood at a glance. Examples include lines outlining equipment locations, shadow boards for tools, data dashboards, color coding, and signs.

W

Waste	In Lean, waste is defined as anything that does not add value from the customer's perspective. Categories of Lean wastes include defects, overproduction, waiting, non-utilized employee resources, transportation, inventory, motion, and excess processing.
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Appendix B: EUM and Lean Resources

This appendix contains an annotated list of resources that can help water-sector utilities use Lean methods to work towards their EUM improvement goals. The resources are not endorsed by U.S. EPA, but are provided to be a starting point for water-sector utilities interested in learning more about EUM and Lean. The appendix is organized in the following categories:

- A. Effective Utility Management Resources
- B. Resources on Lean and Six Sigma Thinking and Process Improvement
- C. Overarching Lean and Six Sigma Implementation Guides
- D. Resources on Specific Lean and Six Sigma Methods

A. Effective Utility Management Resources

U.S. Environmental Protection Agency, Association of Metropolitan Water Agencies, American Public Works Association, American Water Works Association, National Association of Clean Water Agencies, National Association of Water Companies, and Water Environment Federation. *Effective Utility Management: A Primer for Water and Wastewater Utilities*. (June 2008).

www.watereum.org/resources/

The Primer identifies “Ten Attributes of Effectively Managed Water Sector Utilities” that identify what effectively managed utilities strive to achieve, five “Keys to Management Success” or approaches that foster utility management success, and a self-assessment tool to help utilities assess their utilities according to the attributes and identify improvement priorities.

Effective Utility Management Case Studies. (April 2009). www.watereum.org/resources/

The EUM Case Studies document provides an overview of four utilities that have applied all or part of the Primer concepts and tools. The case studies provide concrete examples and “how to” assistance for utility managers applying the Primer concepts and tools.

The Effective Utility Management Resource Toolbox. www.watereum.org/resources/resource-toolbox/

The Toolbox provides descriptions and links to key resources and measures designed to help the water and wastewater utility community improve the management of its infrastructure. The toolbox is designed as a companion resource to the EUM Primer.

B. Resources on Lean and Six Sigma Thinking and Process Improvement

Bens, Ingrid. *Facilitating with Ease!* San Francisco: Jossey-Bass, 2000.

Facilitating with Ease! is a resource for team facilitators. It begins with introducing the concept of facilitation and includes chapters on facilitation strategy and meeting management. It provides checklists, tools, and tips for facilitating in a variety of situations.



Chowdhury, Subir. *The Power of Six Sigma*. Kaplan Business, 2001.

The Power of Six Sigma is told as a fictionalized tale meant to be engaging and provide a high-level understanding of Six Sigma through a dialogue between two men.

Collins, Jim. *Good to Great: Why Some Companies Make the Leap...and Others Don't*. New York: HarperBusiness, 2001.

Good to Great explores the way good organizations can be turned into ones that produce significant, sustained results. Collins reviews companies that achieved greatness in a variety of industries and identifies key characteristics that make them “great.”

Meisel, Robert M., Steven J. Babb, Steven F. Marsh, and James P. Schlichting. *Executive Guide to Understanding and Implementing Lean and Six Sigma: The Financial Impact*. Milwaukee: ASQ Quality Press, 2007.

A part of the ASQ Quality Management Division Economics of Quality Book Series, the *Executive Guide to Understanding and Implementing Lean and Six Sigma* is written by subject matter experts and meant to provide executives with the introductory information on Lean and Six Sigma methods. It provides an overview of both methods, offers suggestions for preparing for implementation, and reviews the economic benefits of using Lean and Six Sigma.

Miller, Ken. *We Don't Make Widgets: Overcoming the Barriers that Keep Government from Radically Improving*. Washington DC: Governing, 2006.

Written for middle- and senior-level managers in state, city, and county government, *We Don't Make Widgets* exposes three “myths” about government: it doesn't make widgets, it doesn't have customers, and it is not here to make a profit. Miller exposes these myths as barriers to a more efficient government and demonstrates how governments are in fact production factories with a bottom line and customers; similar to a business.

Womack, James P. and Daniel T. Jones. *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*. New York: Simon & Schuster, 1996.

Lean Thinking demonstrates how Lean can help a company in any industry in any country. It provides a step-by-step action plan for how to implement Lean in an organization, based on in-depth studies of more than fifty Lean companies in a wide range of industries across the world. The authors are the originators of the term “Lean.”

C. Overarching Lean and Six Sigma Implementation Guides

Brassard, Michael and Diane Ritter. *The Memory Jogger II: A Pocket Guide of Tools for Continuous Improvement and Effective Planning*. Goal/QPC, 1994.

The pocket guide describes tools to help readers make continuous improvements in their organization. The tools are meant to help people at all levels participate in identifying and solving problems; eliminating rework; streamlining processes; improving cross-functional



communication; decreasing costs; and measuring results. The guide supports organization-wide consistency and participation in creating organizational breakthroughs and improvements.

Cole, Brandon. *Lean Six Sigma for the Public Sector: Leveraging Continuous Process Improvement to Build Better Governments*. Milwaukee: American Society for Quality, 2011.

This book addresses the challenges of applying Lean Six Sigma in the public sector. Examples of these challenges include hierarchical environments, a lack of common goals, and the complexity of working in the public sector. The book provides over 30 spotlights highlighting project examples, lessons learned, and tips and tricks for using Lean Six Sigma in the public sector.

George, Michael L. *Lean Six Sigma: Combining Six Sigma Quality with Lean Production Speed*. New York: McGraw-Hill, 2002.

Lean Six Sigma provides an overall treatment how to integrate Lean and Six Sigma, particularly how process excellence can be combined with the goal of enhancing shareholder value creation. It provides insights into the application of Lean Six Sigma to both the manufacturing processes and the less-data-rich service and transactional processes.

Lean Six Sigma for Services. New York: McGraw-Hill, 2003.

Lean Six Sigma for Services explains how companies can cost-effectively translate manufacturing-oriented Lean Six Sigma tools into the service delivery process. It also contains case studies detailing service improvements within organizations.

George, Michael L., David Rowland, and Bill Kastle. *What Is Lean Six Sigma?* New York: McGraw-Hill, 2003.

Written as a plain-English guide, *What Is Lean Six Sigma?* describes how organizations can identify and eliminate waste, cut costs and grow revenue, and enhance job skills. It also contains charts, diagrams, and case studies of teams who have used these methods to improve their workplace.

Joiner, Brian L., Barbara J. Streibel, and Peter R. Scholtes. *The Team Handbook*, Third Edition. New York: Oriol, Inc. 2003.

The Team Handbook, Third Edition, includes a brief description of the Six Sigma improvement method DMAIC, and highlights the methods and strategies that are useful in Lean. It also covers a strategy for using designed experiments to identify and control sources of process variation. The book includes tools and techniques to help leaders manage project pipelines.

Morgan, John and Martin Brenig-Jones. *Lean Six Sigma for Dummies*. New York: For Dummies, 2012.

Lean Six Sigma for Dummies outlines Lean and Six Sigma key concepts in plain English and is designed to be reader-friendly. It illustrates how to use Lean and Six Sigma tools and how to improve and design projects and incorporate the methods in your day-to-day activities. It shows you how to ensure the key principles and concepts of Lean Six Sigma become an integrated part of your organization.



Productivity Press Development Team. *Identifying Waste on the Shopfloor*. New York: Productivity Press, 2003.

This short, user-friendly book is focused on getting rid of waste. It covers the all aspects of identifying and eliminating waste and includes checklists and tools to find and identify waste in an organization and includes numerous sample checklists and forms.

U.S. Department of Defense. *Continuous Process Improvement/Lean Six Sigma Guidebook: Revision 1*. (July 2008). www.au.af.mil/au/awc/awcgate/dod/cpi_leansixsigma_hdbk2008.pdf

The guidebook provides a framework to be used for implementing and sustaining a culture of continuous improvement. It focuses on three key areas: continuous improvement concepts and the Department of Defense approach; tools to support successful continuous improvement implementation; and continuous improvement roles and responsibilities.

U.S. EPA. Lean Website, www.epa.gov/lean

The EPA Lean website includes two major components, a Lean Government website, which is oriented towards government agencies that are using Lean to improve their processes, and a Lean and Environment website, which is oriented towards manufacturers and other organizations that seek to use Lean to reduce environmental wastes. The website includes information on Lean methods, case studies, toolkits, and other resources. Key resources relevant to water-sector utilities include the *Lean in Government Starter Kit*, the *Environmental Professional's Guide to Lean and Six Sigma*, and a case study of Lean and Six Sigma at JEA.

U.S. EPA and the Environmental Council of the States (ECOS). *Lean in Government Starter Kit: How to Plan and Implement Successful Lean Initiatives at Environmental Agencies, Version 3.0*. (November 2012). www.epa.gov/lean/government/starterkit/resources/Lean-StarterKit.pdf

The *Starter Kit* is designed to help government agencies plan and implement successful Lean events. The Starter Kit answers questions to help managers determine whether Lean is right for their agencies, provides practical “how to” guidance on implementing Lean events successfully, and presents ideas for agencies interested in expanding their Lean initiatives.

Wedgwood, Ian D. *Lean Six Sigma: A Practitioner's Guide*. New York: Prentice Hall, 2006.

Lean Six Sigma is designed to be a practical tool, used day-to-day by readers to guide them through how to solve as many different types of business problems as possible using Lean and Six Sigma methodologies and tools. It captures best-practice experience from multiple projects and industries, helping any professional identify the solution that will work best and how to implement it.



D. Resources on Specific Lean and Six Sigma Methods

5S Resources

Fabrizio, Thomas and Don Tapping. *5S for the Office: Organizing the Workplace to Eliminate Waste*. New York: Productivity Press, 2006.

In *5S for the Office*, the authors bring the concepts of the 5S System (for workplace organization, standardization, and cleanliness) into the office context. The book is designed so readers can immediately apply 5S concepts to their office and administrative activities.

MCS Media. *The 5S for the Office User's Guide*. Chelsea: MCS Media, 2010.

5S for the Office User's Guide provides basic information on how to conduct a 5S office event, in addition to forms, worksheets, and checklists to ensure the projects are well planned and are able to be sustained throughout an organization. It is designed with a focus on implementation.

Peterson, James and Roland Smith. *The 5S Pocket Guide*. Portland: Productivity Press, 1998.

The *5S Pocket Guide* is designed to enhance awareness of the principles behind the 5S System and identify its impact on improving efficiency and promoting a safe working environment. It outlines a disciplined methodology for implementing 5S, organized around a six-step method.

Productivity Press Development Team. *5S for Operators: 5 Pillars of the Visual Workplace*. Portland: Productivity Press, 1996.

5S for Operators: 5 Pillars of the Visual Workplace, is a hands-on book that explains the principles, rationale and implementation details of the 5S System. The text includes questions, outlines, summaries, diagrams and illustrations.

Kaizen Event Resources

Martin, Karen and Mike Osterling. *The Kaizen Event Planner: Achieving Rapid Improvement in Office, Service, and Technical Environments*. Portland: Productivity Press, 2007.

The Kaizen Event Planner provides a how-to guide for planning and executing kaizen events in non-manufacturing settings and includes information on conducting post-event follow-ups to sustain the improvements made. It is written for continuous improvement professionals and leaders in manufacturing and the service sector.

Productivity Press Development Team. *Kaizen for the Shopfloor*. Portland: Productivity Press, 2002.

Kaizen for the Shopfloor covers all the steps necessary for conducting an effective kaizen event. It includes background information on kaizen events all the way through planning and preparing for an event, presenting results and conducting follow up activities.



Six Sigma Resources

Breyfogle, Forrest W. III. *Implementing Six Sigma: Smarter Solutions Using Statistical Methods*. New York: John Wiley & Sons, 1999.

This book is a comprehensive reference book on both the process and tools for implementing Six Sigma. It includes plans, checklists, metrics, and pitfalls related to implementing Six Sigma, as well as exercises for understanding how to use the statistical methods.

Gygi, Craig, Neil DeCarlo, Bruce Williams, and Stephen R. Covey. *Six Sigma for Dummies*. Hoboken: Wiley Publishing, 2005.

Six Sigma for Dummies provides an overall guide to Six Sigma including the benefits of Six Sigma, the DMAIC roadmap, how the Six Sigma “belt” system works, and many other topics. It is designed to be easy to read and accessible to anyone interested in the topic.

Michalski, Walter J. *Six Sigma Tool Navigator: A Master Guide for Teams*. Portland: Productivity Press, 2003.

The *Six Sigma Tool Navigator* provides a complete collection of tools for teams engaged in Six Sigma improvement activities. Michalski classifies each tool by process application, description of various applications of the tool, links to “before and after” tools, and problem-solving phases most applicable for each tool.

Pandle, Peter S., Robert P. Neuman, and Roland R. Cavanagh. *The Six Sigma Way Team Fieldbook: An Implementation Guide for Process Improvement Teams*. New York: McGraw-Hill, 2002.

The Six Sigma Way Team Fieldbook is a reference for team leaders and members, outlining both Six Sigma methods and the basic steps a team must follow in an improvement effort. The guide is written to be hands-on and is designed to help teams obtain the skills they need to identify a product, service, or process that needs improvement or redesign; gather data on the process and the rate of defects; find ways to improve quality up to a Six Sigma level.

