U.S. Environmental Protection Agency (EPA) & Major Partners' Lessons Learned from implementing EPA's Portion of the American Recovery and Reinvestment Act: Factors Affecting Implementation and Program Success

Innovative Technologies

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EXECUTIVE SUMMARY

The American Recovery and Reinvestment Act (ARRA) enacted in 2009 bolstered the economy, in part, by encouraging the adoption of innovative technologies, particularly for drinking water and wastewater treatment. The U.S. Environmental Protection Agency (EPA) contracted with Science Applications International Corporation (SAIC) to review examples of innovative technologies adopted through ARRA-funded projects.

PURPOSE

The objective of the review was to capture examples and successful strategies from technological innovation made possible by various EPA programs that distributed ARRA funding.

METHODOLOGY

To achieve this objective, SAIC gathered information regarding nine innovative technologies in the Drinking Water State Revolving Fund and Clean Water State Revolving Fund programs that received support through ARRA funds. For the qualitative analyses, SAIC interviewed local experts familiar with the drinking water and wastewater projects as well as company representatives from the major suppliers. SAIC also reviewed studies of technological innovation and other materials provided by interviewees. The findings are summarized below.

FINDINGS

ARRA funding supported the adoption of innovative technologies. Despite the challenging circumstances, ARRA funding supported the adoption of innovative technologies. The scale and scope of the adoption varied in expected ways (e.g., widespread adoption of advanced metering technologies and regional adoption of tank mixers). These are low-cost or low-risk technologies in that technology failure does not result in noncompliance.

ARRA funding motivated water utilities to consider innovative technologies and assume some additional risk. Normally risk-averse water and wastewater utilities adopted innovative technologies that were potentially cost-effective and/or satisfied additional operating constraints provided their performance claims could be realized. The utilities interviewed evaluated both conventional and innovative technologies before selecting the innovative technologies. It is possible that favorable ARRA funding conditions such as principal forgiveness encouraged utilities to accept a little more risk than they might normally accept. It is clear that the ARRA funding enabled several projects – large and small – to proceed.

ARRA funding supported adoption of innovative technologies that improved environmental protection. All recipients interviewed were satisfied with the performance of the selected innovative technologies. Not only did the technologies help them achieve their main compliance objective, but they also provided green benefits, such as energy savings, less infrastructure, less sludge production, less water use and loss, and less chemical use.

ARRA funding positively affected innovative technology sales during the economic recession. Funding made available specifically for innovative technology projects motivated utility managers interviewed to try new technologies. Funding conditions, such as the Buy American provision that increased the burden on funding recipients, also led some businesses to prefer U.S. manufacturing sources. They learned that onshore manufacturing increased their control over product quality and lowered shipping costs.

Successful demonstration projects sparked follow-on business for technology vendors. In each instance of a first-time installation for vendors interviewed, the vendor has experienced or anticipates follow-on work because of demonstrated performance and positive word of mouth. This suggests the need for demonstration projects that establish the capabilities of new technologies and also identify whether they are ultimately more cost-effective than conventional alternatives.

RECOMMENDATION

Provide a longer timeframe for innovative technology projects. Innovative technologies require time for concept development, design, pilot demonstration, and commercialization phases. Consider extending obligation and expenditure deadlines to encourage innovative technology development.

SECTION 1. INTRODUCTION

In February of 2009, Congress passed the American Recovery and Reinvestment Act, aimed primarily at making new jobs and saving old ones, stimulating economic activity and long-term growth, and fostering accountability and transparency in government spending. Of the $787 billion authorized in the Recovery Act, EPA was given $7.2 billion. EPA distributed the majority of its ARRA funds to states in grants and contracts to support clean water and drinking water projects, diesel emissions reductions, leaking underground storage tank cleanups, Brownfields development, and Superfund cleanups. This was a massive undertaking for EPA. The administration of the funds, which were to be injected into the economy at an unprecedented pace, required that EPA develop or revise policies, processes and automated information systems. In the fall of 2011, EPA tasked SAIC, and its subcontractor Toeroek Associates, Inc., to design and conduct a study to examine several components of EPA's implementation of ARRA. The SAIC Team studied three management topics - **Cost Estimating** processes, **Funds Management** processes and **Systems** enhancement and development. The Team also looked at three topics geared more towards outcomes than management processes. These include the **Green Project Reserve** initiative, the use of ARRA funds to spur **Innovative Technologies** and the use of ARRA funds to **Leverage Local Economic Benefits**. After completion of the research phase, the SAIC Team produced a series of six reports, each covering one of the six topics noted above. The Team also prepared a separate overarching summary report with an Executive Summary, containing highlights of each of the six reports, as well as a description of the goals and methodology for the entire study.

1.1 BACKGROUND - PURPOSE/OBJECTIVES OF THIS STUDY

This chapter describes a review of innovative technologies adopted via ARRA-funded projects. The objective of the review was to capture examples and successful strategies from technological innovation made possible by various EPA programs that distributed ARRA funding. To achieve this objective, SAIC gathered information regarding innovative technologies that received some type of support through ARRA spending.

There are two primary reasons for conducting the review. First, one of the most crucial goals of ARRA was to spur technological innovation to both create economic growth and improve environmental protection. Thus, the first motive for this review was to provide examples of how this goal was met. Second, the success of EPA programs, in general, depends in part on innovative responses among stakeholders to develop new technologies, techniques and processes that can achieve environmental protection goals more cheaply and effectively. Consequently, the second motive for this review was to identify whether ARRA funding supported innovative technologies that were or might become cost-effective options for achieving environmental protection goals.

It should be noted that the mention of trade names, specific vendors, or products does not represent an actual or presumed endorsement, preference or acceptance by EPA or the federal government. Stated results, conclusions, usage or practices do not necessarily represent the views or policies of EPA.

1.2 INNOVATION AND THE POTENTIAL ROLE OF ARRA FUNDING

In the context of this review, innovative technologies are new or transformed products and services that benefit EPA stakeholders. This definition excludes new technologies that have no meaningful benefit to stakeholders, but includes transformation of existing technologies that provide a meaningful incremental benefit.

Innovation is a process that runs through several stages, from development through demonstration to deployment. Whether it occurs because a manufacturer is trying to fill a market niche or a user is adapting a known technology for a new use, the initial stage is developing a new technology. The demonstration stage involves tests to prove that the new concept or technology works. These tests can range from small simulations to full-scale water treatment processes. The final stage is deployment or achieving some level of diffusion or use throughout an industry.

The potential for ARRA funding to affect innovation varies by stage. It is unlikely that ARRA funding distributed by EPA had much effect on technologies in the development stage because the timeframe was too sudden and too short to create and support technology 'incubators.' EPA distributed the vast majority of its ARRA funding through existing mechanisms that primarily support infrastructure investments to achieve or maintain compliance with regulatory standards. Therefore, the greatest potential for impact of ARRA funding is either on technology demonstration or deployment.

Whether ARRA funding can be said to have had an impact on technology demonstration or deployment depends, in part, on whether the funding helped overcome some type of barrier that would have inhibited adoption in the absence of the funding. A fundamental barrier to adoption of new technology is affordability. This barrier was potentially exacerbated by the recession that started in 2008, and the resultant budget cuts and limited financing for public water and wastewater systems. Another key barrier is whether the water or wastewater system owner can be confident that the new technology will fulfill performance requirements, especially those that affect compliance with regulatory standards. By definition, innovative technologies are not well-known. Consequently, it may be difficult to get approval from a regulatory entity to adopt a technology that does not have a long, proven track record.

1.3 STUDY QUESTIONS

SAIC developed study questions to address the factors motivating the review, as well as the barriers discussed above. Table 1 contains the questions, which are organized into three groups. The table also shows the data sources that SAIC anticipated using to answer each question. Primary data sources came from the Clean Water State Revolving Fund (CWSRF), Drinking Water State Revolving Fund (DWSRF), and Diesel Emissions Reduction Act (DERA) programs.

TABLE 1. STUDY QUESTIONS AND DATA SOURCES

Overarching Study Questions	Detailed Study Questions	Data Sources
What types of innovative products or services did ARRA support?	• Were any innovative technologies (products or services) supported by ARRA funding? • If yes, what types of innovative products and services were funded? • What new products (introduced within the last 5 years) were purchased and used?	• CWSRF, DWSRF, DERA and Brownfields databases. • State files on SRF loan applications.
Why did ARRA recipients choose to implement innovative products or services?	• What alternatives did a recipient consider before selecting a particular innovative product or service and how did they learn about each option? • Why did a recipient select a particular innovative product or service? • Did the ARRA funding help overcome any barriers or impediments to implementation for the innovative product or service?	• Interviews of loan or grant recipients.
How did ARRA funding affect vendors of innovative technologies and the industries or markets for the innovative products and services identified above?	• Was any project the 'first-time full-scale' implementation for a particular innovative product or service, or an early adoption case used for product development or demonstration purposes? • What effect did ARRA funding have on product or service sales and overall business operation compared to projections without ARRA funding? • Did ARRA-funded projects lead to improvements in products or services or changes in market diffusion strategies? • Did ARRA funding have a measurable impact on local or national markets for a particular innovative product or service? • What are the anticipated effects of ARRA-funded projects in terms of generating new customers or follow-on work?	• Interviews of consultants, vendors and manufacturers used by the grantees.

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SECTION 2. METHODOLOGY AND DATA SOURCES

The review method combined literature research and database analysis with interviews to address the study questions from both macro and micro scales. SAIC used the macro scale analysis to answer the first set of questions in Table 1, and the micro scale analysis to address the second and third sets of questions.

In the macro scale analysis, SAIC used literature research and database analysis and interviewed EPA subject matter experts (SMEs) to identify innovative technologies (either products or services) and group them into categories for the purpose of characterizing the types of innovation that benefited from ARRA funding. SAIC reviewed background literature pertaining to the projects under the CWSRF and DWSRF, and the National Clean Diesel Campaign Emerging Technologies programs. The background literature included program descriptions, guidance documents, publications and database descriptions. Where available, SAIC also obtained loan or grant files for the projects under the CWSRF and DWSRF programs and reviewed 'business case' information to obtain additional detail on the innovative technologies, potential recipient and vendor contact information, as well as explore the availability of market impact information. SAIC contacted SMEs at EPA with expertise regarding technologies considered to be innovative within each of the three programs. The SMEs provided insight into what is classified as an innovative technology, and how the respective industries respond to innovation (e.g., whether the adoption periods are short or lengthy).