Standard Work Resources

Productivity Press Development Team. *Standard Work for the Shopfloor*. New York: Productivity Press, 2002.

This book covers the characteristics of standard work, key benefits and applications of standardization, standard work concepts and calculations, and documentation. It includes standard work manuals, charts, and worksheets.

Total Productive Maintenance Resources

Japan Institute of Plant Maintenance (eds.). *TPM for Every Operator*. Portland: Productivity Press, 1992.

Designed to be user-friendly, this book covers the information that needs to be communicated to operators when facilitating a company-wide TPM initiative. It covers the main aspects of TPM, including introducing workers to TPM strategies and initiating routine maintenance.



Value Stream Mapping Resources

Rother, Mike and John Shook. *Learning to See: Value Stream Mapping to Create Value and Eliminate Muda*. Brookline: The Lean Enterprise Institute, 2003.

Learning to See is one of the main resources for value stream mapping. This workbook explains everything readers will need to know about how to create accurate current-state and future-state maps for processes. It also describes how to turn the current state into the future state.

Tapping, Don, Tom Shaker and Tom Luster. *Value Stream Management: Eight Steps to Planning, Mapping & Sustaining Lean Improvements*. Portland: Productivity Press, 2002.

This book introduces the reader to value stream mapping and links the metrics and reporting with the Lean tools needed for implementation. A central feature of this book is a value stream management storyboard, a tool representing an eight-step process for Lean implementation. The storyboard brings together people, tools, metrics, and reporting into one visual document.



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Appendix C: Case Studies



Charleston Water System Case Study

Summary

The Charleston Water System (CWS), located in Charleston, South Carolina, oversees one water treatment plant and two wastewater treatment plants and serves approximately 400,000 customers.¹⁶ The overarching management framework for CWS is the Baldrige Criteria for Performance Excellence, coupled with the Effective Utility Management (EUM) framework and the Environmental Management System (EMS). CWS also used the Baldrige Criteria to develop the utility's most current strategic plan, which support the EUM Attributes.

As a precursor to this management system, CWS uses its comprehensive EMS, which was developed using the International Organization for Standardization's ISO 14001 Standard. This initiative was started in 1998, with the first department certified in 1999, and all departments certified by 2003. The EMS is used throughout the organization for process and organizational improvements and for reducing CWS' adverse impacts on the environment.¹⁷

The Baldrige Criteria and the EMS provide the utility with a powerful and proven structure for using process improvement tools, including Lean and Six Sigma methods, to achieve the outcomes described in the EUM Attributes. The utility has a long history of using quality tools, but has recently begun to regularly use process-improvement tools from Lean and Six Sigma to enable the utility to increase its overall productivity.

¹⁶ Charleston Water System, Drinking Water Service, http://www.charlestonwater.com/water_overview.htm (Accessed 15 June 2012).

¹⁷ The Malcolm Baldrige Criteria for Performance Excellence are an integrated framework for managing an organization. They are simply a set of questions focusing on critical aspects of management that contribute to performance excellence and include: leadership; strategic planning; customer focus; measurement, analysis, and knowledge management; workforce focus; operations focus; results. Source: National Institute for Standards and Technology, *Criteria for Performance Excellence*, <http://www.nist.gov/baldrige/publications/criteria.cfm> (accessed 19 June 2012).



Summary of Results from Lean, Six Sigma, and EUM Projects

CWS' improvement efforts have produced impressive results. CWS' Lean and Six Sigma process-improvement efforts have achieved the following results:

Wastewater Collection System Infiltration and Inflow (I&I) Project

- Improved financial viability and optimized operations by reducing I&I, creating \$1.3 million in savings in operations and maintenance costs per year.
- Improved water resource adequacy by increasing wastewater treatment capacity by 2.62 million gallons per day (MGD).
- Improved financial viability by achieving \$9.17 million in impact fee savings.

Water Treatment Plant Chemical Disinfection Process Project

- Improved financial viability by achieving \$50,000 in chemical savings per year.
- Improved financial viability by saving \$50,000 in labor costs per year.
- Improved employee and leadership development by increasing staff training and establishing guides, standard operating procedures, and task instructions for calibrating instruments, monitoring processes, and adjusting chemical dosage.

Utility Experience with Effective Utility Management and Lean

CWS views the Baldrige Criteria for Performance Excellence as a key strategy for becoming an effectively managed utility. In 2007, CWS began using the Baldrige Criteria to improve the current strategic plan and to further effective utility management. It is a comprehensive, systematic framework to optimize organizational performance. The Baldrige framework is centered on a set of core values and concepts focused on delivering value to customers, improving organizational effectiveness, and promoting organizational and staff learning.¹⁸ Lean and Six Sigma methodologies overlap with and can act in support of Baldrige Criteria in that they are tools to enhance performance and continuous improvement; the Baldrige Criteria are often viewed as an overarching assessment framework in which Lean and Six Sigma tools can be incorporated.

CWS used the strategic plan and the Baldrige Criteria to develop 100 different measures to track the quality of process outputs for the water and wastewater treatment facilities, employee development performance, safety improvement, organizational leadership, financial health, and many other key focal areas. As part of this process, the utility also examined customer requirements to ensure it was meeting customer expectations. These measures and quality checks were included in the foundation of the utility's most current strategic plan. Even though CWS developed the strategic plan prior to the publication of the EUM Primer, CWS was involved in the development of the framework. After

¹⁸ Paul Grizzel and Mark Blazey, "Alignment of Baldrige with Six Sigma, Lean Thinking, and Balanced Scorecard," *Insights on Professional Excellence*, 2006. <http://statorgservices.com/Papers/Alignment%20of%20Baldrige-Six%20Sigma-Lean-Bal%20Scorecard.pdf> (Accessed 18 June 2012).



publication, CWS found that its strategic plan, EMS and adopted Baldrige Criteria framework all closely aligned with all of the 10 Attributes and five Keys in the Primer.

CWS began using Lean and Six Sigma tools in 2009 to achieve its desired outcomes identified in its EMS and strategic plan. CWS regularly uses Lean and Six Sigma tools, including:

- DMAIC (Define-Measure-Analyze-Improve-Control) process improvement approach. This approach is directly aligned with the PDCA (Plan-Do-Check-Act) process improvement approach used in EMS and Baldrige quality programs
- Value stream mapping (a process-mapping method focused on identifying non-value added activity and prioritizing improvements)
- Standard work (documented standard operating procedures)
- 5S (sort, set in order, shine, standardize, and sustain)
- Six Sigma statistical process quality control and variation analyses
- “Fishbone” cause-and-effect diagrams and other root-cause analysis problem-solving tools
- Visual controls (signs, color coding and other visual cues to reinforce proper procedures)

Lean and EUM Projects and Results

This section describes two projects that Charleston Water System conducted using Lean and Six Sigma—an I&I reduction project and a project to improve the chemical disinfection process at the utility’s water treatment plant. Both these projects used a similar implementation process, as described below.

Overview of Lean and EUM Projects

Wastewater Collection Infiltration and Inflow Reduction Project

Problem and Project Goals: CWS was treating excess water in its wastewater collection system, because rain and groundwater entered the system through cracks and cross-connections. To address this problem, CWS used Six Sigma process improvement methods and statistical process control tools to: (1) improve predictive maintenance, and (2) prioritize sub-basins to undergo further investigation through the Sewer System Evaluation Survey (SSES) and for infiltration and inflow reduction efforts.

Project Team: For this Six Sigma project, CWS assembled a cross-functional team consisting of ten staff members. Representatives included members of the Wastewater Collections Department, the Supervisory Control and Data Acquisition (SCADA) Manager, IT personnel, and a member from the Water Treatment Plant with Six Sigma experience. Extensive mentoring and training was provided to the team to ensure success. Follow-up training was also provided to ensure the team stayed on track and to answer questions that arose.

Water Treatment Plant Disinfection Process Project

Problem and Project Goals: CWS was unsure whether employees were adding excess chemical disinfectants to the water treatment plant disinfection process to correct or buffer for variability and to ensure compliance. Using Six Sigma process improvement methods and statistical process control, CWS



sought to reduce the daily variability in the disinfection process and to increase predictability in the overall process. In addition, CWS sought to reduce costs associated with using excess chemicals.

Project Team: CWS assembled a cross-functional team ranging from five to ten active staff members who participated in the project over its duration, including subject-matter experts who were included as needed. Staff participation ranged from plant operators, to maintenance technicians, to supervisors, and management level staff. Extensive training was provided to the team to ensure success. Follow-up training was also provided to ensure the team stayed on track and to answer questions that came up.

Implementation Process—Six Sigma and Lean Tool Application in Both Projects

The project teams from both the I&I reduction project and the disinfection process project used a variety of Six Sigma and Lean tools and as part of their implementation processes, including:

- Six Sigma DMAIC process improvement process
- Six Sigma project definition worksheet
- Process flow charts
- Fishbone cause-and-effect diagrams to examine root causes of problems
- Run charts (graphs that display data in a time sequence)
- Statistical process control charts (run charts that show the range of acceptable variability)
- Correlation charts (correlation tables show how items correlate with each other)
- Box plots (a graphical way of depicting ranges of data as boxes or boxes with extending lines)

“Lean focuses on the more visible problems associated with inefficiencies, where Six Sigma focuses on the less visible concerns associated with real data. Combining these approaches (Lean Six Sigma) allows the organization to reduce inefficiencies and waste using validation, and a structured, proven approach to pursuing improvement projects.”

“Without a methodology and structured framework in place, it is difficult to identify inefficiencies, plan improvements, execute your plans, and make them stick, all in a timely manner.”

– Richard Bickerstaff, Strategic Business System Manager, Charleston Water Services, South Carolina

To facilitate project deployment, the teams used a standard process improvement Six Sigma template that included the Plan-Do-Check-Act/Define-Measure-Analyze-Improve-Control (PDCA/DMAIC) framework. The first step was to define in writing the problems that were being considered for improvement. The teams also selected metrics to measure the level of results attained. In addition, the teams established process goals to help measure progress.

For the teams to better understand the inputs, outputs, and systems involved, they developed process flow diagrams. The first diagram each team created was a high-level process map. Then both teams mapped each major category of the processes, resulting in approximately 15 process-flow diagrams that



further dissected the interworking of the overall process. Both teams also created cause-and-effect diagrams to evaluate the process inputs in four categories: machine, man, methods, and measurement.

To prepare for the analyzing phase, the teams gathered data from the SCADA system and analyzed it using statistical process control methods (e.g., control charts). This allowed the Water Treatment Team to identify the level of chemical dosage variation, and allowed the I&I Team to analyze pump run time variation. Scatter diagrams based on regression analysis were also used to analyze the relationships between various data sets and aided in the decision-making process.

The teams then identified recommendations for improvement that were implemented. After seeing significant success in a short period of time, the recommendations were formally adopted.

- For the *I&I project*, the analyses resulted in inspecting 449,566 linear feet of wastewater mains and 2,108 manholes. The I&I Team then identified priorities and scheduled repairs and/or rehabilitation.
- For the *water treatment process*, standard operating procedures were updated and a contact time (CT) calculator was created to aid water operators in “controlling” and maintaining the new, improved process.

Using the Lean and Six Sigma tools helped the project team better understand the problem and the processes that were being analyzed. CWS staff noted that with the increased understanding of the benefits Lean and Six Sigma tools provide resulted in the opportunity for Lean-style thinking to be applied more broadly at the utility. In addition, the tools allowed teams to be better equipped to analyze the available data and to make data-driven versus subjective decisions.

Results from the Wastewater Collection I&I and Water Treatment Plant Disinfection Process Projects

By using a variety of Lean and Six Sigma tools, CWS achieved significant results from its Wastewater Collection I&I Reduction Project and its Water Treatment Plant Disinfection Process Project. CWS uses the data collected from the Six Sigma statistical tools to increase the use of data-driven decision making. SCADA data is now captured on a daily basis and is used to make real-time adjustments. This Six Sigma approach has also been incorporated into the daily duties of staff personnel. CWS has set new goals and targets for the wastewater collection operations and water treatment plant based on the data.

Specific results and associated EUM Attributes from the projects include the following.¹⁹

Wastewater Collection I&I Reduction Project Results

- Improved financial viability and optimized operations by achieving \$1.3 million in operations and maintenance cost savings per year.
- Improved water resource adequacy by increasing wastewater treatment capacity by 2.62 million MGD.

¹⁹ The following results are from Richard Bickerstaff, Charleston Water System, personal communication, 30 May 2012 and 24 Sept 2012.



- Improved financial viability by achieving \$9.17 million in impact fee savings from the increased treatment capacity.²⁰

Water Treatment Plant Disinfection Process Project Results

- Improved financial viability by achieving \$50,000 in chemical savings per year.
- Improved financial viability by saving \$50,000 in labor costs per year.
- Enhanced operational optimization by using variation evaluation to determine when the system is “out of control.” Operators now only make adjustments when the system is “out of control” instead of on a continual basis. This reduced the frequency with which operators were taking readings and notifying instrumentation/electrical personnel to make adjustments to the system.
- Improved employee and leadership development and optimized operations by increasing staff training and establishing guides, standard operating procedures, and task instructions for calibrating instruments, monitoring processes, and adjusting chemical dosage.
- Optimized operations by developing a CT real-time calculator increased the use of statistical process control and difference charts, and updating process system flow charts.