In the micro scale analysis, SAIC selected nine innovative technologies for development of in-depth case studies of funding recipient decision-making processes and industry or market impacts. The selection process took into consideration the project summary results and opinions of EPA experts obtained from the macro scale analysis.[1] SAIC also restricted the total number of selected innovative technologies to nine, in accordance with the Paperwork Reduction Act. SAIC provided the recommended set of innovative technologies along with selection rationale to EPA experts for review, prepared case-specific study questions, and interviewed a funding recipient and vendor for each case study. The funding recipient interviews explored the perceived impact of ARRA funding on the technology selection process. Among the objectives was an assessment of whether there was a barrier to implementation that the ARRA funding addressed, such as lack of project financing (recession-driven or other), lack of technology familiarity, or lack of technology competitiveness (e.g., early adopters often pay more for new technology than later adopters). The vendor interviews explored the perceived impact of ARRA funding on product markets and production from the vendor's perspective.

2.1 STUDY LIMITATIONS

The small case study sample size limits the extent to which the findings can be generalized. This review includes only nine case studies. SAIC limited the number of case studies to comply with the requirements of the Paperwork Reduction Act, which places restrictions on federal data collections to prevent unnecessary burdens on the public. Because nine is too small a number to be statistically representative

[1] One case study was identified through work on another SAIC task to study local economic impacts of ARRA projects in communities.

of the ARRA-funded projects as a whole, the findings cannot be extrapolated to all ARRA-funded projects. Instead, the findings are limited to the small sampling of individual case studies included in the review.

The interpretation of the term “innovative” limited the technology selection process. In the context of this review, innovative technologies are new or transformed products or services that benefit EPA stakeholders. This definition leaves the time frame open to interpretation based on the relative acceptance period of the technology (i.e., adoption rate), which can be quite variable. Thus, there is no bright line that distinguishes innovative from non-innovative technologies, which may have led to excluding some technologies that certain vendors and/or recipients may consider innovative.

Data collection procedures limited the findings in this review. One such procedural limitation was the extent of the literature search, which was restricted to only readily available public information (i.e., exhaustive searches were not conducted). Another procedure placed focus on identifying case studies within the Clean Water program because the CWSRF received the greatest portion of ARRA funding. This focus may have resulted in missed opportunities to identify interesting case studies among other programs. The subjective nature of the interview responses introduces the potential for reporting bias, e.g., a respondent emphasizing the positive impacts of a product or project. In addition, EPA staff participated in most of the interviews. Although this approach had the potential to influence respondent feedback, there was no apparent difference in the respondents’ candidness between calls with and without EPA personnel. In fact, respondents readily replied to follow-up questions from EPA staff.

SECTION 3. FINDINGS

This section contains two subsections of study results – macro review results and micro review results. Table 2 below summarizes the big picture findings for each study question. The big picture findings are based on information from EPA data analyses, literature review and interviews of EPA subject matter experts, project recipient staff and vendors of innovative technologies. The sections of the report following Table 2 include a thorough discussion of the findings.

TABLE 2.STUDY QUESTIONS WITH BIG PICTURE FINDINGS

Overarching Study Question – Types of Products Supported	
What types of innovative products or services did ARRA funding support?	
Detailed Study Questions	**Big Picture Findings**
Any products funded? Were any innovative technologies (products or services) supported by ARRA funding?	**The DWSRF, CWSRF and Brownfields programs supported innovative technologies through ARRA funding.** For loans with Green-Innovative expenditures/technologies, the DWSRF database contained 66 loans mostly to construct or upgrade treatment plant projects and the CWSRF database contained 88 loans mostly for decentralized wastewater treatment projects and upgrades to wastewater treatment plants. The Brownfields program supported at least one innovative technology through ARRA funding - an innovative stormwater technology. Review of the DERA program did not reveal clear candidates for innovative technology case study development. The ARRA-funded technologies were pursuing performance verification during SAIC's review period, and therefore, were not amenable to case study development.
Types of products funded. If yes, what types of innovative products and services were funded?	The DWSRF program provided extensive support to the following technologies: **Automated Meter Reading (AMR)/Advanced Metering Infrastructure (AMI) metering technology projects.** Project recipients installed more than 100,000 AMR/AMI meters, suggesting it was potentially a successful and widespread deployment of innovative technology. **Solar-powered mixers for drinking water storage tanks.** Funding recipients in North Carolina installed mixers in 21 of the 22 projects identified. This situation may be the result of a marketing strategy to create a cluster of experience in a region that has a reputation for innovation. **Technologies to improve effluent quality.** The CWSRF program provided funding support to a variety of innovative wastewater treatment technologies to reduce nutrients and metal concentrations in secondary wastewater effluent. The CWSRF database did not include sufficient descriptions to identify the full scope of specific technologies.
New products purchased. What new products (introduced within the last 5 years) were purchased and used?	**Several new products were purchased and used.** Examples of purchased products developed in the last 5 years are the CoMag™ Ballasted High-Rate Clarification system, the BCR Clean B™ system, the Blue PRO® Reactive Filtration system and the SAFL Baffle.

Overarching Study Question – Reasons For Selection	
Why did ARRA recipients choose to implement innovative products or services?	
Detailed Study Questions	**Big Picture Findings**
Alternatives considered. What alternatives did a recipient consider before selecting a particular innovative product or service and how did they learn about each option?	**Funding recipients evaluated a wide variety of conventional and innovative technologies.** They completed an alternatives evaluation process to thoroughly identify the benefits and drawbacks of the viable candidate technologies. **Funding recipients considered many factors beyond regulatory compliance in accessing technologies.** Some factors mentioned by respondents are cost, reliability, resiliency, size, appropriateness for geographic region, and operating costs. Respondents also discussed their perceived trade-off between requirements to use funds quickly versus the ability to assess new technologies. The innovative technology provision in ARRA incentivized respondents to search for alternatives to conventional technologies.
Specific product selection. Why did a recipient select a particular innovative product or service?	**All respondents selected innovative products or services that were the best fit for their site-specific design constraints.** Funding recipients considered the following design constraints: • Geographic-specific (i.e., cold climate or mountainous terrain). • New stringent National Pollutant Discharge Elimination System (NPDES) permit requirements or new drinking water rules. • Space constraints. • Flexibility. • Green benefits (i.e., reduced energy demand or water use).
Barriers to implementation. Did the ARRA funding help overcome any barriers or impediments to implementation for the innovative product or service?	**ARRA funding helped funding recipients overcome financial barriers.** Financial barriers prevent adoption of new technologies because either a utility lacks funding to afford any technology or the new technology is more expensive. ARRA funding helped funding recipients overcome this barrier. **ARRA funding helped funding recipients overcome risk barriers.** Risk barriers mainly arise because of a lack of demonstrated performance, especially under conditions at a particular utility. ARRA funding and subsidies such as principal forgiveness encouraged utilities to accept the additional risk of adopting innovative technologies.

OVERARCHING STUDY QUESTION – FUNDING EFFECT ON VENDORS AND INDUSTRIES OR MARKETS	
How did ARRA funding affect vendors of innovative technologies and the industries or markets for the innovative products and services identified above?	
DETAILED STUDY QUESTIONS	**BIG PICTURE FINDINGS**
Early adoption cases. Was any project the 'first-time full-scale' implementation for a particular innovative product or service, or an early adoption case used for product development or demonstration purposes?	**ARRA funding afforded some vendors the opportunity to conduct the first-time full-scale demonstration of their innovative technology.** ARRA-funded first-time full-scale projects played key roles in expanding their technology's reference cases, accelerating rates of adoption and creating company growth.
DETAILED STUDY QUESTIONS	**BIG PICTURE FINDINGS**
Changes in product sales. What effect did ARRA funding have on product or service sales and overall business operation compared to projections without ARRA funding?	**ARRA funding boosted sales revenues and saved jobs.** Eight case study vendors reported significant increases in sales due to ARRA-funded project participation. The increased sales revenues provided stability throughout the recession. **ARRA-funded revenue growth was sustainable for most respondents.** The ARRA funding did not create a funding shock condition (i.e., temporary funding bubble) for most respondents. Respondents believe that ARRA funding enabled municipalities/utilities to push projects forward that would not have otherwise been funded during recessionary times, which created additional product exposure and associated growth for the vendors in subsequent years. **ARRA funding boosted sales revenues and growth in associated business sectors.** The engineering and construction management sector is one example of a sector that benefited from ARRA funding.
Product improvements. Did ARRA-funded projects lead to improvements in products or services or changes in market diffusion strategies?	**ARRA funding led to improvements in some innovative technology products.** For example, the sale of 13 solar-powered mixers enabled PAX Water to perfect the design and fabrication of its tank mixer's solar-powered component. **ARRA funding brought manufacturing jobs back to the United States.** The large production requirement and the Buy American provision of the ARRA-funded AMR/AMI projects at Datamatic allowed it to close down some of its overseas production plants and expand its United States-based production plant. Likewise, Kruger made a permanent change from offshore to onshore sourcing. **ARRA funding supported research and development (R&D) efforts and the launch of new innovative products.** For example, PAX Water continued to develop its products while ARRA-funded projects maintained demand for their products during the recession. Without the steady supply of orders, R&D activities would have stopped. **ARRA funding helped vendors improve operations.** For example, ARRA funding helped Schreiber, the vendor of the Fuzzy Filter® technology, fine tune its operations for compliance with unrestricted water reuse under Title 22, Chapter 4 of the California Code of Regulations.

Impact on markets. Did ARRA funding have a measurable impact on local or national markets for a particular innovative product or service?	**ARRA funding impacted market exposure for clarification products.** The market exposure helped companies establish credibility with engineers and wastewater utilities, and fast track their products. **ARRA funding shifted the adoption trend for some innovative technologies.** Some recipients would not have tried the innovative technologies without ARRA funding; thus, the availability of ARRA funds enabled the recipients to purchase and install products earlier than anticipated, shifting the adoption trend. **ARRA funding helped vendors expand into foreign markets.** The successful demonstration of the Blue PRO® technology at a Colorado wastewater treatment plant helped the vendor market its Blue PRO® product in South Korea (between one and two dozen Blue PRO® plants were installed in South Korea).
DETAILED STUDY QUESTIONS	**BIG PICTURE FINDINGS**
New customer generation. What are anticipated effects of ARRA-funded projects in terms of generating new customers or follow-on work?	**Vendors thought that ARRA funding led to new customers and follow-on work.** The water industry is a small community where participants regularly share experiences at conferences and meetings. This 'word of mouth' exposure provides the opportunity for new technology information to spread nationally and internationally. **Successful installations lead to new customers.** One vendor noted that successful installation helps build your reputation and helps others envision how the technology can be used in their utility, which leads to new customers. **Release of ARRA funds created a boom of business.** PAX Water experienced a boom of business in North Carolina, created by the release of ARRA funds. After completion of the ARRA-funded installations, the sales of the PAX active tank mixers continued to grow in North Carolina.