Looking Forward to the Future

CWS has used the EMS and EUM frameworks to improve utility systems and management. The utility has recently begun using Lean and Six Sigma tools in support of these frameworks and had some important, immediate successes. In October 2011, CWS was awarded the South Carolina Governor’s Quality Award. The Governor’s Quality Award is a top honor for organizations that achieve performance excellence by implementing the Baldrige Criteria for Performance Excellence. In July 2012, CWS was awarded NACWA’s Excellence in Management award for continuous improvements in the EUM Attributes, and for other sustainability initiatives.

CWS plans to expand the use of Lean and Six Sigma tools in its process-improvement efforts, building on the successes it has had in the past several years. All department directors and assistant directors have been trained on Lean and Six Sigma tools, and the model has been incorporated into the standard process improvement frameworks that exist in the organization. The use of EUM, the utility’s EMS, the Baldrige Criteria, and Lean and Six Sigma tools will help CWS in the attainment of its new vision: by 2017, CWS’s 100th anniversary, its vision is to become worthy of the Malcolm Baldrige National Quality Award for its customers, its community, and its future.

²⁰ The impact fee savings was calculated based on the following formula: \$3.5/MGD saved x 2.62 MGD = \$9.17 million.





Summary

Clean Water Services is a water resources management utility serving 536,000 customers in Washington County, Oregon (west/southwest of Portland).²¹ Clean Water Services and its member cities support healthy rivers and streams through four wastewater treatment facilities, over 1,200 miles of storm and wastewater lines, flood management projects, water quality and stream enhancement projects, fish habitat protection/restoration, and resource recovery. Clean Water Services also manages summertime flow in the Tualatin River to improve water quality and fish habitat by releasing purchased water from a Bureau of Reclamation project. Clean Water Services has a long history of implementing utility management initiatives, and in doing so, the utility has adapted the approaches from industry to fit the organization's needs and culture. The utility has numerous strengths across the EUM Attributes, including community sustainability, as Clean Water Services holds the first integrated, municipal watershed-based permit in the country.

Clean Water Services was already a well-running utility, but it decided further leverage the gains made in the late-90s with its business process re-engineering initiative by investing in Lean and Six Sigma, and using the EUM Self-Assessment to move "from good to great" and advance its new vision of becoming a resource-recovery utility. The utility has invested in Lean and Six Sigma training, established a Business Process Management Center of Excellence, initiated several Lean and Six Sigma projects, and is using the priorities identified in a EUM Self Assessment to drive future improvement projects. Based on the EUM Self Assessment initially conducted in 2008 and updated in summer 2012, Clean Water Services has identified key performance indicators for the utility's improvement priorities, organized Lean and Six Sigma process improvement projects through the utility's annual "Goal Share" strategic planning process, and the utility is currently developing dashboards for each indicator to track its progress.

²¹ For more information about Clean Water Services, see <http://www.cleanwaterservices.org>.



Case Study Highlights

- Clean Water Services invested in Lean and Six Sigma training and implementation, because it needed more robust and proven, data-driven, performance-enhancement tools that could help it transition from a wastewater and stormwater utility to a resource-recovery utility.
- The utility is using the EUM framework to benchmark its performance against utility-relevant measures, select the most important improvement opportunities, and inform its “Goal Share” strategic planning process.
- Lean provides a simple and effective structure to engage staff in continually improving processes, while Six Sigma provides the analytic rigor needed to address complex operational processes.
- The utility’s investment in Lean and Six Sigma is expected to save hundreds of thousands of dollars in a relatively short time frame.
- For example, the “Bio-P” Six Sigma and EUM Project is expected to produce the following results:
 - Enhance financial viability and operational optimization by reducing chemical usage by \$250,000 per year.
 - Improve operational optimization, financial viability, and community sustainability by increasing the production of Crystal Green fertilizer (struvite recovery) by 20 percent.
 - Develop advanced process-control knowledge that is transferable to other utilities for biological nutrient removal and nutrient recovery, providing benefits for operational optimization and operational resiliency to Clean Water Services and others.

Utility Experience with Effective Utility Management and Lean

History of Management Improvement Initiatives

Like many utilities facing increasingly stringent state and federal pollution control requirements, aging infrastructure, and a growing service district, Clean Water Services has needed to reduce costs, produce measurable results, and deliver services at unparalleled value for ratepayers and the environment. In 1995, the Clean Water Services embarked upon a strategic initiative designed to control its destiny, chart its future, and reach “beyond excellence.” Since that time, the utility launched a series of management improvement efforts, including the following:²²

- Business process reengineering, including aggressive budget reductions and staffing cuts in the late 1990s, including cutting positions from 366 to 278 in three years
- A Goal-Share Program to support collaborative improvement efforts
- A pay-for-performance system for all employees, including those subject to a collective bargaining agreement
- The nation’s first integrated, municipal watershed-based permit allowing water-quality trading

²² Information in this section provided by Bill Gaffi, Mat Stickler and Diane Taniguchi-Dennis, Clean Water Services, Personal Communication, May and August 2012.



- A business partnership with Ostara Nutrient Recovery Systems, to provide the nation’s first full-scale commercial phosphorus recovery system
- Formation of the Clean Water Institute non-profit organization, which commercializes Clean Water Services’ intellectual property and other watershed management innovation
- A Business Process Management Center of Excellence, with core staff trained on Lean and Six Sigma methods

Due to these and other efforts, Clean Water Services has been recognized by sister organizations and business magazines as a best-in-class utility. The utility’s accomplishments include the following:²³

- Achieved nearly \$100 million in operating cost savings while operating within one of the nation’s most stringent and rapidly evolving regulatory environments.
- During a period of program expansion, reduced the ratio of employees to customers by over 35 percent, including reducing the fleet by one-third and cutting two levels of management.
- Maintained only very modest rate increases during a period of dramatic program expansion and capital investment driven by new regulations.
- Shifted the organizational vision from a traditional “pumps, plants, and pipes” view to a broader, holistic watershed and public health vision, including changing the organization’s name from Unified Sewerage Agency to Clean Water Services.
- Received Platinum or Gold Awards from the National Association of Clean Water Agencies for all four wastewater treatment plants based on multiple years of 100 percent compliance with wastewater discharge permits.
- Twice recognized by EPA as the having the nation’s best source-control program of its size.
- Instituted the nation’s first temperature water quality trading program, which saved the utility \$140 million in capital and operating costs beyond the savings noted above.

“EUM is the magnifying glass for utilities to provide deliberate focus for a utility’s strategy and outcomes, and Lean is the tool to make lasting change for utilities to become more efficient and effective.”

“Unless utilities are equipped with robust management tools to improve their operations, changes are made based on gut instincts without the benefit of data. It is very helpful to have tools for structured process improvement such as Lean and Six Sigma.”

– Diane Taniguchi-Dennis, Deputy General Manager, Clean Water Services, Oregon

²³ Information in this section provided by Diane Taniguchi-Dennis, Clean Water Services, Personal Communication, August 2012.



The utility's Lean, Six Sigma, and EUM efforts represent the latest evolution of this long history of management improvement efforts. The purpose of the Lean and Six Sigma efforts is to reduce efficiency bottlenecks in transactions and procedures, reduce non-value added workflow, and optimize processes to provide quality services and maximum value for the cost of services provided. The Goal Share Program (noted above) at Clean Water Services provides an important strategic focus for the utility's management improvement efforts. In the Goal-Share Program, the Board and Leadership Team select annual strategic priorities based on the utility's needs and challenges, and then identify 80–100 actionable, measurable stretch goals that employee teams work on across organizational silos. Each employee receives an equal share in the benefits from the goal-share efforts, so this rewards collaborative work. The utility's annual strategic priorities address many of the areas in the EUM Attributes, including financial viability, product quality, and community sustainability. Clean Water Services is using the EUM Self Assessment as a tool to sharpen the focus of the planning process for the Goal-Share Program, and is using Lean and Six Sigma methods to support implementation of Goal Share process-improvement goals through the Business Process Management Center of Excellence.

Reasons for Introducing EUM, Lean, and Six Sigma

As noted above, Clean Water Services exemplifies many aspects of an effectively managed utility, and it scores well across the EUM Attributes. However, Clean Water Services sought to move “from good to great” and advance a new vision for the utility: transitioning from a wastewater and stormwater utility to a resource-recovery utility (see quote box). The utility used the proven tools of Lean and Six Sigma to take its process-improvement efforts to the next level and work towards that vision, as well as the EUM framework to guide the overall improvement priorities in the “Goal Share” strategic planning process.

“It’s not wastewater anymore; it’s a resource that will shape the sustainability of our watersheds and communities.”

– Bill Gaffi, General Manager, Clean Water Services, Oregon

Clean Water Services chose to focus on Lean and Six Sigma for these key reasons:

- Lean and Six Sigma are demonstrated approaches used throughout multiple industries (including Clean Water Services' customers) that have produced unparalleled success.
- Lean and Six Sigma give good managers better tools to improve processes.
- Lean provides structured and effective processes for engaging employees in continual improvement efforts. (Clean Water Services uses Lean methods, in particular, for transactional and administrative processes.)
- Six Sigma provides the analytical rigor necessary for optimizing complex operational processes.

Clean Water Services completed a EUM Self Assessment in 2008, when the EUM Primer was developed, but managers thought that re-doing the assessment would be valuable, based on the utility's new vision



and commitment to implementation through the Business Process Center of Excellence. The utility chose to incorporate EUM into its Goal-Share planning process, rather than launch an independent initiative, in order to fit with the organization's culture. Key reasons for conducting the EUM Self Assessment include:

- The EUM Self Assessment will help the utility to select improvement priorities and decide where to target future Goal Share process improvement projects.
- The EUM Self Assessment provides a simple and quick process to engage leadership and managers in a discussion of utility performance and improvement priorities.
- Framing the utility's goals and performance metrics in common language (e.g., in annual reports) relevant to the utility industry will help simplify communications with stakeholders.

Lean, Six Sigma, and EUM Deployment Efforts

In 2010, Clean Water Services formally introduced Lean and Six Sigma methods to its business process improvement program. This supported an annual "goal share measure" focused on business process improvement and built on training conducted for 75 staff on business process modeling techniques in 2008. Lean, in particular, has been empowering for employees. Staff has been less receptive to Six Sigma terminology as compared to the simpler waste-reduction concepts of Lean, but complicated processes such as treatment plant operations directly benefit from the data analysis of Six Sigma.

The utility has taken the following steps to introduce and incorporate Lean, Six Sigma, and EUM into the organization:

- **Staff Training:** Clean Water Services significantly expanded formal training of staff in Lean and Six Sigma methods in 2011-12. As of summer 2012, 15 staff had received training from the Lasater Institute²⁴ on Lean and Six Sigma methods at the "gold belt" (introductory) level²⁵ and one had received training at both the "green belt" (middle) and "black belt" (advanced) levels. The utility plans to move one more staff person to the "black belt" level of training and six staff to the "green belt" level.
- **Allocated Resources:** The Lean and Six Sigma training has cost the utility \$40,000, as well as staff time, but the utility expects to save hundreds of thousands of dollars from the investment in a relatively short period.
- **Established a Center for Excellence:** In 2011, Clean Water Services established a "Business Process Management Center of Excellence." This formalized the Lean and Six Sigma improvement program and elevated its importance within the utility. About 15 people from across the utility work on Center for Excellence initiatives.
- **Initiated Improvement Projects:** The Center of Excellence initiated several process improvement projects, including the treatment plants' biological-Phosphorus processes (described below), the

²⁴ The Lasater Institute (<http://www.lasaterinstitute.com/>) is a private Lean and Six Sigma consulting and training firm.

²⁵ The more common name for the introductory level of Lean Six Sigma training is "yellow belt" rather than "gold belt."



parts-stocking process for treatment plants, establishing a documented process for security provision, and reducing the costs of landscaping. The EUM Self Assessment completed in 2012 and the revised Goal-Share program will guide future improvement projects.

- Adapted the Lean Tools to Fit with the Organizational Culture: To better fit with the utility's operational needs, Clean Water Services has adapted the implementation process for Lean events so that they occur over non-sequential days spread out over weeks or a couple of months, rather than a single week-long event. The utility has also tried to minimize the introduction of new terms and jargon, and all projects support the Goal Share program.
- Incorporated EUM Into the Goal Share Process: After completing initial Lean and Six Sigma projects and training in 2011-12, Clean Water Services decided to more explicitly incorporate Lean and Six Sigma methods into the Goal Share process for the 2013 fiscal year, as well as align the Goal Share efforts with the EUM framework. The utility completed a EUM Self Assessment in summer 2012 (described below) and is using the results to inform planning for future Lean and Six Sigma process improvement projects in the Goal-Share process.

In these efforts, Clean Water Services has used a variety of tools from the Lean and Six Sigma toolbox, including:

- Lean waste identification ("DOWNTIME" = Defects, Overproduction, Waiting, Non-utilized or underutilized employee resources, Transportation, Inventory, Motion, Excess Processing)
- Current state and future state process mapping
- 5S (a 5-step method for cleaning, organizing, and standardizing work areas)
- Cause-and-effect analysis (e.g., "fishbone" diagrams)
- Failure mode effect analysis (a method for analyzing the causes of failures and developing corrective actions to address problems)
- Six Sigma statistical process control analyses

In summer 2012, Clean Water Services conducted a EUM Self Assessment with its Leadership Team and with a group of about 55 supervisors across the utility. The utility did the assessment as an interactive exercise that used an audience response system, where meeting participants could provide their input on EUM Attribute importance rankings and achievement ratings electronically, and results could be updated in real time. This proved to be a very effective tool for engaging participation and collecting input in a short time. The leadership's EUM Self Assessment revealed that product quality, financial viability, and customer satisfaction scored the highest in terms of both importance and achievement.

Clean Water Services is committed to familiarizing utility managers with the EUM framework. Based on the EUM Self Assessment priorities and other planning for the Goal-Share process, the utility will identify a set of about 20 key performance indicators to drive improvement efforts over the next year, and then will develop dashboards to help managers and staff track progress on those indicators throughout the



year. The utility intends to align the Goal Share goals and indicators with the EUM Attributes, and then continue to use Lean and Six Sigma in process improvement projects to meet the annual goals.

Clean Water Services' Preliminary Results from the 2012 EUM Self Assessment

Rating	Lower Achievement	5										
		4										
	Higher Achievement	3		FV				ED		IS	OR	WA
		2	PQ		CS	SS	OO					
		1							SU			
			1	2	3	4	5	6	7	8	9	10
			More Important					Less Important				
			Ranking									

- | | | | |
|----|---|----|-------------------------------------|
| WA | Water Resource Adequacy | FV | Financial Viability |
| PQ | Product Quality | OO | Operational Optimization |
| CS | Customer Satisfaction | IS | Infrastructure Stability |
| CE | Community Sustainability & Economic Development | OR | Operational Resiliency |
| ED | Employee & Leadership Development | SS | Stakeholder Understanding & Support |

Lean and EUM Projects and Results

Clean Water Services launched a series of improvement projects through its Business Process Management Center of Excellence; this section highlights the status and expected results of a project that is central to the utility’s future vision of becoming a community resource-recovery utility.

Improving the Treatment Plant “Bio-P” Process with Six Sigma (Ongoing Project)

Problem: Clean Water Services uses biological phosphorus (bio-P) treatment technology at its Durham wastewater treatment plant and intends to use a similar approach at its other treatment plants, once it has optimized the Durham bio-P process to reduce chemical use and costs. The utility must seasonally treat discharges to the Tualatin River to a limit of 0.1 milligrams/liter (mg/l) of phosphorus, and would prefer to meet the requirements cost effectively without using a lot of chemicals. The goals of the project include reducing costs and chemical use, while meeting discharge limits and performance standards. The project is expected to provide benefits for EUM Attributes including financial viability, operational optimization, and community sustainability.



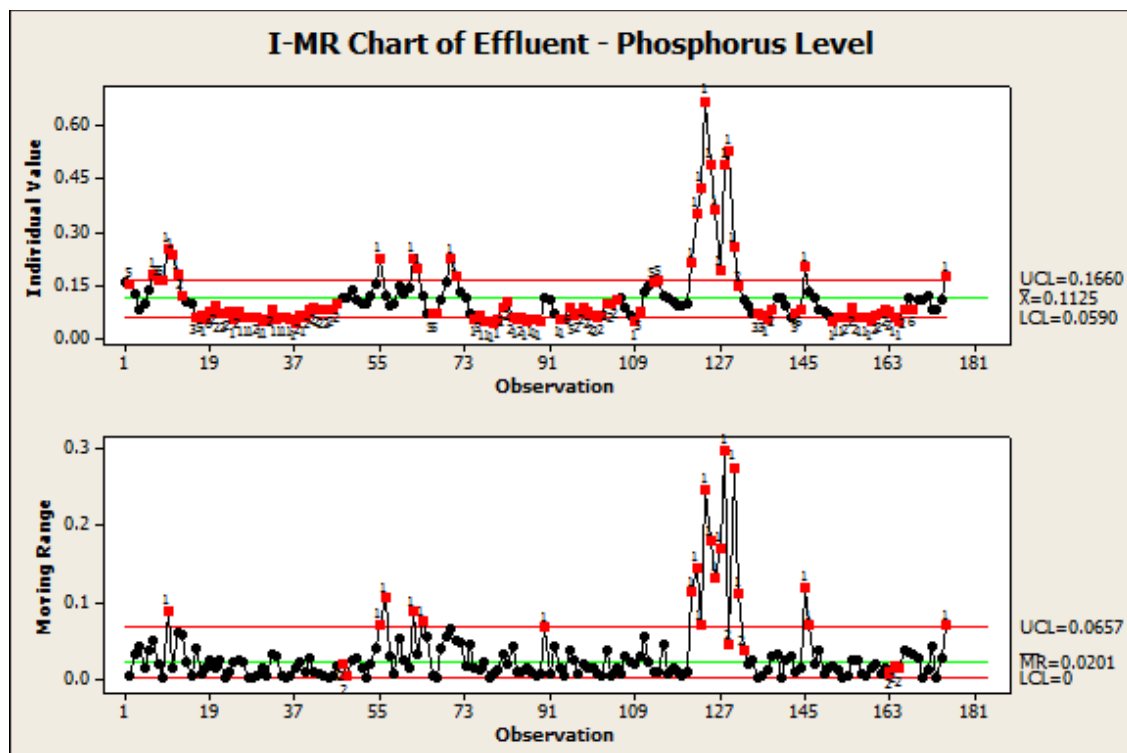
Implementation Process: Clean Water Services is using the Six Sigma DMAIC (Define-Measure-Analyze-Improve-Control) process for this project. The IT Division Manager is leading this project for his “black belt” training certification, and he is working with a cross-functional team of eight employees to conduct the project. The complexity of the process and the number of inter-dependent variables that the utility seeks to optimize makes this a particularly appropriate project for Six Sigma methods.

So far, the project team has completed the first two phases in the process and begun work on the third:

- **Define:** Clean Water Services began the project by selecting a project team and developing a charter for the project. The team is made up of Operational Analysts and a Process Engineer from the Waste Water Treatment Department, a statistics expert from the Regulatory Affairs Department, the Manager of the IT Division who has received the most Lean and Six Sigma training at the utility, and the Director of the Business Operations Department who serves as the project lead and sponsor, has extensive background in waste water treatment processes, and “gold belt” level training in Lean and Six Sigma. The project goal is to increase the use of Bio-P treatment (i.e., the “Y” the utility seeks to improve) by stabilizing the process.

Individual-Moving Range (I-MR) Charts for Phosphorus Effluent Levels for the Bio-P Process

The goal of the Bio-P project is to control phosphorus effluent levels to within the upper control limit (UCL) and lower control limit (LCL), which are shown in these charts as red lines.



- **Measure:** In the second phase of the project, the project team worked together to create a process map and then used a “Cause and Effect Matrix” to identify and prioritize the “Xs” (dependent



variables or inputs) that contribute to varying process outputs. This resulted in short list of key inputs to be more highly scrutinized.

- **Analyze:** In the Analyze phase, the team has begun using Minitab statistical software to graph control charts, and conduct regression analysis of the key inputs. The utility is fortunate in that the process has been highly monitored for years, so the team has access to detailed, electronic, and continuous measurements.

Over the next 8–12 months, the utility will complete the Analyze phase and conduct the Improve and Control phases for the project. This will involve the following activities:

- **Analyze:** The team will determine the true sources of variation and potential failure modes that lead to poor “Y” performance—that is, the root causes that limit the ability of the utility to maximize recovery of struvite through the Bio-P process.
- **Improve:** In the Improve phase, the team will conduct multi-variable analysis and use the “Design of Experiments” (DOE) method to optimize the most critical inputs (i.e., the “Xs”) for the process.
- **Control:** The purpose of the Control phase is to establish tools that will ensure the key variables stay within the accepted variances over the long run. In this phase, the project team will create a plan for handing off the process, which will include response procedures and educational information to guarantee the process will continue to meet performance expectations and produce long-term project savings.

“The bio-P process improvement project will require the highest level concepts of the Lean/Six Sigma training we've received, definitely black-belt level.

However, we expect the effort will improve and develop a far more stable process that will quickly pay for itself in chemical costs savings, and increased revenue from recovered resources.”

– Mat Stickler, IT Division Manager, Clean Water Services, Oregon

Expected Results:

Clean Water Services expects to realize the following benefits from the bio-P process improvement project upon its completion. In addition, since the project is a capstone project for a Lean and Six Sigma “black belt” training class, it also represents an example of employee leadership and development, as Clean Water Services builds its internal capacity for continual learning and improvement.

- Enhance financial viability and operational optimization by reducing chemical usage by \$250,000 per year. Stabilizing the bio-P process not only will reduce chemical costs, it will also increase revenues from the utility’s resource recovery system, which can only produce the Crystal Green fertilizer during Bio-P treatment.
- Improve operational optimization, financial viability, and community sustainability by increasing the production of Crystal Green fertilizer (struvite recovery) by 20 percent.



- Develop advanced process-control knowledge that is transferable to other utilities for biological nutrient removal and nutrient recovery, providing benefits for operational optimization and operational resiliency to Clean Water Services and others.
- Enhance community sustainability by reducing chemical use and maximizing resource recovery. With expanded use of the Bio-P process, the utility will produce less biosolids, which need to be hauled to eastern Oregon. Reducing consumption of chemicals minimizes the impacts associated with chemicals, such as mining and transportation.

Looking Forward to the Future

Clean Water Services is a leader in effective utility management and sustainability efforts. It was the first utility to obtain an integrated, watershed-based permit addressing water quality, water quantity, and wildlife habitat issues, and through its partnership with Ostara, it operates the nation's first full-scale commercial phosphorus recovery system. Clean Water Services is transitioning its business from a wastewater and stormwater utility to a resource-recovery utility, and utility managers see Lean and Six Sigma methods as being essential to that transition. The utility plans to continue its initial investment in Lean and Six Sigma training for managers and staff to establish a core group who can lead process-improvement projects for the utility in the future. Future Lean and Six Sigma improvement projects will address priorities identified through the utility's EUM Self Assessment and annual goal-share objectives.





City of Palm Bay Utilities Case Study

Summary

The City of Palm Bay Utilities Department (PBUD), located in Palm Bay, Florida, oversees three water and two wastewater treatment plants and serves over 32,000 water and 15,000 sewer customers. The overarching management framework for Palm Bay Utilities is its certified ISO Standard 14001:2004 Environmental Management System (EMS), which covers both water and wastewater facilities, as well as the department. It is the only water and wastewater utility department in Florida to have the entire department registered to ISO Standard 14001:2004. PBUD's EMS provides the utilities department with a powerful and proven structure for using process improvement tools, including Lean and Six Sigma methods, to achieve the outcomes described in the EUM Attributes.

Summary of Results

PBUD's Lean and EUM improvement efforts have produced impressive results. Below are selected results from improvement projects linked to the EUM Attributes:

Water and Wastewater Treatment Plant Energy Efficiency Six Sigma Chartered Projects

- PBUD improved financial viability and operational optimization using Six Sigma techniques to facilitate a 39.8 percent reduction in energy costs at the water and wastewater treatment plants from the base year 2008 projected through 2012.
- PBUD improved community sustainability and made operational optimization improvements by reducing greenhouse gas emissions by 16.8 percent from the base year 2009 projected through 2012 as a result of decreased energy consumption at the water and wastewater treatment plants.

Utility Billing Improvement Project

- Through a Lean process improvement project using a kaizen event and value process mapping exercise, PBUD achieved improvements in financial viability through cost savings and avoided costs. For instance, with the elimination of a delinquency notice or second bill, the City realized a cost savings of approximately \$33,000 annually.



Summary of Results, continued

Overall Process Improvement Program

- PBUD improved financial viability by saving approximately \$1.15 million in 2011 through continuous improvement initiatives supported by Lean and Six Sigma methods, as well as the objectives, targets, and programs of the EMS.
- PBUD bolstered employee and leadership development through a process improvement program that trained employees in Lean, Six Sigma, 5S+S, and other continuous improvement tools.
- Bolstered financial viability by improving all bond ratings, both Standard and Poor's and Moody's since initiation of continuous improvement management framework and Lean improvement techniques; driving down operational costs and reducing environmental and business risks.

Utility Experience with EUM and Lean

In 2008, PBUD established its EMS, called “GreenWay,” and completed a strategic plan as part of the EMS process prior to final publication of the EUM Primer. PBUD developed its EMS with assistance from the University of Florida’s Center for Training, Research and Education for Environmental Occupations (TREEO).²⁶ TREEO helped PBUD set up its EMS management framework and ISO standards, and it has conducted annual compliance evaluations since 2008 for the utility. PBUD completed the EUM Self Assessment tool as a litmus test of its EMS and found that its EMS aligned very closely with and supported all of the 10 Attributes. Having the opportunity to compare its EMS with another utility management and improvement framework developed by its peers gave PBUD confidence that its continuous improvement framework was headed in the right direction.

PBUD has used Lean and Six Sigma to implement its EMS and address the EUM Attributes through a number of improvement projects. This includes projects in the three priority areas for improvement that PBUD identified in its EMS as significant environmental aspects:

- Energy use;
- Production, handling, and disposal of biosolids; and
- Environment, safety, and health of the work force.