3.1 MACRO REVIEW RESULTS

This section presents information from the macro scale review that SAIC undertook to answer the initial set of research questions listed in Table 1 regarding whether the ARRA funding supported any innovative technologies, and if so, which types and in what capacity.

3.1.1 REVIEW OF DWSRF INNOVATIVE TECHNOLOGIES

SAIC reviewed data in the DWSRF database to identify candidate innovative technologies for the DWSRF case study selection process. The DWSRF database contains 519 loans that received ARRA funding. Of these, 66 loans included expenditures categorized as Green-Innovative. SAIC reviewed the project descriptions for the Green-Innovative loans and assigned each loan to a project category (shown in Table 3). The project categories in the top row of the table are ones for which the description in DWSRF database does not clearly identify an innovative technology. The categories contain projects to construct or upgrade treatment plants, but the Green-Innovative technology is either not identified or the technology listed is considered a best available treatment (BAT) for one or more regulated contaminants.

SAIC consulted with a SME in the EPA Office of Ground Water and Drinking Water about the approach used to identify candidates. The SME concurred with the approach and the conclusion that the set of identifiable innovative technologies was small given the quality of the data. Furthermore, the SME recommended selecting from among two technology categories for case studies: solar-powered equipment (mainly mixers in treated water storage tanks or reservoirs that are used to achieve or maintain required disinfectant contact time) and Automated Meter Reading/Advanced Metering Infrastructure (AMR/AMI). The remaining two technologies, magnetic ion exchange (MIEX®) treatment and aquifer recharge, were eliminated from further consideration because the MIEX® treatment vendor was not a U.S. manufacturer and aquifer recharge is commonly utilized in the Western United States (i.e., not considered innovative in all areas of the United States).

TABLE 3. DISTRIBUTION OF GREEN-INNOVATIVE PROJECTS IN DWSRF DATABASE

Status Based on Project Description	Project Categories	Number of Projects
Innovative technology not clearly identified	New Treatment – BAT	12
	New Treatment – Unknown	12
	Covered Storage	3
	Piping/Pumping/Source Water	16
	Metering (not identified as AMR/AMI)	1
	Other	5
Innovative technology identified	Treatment (MIEX®)	1
	Aquifer recharge	2
	AMR/AMI metering	2
	Solar-powered equipment	12
Total All Categories		66

To assess the potential scope of ARRA funding for AMR/AMI meter installations, SAIC reviewed all of the DWSRF loans that received ARRA funding (not just the subset identified as Green-Innovative loans). The review identified several additional metering projects, including many that installed AMR/AMI meters. There are a total of 142 identifiable metering projects, of which 53 provide enough information in the project description to determine that the meters being installed are AMR/AMI meters. Some of these 53 projects also included an estimate of the number of meters to be installed. This subset identified over 100,000 meters installed as a result of ARRA funding. The estimate is most likely a lower bound estimate because it excludes many projects that either did not provide a meter estimate or did not identify the type of meters. The sheer numbers of AMR/AMI meters installed by ARRA-funded projects suggest it was potentially a successful and widespread deployment of innovative technology.

To assess the potential scope of ARRA funding for solar-powered mixer installations, SAIC reviewed all of the DWSRF loans that received ARRA funding (not just Green-Innovative loans). The review identified additional solar-powered mixer projects. A total of 22 mixer projects were identified during this check, of which only 12 were classified as Green-Innovative. Of the 22 loans, 21 occurred in North Carolina. This situation raised a question about whether there may be a marketing strategy, such as an attempt to create a cluster of experience in a region that has a reputation for innovation.

3.1.2 REVIEW OF CWSRF INNOVATIVE TECHNOLOGIES

SAIC used multiple sources to identify candidate innovative technologies for the CWSRF case study selection process. The initial source was the CWSRF database. It contains 1,884 loans that received ARRA funding. SAIC initially limited the case study selection process to the 88 loans that included expenditures categorized as Green-Innovative. SAIC reviewed the project descriptions for these loans and assigned each loan to a category based on the type of project funded. Table 4 shows the breakdown of the 88 Green-Innovative loans into the project categories. Most of the projects fell into two categories: decentralized wastewater treatment and upgrades to wastewater treatment plants (WWTPs). Unfortunately, the project descriptions for the loans were brief and general in nature, excluding details such as the type of technology processes used in the project.

TABLE 4. DISTRIBUTION OF GREEN-INNOVATIVE PROJECTS IN CWSRF DATABASE

Project Categories	Number of Projects
Green Infrastructure/LID	4
Wetland Restoration and Construction	4
Decentralized Wastewater Treatment	49
Water Reuse	0
Sustainable Landscaping and Site Design	1
Climate Change (e.g., sustainable infrastructure to withstand rising sea levels)	1
Energy Saving and Greenhouse Gas Reduction	6
Upgrades to WWTPs (innovative technologies not specified)	23
Total All Categories	88

SAIC contacted an SME in the EPA Office of Wastewater Management to discuss the preliminary review. The SME suggested expanding the database review to include key word searches on several innovative technology processes [e.g., wetlands, nutrient recycling, struvite recovery, and fats, oil and grease (FOG) digesters]. In response, SAIC returned to the full CWSRF dataset of 1,884 loans to search project descriptions for the recommended technology processes. The broader search of the CWSRF database identified several nutrient recycling projects and some FOG-related projects; however, the project descriptions did not include the specific information required to identify the candidate technology for case study development (i.e., process name or product manufacturer/vendor information). Possibly this information was not provided because wastewater process names are often vendor-specific and vendor selection may have occurred after the project information was entered into the CWSRF database.

SAIC continued the search for wastewater process names by reviewing business plans that states submitted to EPA for some of the Green-Innovative designated projects. Unfortunately, there were few submittals because states were only required to complete a business plan to explain a technology when it did not fit into one of the categories listed in EPA's guidance defining 'green' projects (EPA, 2009). Therefore, this effort did not result in any additional innovative technologies.

In a final effort to identify innovative technologies, SAIC expanded its research method to include technologies listed in two resource documents: *Emerging Technologies for Wastewater Treatment and In-*

Plant Wet Weather Management (EPA, 2008) and *Emerging Technologies for Biosolids Management* (EPA, 2006). These documents listed the product names of emerging wastewater technologies and classified them into several categories including three of potential relevance to this review:

- Embryonic – Technologies in the development stage and/or that have been tested at a laboratory or bench scale only.
- Innovative – Technologies that have been tested at a demonstration scale, have been available and implemented in the United States for less than five years, or have some degree of initial use (i.e., implemented in less than one percent of treatment facilities).
- Innovative Uses of Established Technologies – Established technologies that have been modified or adapted resulting in an emerging technology, or a process developed to achieve one treatment objective that is now being applied in different ways or to achieve additional treatment objectives.

Using the innovative product names listed in the three relevant categories, SAIC searched for articles that described their use in ARRA-funded projects. SAIC identified several candidate technologies using this approach. This approach, however, was labor intensive and unlikely to provide a comprehensive picture of the innovative technologies funded by the CWSRF given the random nature of online information linking specific technology names to ARRA funding resources.

Consequently, SAIC focused this research effort on identifying case studies for the micro-scale study. SAIC provided the list of identified technologies to the SME at the EPA Office of Wastewater Management for feedback. The SME preferred the candidate technologies classified as embryonic (BCR Clean B™ System, Blue PRO® Reactive Filtration, and CoMag™ Ballasted High-Rate Clarification) because they are still considered to be innovative today. To comply with the requirement to select an additional two CWSRF technologies for case study development, SAIC added the HYBAS™ Integrated Fixed-Film Activated Sludge System and the Fuzzy Filter® technologies, which were classified as innovative and manufactured in the United States.

3.1.3 REVIEW OF INNOVATIVE TECHNOLOGIES UNDER OTHER EPA PROGRAMS

SAIC did not originally include case studies from four programs: Leaking Underground Storage Tanks (LUST), Brownfields, Superfund and DERA. LUST programs were shovel-ready projects managed by the states with timelines that did not offer a high probability of identifying innovative technologies. Superfund projects were mainly additions to existing contracts. Brownfields projects were still being completed when analysis started making data assessment challenging; however, SAIC identified an innovative stormwater technology being used as part of a Brownfields project and added it as a case study.

For the DERA program, SAIC reviewed projects funded under the Clean Diesel Emerging Technologies Program. This is a relatively new competitive grant program that specifically seeks to advance new technologies that reduce diesel emissions from existing fleets. This program provides grant funding for one to two years for studies to test and demonstrate the performance of new technologies designed to reduce emissions from diesel engines.

Despite the focus of this program, it was unlikely to have much impact on innovative technologies developed by U.S. companies. EPA distributed less than $21 million in ARRA funding through this program. The funding supported 14 projects, 13 of which were projects to retrofit emissions control technologies on diesel engines or study the feasibility of a retrofit. Nine of the projects involved technologies developed by companies that are either not based in the United States or are no longer in business. U.S. producers of the technologies tested in the other four projects were pursuing performance verification at the time SAIC reviewed the database, but had not completed this process. Therefore, the technologies remained in the gray area between the development and demonstration stages. If the verification processes are successful, then the technologies will be eligible for funding through the National Clean Diesel Funding Assistance Program, which financially supports reductions of emissions from diesel engines. As a result of these issues, the benefits of the ARRA funding on innovative diesel technologies could not be reviewed.

3.2 SUMMARY OF ARRA SUPPORT FOR INNOVATIVE TECHNOLOGIES

Based on the review of the DWSRF, CWSRF and DERA databases, SAIC found that ARRA funding did support innovative technologies. A complete inventory of the types of technologies supported and the extent of ARRA support cannot be determined using the available data. There is evidence – as discussed in the next section – that ARRA funding supported new technologies (i.e., technologies that were developed during the five year period preceding the ARRA) including first-time full-scale implementation of them.

Under the DWSRF program, AMI/AMR metering technologies received extensive support because of ARRA funding. In North Carolina, solar-powered mixers for drinking water storage tanks also received support as a result of ARRA funding. It does not appear, however, that ARRA funding provided much support for innovative drinking water treatment technologies; most of the technologies identified in the database are listed as best available technologies in drinking water regulations and they have been adopted by many utilities, so while they may be innovative to a particular utility, they are conventional technologies by industry standards.

In contrast, under the CWSRF program, SAIC was able to identify innovative wastewater treatment technologies implemented with the help of ARRA funding. The extent to which ARRA funding supported such technologies cannot be ascertained, however, because the CWSRF database did not include sufficient descriptions to identify the full scope of specific technologies.

3.3 MICRO REVIEW – CASE STUDY RESULTS

3.3.1 INNOVATIVE TECHNOLOGIES SELECTED FOR CASE STUDY DEVELOPMENT

The innovative technologies selected for case study development are in Table 4 along with brief technology descriptions. Appendices 1 through 9 contain detailed descriptions of each technology listed in Table 5.

TABLE 5. INNOVATIVE TECHNOLOGIES SELECTED FOR CASE STUDY DEVELOPMENT

TECHNOLOGY NAME	TECHNOLOGY DESCRIPTION	CASE STUDY APPENDIX LOCATION
Drinking Water State Revolving Fund Technologies		
Advanced Metering Systems	An advanced metering system uses a digital electronic meter and a communication system, to capture and transmit the water use data through the network to the utility in real time.	1
PAX Water Technologies™ Active Tank Mixer	The PAX Water Technologies™ solar-powered active water mixer stirs potable water in storage tanks to eliminate thermal stratification and reduce disinfection byproducts.	2
SolarBee® Active Tank Mixer	The SolarBee® solar-powered active water mixer stirs potable water in storage tanks to eliminate thermal stratification and reduce disinfection byproducts.	3
Clean Water State Revolving Fund Technologies		
CoMag™ Ballasted High-Rate Clarification	The CoMag™ Ballasted High-Rate Clarification is a wastewater treatment technology that uses magnetite to remove phosphorus and other suspended solids from secondary wastewater effluent.	4
Fuzzy Filter®	The Fuzzy Filter® is a wastewater treatment technology that uses a unique compressible media to enhance filtration of suspended solids in wastewater effluent.	5
HYBAS™ Integrated Fixed-Film Activated Sludge System	The HYBAS™ integrated fixed-film activated sludge system is a wastewater treatment technology that combines conventional activated sludge and fixed-film processes to enhance biological nutrient removal in wastewater effluent.	6
Blue PRO® Reactive Filtration	The Blue PRO® reactive filtration technology is a wastewater treatment technology that combines filtration and adsorption processes to achieve very low levels of phosphorus and metals in wastewater effluent.	7
BCR Clean B™ System	A BCR Clean B™ System is a wastewater treatment technology that stabilizes waste activated sludge (biosolids) to meet Class "B" standards as specified in Subpart D of 40 CFR Part 503.	8
Brownfields Technologies		
SAFL Baffle	The SAFL Baffle is a new type of hydrodynamic separator with a simple and cost-effective design that can be retrofit into a stormwater sump manhole.	9

Table 6 provides case study information for each selected technology. The table identifies the vendors and recipients of the technologies along with the project locations. Each of the vendors specializes in technology research and development for the water treatment industry. With one exception, the technology vendors are small U.S. businesses. Kruger, Inc. is a U.S.-based subsidiary of Veolia Water, a French conglomerate. In addition, in 2012, another international conglomerate, Siemens, acquired Cambridge Water Technologies to obtain the latter's patented water treatment technologies including the CoMag™ Ballasted High-Rate Clarification.

The ARRA funding was a primary financial resource for most of the projects. Table 6 shows total project costs and ARRA funding levels and other DWSRF or CWSRF funding levels. For six of the projects, ARRA funding was the sole source of project funding; there was no additional SRF funding or funding from other sources. For seven of the projects, ARRA and SRF funding comprise 100 percent of project funding; no other sources of funding were identified in the DWSRF or CWSRF databases.

The table also shows the amount of a principal forgiveness subsidy. The principal forgiveness values do not need to be repaid and, therefore, utility customers will not incur increases in service fees to cover those costs. Every project included some degree of principal forgiveness subsidy. For seven projects, principal forgiveness accounted for at least 50 percent of ARRA funding. The interviewed recipients mentioned principal forgiveness as an added incentive to consider new technological options, one that helped mitigate the risk of trying something new.

Any additional ARRA or SRF funding constitutes a loan that will eventually be repaid through fee increases, although the repayment terms are generally favorable (e.g., interest rates between 0 and 3 percent) compared to traditional municipal bond financing options.

TABLE 6. CASE STUDY TECHNOLOGIES, RECIPIENT, LOCATION AND AWARD VALUES

Technology Name	Technology Vendor	Technology Recipient/ Project Location	Total Project Cost[1]	ARRA Funding	ARRA Principal Forgiveness Subsidy	Other SRF Funding
Drinking Water State Revolving Fund Technologies						
Advanced Metering Systems	Datamatics	West Virginia American Water with installations in Fayette County, WV	$4,200,000	$1,925,000	$1,925,000	$1,925,000
PAX Active Tank Mixer	PAX Water Technologies™	Town of Holly Springs Public Utility Department, NC	$67,067	$67,067	$33,533	$0
SolarBee® Active Tank Mixer	Medora	Stanly County Utility Department, NC	$196,818	$196,818	$98,409	$0
Clean Water State Revolving Fund Technologies						
CoMag™ Ballasted High-Rate Clarification	Cambridge Water Technologies	Town of Billerica Public Works Department, MA	$10,792,389	$1,264,932	$1,264,932	$9,527,457
Fuzzy Filter®	Schreiber LLC	Linda County Water District, CA	$36,541,671	$18,368,130	$10,000,000	$18,173,541
HYBAS™ Integrated Fixed-Film Activated Sludge System	Kruger, Inc. (U.S. Subsidiary of Veolia Water)	Town of Georgetown Water and Wastewater Departments, CO	$5,800,000	$5,800,000	$2,000,000	$0
Blue PRO® Reactive Filtration	Blue Water	Town of Georgetown Water and Wastewater Departments, CO	$5,800,000	$5,800,000	$2,000,000	$0
BCR Clean B™ System	BCR Environmental	City of Alachua Wastewater Division, FL	$20,550,074	$20,550,074	$12,902,000	$0
Brownfields Technologies.25						
SAFL Baffle	Upstream Technologies	St. Paul Port Authority (SPPA), Beacon Bluff Redevelopment Site, St Paul, MN	$2,590,000[2]	$1,600,000	$1,600,000	$0

1. For the DWSRF projects, the total project value is the cost to implement the innovative technology; for the CWSRF projects the total project value represents funding for all wastewater treatment plant improvements, not just the installation of the innovative technology selected for the case study.
2. The funding information for St. Paul differs from the other entries. The Total Project Cost refers to the estimated cost for the Beacon Bluff redevelopment site. The ARRA total includes all ARRA funding SPPA received, most of which applied to the Beacon Bluff project. The total ARRA amount is included in the Principal Forgiveness column because the funding is a grant to SPPA that is not repaid to EPA, which has the same subsidy effect as 100 percent principal forgiveness.

Detailed information for each case study in Table 6 is included in Appendices 1 through 9.

3.3.2 RECIPIENT OBSERVATIONS

This section presents information extracted from interviews with the recipients of the innovative technology products. A summary of the recipient responses is provided based on questions listed in Table 1, which are:

- What alternatives did a recipient consider before selecting a particular innovative product or service and how did they learn about each option?
- Why did a recipient select a particular innovative product or service?
- Did the ARRA funding help overcome any barriers or impediments to implementation for the innovative product or service?

IDENTIFICATION OF TECHNOLOGY ALTERNATIVES

Most respondents used an alternatives evaluation process for selecting technologies. Respondents evaluated a wide variety of technology alternatives, composed of both conventional and innovative technologies. Respondents considered many factors beyond environmental in assessing technologies. Respondents mentioned cost, reliability, resiliency, size, appropriateness for geographic region, and operating costs factors. Respondents also discussed their perceived trade-off between requirements to use funds quickly verses the ability to assess new technologies. This was particularly important when any such technology required design changes or other changes in engineering plans. Respondents filtered through the alternatives to identify candidates capable of achieving their site-specific design goals. As a final step, the respondents completed an alternatives evaluation to thoroughly identify the benefits and drawbacks of the viable candidate technologies.

Respondents reported that the innovative technology provision in ARRA incentivized them to search for alternatives to conventional technologies. According to Frachetti Engineering Incorporated (FEI), the design firm on the ARRA-funded Georgetown wastewater treatment plant project, FEI reviewed advanced biological nutrient removal treatment technologies to identify alternatives capable of meeting the upcoming stringent National Pollutant Discharge Elimination System (NPDES) permit limits. As part of the process, FEI searched for ’innovative technologies’ in response to the ARRA innovative technology provision. For assistance in identifying technologies that EPA considered to be ‘innovative’, FEI referred to the EPA guidance document titled *Emerging Technologies for Wastewater Treatment and In-Plant Wet Weather Management* (EPA, 2008). When appropriate, FEI incorporated innovative technologies into the alternatives evaluation process.

SELECTION OF INNOVATIVE TECHNOLOGY PRODUCTS

Respondents selected technologies that were the best fit for their site-specific design constraints as shown in Table 7. For a few of the respondents, geographic-specific design constraints dictated the selection. Other respondents selected technologies based on design constraints driven by new stringent NPDES permit requirements or new drinking water rules. When multiple viable options existed based on site-specific design constraints, some respondents also selected technologies based on green benefits such as reduced energy demand or water use. In all case studies, innovative technology products were selected because they were the best fit for the recipients’ site-specific design constraints.