PBUD began implementing Lean and Six Sigma methods in 2008. It embedded Six Sigma strategies, including the DMAIC (Define-Measure-Analyze-Improve- Control) process within its EMS to evaluate, analyze, and change processes when improvement is needed. PBUD trained several managers and staff (ranging from business managers to engineers) on Six Sigma and Lean methods on a volunteer basis; nine staff members have received training at the Six Sigma “green belt” level, and one has advanced Six Sigma “black belt” training. Black belts and green belts are people within an organization that are

²⁶ More information on TREEO and the EMS services they offer can be found on their website: <http://www.treeo.ufl.edu/ems/>.



trained in Six Sigma statistical methods. In addition to Six Sigma, PBUD has used Lean to support continuous improvement initiatives. For example, PBUD partnered with TechSolve, Inc., a not-for-profit professional services organization, to train staff on Lean methods and conduct three lean projects using kaizen events and value stream mapping, including one event described below on the utility billing process. PBUD also regularly uses the Lean 5S+S method (which is the 5S method with safety added) in its process improvement program.

EUM and Lean Projects and Results

Water and Wastewater Treatment Plant Energy Efficiency Six Sigma Chartered Projects

Problem: Palm Bay Utilities' EMS is based on a strong commitment to regulatory compliance, pollution prevention, and continual improvement. It takes a significant amount of energy to treat and process potable water and wastewater; thus, plant efficiency and reducing consumption of energy was a high priority for Palm Bay Utilities. Two sister Six Sigma chartered projects sought to reduce energy use and costs, consistent with the EMS implementation priority and the EUM attribute for operational optimization.

Implementation Process: PBUD assembled a Six Sigma project team, which included a Six Sigma project champion, a green belt, and PBUD engineering and plant operations personnel. The team used the Six Sigma DMAIC process. No outside consultants were used for the project. The team began work by developing a project charter and identifying additional team members as supporters. The charter defined the project and included information such as: process start and stop points, process importance, process problem, project goals, process measurements, and the project time-frame. The team used a project template to document the charter.

As a result of the desire to compare multiple water and wastewater treatment plants, PBUD decided to normalize incremental improvements by measuring treatment costs per 1,000 gallons of water treated. The resulting measurement plan included baseline costs for each plant for four cost categories (energy use costs, chemical costs, labor costs, and maintenance costs) and then compared component and total costs by plant. For each water plant, for instance, measurement showed that energy costs were the greatest of the four cost categories. The water plants with the greatest energy cost per 1,000 gallons of treated water were identified as high priority for cost-reduction efforts. Based on the Six Sigma study, PBUD set an annual goal to achieve a minimum 10 percent reduction in electrical costs each fiscal year.²⁷ Reporting each month on the progress of reduction efforts and providing a Six Sigma control plan were important in capturing incremental improvements and sustaining them once captured.

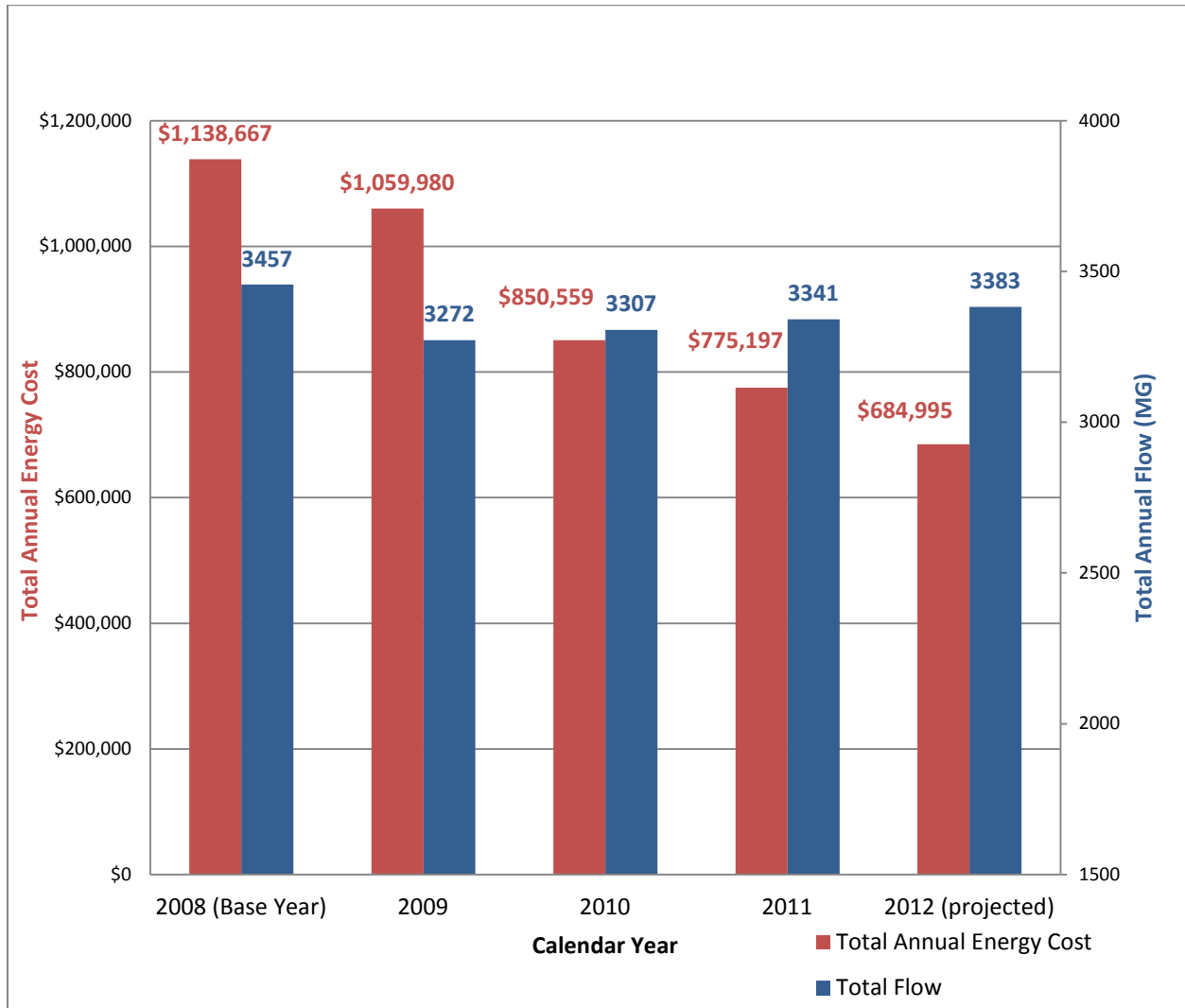
Results: To achieve the annual reduction in electrical costs, PBUD personnel made process changes to allow each treatment plant to run at its most efficient capacity. The graphs below illustrate the annual energy cost reductions for water and wastewater treatment plants from reduced electrical consumption

²⁷ Sustainable Palm Bay, *City Initiatives*, http://gogreen.palmbayflorida.org/CityInitiatives_Uilities.html (Accessed May 15, 2012). Personal correspondence with Dan Roberts of Palm Bay Utilities.

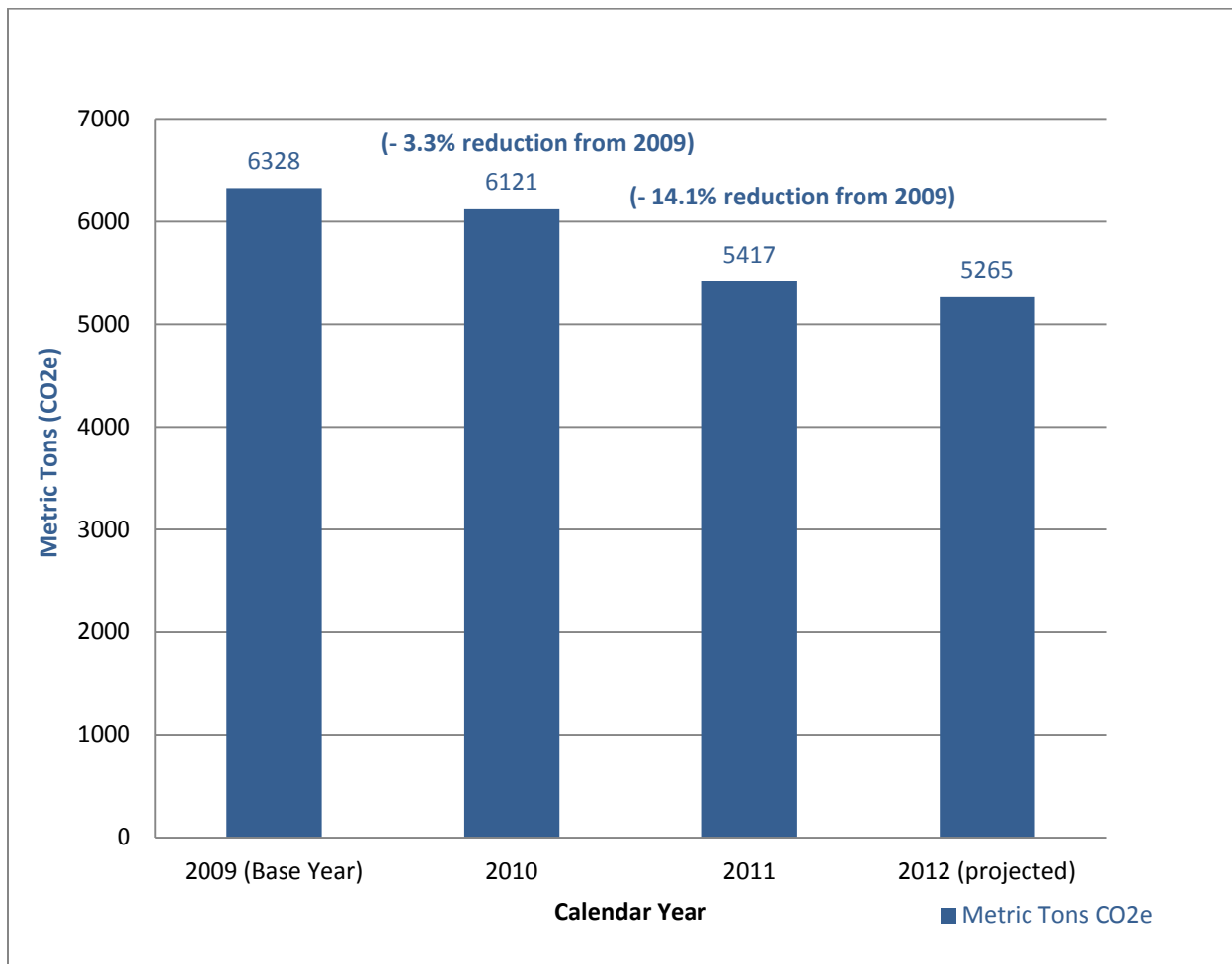


for water and wastewater treatment measured from a base year of CY 2008 and the metric tons of carbon dioxide equivalent reduction measured from the base year of 2009.

Annual Energy Cost Reduction and Treatment Flow
 (City of Palm Bay Utilities Department's Water and Wastewater Treatment Plants)



Metric Ton (mt) of Carbon Dioxide Equivalent (CO₂e)-Electrical Use
 (City of Palm Bay Utilities Department's Water and Wastewater Treatment Plants)



Benefits from the Water and Wastewater Treatment Plant Energy Efficiency Six Sigma Projects include:

- Six Sigma techniques improved financial viability and operational optimization to facilitate a 32-percent reduction in energy costs at the water and wastewater treatment plants from the base year 2008 through 2011.²⁸ The results were monitored and improved through the use of the Six Sigma DMAIC process over multiple years. Peak power rate periods were identified and plant operation, plant processes and equipment operation were manipulated and controlled resulting in lower peak power charges. Acidization of a deep injection well provided efficiencies in pumping, providing for one pump to be used routinely rather than three. Variable Frequency Drives for selected pumps were installed further driving energy use and costs downward.
- Financial viability was improved achieving an 11.7-percent cost savings in energy use alone at the potable water treatment plants in spite of rate increases. The result was an 18-percent

²⁸ Sustainable Palm Bay, *City Initiatives*, http://gogreen.palmbayflorida.org/CityInitiatives_Utilities.html (Accessed May 15, 2012).



overall budgetary savings in plant energy costs in 2008 from the base line year of 2007, which was the original base line year for the water treatment plants' Six Sigma project.²⁹

- Community sustainability and operational optimization improved by reducing greenhouse gas emissions by 23.7 percent from the base line inventory year of 2009 through 2011 as a result of decreased electrical energy and fossil fuel consumption.³⁰
- Customer satisfaction improvements were achieved through the reduced energy and cost savings from Lean and Six Sigma implementation. These cost reductions allowed PBUD to minimize rate increases, ultimately benefiting its customers.

These two Six Sigma projects were formulated and implemented by utilities personnel without significant costs or consultant assistance. Embedding the Six Sigma project in an established EMS provided a synergy or “added value” to the resulting efficiencies that neither continuous improvement method, applied alone, could achieve or sustain over an extended period. Some energy solutions are process- or design-oriented, while others are related to behavioral or operational issues, and an EMS is well suited to address each of these categories. Furthermore, an EMS like that of PBUD is not only an environmental management system, it also has the parameters of an ISO Standard 9001:2008 Quality Management System, and is well suited to provide the quality control of documented procedures and processes to base improvement upon whether the improvements are process, design-oriented, behavioral or operational. The Six Sigma methodology allowed for a structured team approach, technical tools, and continuous improvement methodology for incremental improvements that were captured and maintained utilizing the quality management system components of an EMS and the control measures of the Six Sigma process. Having a structured, technical process-improvement tool embedded in an environmental management framework allowed improvements to be realized, documented, and most importantly, sustained.