TABLE 7. MAIN REASONS FOR INNOVATIVE TECHNOLOGY SELECTION

Technology Name	Technology Recipient/ Project Location	Main Reasons For Technology Selection
Drinking Water State Revolving Fund Technologies		
Advanced Metering Systems	West Virginia American Water with installations in Fayette County, WV	Mountainous Terrain and Green Benefits
PAX Water Technologies™ Active Tank Mixer	Town of Holly Springs Public Utility Department, NC	Regulatory Compliance and Green Benefits
SolarBee® Active Tank Mixer	Stanly County Utility Department, NC	Regulatory Compliance and Green Benefits
Clean Water State Revolving Fund Technologies.25		
CoMag™ Ballasted High-Rate Clarification	Town of Billerica Public Works Department, MA	Regulatory Compliance, Space Constraints and Green Benefits
Fuzzy Filter®	Linda County Water District, CA	Regulatory Compliance, Flexibility to Accommodate Variable System Conditions and Green Benefits
HYBAS™ Integrated Fixed-Film Activated Sludge System	Town of Georgetown Water and Wastewater Departments, CO	Regulatory Compliance, Cold Climatic Conditions, Space Constraints and Green Benefits
Blue PRO® Reactive Filtration	Town of Georgetown Water and Wastewater Departments, CO	Regulatory Compliance, Space Constraints and Green Benefits
BCR Clean B™ System	City of Alachua Wastewater Division, FL	Green Benefits
SAFL Baffle	St. Paul Port Authority, Beacon Bluff Redevelopment Site, St Paul, MN	Regulatory Compliance, Ease of Maintenance and Green Benefits

The following examples do not provide a comprehensive discussion of all the reasons listed for each case study in Table 7. These details are found in the Appendices. Rather the text provides a snapshot of the funding recipients' discussion of some of their reasons for the technology selection.

West Virginia American Water (WVAW) selected an innovative mesh fixed network AMR/AMI system to address a challenging geographic-specific design constraint (i.e., mountainous terrain). Mountainous terrain makes signal transmission of AMR/AMI data difficult to relay from the meters to the data collector units. A mesh fixed network AMR/AMI system has an advantage over conventional technologies because it uses repeaters to pass data around obstacles, such as mountains, which reduces the number of collection points that are usually required. WVAW considered the mountainous terrain of Fayette County, West Virginia, to be a good test of the effectiveness of the AMR/AMI technology, and thus, selected it for a pilot study.[2]

The Town of Billerica, Massachusetts, selected the innovative CoMag™ technology as the best fit for addressing the municipality's design constraints (i.e., very low effluent phosphorus levels and space

[2] WVAW is part of American Water, which is the largest publicly traded owner of water and wastewater utilities in the United States. The company owns and operates over 1,100 utilities that serve 15 million customers in 30 states (American Water, 2012). Because of the company's size, a successful AMR/AMI pilot study has a large follow-on market potential.

constraints). The CoMag™ technology treats a large flow of wastewater in a small volume of tanks, thereby reducing the process footprint and costs. The small footprint feature was critical to the municipality due to the very limited availability of space. In addition to its small footprint feature, the CoMag™ system allowed reuse of existing structures. The system also provided flexibility with an add-on electromagnetic filter, capable of reaching very low effluent phosphorus levels in the future, if required. Lastly, the CoMag™ system provided a cost-effective solution.

The Town of Georgetown, Colorado, (Georgetown) selected the innovative HYBAS™ system based on its two site-specific design constraints (i.e., cold climate and space constraints). The HYBAS™ system performs well in cold climates, unlike conventional technologies. Georgetown's cold climate presents a challenge for biological treatment systems because microorganisms are extremely sensitive to temperature. FEI explained that the colder the climate, the slower the microorganisms work. When the microorganisms are working slowly, more are needed to breakdown organic matter in the wastewater and larger tanks are required to house them. To overcome this obstacle, the HYBAS™ system adds media to retain the microorganisms in the tank. By adding media to the tank, it also greatly increases the surface area for the microorganisms to grow on, and thus greatly increases the number of organisms within an existing tank footprint. Due to Georgetown's space constraints, using the existing footprint was an important requirement that the HYBAS™ was designed to achieve.

The Linda County Water District in California selected the innovative Fuzzy Filter® technology for two reasons: its flexibility and green benefits (i.e., reductions in water use and electricity). First, the Fuzzy Filter® is more flexible than conventional technologies; it changes media properties 'on the fly.' The Linda County Water District wanted the flexibility to change the media properties, most importantly compressibility ratio, to accommodate uncertain flow and influent characteristics. Due to a tight timeframe, they did not have the luxury of pilot testing the plant features, so the composition of the secondary effluent was uncertain. Seasonal variations in flow and effluent characteristics also added to the uncertainty of the effluent composition and made the flexibility of the Fuzzy Filter® desirable. Second, the Fuzzy Filter® uses less water in the backwash cycle (i.e., Fuzzy Filter® only uses 2 percent of the wastewater effluent for backwashing as compared to 8 to 10 percent used by conventional sand filters). The wastewater effluent reduction creates huge energy savings because the lower flow requires less pumping, which is energy intensive.

Other respondents factored the green benefits associated with the innovative technologies into the technology selection process. Table 8 summarizes the green benefits of the selected innovative technologies, as described by the funding recipients. In addition, all respondents stated they were satisfied with the performance of the innovative technologies and most stated the ARRA funding helped them to accelerate the implementation schedule.

TABLE 8. RECIPIENT OBSERVATIONS ON TECHNOLOGY GREEN BENEFITS AND EFFECTS OF ARRA FUNDING

Technology Name Drinking Water Innovative Technologies / Clean Water Innovative Technologies	Energy Savings	Less Infrastructure	Sludge Benefits*	Less Chemical Use	Smaller Footprint	Less Water Loss in Pipes / Less water use in process	Water Quality (Lower Contaminant Limits)	Accelerated Implementation Schedule
Advanced Metering Systems	✓					✓		*See note
PAX Water Technologies™ Active Tank Mixer	✓			✓			✓	✓
SolarBee® Active Tank Mixer	✓			✓			✓	✓
CoMag™ Ballasted High-Rate Clarification	✓	✓			✓		✓	✓
Fuzzy Filter®	✓				✓	✓	✓	✓
HYBAS™ Integrated Fixed-Film Activated Sludge System	✓		✓		✓		✓	✓
Blue PRO® Reactive Filtration	✓		✓	✓			✓	✓
BCR Clean B™ System	✓	✓	✓		✓			✓
SAFL Baffle		✓			✓		✓	

* Sludge benefits include less sludge produced, less odor, and more sludge reuse.

Note: ARRA Funding greatly increased size of Advanced Metering Systems demonstration, but did not accelerate schedule.

EFFECT OF ARRA FUNDING ON OVERCOMING BARRIERS

ARRA funding helped respondents overcome two kinds of barriers that might prevent adoption of an innovative technology: financial and risk. Financial barriers prevent adoption of new technologies because either a utility lacks funding to afford any technology or the new technology is more expensive. Even new technologies that have superior overall cost-effectiveness compared to conventional alternatives may have higher upfront or capital costs. Risk barriers mainly arise because of a lack of demonstrated performance, especially under conditions at a particular utility. Water utilities cannot afford to adopt new technologies that might put their regulatory compliance at risk. The following subsections provide examples of how ARRA funding assisted respondents in overcoming these barriers.

Examples of Overcoming Financial Barriers

ARRA funding made the purchase of the innovative CleanB™ technology possible for a new wastewater treatment facility in the City of Alachua, Florida. The entire system upgrade received ARRA funding for a complete 1.5 million gallons per day plant including the CleanB™ technology, and more than 60 percent of the principal was forgiven. Alachua is a small town without substantial funding resources. Even though the CleanB™ system reduces operating costs and has the potential to be cost effective in the long run, Alachua did not have the upfront capital funds to purchase it. Thus, without ARRA funds, the Alachua Wastewater Treatment Facility Superintendent believes Alachua probably would have proceeded with a plan that did not include CleanB™ biosolids treatment.

ARRA funding made the necessary upgrades to the wastewater treatment plant in Georgetown, Colorado a reality. In 2009, the Town's vintage treatment facility was unable to meet the upcoming stringent water quality standards. The plant needed comprehensive improvements and innovations, but lacked the funding to implement them. ARRA funding covered the full cost of the project and included 34 percent principal forgiveness. Without ARRA funding, the Town would have done nothing in 2009 because a funding source was not available. The existing facility would have struggled to operate until something failed and then the operators would have fixed the failed component of the system (i.e., not the entire system, which included the use of the innovative HYBAS™ and Blue PRO® technologies). This reactive approach was the Town's only option, which was tenuous at best in terms of meeting standards. According to FEI, "ARRA funding gave the town the ability to do things right the first time without having to piecemeal the plant together."

ARRA funds covered 50 percent of the upgrade to the Linda County (California) Water District's wastewater treatment facility, which included the innovative Fuzzy Filter®. Principal forgiveness accounted for more than half of the ARRA funding. The upgrades were necessary to meet new effluent discharge limits for ammonia, nitrogen, biochemical oxygen demand, coliform and suspended solids (including many metal and organic constituents). Without ARRA funding, the upgrade with Fuzzy Filter® might not have happened. According to Kennedy/Jenks Consultants, the District "might have gone back to the Regional Control Board and renegotiated the NPDES permit limits; so it is fair to say the Fuzzy Filter® would not have been purchased without ARRA funding."

ARRA funding also helped the adoption of relatively inexpensive technologies, which can still be difficult to afford for some communities. It made the immediate purchase of the SolarBee® solar-powered tank mixers manageable and affordable. In 2009, when ARRA funding became available, Stanly County, North Carolina, was searching for a solution to the high total trihalomethane (TTHM) levels in its water, but did not have the resources to purchase tank mixers or any other technology capable of addressing the issue. The terms of the ARRA funds, including 50 percent principal forgiveness, made it possible to immediately install tank mixers in all five of its County-owned storage tanks. According to the Director of the Stanly County Utilities Department, without ARRA funding, Stanly County would likely have purchased fewer mixers, or alternatively, it might have purchased the same number of mixers, but in a more extended timeframe (i.e., fewer mixers purchased per year). Budget constraints would have dictated the purchasing approach. The Director of the Stanly County Utilities Department commented that, as with many communities during the recession, operational funds were limited and extreme caution was exercised, particularly if it needed to borrow funds.