Utility Billing Improvement Project

Problem: The Finance Department and Utilities Department had an overly complicated and inefficient process for utility billing, as the result of several years of “process creep” in which the process had become increasingly complex and time consuming. As a result, PBUD was experiencing delays in customer inquiries, hookups, meter reading, and billing practices. In 2009, the Finance and Utilities Departments and associated divisions participated in a Lean kaizen event, or rapid improvement process, on the utility-billing process. This Lean event sought to reduce the process time and complexity of the utility billing process and increase overall efficiencies concerning revenue collection.

Implementation Process: This project was one of three initial Lean events that the not-for-profit Lean service provider TechSolve, Inc. facilitated for PBUD. Prior to the event, with the assistance of TechSolve, the Finance and Utilities Departments identified the key stakeholder groups and formed

²⁹ Dan Roberts, Utilities Department, Palm Bay, Florida, “Establishing an Accountability Management System in the Palm Bay Utilities Department,” *Government Finance Review* (December 2009).

³⁰ These calculations were based on the protocol guidance of the Local Government Operations Protocol, Version 1.1, as was the entire City of Palm Bay Governmental Operations Greenhouse Gas Emission Inventory.



implementation teams for the project. They also took part in team chartering meetings to clarify the expectations, scope, and logistics for the Lean event. Finally, the teams identified performance measures and gathered data about the workflow processes in both departments.

At the three-day event, PBUD and Finance Department staff, with assistance from the TechSolve facilitator, reviewed and created a visual map of the current state of the process of utility billing (a current state value stream map), in “swim-lane” format, which places emphasis on concurrent steps. They identified places on the map where there were non-value added steps in the process, and recognized improvement opportunities, as well as process metrics. The team then created a map of a new and improved process (a “future state” value stream map) and developed new performance metrics and targets to help achieve, sustain, and continuously improve the future-state goals. The future state map provided detailed documentation of each step in the new process, along with process metrics and improvement projects. In addition to creating the current state and future state maps, the team also developed a roadmap for implementation. This document bridged the current and future states of the utility billing process and documented all needed changes, associated responsibilities, and a timeline.

Results: Through a Lean project, PBUD was able to reduce the time and complexity of the utility-billing process, as well as improve customer-service practices around billing processes, which achieved better customer satisfaction. The Utility Billing Improvement Project resulted in:

- Financial viability improved through cost savings and avoided costs. For instance, with the elimination of a delinquency notice or second bill, the City realized a cost savings of approximately \$33,000 annually.³¹
- Operational optimization improved through reduced processing time, number of process steps, and complexity. For example, through the value stream process, it was apparent that the initiation process for water service was too complicated and involved numerous personnel from different departments. In the typical initiation process, the Building Department sent a representative to inspect the backflow preventer and then the building inspector called or issued a work order for a member of the Utilities Department’s staff to come back to the site to turn on the water. The simple fix was to eliminate the travel to and from the work site and allow the building inspector to turn on the water upon a satisfactory inspection. This process reduction also allowed for fewer miscommunication issues between departments, and valuable time, energy, and resources were conserved.³²
- Operational optimization and customer satisfaction improved by creating more balanced meter reading routes to reduce scheduling issues and unnecessary stress on staff. PBUD also gave laptops to field service representatives which enabled them to create work orders in the field. This enhancement eliminated unnecessary fuel costs associated with travel back to the office to pick up work orders, ultimately freeing up time for employees to provide more value-added

³¹ Dan Roberts, Palm Bay Utilities Department, personal communication, 20 June 2012.

³² *ibid*



services for the customer. The event also empowered staff to accept late payments in the field to reduce staff's travel time to a customer's residence, avoiding further staff time and fuel usage.³³

Process Improvement Program

Approach: As part of its EMS continuous improvement framework, PBUD established a process improvement program focused on employee and leadership development. The process improvement program includes staff training on Lean tools including analytic tools such as Pareto charts, workplace organization/standardization tools like 5S+S (5S plus safety), visual management strategies such as storyboards for displaying project activities and metrics, and other process-improvement tools.

One of the focuses of the process improvement program was around standard work. PBUD developed and regularly uses templates for standardized processes, procedures, and standard operating procedures (SOPs). The use of templates was particularly helpful to ensure that SOPs and processes addressed ISO 14001:2004 elements (e.g., purpose, scope responsibilities, associated documents, measurements, records, etc.). For example, a ten-paragraph template for SOPs provided a standard template for use by managers that streamlined the implementation process and provided replicability, familiarity, commonality, and quality control aspects to document control efforts. The critical element to the success of the standard work procedures was communication and training for all staff involved in developing and using the templates, procedures and SOPs. PBUD relied on an aggressive training program and utilized a pocket guide of tools for continuous improvement and effective planning. "The Memory Jogger II" by Michael Brassard and Diane Ritter (see Appendix B) was provided to each Core and Implementation Team members early in the implementation period. It provided a common reference point to learn and apply tools to situations that would improve the procedures, systems, and quality.

The process improvement program also requires that PBUD staff participate in at least two process improvement activities per year. Many of these process improvement projects use the Lean 5S+S method, which is a 6-step process for creating and maintaining a clean, neat, orderly, and safe work environment for employees. PBUD uses a standard template (a Process Improvement Form) to document and verify process improvements completed by employees; this form records the type of improvement, techniques or tools used to implement the improvements, and quantification of the financial benefit (increased revenue, cost avoidance, cost savings) for the process improvements. The documentation provides the basis for undertaking detailed process improvement efforts within PBUD divisions and throughout the organization. Supervisors and division managers verify the improvements and financial impact, and the results and improvement ideas are circulated between divisions to seed ideas.

³³ Dan Roberts, Palm Bay Utilities Department, personal communication, 20 June 2012.



Results:

- PBUD improved financial viability by saving approximately \$1.15 million in 2011 through continuous improvement initiatives supported by Lean, Six Sigma methods, and objectives, targets, and programs embedded in the EMS.³⁴
- PBUD bolstered employee and leadership development through a process improvement program that trained employees in Lean, Six Sigma, and other problem-solving continuous improvement tools. Subsequently, a higher level of competence and confidence encourages employee involvement and leadership in improvement efforts.
- In about 18 months of implementation, 70 percent of the utility's workforce participated in the program and documented 124 process improvement actions, using Lean tools including 5S+S, standard work, and visual controls.³⁵
- Improved operational optimization by standardizing work truck cargo beds in one improvement project using 5S+S. A simple rack mechanism for carrying hand tools was fabricated and replicated for installation on work truck bed sides to organize and standardize hand tools. The process improvement prevented damage to tools and other equipment and provided for a more organized, and thus more efficient and safe work environment.³⁶

The program has addressed a wide range of utility processes and EUM attribute areas. Examples of improvement efforts include the following:

- Objectives, Targets, and Programs from EMS Implementation.
- Enhanced financial viability through improvements in all bond ratings, both Standard and Poor's and Moody's, since initiation of continuous improvement management framework and Lean improvement techniques. Operational costs were driven down, reducing environmental and business risks. Both the previous and current utilities director's attributed the improvement to cost savings and reduced environmental and business risk brought about by the continuous improvement management framework and embedded continuous improvement tools.³⁷

Looking Forward to the Future

Since implementing an EMS, PBUD has been recognized with numerous awards for operational excellence, regulatory compliance, and environmental and safety performance. PBUD was only one of six utilities in the nation recognized in 2010 for an AMWA Gold Award and, at the time, only one of nine utilities in the nation to be awarded the Gold Award since the EUM criteria were added to the application. The new PBUD reverse osmosis plant won the American Membrane Technology Association's (AMTA) national award for superior plant operations in 2011. PBUD has also achieved

³⁴ Dan Roberts, Utilities Department, Palm Bay, Florida, "Environmental Management Systems (EMS): A Key to Financial Viability, Environmental Excellence - and Worthy of Regulatory Incentives," 2012, <http://www.peercenter.net/ewebeditpro/items/O73F24974.pdf>

³⁵ *ibid*

³⁶ Dan Roberts, Palm Bay Utilities Department, personal communication, 20 June 2012.

³⁷ *ibid*



many state operational excellence awards from industry and regulatory associations and agencies since implementation of a continuous improvement EMS.

PBUD plans to continue to embed Lean, Six Sigma methods, process improvement tools, and the ANSI Z10 Safety Management System in its EMS and build on the success it has had in the past several years. The operational improvements, cost savings, and employee health and safety improvements achieved through the EMS and Lean methods continue to drive PBUD to identify other improvement opportunities to achieve EUM outcomes.





City of Pompano Beach Utilities Case Study

Summary

The City of Pompano Beach Utilities Department (Pompano Beach Utilities), located in Pompano Beach, Florida, oversees two water treatment plants and one water reuse treatment plant and serves nearly 80,000 customers. Pompano Beach Utilities used the EUM Attributes and the EUM Self Assessment to draft an action plan that drives its improvement activities. The utility regularly uses process-improvement tools from Lean and Six Sigma to enable the utility to increase its overall productivity.

Summary of Results

Pompano Beach Utilities' Lean and EUM improvement efforts have produced impressive results. Below are selected results from the ICanWater Reuse Connection improvement project linked to the EUM Attributes:

ICanWater Reuse Connection Program

- Improved water resource adequacy and community sustainability by using Six Sigma tools to potentially save 92.4 million gallons of water as a result of the ICanWater Reuse Connection Program in 2011–13 (if all 770 connections are accomplished). Over 10 billion gallons of water have been saved by the OASIS Reuse Program since 1989.
- Improved water resource adequacy and operational optimization by completing 270 reuse connections between October 2011 and April 2012, with 770 planned by July 2013. This represents an increase from 1.5 to 35 connections per month on average due to the project.
- Improved customer satisfaction by promoting the ICanWater Program, which creates lower customer watering bills, allows nearly unrestricted watering, and reduces fertilizer usage. A reuse customer that uses approximately 10,000 gallons of water per month (4,000 for irrigation) can expect to save approximately \$200 per year.
- Improved community sustainability and water resource adequacy by extending the drinking water supply, lowering future capital costs for upgrades to the water plant and other alternative water supplies, preventing saltwater intrusion and protecting drinking water wells, and providing jobs for local plumbers.



Utility Experience with Effective Utility Management and Lean

In 2009, Pompano Beach Utilities hired Sunesis Consulting Group to conduct an EUM training session and complete the EUM Self Assessment with a variety of staff including Utilities, Human Resources and Finance (Customer Service) directors. Pompano Beach Utilities used the Self Assessment process to identify its strengths and areas for improvement within each Attribute area. Based on the results of the Self Assessment, Pompano Beach Utilities drafted an action plan to address high priority areas. The high priority attributes were: (1) product quality, (2) financial viability, (3) infrastructure stability, (4) operational optimization, and (5) employee and leadership development. Pompano Beach Utilities did not prioritize customer service in the top five attributes as managers felt that by focusing on the “core” processes, that many of the customer service issues would be addressed.

After completing the Assessment, the utility created two groups to focus on safety and job performance standards based on the action plan and then used the Lean failure mode effects analysis (FMEA) method to make improvements. FMEA is a systematic method for evaluating a process to identify where and how it might fail. The method also assesses the relative impact of different failures, in order to identify the parts of the process that are most in need of change. Pompano Beach Utilities used FMEA to evaluate possible failures in each step of specific jobs or tasks. This analysis led to the addition of personal protective equipment and other controls that were required or would reduce workplace hazards. Pompano Beach Utilities also documented the safety requirements based on the expected failures for each safety and job performance task for employee and supervisor reference.

After its initial use of FMEA, Pompano Beach Utilities began using a variety of Lean and Six Sigma tools to achieve its desired outcomes identified in the EUM Self Assessment, as noted above. Utility staff discovered Lean tools through research and conducted training for staff on Lean and Six Sigma based on materials from reference books. Pompano Beach Utilities now regularly uses Lean tools, including:

- Failure mode effects analysis.
- Value stream mapping (a map that depicts the flow of all the activities and information needed to produce a product or deliver a service, and examine key process metrics.).
- Fishbone diagrams and failure mode effects analysis (root-cause analysis problem-solving tools).
- Critical-to-customer analysis (a method for assessing and categorizing issues relevant to the customer) that can be useful to help analyze issues relevant to a process.
- Six Sigma improvement cycle, Define-Measure-Analyze-Improve-Control (DMAIC) for larger improvement projects. (DMAIC is a data-driven improvement cycle used for improving, optimizing, and stabilizing business processes and is the core process used to drive Six Sigma projects).

Pompano Beach Utilities participates in the Florida Benchmarking Consortium (FBC), which is an intra-state collaboration of local governments seeking to improve the delivery of local government services through the use of performance measurement data and benchmarking tools and techniques. Pompano



Beach Utilities compares its performance metrics and best practices with other utilities in the FBC, and uses EUM and Lean tools as part of this comparison to identify other potential areas of improvement.

Lean and EUM Projects and Results

ICanWater Water Reuse Connection Program

Problem: In 2011, in response to low residential customer water reuse connections, Pompano Beach Utilities used the Six Sigma methodology to improve the process and launch the ICanWater Water Reuse Connection Program. The ICanWater Reuse Connection Program is part of a broader utility reuse initiative called Our Alternate Supply Irrigation System (OASIS). ICanWater is a campaign to target single family residential reuse connections. Water reuse connections or “purple pipes” are a system for delivering reclaimed water for landscape irrigation. Pompano Beach Utilities’ customers were paying close to half of their water bill on watering their lawns and were restricted to specific days they could water. Even though water reuse rates were significantly lower than potable water rates, customers were not signing up for reuse connections. For example, rates for reuse start at 85 cents per 1,000 gallons, compared to \$2.24 for potable water.³⁸ This project sought to increase water reuse connections and make other improvements in the program consistent with the EUM Attributes for water resource adequacy and community sustainability.

Implementation Process: Pompano Beach Utilities used the Six Sigma DMAIC process to improve the reuse connection program using the steps described in detail below.

- **Define:** Pompano Beach Utilities defined its problem statement as low single family residential customer water reuse connections. Unlike multifamily and commercial customers, the single family residential customers were not mandated to connect to the reuse system.
- **Measure:** In the “Measure” data collection step, the utility noted that it had installed 73 connections in the four years preceding the project (1.5 connections per month on average). Based on customer billing records, Pompano Beach Utilities set its goal for 770 connections for the first two years of the ICanWater Program with an ideal goal of 1,200 connections.
- **Analyze:** Based on the data target identified in the “Measure” step, Pompano Beach Utilities analyzed all reuse connection data sources to determine root causes of problems. The utility examined customer impediments to water reuse connections using a modified critical-to-customer analysis and created a value stream map of the existing water reuse connection process. (A critical-to-customer analysis is a method for assessing and categorizing issues relevant to the customer. Value stream maps visually depict the flow of all the activities and information needed to produce a product or deliver a service, and examine key process metrics.) Using the critical-to-customer analysis and the current state process map, Pompano Beach Utilities listed all the complaints and impediments it received about why residential customers did not want a reuse connection. The utility also used a public relations firm to telephone eligible customers to determine why they were not connecting to the reuse system.

³⁸ ICanWater, *Why I Can Water*, <http://www.icanwater.com/why-i-can-water/> (accessed May 23, 2012).



The team then identified unnecessary steps in the process and opportunities to implement desired outcomes, as well as reviewed customer comments on the reuse connection program.

- **Improve:** Pompano Beach Utilities used brainstorming to identify creative solutions to fix and prevent process problems. In particular, utility staff brainstormed options to connect customers based on the problems identified during the “Analyze” step. After brainstorming, the team created a map of the new process. Pompano Beach Utilities then identified and itemized the major components critical to implementing the new reuse process using an implementation matrix and task list. The general categories of tasks included:
 - Financing
 - Ordinance changes
 - Contractor selection process
 - Public relations firm selection
 - Backflow manual changes
 - Changes to City department processes
 - Updating website and adding new pages
 - Creating a hotline
 - New automated meter program (project described below)

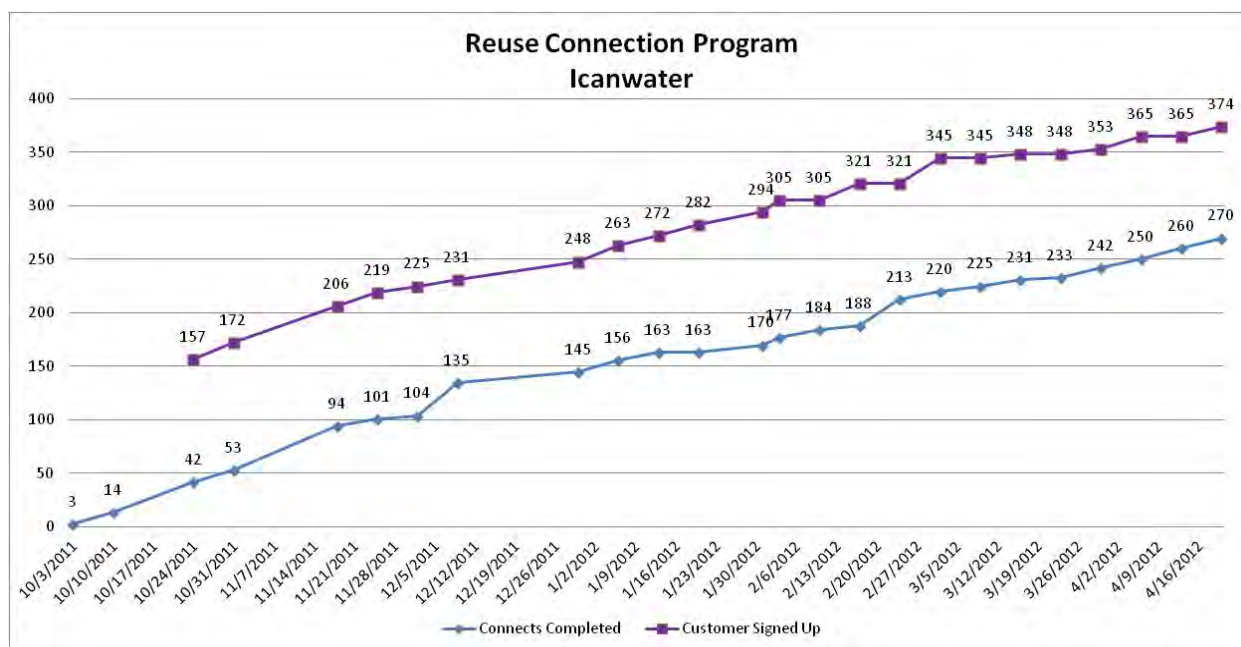
When all of the tasks were completed, Pompano Beach Utilities hosted several meetings with other city department staff to finalize and fine tune the new reuse connection process. Using feedback from the meetings, Pompano Beach Utilities created a revised process map for the new process and conducted simulations of the process using table-top exercises. The utility piloted the process with one customer, resolved issues identified during the pilot, and then continued to refine the reuse connection process as customers made connections in the program.

- **Control:** The “Control” step is focused on monitoring the improvements to ensure continued success. Pompano Beach Utilities used a time series plot to track the number of reuse connections per week, including number of customers signed up and number of connections installed (see graph below). Pompano Beach Utilities also used the plot to compare the rate of connections to the program’s goals and grant requirements.

When the connection rates plateau, Pompano Beach Utilities studies the process to look for bottlenecks that could be contributing to the stagnant rates. For example, in December 2011 Pompano Beach Utilities saw the number of connections completed decrease and continue to remain low into January and February 2012, while the number of customer sign-ups was increasing. The Utilities Department examined the process for bottlenecks in late February 2012 and as a result, the connection rates improved and the delta between signups and connections decreased. In addition, the Department sends out surveys to customers that have installed reuse connections and monitors hotline messages for dissatisfaction or trends in complaints.³⁹

³⁹ Maria Loucraft, Pompano Beach Utilities, personal communication, 27 April 2012.





Pompano Beach Utilities selected the DMAIC process for the ICanWater Reuse Connection Program because of its emphasis on using data to identify areas for improvement. In addition, the utility did not want to experience any failures in the implementation of the ICanWater Program and felt that the DMAIC process provided a structured approach with a focus on continuous review and improvement. By using Six Sigma methods, Pompano Beach Utilities was also able to address many high-priority attributes identified in its EUM Self Assessment and described in more detail below.

Results: By using Six Sigma's DMAIC method, Pompano Beach Utilities achieved the following results from its ICanWater Reuse Connection Program:

- Improved water resource adequacy and operational optimization by completing 270 reuse connections between October 2011 and April 2012, with 770 planned by July 2013.⁴⁰ This represents an average of 35 connections per month over the October 2011 to July 2013 period, which vastly exceeds the pre-project average rate of 1.5 connections per month.
- Improved water resource adequacy and community sustainability by using Six Sigma tools to potentially save 92.4 million gallons of water as a result of the ICanWater Reuse Connection Program in 2011–13 (if all 770 connections are made). Over 10 billion gallons of water have been saved by the OASIS Reuse Program since 1989.⁴¹

⁴⁰ Pompano Beach Oasis Reuse Water Utilities, *Customer Connection Program Presentation*, 24 April 2012.

⁴¹ ICanWater, *About OASIS*, <http://www.icanwater.com/about-oasis/> (accessed May 23, 2012).



- Improved customer satisfaction by promoting the ICanWater Program which creates lower customer watering bills, allows nearly unrestricted watering, and reduces fertilizer usage. A reuse customer that uses approximately 10,000 gallons of water per month (or 4,000 gallons for irrigation) can expect to save approximately \$200 per year.⁴²
- Improved community sustainability and water resource adequacy by extending the drinking water supply, lowering future capital costs for upgrades to the water plant and other alternative water supplies, preventing saltwater intrusion and protecting drinking water wells, and providing jobs for local plumbers.⁴³
- Improved customer satisfaction through the ICanWater Program by allowing reuse customers to water their lawns any day of the week before 10 a.m. and after 4 p.m.⁴⁴
- Improved water resource adequacy by increasing water reuse and thereby freeing up more potable water for future growth and conservation.⁴⁵
- Increased community sustainability through the ICanWater Program by helping to ensure compliance with the City of Pompano Beach’s Consumptive Use Permit and providing water for future growth.⁴⁶
- Improved stakeholder understanding and support by educating the public on water reuse through the ICanWater Program website.⁴⁷

“Lean is the *how* to accomplish the outcomes described in EUM. It is a powerful tool because it can be adapted to best suit the process or project that needs improvement. To be effective, utilities must keep the process and tools simple.”

– Randy Brown, Utilities Director, Utilities Department, City of Pompano Beach, Florida and Maria Loucraft, Utilities Compliance and Efficiency Manager, Utilities Department, City of Pompano Beach, Florida

Automated Meter Reading Project

In a related project, Pompano Beach Utilities used the Six Sigma DMAIC process to implement an automatic meter reading process to support the ICanWater Reuse Connection Program. The project sought to improve system performance, making it more cost effective and reliable consistent with the EUM attribute for operational optimization. The utility used DMAIC because it needed a method that included a rigorous system for checking and evaluation at each step of the process, which helped to

⁴² Pompano Beach Oasis Reuse Water Utilities, *Customer Connection Program Presentation*, 24 April 2012.

⁴³ *ibid*

⁴⁴ ICanWater, *When I Can Water*, <http://www.icanwater.com/when-i-can-water/> (accessed May 23, 2012).

⁴⁵ Randy Brown and Maria Loucraft, Pompano Beach Utilities, personal communication, 25 June 2012.

⁴⁶ *ibid*

⁴⁷ *ibid*



avoid failures in the automated meter reading. Pompano Beach Utilities achieved the following results from its automated meter reading project:

- Improved operational optimization by installing over 19,000 meters, with 99 percent of meter information recorded correctly.
- Improved customer service and community sustainability by saving energy and eliminating drive-bys to read the water meters, saving gas and allowing staff to be redirected to other areas. The automated meter reading system will also produce detailed water usage histories, which will allow us to identify leaks and backflow problems and assist customers with more detailed information on their usage.

Looking Forward to the Future

In July 2011, The Florida Water and Pollution Control Operators Association selected the Pompano Beach Utility's Department Safety Program as a winner in the "Utility Overall" category. Pompano Beach Utilities also received a "Top Ten Safety Award" in May 2011 from The Florida Water Environment Association.

Pompano Beach Utilities also revisits its initial EUM Self Assessment completed in December 2009 annually to determine what it has accomplished and what remains to be budgeted for and implemented. The Utilities Department has also created a position to manage the efficiency and process improvement efforts as well as permits and regulatory compliance. Once the high-priority projects identified in the initial EUM Self Assessment have been completed, Pompano Beach Utilities plans on conducting another EUM self assessment and developing a new action plan.

Pompano Beach Utilities plans to continue using Lean and Six Sigma tools in its EUM and process improvement efforts in the future, building on the successes it has had in the past several years. Senior managers of the utility will be attending additional training on Lean and Six Sigma in the fall of 2012, to become more familiar with the methods and help Pompano Beach Utilities to identify other opportunities to achieve EUM and continual improvement outcomes.

"Lean and Six Sigma tools provide an opportunity to collaborate with other utilities in training events and working together on process improvement, particularly for small utilities."

– Randy Brown, Utilities Director, Utilities Department, City of Pompano Beach, Florida and Maria Loucraft, Utilities Compliance and Efficiency Manager, Utilities Department, City of Pompano Beach, Florida



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Appendix D: Sample Templates

This appendix includes several sample templates for Lean and Six Sigma processes. Templates can enable effective and replicable applications of Lean and Six Sigma tools, help train staff, and sustain a successful implementation of a continual improvement framework and the key aspects of EUM. They also can help facilitate quality, consistency, and sustainability of processes and procedures.

All of the templates included in this Resource Guide, with the exception of the Lean Event Charter, have been used by water-sector utilities for their Lean and Six Sigma processes. The templates are not exhaustive but are meant to be examples of documents that help support Lean and Six Sigma projects.