Examples of Risk Barriers

According to the Director of Public Works, Billerica, Massachusetts, "took a chance by selecting the CoMag™ system." The CoMag™ system was new and unknown when the Town was planning the ARRA-funded facility upgrade. On paper, it appeared to be the most viable option for meeting the permit limits; however, Cambridge Water Technologies had demonstrated the CoMag™ system at only one wastewater treatment plant, located in Concord, Massachusetts. The Concord wastewater treatment plant provided limited operating experience and process data for evaluation purposes. Ultimately, Billerica decided the benefits of the CoMag™ system outweighed its shortcomings (i.e., unproven long-term operation capability) and selected it.[3]

The ARRA-funded purchase of AMR/AMI meters enabled West Virginia American Water to implement a full-scale project for all 12,000 Fayette County customers rather than a more limited and less risky pilot study of 500 to 1,000 customers. The full-scale study allowed WVAW and its parent company American Water to learn about the effects of a system-wide roll-out of the new metering and data logging technology. Although about 98 percent of mesh transmitters operated on start-up, those that didn't provided important lessons learned for future American Water projects.

Because it undertook the risk of a full-scale project, WVAW has been able to benefit from implementing a comprehensive leak detection program to help the system overcome high water losses within the deteriorating Fayette County infrastructure. Prior to installing the innovative AMR/AMI system, nonrevenue water accounted for 55 percent of produced water within the Fayette County utility district. Nonrevenue water is water that is not delivered through a metered service and often reflects leaking pipes and valves in the water distribution system. (Other nonrevenue water includes water used for certain public services, such as fire fighting.) This loss represents a large waste of utility resources. An important benefit of the new AMR/AMI system is its ability to detect water leaks and transmit reports to the WVAW office on a daily basis. With the installation of the new AMR/AMI system, WVAW believes a 30 percent reduction in water loss will be achieved in time. How quickly this reduction will be achieved depends on how quickly WVAW can detect and fix the "big" leaks; the rate of repair or replacement depends on availability of funds. WVAW plans to address the main water loss problems within the next one to two years. WVAW also plans to use the data from the AMR/AMI monitors to guide its capital investment decisions for main replacement and repairs.

[3] Through data collection for the CoMag™ system, SAIC learned that ARRA funding helped the buyer of another Cambridge Water Technologies product overcome financial barriers. The Allentown, PA municipality was evaluating technologies to increase their plant flow-through capacity at the time the ARRA funding was announced. They were evaluating conventional technology options, as well as the innovative BioMag™ technology. The BioMag™ technology could double the plant's capacity without increasing its footprint, so the Allentown municipality was very interested in it. However, Allentown was hesitant to move forward with the purchase of the innovative BioMag™ technology due to its capital cost. With the award of ARRA funding, Allentown overcame the capital cost hurdle and purchased the BioMag™ technology. According to the Vice President of Sales and Marketing for Siemens (formally Cambridge Water Technology), "it was because of the ARRA funding that Allentown was able to make a decision to move forward with a newer technology, which they normally wouldn't have done."

3.3.3 VENDOR OBSERVATIONS

This section presents information extracted from interviews with the vendors of the innovative technology products. A summary of the vendor responses is provided based on questions listed in Table 1, which are:

- Was any project the first-time full-scale implementation for a particular innovative product or service, or an early adoption case used for product development or demonstration purposes?
- What effect did ARRA funding have on product or service sales and overall business operation compared to projections without ARRA funding?
- Did ARRA-funded projects lead to improvements in products or services or changes in market diffusion strategies?
- Did ARRA funding have a measurable impact on local or national markets for a particular innovative product or service?
- What are anticipated effects of ARRA-funded projects in terms of generating new customers or follow-on work?

FIRST-TIME FULL-SCALE IMPLEMENTATION OF INNOVATIVE TECHNOLOGY PRODUCTS

ARRA funding afforded some vendors the opportunity to conduct the first full-scale demonstration of their innovative technology. The BCR Environmental vendor had this opportunity when Alachua's ARRA-funded project purchased the CleanB™ system. As such, Alachua became the initial adopter of the BCR Environmental CleanB™ system. According to the President of BCR Environmental, finding an initial adopter is always a positive step for a new technology. It expands the technology's reference cases, accelerates its rate of adoption, and creates company growth. Thus, the ARRA-funded Alachua project played a role in the development of the CleanB™ system and BCR Environmental.

The ARRA-funded Georgetown project provided Blue Water with the opportunity to install its first full-scale Blue PRO® plant designed to remove metals, as well as phosphorus, from the wastewater. With this first installation up and running, Blue Water was able to collect operating data to share with its network in the wastewater business. By word of mouth, engineers with similar needs have subsequently become aware of the Blue PRO® technology and contacted Blue Water. Today, Blue Water is working with the City of East Helena, Montana to remove copper, lead, zinc, and phosphorus from its wastewater, and also with the Town of International Falls, Minnesota for the removal of mercury and phosphorus. Because the first installation is always the most difficult to secure, the ARRA-funded Georgetown project helped Blue Water launch the Blue PRO® technology into the metals removal portion of the reactive filter technology business sector.

The ARRA-funded Beacon Bluff redevelopment project provided the University of Minnesota St. Anthony Falls Laboratory (SAFL) with the opportunity to install the first full-scale SAFL Baffle, an innovative technology created by researchers at the laboratory. The creation of the SAFL Baffle resulted from researchers working with agencies to solve real-world problems. The SAFL researchers were funded by the Minnesota Department of Transportation (MnDOT) to develop standard testing protocols for hydrodynamic separators and the collection of sediment in sump manholes. This applied research led MnDOT to request a solution to the problem of sediment washout from sumps under high flow conditions. The SAFL researchers responded to the request with the creation of the SAFL Baffle. Unfortunately, according to the Chief Executive Officer of Upstream Technologies (the SAFL Baffle vendor), there are few grant opportunities available to the SAFL researchers for applied research; most available funding is for basic research. The Chief Executive Officer of Upstream Technologies believes “You need to change how university research is funded before there will be more focus on applied research.” In this case, funding from agencies interested in applied research, such as the MnDOT, supported the applied research agenda. ARRA also supported the development of the SAFL Baffle by providing funding for its first installation, which opened the door to commercialization of the product and generated actual field monitoring data to verify its effectiveness and share with potential clients.

EFFECT OF THE ARRA FUNDING ON SALES

Some respondents reported that ARRA funding boosted sales revenues and saved jobs. Eight vendors reported significant increases in sales due to ARRA-funded project participation. Three of the vendors (Cambridge Water, PAX Water Technologies™ (PAX Water), and Medora) estimate the increases were in the 20 to 30 percent range. The increased sales revenues provided stability throughout the recession. At PAX Water, the 2009 increase in direct sales created the opportunity for the company to grow and market its tank-mixing product more widely across the United States. The additional marketing effort accelerated exposure and acceptance of the PAX Water tank mixer. According to the Chief Executive Officer of PAX Water, “the stimulus money came at a critical moment for us; it was a real shot in the arm. Without the ARRA-funded projects, we would still be in business, but the company would be significantly smaller.” PAX Water continues to grow, experiencing substantial increases in revenue each year since 2009.

The ARRA-funded revenue growth was sustainable for most respondents. In other words, the ARRA funding did not create a funding shock condition (i.e., temporary funding bubble) for most respondents. Respondents believe that ARRA funding enabled municipalities/utilities to push projects forward that would not have otherwise been funded during recessionary times, which created additional product exposure and associated growth for the vendors in subsequent years. Not all respondents experienced sustainable revenue growth, however. Company sales significantly increased in the 2009 to 2010 timeframe from ARRA-funded projects for the Fuzzy Filter® and HYBAS™ technology vendors, but not beyond it. The Vice President of Strategic Planning for Kruger (HYBAS™ product) explained that 2011 was the worst sales year on record because its municipality/utility projects got moved up and there were no new projects to follow them (i.e., the pipeline was accelerated and emptied). Today, the Vice President of Strategic Planning for Kruger believes sales have bottomed out and some recovery is occurring.

The ARRA funding also boosted sales revenues and growth in associated business sectors. One such business sector interviewed is the engineering and construction management consultants that were hired to perform design services on the ARRA-funded projects, such as product alternatives analyses and system designs. For example, Frachetti Engineering Incorporated (FEI), accepted the challenge of designing the water and wastewater treatment facility upgrades in Georgetown, Colorado, despite the severe time constraints imposed by the ARRA. As a result, FEI grew during the economic downturn and its reputation benefited. FEI received recognition for a job well done through two American Council of Engineering Companies (ACEC) awards (i.e., the ACEC State Engineering Excellence Honor Winner for the Georgetown Wastewater Treatment Systems Improvement Project and the ACEC State Engineering Excellence Award for the Georgetown Water Treatment Systems Improvement Project). Now FEI has new customers and business opportunities as an added benefit from participating in this ARRA-funded project.

EFFECT OF ARRA FUNDING ON PRODUCT IMPROVEMENTS AND CHANGES IN COMPANY OPERATIONS

The ARRA funding led to improvements in some of the innovative technology products. One example is the solar-powered feature of the PAX Water tank-mixer design. The North Carolina Department of Environment and Natural Resources (NCDENR) required ARRA-funded tank mixers to be solar-powered, which is an optional feature of the PAX Water tank mixer. The sale of 13 solar-powered mixers enabled PAX Water to perfect the design and fabrication of its tank mixer's solar-powered component. The ARRA funding also allowed Medora to improve and refine its tank mixer product line during the recession. The tighter industry budgets provided the incentive for Medora to develop lower cost solutions, enabling customers to continue to purchase its mixers.

The ARRA funding brought manufacturing jobs back to the United States for two innovative technology vendors (Datamatic and Kruger). At Datamatic, the large production requirement of the ARRA-funded AMR/AMI projects allowed them to close down some of its overseas production plants and expand its United States-based production plant. During the operational change, Datamatic learned that the extra cost of manufacturing in the United States is offset by not having to cope with the project quality issues they experienced with overseas production. Datamatic plans to continue the expansion of its U.S. manufacturing facility as it reduces its overseas manufacturing.

Likewise, Kruger made a permanent change from offshore to onshore sourcing. Kruger does not have a production facility. It outsources the fabrication of the HYBAS™ system to a third party in the United States; however, in 2009 not all of the system components were manufactured onshore. For example, the plastic media was mass-produced in South Korea. To comply with the Buy American provision, Kruger had to find a fabricator in the United States to replace its offshore plastic media source. The change to onshore sourcing was difficult, time-consuming and expensive (e.g., time spent to find a fabricator, establish quality assurance/quality control procedures, and validate the manufacturer), but Kruger knew it needed to be done and the process did not delay the project. Since then, Kruger made the change to onshore sourcing permanent because they found it easier to control product quality from its headquarters in North Carolina. The switch to onshore sourcing also lowered shipping costs. Kruger's HYBAS™ system is now a 100 percent U.S. product with components manufactured in Wisconsin, Pennsylvania, Alabama and New Jersey. Today Kruger realizes the long-term benefits of onshore sourcing and has switched to onshore sourcing for all of its technology needs.

The ARRA funding supported R&D efforts and the launch of new innovative products for vendors interviewed. For example, at PAX Water, 20 percent of the revenue is reserved for R&D. Because funding recipients continued to order products during the recession, PAX Water continued to develop its products. Without the steady supply of orders, R&D activities would have stopped.

PAX Water's participation in ARRA-funded projects in North Carolina helped launch a new innovative product, the THM Removal System (TRS) technology. According to the Chief Executive Officer of PAX Water, an ARRA-funded tank mixer project led to the first TRS demonstration, which created enormous interest in the TRS technology throughout North Carolina and South Carolina. The demonstration also led to direct improvements in the TRS technology design based on lessons learned from an actual installation. Indirectly, improvements in marketing strategy occurred because the demonstration provided a marquee example with as-built data that PAX Water could share with other prospective buyers. Thus, PAX Water's participation in ARRA-funded projects in North Carolina expanded its line of innovative products.

The ARRA funding helped Schreiber, the vendor of the Fuzzy Filter® technology, fine tune its operations for compliance with unrestricted water reuse under Title 22, Chapter 4 of the California Code of Regulations. Under Title 22 unrestricted water reuse regulations, effluent must be treated with advanced wastewater treatment processes, specifically filtration (such as the Fuzzy Filter®) and disinfection. For equipment manufacturers, Title 22 adds complexity to projects because of the stringent demonstration, treatment and monitoring requirements. The manufacturers must study the Title 22 regulatory requirements and establish procedures to test, adjust, and monitor the filtration process. A pilot study must be completed and approved by the California Department of Health Services. Additionally, the treatment process must be adjusted to comply with specific equipment criteria (e.g., filter media height and backwash specifications). Schreiber gained experience with the Title 22 process by working on the ARRA-funded project. The experience resulted in adjustments to its operational procedures. According to the President of Schreiber, there were no “groundbreaking” changes, but adjustments were made.

EFFECT OF ARRA FUNDING ON LOCAL AND NATIONAL MARKETS

The ARRA funding impacted the local and national markets for some innovative technology products. According to the Vice President of Sales and Business Development for Datamatic, the water and electric AMR/AMI system is one example. Although electric utilities received more ARRA funding than water utilities, both sides moved forward with investments in AMR/AMI systems. Because the electric utilities are farther along with the transition to AMR/AMI than the water utilities, the ARRA funding to the electric utilities accelerated the deployment of the AMR/AMI technology, whereas the ARRA funding to the water utilities opened up the market, especially by demonstrating the benefits of leak detection. The Vice President of Sales and Business Development for Datamatic commented, “On both sides, ARRA funding mitigated industry and employee suffering during the recession.”

ARRA funding impacted market exposure for clarification products. The installation of ARRA-funded projects created greater exposure of the products in the market place. The market exposure helped companies, such as Cambridge Water Technologies, establish credibility within the engineering and wastewater clarification communities and fast track their products. According to the Vice President of Sales and Marketing for Siemens, “Cambridge Water Technologies could have gone to private equity funding to achieve this goal, but ARRA did it for us.”

ARRA funding impacted the market for potable water tank mixing systems. Projects went forward that would not have otherwise been funded. Tank mixing solves problems with loss of residual chlorine level, which is a minor problem compared to other issues, such as lack of capacity or broken pipes. During a recession, only major problems are normally addressed. Thus, according to the President of Medora, “the potable tank mixer market would have been substantially impacted in a negative way without the influx of ARRA-funded projects.”

The ARRA funding shifted the adoption trend for some innovative technologies. Vendors interviewed reported that ARRA funding helped increase product exposure, which led to greater interest in the products and the opportunity to establish credibility in the technologies. Funding recipients interviewed reinforced the vendor perception by stating they would not have tried the innovative technologies without ARRA funding; thus, the availability of ARRA funds enabled the funding recipients interviewed to purchase and install products earlier than anticipated, shifting the adoption trend. Several vendors, including Datamatics, Cambridge Water Technologies and BRC Environmental, experienced a shift.

EFFECT OF ARRA FUNDING ON GENERATING NEW CUSTOMERS

All interviewed vendors agreed that the ARRA funding will most likely generate new customers and follow-on work. The product exposure created from successful ARRA-funded project installations of the innovative technologies is valuable. The water utility industry is a small community where participants regularly share experiences at conferences and meetings. This 'word of mouth' exposure provides the opportunity for a new technology to rapidly spread nationwide and beyond.

Additional exposure from the ARRA-funded WVAW pilot study will most likely help with future Datamatic product sales. According to the Vice President of Sales and Business Development for Datamatic, the utility industry tends to be risk adverse, and utilities prefer to see successfully completed examples of new technologies before investing. ARRA funding provided the means for Datamatic to get the MOSAIC mesh fixed network AMR/AMI technology installed and show the utility industry that AMR/AMI technology can control its assets and provide a return on investment. Thus, the ARRA-funded WVAW pilot study supplied Datamatic with the opportunity to complete a successful AMR/AMI field demonstration to present to the utility industry.

Medora will most likely experience benefits from ARRA funding in the form of follow-on work with the utilities. According to the President of Medora, new technology is often first implemented to solve the worst-case circumstance (i.e., the potable water tank with the biggest water quality issues). After the utilities become familiar with the effectiveness of the new technology, they often install it in their additional tanks. At this point, Medora's SolarBee® potable water mixers have been installed in hundreds of tanks; but thousands more can benefit from active mixing. The ARRA funding provided Medora with the opportunity to demonstrate the effectiveness of its potable tank mixing technology at utilities that were previously unfamiliar with the product, which will most likely result in additional product orders.

Likewise, the ARRA-funded projects created follow-on work opportunities and new customers for PAX Water. In 2009, according to the Chief Executive Officer of PAX Water, the release of ARRA funds created a boom of business for PAX Water in North Carolina. After completion of the ARRA-funded installations, the sales of the PAX active tank mixers continued to grow in North Carolina; it is one of its top sales states. The repeat and new business is most likely the result of 'word of mouth' marketing exposure from the ARRA funding recipients.

The ARRA-funded Georgetown wastewater treatment project will most likely create new customers for Kruger. The Georgetown project gave Kruger the opportunity to successfully demonstrate the effectiveness of its HYBAS™ system. The Vice President of Strategic Planning for Kruger noted that a successful installation helps build your reputation and helps others envision how the technology can be used in their application, which leads to new customers. A successful installation also creates marketing exposure. Kruger's successful installation of the HYBAS™ system at the Georgetown wastewater facility was widely discussed in wastewater industry publications and conferences due to the project's award-winning status.

Example Project with International Impact

The successful demonstration of the Blue PRO® technology at the Georgetown Colorado wastewater treatment plant helped Blue Water market Blue PRO® internationally. South Korea has become a good market for the Blue PRO® process because President Lee Myung-Bak acquired $6 billion of funding in 2010 to make clean water his legacy. To date, between one and two dozen Blue PRO® plants have been installed in South Korea. Europe is another market that is interested in the Blue PRO® process because of its metals removal capability in addition to phosphorus. Thus, Blue PRO®'s proven metals removal capability, as demonstrated by the ARRA-funded Georgetown Colorado project, is helping the company expand into foreign markets.

Table 9 summarizes the effects of the ARRA funding, as described by the innovative technology vendors. Most vendors interviewed stated the ARRA funding boosted their sale revenues during the recession, and created new customers and follow-on work opportunities for them. Some vendors also stated the ARRA funding helped their companies grow, improved their products, shifted the adoption trend for their innovative product, and helped them expand into other markets. In addition, two vendors stated that ARRA funding caused them to change their operations, returning manufacturing of their products to the United States.

TABLE 9. VENDOR OBSERVATIONS ON EFFECTS OF ARRA FUNDING

Technology Name	Return to Onshore Manufacturing	Boost in Sales Revenue (saved jobs)	Small Company Growth	Shift in Adoption Trend	Product Improvements (R & D Suppo	First Time Full Scale / New Market	ow-on Work	sion to Other Markets
Drinking Water Innovative Technologies								
Advanced Metering Systems	✓	✓		✓		✓	✓	✓
PAX Water Technologies™ Active Tank Mixer		✓	✓		✓		✓	✓
SolarBee® Active Tank Mixer		✓	✓		✓		✓	✓
Clean Water Innovative Technologies								
CoMag™ Ballasted High-Rate Clarification		✓		✓			✓	✓
Fuzzy Filter®		✓			✓		✓	
HYBAS™ Integrated Fixed-Film Activated Sludge System	✓	✓	✓		✓		✓	
Blue PRO® Reactive Filtration		✓	✓			✓	✓	✓
BCR Clean B™ System			✓	✓		✓	✓	
SAFL Baffle		✓	✓			✓	✓	✓

3.4 RECOMMENDATION

The study shows that ARRA funding was effective in supporting the development and use of some innovative technologies, particularly for wastewater projects. The tight obligation and expenditure deadlines in ARRA, however, generally did not provide sufficient lead time for the development of totally new innovative technologies. In the future, EPA should consider extending the deadlines for innovative technology development to allow for concept, design, demonstration, and commercialization phases.

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APPENDIX 1: ADVANCED METERING SYSTEMS CASE STUDY

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SUMMARY

Under a work assignment issued by the EPA Office of the Chief Financial Officer (OCFO), SAIC is gathering information regarding new or expanded industries or markets that were fostered as a result of ARRA spending. SAIC screened the Office of Water databases for drinking water and clean water projects to identify technologies considered innovative. In consultation with the EPA Office of Water, SAIC selected two drinking water technologies for case studies: Automated Meter Reading (AMR)/Advanced Metering Infrastructure (AMI) and solar-powered mixers.

This case study focuses on a study of the AMI technology conducted by West Virginia American Water (WVAW), the recipient of the ARRA funding. For this report, SAIC obtained information both from the WVAW and Datamatic Ltd. (Datamatic), the manufacturer of the AMI technology.