The sample templates include:

- **Lean Event Charter:** The charter is an important document that sets out the scope of the process that will be addressed in the event, establishes the goals and objectives of the event, identifies any work that must be completed prior to the event, and identifies all the participants of the event.
- **Six Sigma Plan-Do-Check-Act Project Worksheet:** This worksheet enables the user to walk through all the steps of the Plan-Do-Check-Act and Define-Measure-Analyze-Improve-Control Six Sigma process steps. It breaks down each step into individual components and includes a column to track tools used and results.
- **Root Cause Analysis “Fishbone” Diagram:** The fishbone diagram is used to illustrate the causes of a specific event or problem. The causes are usually grouped into major categories to identify the sources of variation or errors. The category of causes in the sample template include:
 - Machines/Plant Equipment
 - Methods/Procedures
 - Materials/Money/Policies
 - Manpower/People
- **SIPOC Process Definition Sheet:** SIPOC stands for Suppliers-Inputs-Process-Outputs-Customers and is a framework for analyzing the requirements of a process. A SIPOC process definition sheet is a tool used in Six Sigma to map an organization’s current process so it can quickly define, document, analyze, prioritize, and recommend solutions and follow-up plans.
- **Process Improvement Form:** This form is designed to support an overall process improvement program by describing, categorizing, and estimating the benefits from process improvement projects, including cost savings, cost avoidance, and increased revenues. These improvements can include team-based projects or individual efforts, and the form provides a system for obtaining verification of the changes and results. Some utilities have found this form to be particularly useful for soliciting and documenting process improvements that use the Lean 5S+S (5S+Safety) method. This form can also be used as part of a program to incentivize improvement efforts.



Lean Event Charter

[Organization]

[Department of event and event name]

[Event Date]

SCOPE

The breadth, or area, of opportunity to change and improve [e.g., *this event will address the process from / of _____ to _____.*]

GOALS

[A narrower version of the scope of the improvement event.]

OBJECTIVES

Specific numbers or percentages

For example:

1. Reduce lead-time by XX%, from ___ to ___.

PARTICIPANTS (Typically 6-12; no more than 20 people/event)

Project Team	
Team leader:	[Insert Team Leader Name, Department]
Facilitator:	[Insert Facilitator or Consultant Name]
Team Members:	[Insert Name, Department]
(members can be from inside & outside process)	[Insert Name, Department]
	[Insert Name, Department]
	[Insert Name, Department]
	Etc.

PRE-WORK

1. [e.g., determine average lead time] (name person responsible)
- 2.

FOLLOW-UP DATES

Month, day, year – 30 day

Month, day, year – 60 day

Month, day, year – 90 day

Month, day, year – 6 month

Month, day, year – 1 year



Six Sigma Plan-Do-Check-Act Project Worksheet

Process / System: _____

Start Date: _____

Team: _____

Completion Date: _____

Step	Element	Tools / Results
PLAN Step 1: <u>Define</u>	Assemble & support the right team	
	Create a team charter	
	Clearly define the problem: Establish a concise problem statement in sentence form	
	Identify internal & external customers affected by the problem, & establish a process for coordinating w/ & gaining preliminary approvals (as necessary)	
	Identify the customers' requirements that are critical to quality (CTQ)	
PLAN Step 2: <u>Measure</u>	Set measurable goal(s)/milestones(s) for the problem solving effort.	
	Identify measures (Results) to monitor that reflect process or system performance. Align with customer requirements.	
PLAN Step 3: <u>Analyze</u>	Map the process: Identify the processes that impact the problem and select one. List the steps in the process that currently exists. Map the Process and validate.	
	Identify Root causes of the problem.	
	Collect and analyze data related to the problem. Use metrics, results, data, etc. (Collect additional data if needed to verify root causes.)	
	Determine variance in the process & what is acceptable. Align with customer requirements.	
	Verify or revise the original problem statement (as needed). Develop a hypothesis.	
DO Step 4: <u>Improve - Develop Solutions</u>	Generate potential solutions that will address the root causes of the problem.	
	Select a solution: Establish criteria for selecting a solution.	
	Plan the solution: Establish SMART goals/action items	
	Gain approval & support of the chosen solution from customers/stakeholders & plan accordingly.	



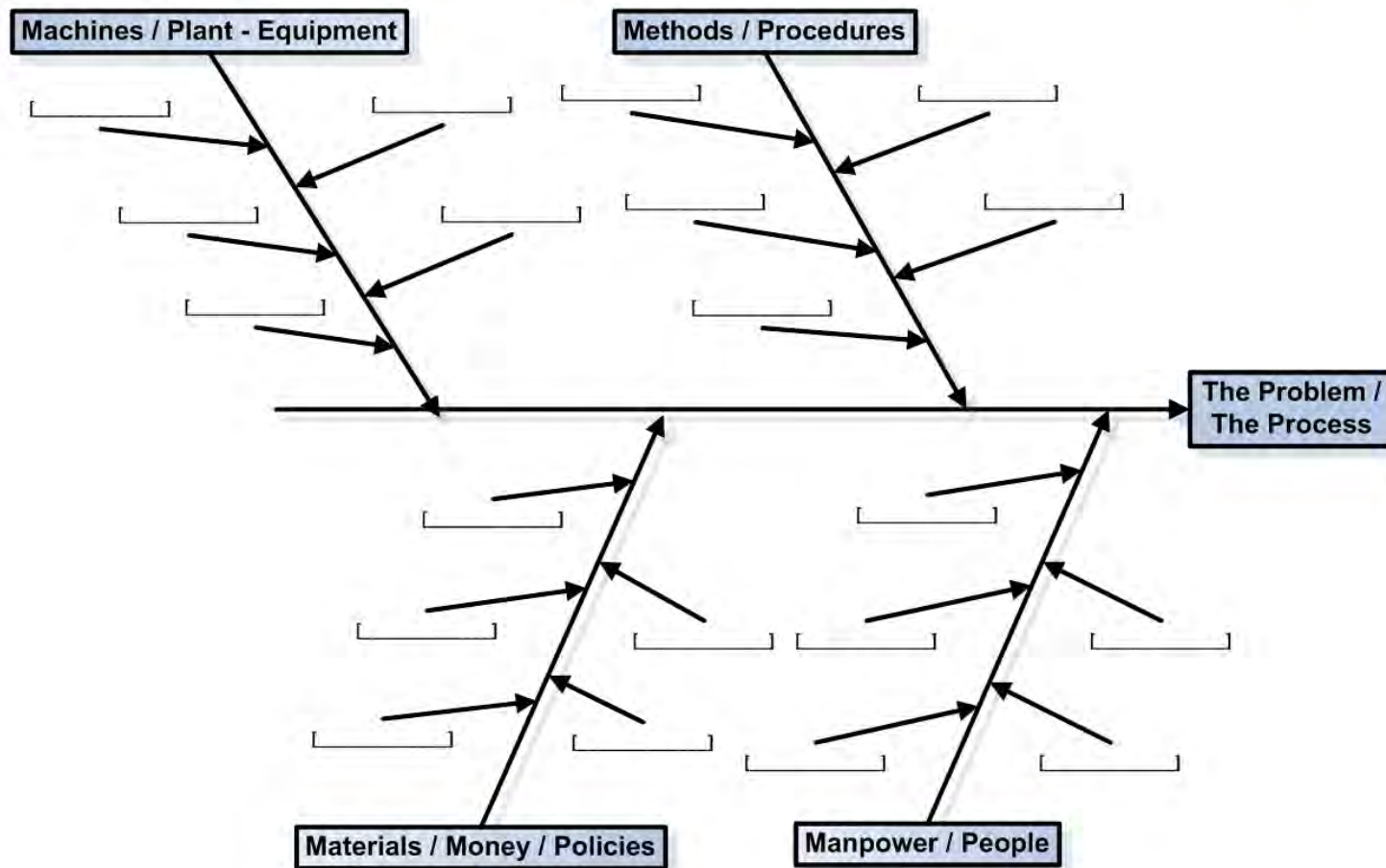
Step	Element	Tools / Results
<p>DO Step 5: Improve - Implement</p>	Implement the chosen solution on a trial/ pilot basis	
	If the Problem Solving Process is being used as a standalone, continue to Step 6. If the Problem Solving Process is being used in conjunction with the Continuous Improvement Process, go to Step 7.	
<p>CHECK Step 6: Evaluate/Analyze the Results</p>	Gather and analyze data on the solution. This step may include additional study, including research and detailed analyses of collected data and review of customer/stakeholder feedback information.	
<p><i>Achieved the Desired Goal?</i></p>	<p>If YES, go to Step 7. If NO, go back to Step 1.</p>	
<p>ACT Step 7: Control - Standardize the Solution and Capitalize on New Opportunities</p>	Adopt Solution: Identify systemic changes & training needs for full implementation & adopt solution. Standardize, document, & institutionalize solution.	
	Continue to improve process: Plan ongoing monitoring of the solution and continue to look for incremental improvements to refine the solution	
	Look for another improvement opportunity	



Root Cause Analysis “Fishbone” Diagram

Cause and Effect Diagram (Fishbone Diagram) - Root-cause Analysis (4 Ms or 4 Ps)

[Insert date]



SIPOC Process Definition Sheet

Revision Date:				
Key Process:				
Purpose:				
Process Owner(s) (include at least one Internal Customer/Supplier):				
Suppliers	Inputs	Process Steps	Outputs	Customers
<u>External</u>				
<u>Internal</u>				
Customer Requirements:				
How Requirements Determined:				
Performance Indicators:				
Direct (Leading):				
Indirect (Lagging):				
Control Strategies:				



Process Improvement Form

(Instructions for completing this form are located on the following page)

Division/Section:

Date:

Name/Team Name:

Position:

Team Member Names:

Approved By: Supervisor:

Division Manager:

Process Improvement Type

(If increased revenue, cost savings or cost avoidance document actual dollar impact at bottom of page.)

Increased Revenue

Improved Morale

Improved Safety/Health

Cost Savings

Product Improvement

Pollution Prevention

Efficiency/Productivity

Cost Avoidance

Customer Service/Satisfaction

Waste Reduction

Other _____

Pre-Improvement Process Description

Process Improvement

Process Improvement Impact (cost savings - Decision or action that will result in fulfillment of the objectives of a purchase, at a cost lower than the historical cost or the projected cost; cost avoidance - Cost avoidance may incur higher (or additional) costs in the short run but the final or life cycle cost would be lower, example replacing a part before it fails and thus saving the expense of higher repair costs or replacement of more expensive components; increased revenue - estimate for FY)

_____ \$/day _____ \$/week _____ \$/month _____ \$(FY Savings)



Guide and Instructions for Completion of the Process Improvement Form

A documented process improvement is an improvement that has been accomplished and is providing benefits to the Utilities Department. The instructions below will assist in completing the form.

Division/Section/Date: If more than one section or division participated in the improvement all are to be identified. The date on the form is to be the date the form is completed.

Name/Team Name: An individual or team name can be provided; if a team name is provided, team member names should be listed with associated positions (a continuation sheet may be attached).

Approved by Supervisor/Division Manager: The immediate Supervisor and Division Manager will validate the process improvement. Division Manager improvements will be validated by the Utilities Director. Validation will entail review of the improvement and its documentation to ensure that the process addresses improvement types correctly, the cost benefits are verifiable and accurate, and the process improvement form has been completed in accordance with these instructions.

Process Improvement Type: Place a check beside the improvement type that most closely captures the type of improvement. More than one type of improvement may be identified for a process that was changed or initiated; however, no more than three of the most important are to be identified. A cost savings or cost avoidance, if applicable, will always be identified as an improvement type if multiple improvement types are identified. An example of cost avoidance would be a process that avoids incurring some future cost – a cost savings would be a process that saves money now; a process improvement could do both. An example of a process improvement having multiple improvement types is the purchase and use of the automatic valve exerciser. It improves efficiency/productivity, saves the cost of man-hours when manual valve exercising was necessary, and improves safety/health by using mechanical rather than manual means to exercise valves.

Pre-Improvement Process Description: Provide a brief description of the pre-existing condition or process. Photos may supplement the description (before and after photos are preferred). The description should state what problem(s) existed with the pre-existing condition or process.


Process Improvement: *A brief description of the improvement, when it was initiated, and how the improvement supported the type of improvement(s) identified previously.* Also, if an improvement tool was utilized to address the situation, *the tool or catalyst should be identified;* i.e., employee suggestion, brainstorming session, report trends, six sigma project, storyboard, value stream mapping, process mapping, Corrective Action Request (CAR) or accident investigation with root cause identification, 5S+S project (Sort, Set in Order, Shine, Standardize, Sustain, + Safety). (5S+S projects “clean up” and organize the workplace; they are often the starting point for other improvements. A typical 5S+S project would significantly reduce the square footage of space needed for operations. It also would result in the organization of tools and materials into labeled and color-coded storage locations as well as “kits” that contain just what is needed to perform a task. Increased orderliness also improves workplace safety.)

Process Improvement Impact (cost savings, cost avoidance): Some costs savings or cost avoidance benefits can be calculated on a daily, weekly, or monthly basis, and some cost saving/avoidance benefits may be one time occurrences. The cost benefits whether figured on a daily, weekly, monthly, and/or as a onetime occurrence will be identified as FY cost benefits in the space provided.



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United States Environmental Protection Agency

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