Located within Fayette County, West Virginia, the pilot study area encompasses a 333-square mile service area, roughly half of the counties 664 square mile region. This mountainous area rises from the valleys in the northwest to the Allegheny Mountains in the east. WVAW selected the area for the pilot study because the snowy mountainous terrain makes signal transmission of AMI data difficult, and thus provided a good test of the effectiveness of the AMI technology.

During the pilot study, WVAW successfully installed a mesh fixed network AMI system servicing 12,000 water utility customers. The mesh fixed network AMI technology proved to be 98 to 99 percent effective in transmitting meter reading and acoustic monitoring data remotely to the WVAM utility office despite challenging conditions (i.e., mountainous terrain). The green infrastructure benefits included a substantial reduction in water loss (i.e., an initial drop in nonrevenue water (NRW) from 55 to 38 percent), and energy savings (i.e., reduction in vehicle use). WVAW is satisfied with the performance of the mesh fixed network AMI system and has recommended it to its industry peers.

The WVAW pilot study provided an excellent opportunity for Datamatic to field demonstrate the strengths of the MOSAIC mesh fixed network AMI technology. The ARRA funds positively affected Datamatic's product sales and manufacturing approach, allowing it to close down some of its overseas production plants and expand its United States-based production plant. On a national scale, ARRA funding to the water utilities opened up the AMI technology market and shifted the technology adoption trend. Datamatic expects follow-on work from the ARRA-funded WVAW pilot study and has benefited from the additional product exposure it has provided.

CASE STUDY OF AUTOMATED METER READING/ADVANCED METERING INFRASTRUCTURE IN DRINKING WATER SYSTEMS

This document presents the case study conducted by Science Applications International Corporation (SAIC). Section 1 contains a detailed description of the project. Section 2 describes the Automated Meter Reading (AMR)/Advanced Meter Infrastructure (AMI) technology including its advantages, disadvantages and market potential. Section 3 presents information and lessons learned from the technology vendor for this case study (Datamatic Ltd.), and Section 4 presents information and lessons learned from the recipient of the ARRA funds (WVAW).

I. PROJECT DESCRIPTION

West Virginia American Water (WVAW) undertook the pilot study of the AMI technology to test its ability to provide two-way remote meter reading capability between the WVAW utility and its customers, and also detect leaks in the water distribution system. The AMI technology is an alternative to the manual and mobile (drive-by) approach to meter reading. WVAW is a subsidiary of American Water, which owns and operates drinking water utilities in several states.

Located within Fayette County, West Virginia, the pilot study area encompasses a 333-square mile service area, roughly half of the County's 664-square mile region. This mountainous area rises from the valleys in the northwest to the Allegheny Mountains in the east. In 2011, Fayette County had a population of 45,699 residents in 21,618 households (United States Census Bureau, 2012). The county has a tradition of coal mining, which still serves as one of the primary sources of employment (United States Census Bureau, 2012).

The total cost of the pilot study was $4,697,734. The government-funded portion of the pilot study totaled $3,850,000 with $1,925,000 provided by ARRA, $1,925,000 provided by the West Virginia DWSRF, and the remaining $847,734 provided by WVAW.

WVAW installed the AMI technology during the spring/summer of 2011. WVAW purchased new AMI equipment to supplement the existing metering equipment within the Fayette County study area. In addition, WVAW purchased acoustic monitors to provide 100 percent leak monitoring of the water distribution system. These improvements were designed to increase the efficiency of the meter reading collection and reporting process and reduce the high water loss occurring from the decaying infrastructure.

II. ADVANCED METERING TECHNOLOGY

INTRODUCTION

Advanced metering technology makes remote reading of meters possible. It is not a new technology, but instead it is one that has evolved over the last 50 years with many innovative changes along the way. It was first tested by AT&T in the 1960s; however, the technology was not considered feasible until 1985 when Hackensack Water Co. and Equitable Gas Co. committed to full-scale implementation on water and gas meters, respectively (Tamarkin, 1992). Advances in solid-state electronics, microprocessor components and low-cost surface-mount technology assembly techniques catalyzed the evolution of the technology. In this section of the document, the advanced metering technology is explained, and the benefits, road blocks and projected demand for the technology are described.

ADVANCED METERS

An advanced meter is a digital electronic measurement device used by utilities to remotely communicate information. Like a traditional electromechanical meter, an advanced meter measures flow of a commodity (e.g., gallons of water, cubic feet of gas or kilowatt-hours of electricity) and records the usage at a customer's home or business. However, an advanced meter does more than a traditional electromechanical meter; it quantifies the use of the commodity during defined time intervals and records data on its consumption and time of use. Such meters use the consumption and time data to calculate the rate of use (demand) in fixed or rolling time intervals (such as 15, 30 or 60 minutes).

An advanced meter is also referred to as a 'Smart Meter.' The term 'Smart Meter' was coined in 2009 following the Smart Grid Initiative, when the Obama administration provided $3.4 billion in government support of 100 projects aimed at modernizing the nation's power grid (Fletcher, 2009).

ADVANCE METERING SYSTEMS

An advanced metering system has two distinct elements: an advanced meter and a communication system**,** which captures and transmits the water-use information as it happens, or almost as it happens.

The communication portion of the advanced metering system has evolved from AMR to AMI. The AMR system utilizes one-way communication to transmit data from the meter to a mobile or fixed-base system, saving the cost of manual reading. The newer AMI system goes further than AMR. It allows utilities to collect more information, engage in two-way communication with customers and control customer-level functions more promptly.

AMI systems are varied in technology and design but operate through a simple overall process. The advanced meter collects data locally and transmits it via a Local Area Network (LAN) to a data collector. This transmission can occur as often as once every 15 minutes or as infrequently as daily. The collector retrieves the data and may process it, or simply pass it on for processing upstream. When the data are passed on, it is transmitted via a Wide Area Network (WAN) to the utility central collection point for processing and use by business applications. Because the communications path is 'two way,' signals or commands can be sent directly to the meter, customer premise or distribution device. The utility selects the best technology to meet its demographic and business needs.

The AMR and AMI advanced metering system data are collected using handheld, mobile and/or network technologies that are based on telephony platforms (wired and wireless), radio frequency (RF) or power line transmission. These data collection methods are described below.

HANDHELD DATA COLLECTION

Handheld data collection is also referred to as 'walk-by' meter reading. With this approach, a handheld computer with a built-in receiver collects meter readings from an AMR-capable meter. The meter reader walks by the locations where meters are installed and presses a button to download the meter readings electronically from the AMR to the handheld computer. The handheld computer may also be used to manually enter readings without the use of AMR technology.

MOBILE DATA COLLECTION

Mobile data collection is also referred to as ‘drive-by’ meter reading. With this approach, a reading device is installed in a vehicle to automatically collect AMR meter readings while the meter reader drives the vehicle. The drive-by reading equipment often includes navigational and mapping features provided by Global Positioning System (GPS) and mapping software. With mobile technology, the meter reader does not normally have to read the meters in any particular route order, but just drives the service area until all meters are read. Mobile technology components consist of a laptop or proprietary computer, software, RF receiver/transceiver and external vehicle antennas.

FIXED NETWORK DATA COLLECTION

Fixed Network AMI captures and transmits meter readings with permanently installed communications equipment (e.g., antennas, towers, collectors and repeaters). This technology eliminates the need for field data collection.

A star or mesh fixed AMI network is used to transmit data from meters back to a central computer. A star network is the most common, where a meter transmits its data to a central collector. Some star networks also use repeaters, which forward readings from a more remote area back to a main collector without actually storing it. Repeater data can be forwarded by an RF signal or it can be converted to a wired network (e.g., a telephone or internet protocol network).

In mesh networks, the meters themselves act as repeaters, passing the data to nearby meters until the data reaches a main collector. The meter readings are transmitted along a path by ‘hopping’ from repeater to repeater until the collector is reached, similar to the way someone might jump from rock to rock to cross a river (Milburn, 2008). The routing network allows for continuous connections and reconfiguration around broken or blocked paths, using self-healing algorithms. As a result, the network is typically quite reliable, as there is often more than one path between a meter and a collector (Datamatic Ltd., 2012). Although mostly used in wireless networks, this concept is also applicable to wired networks.

Some fixed network systems can also be installed as a hybrid AMR/AMI system, where mobile and fixed networks are intermixed by design. In a hybrid system, part of the system is read by fixed network, and parts are read by mobile and/or handheld technology. A hybrid system is advantageous for utilities with low-density rural areas that may not be able to cost justify the fixed network infrastructure for parts of their service area, using it only for higher density zones or commercial accounts (Datamatic Ltd., 2012). Hybrid networks also allow reading of a meter by both methods concurrently as a source of redundancy. In the event of a failure of the network due to a natural disaster, sabotage, power failure or other network interruption, the mobile reading system is available in the disaster recovery plan as an alternative means of data collection to the fixed network.

BENEFITS

The principal benefit of advanced metering systems is their ability to provide more information. With advanced metering systems, consumers can track their water use in near real-time via the Internet or an in-home monitor to assist with its management, such as regulation of lawn irrigation and leak detection. Whereas electromechanical meters are manually read once per month, providing no information on when a customer used water during that month, advanced meters can be read instantaneously and can provide information much more frequently. The advanced meter's typical 15-minute reading frequency equates to almost 3,000 reads per month versus the one reading per month normally collected. With timely usage information available to the customer, opportunities exist to manage their water consumption.

Advanced metering systems provide benefits to utilities and retail providers, as well as the customers. Benefits recognized by the utilities include tamper notification, reduced labor cost and efficiency of almost every major business function within a utility (e.g., billing, planning, operations, maintenance, customer service, forecasting, etc.). Retail providers can benefit by developing and offering new innovative products, in addition to, customizing packages for their customers. **Table 1** summarizes the major benefits that advanced metering systems provide to utility managers and customers.

ROAD BLOCKS

Several disadvantages of advanced metering systems are perceived to exist. They are:

1) Lack of cost recovery or measurable Return on Investment (ROI).
2) Upfront utility expenses required.
3) Upfront customer expenses.
4) Lack of customer interest.
5) Loss of privacy – details of use reveal information about user activities.
6) Greater potential for monitoring by other/unauthorized third parties.
7) Reduced reliability (more complicated meters, more potential for interference).
8) Increased security risks from network or remote access.
9) Meter readers losing their jobs.
10) Health issue concerns (radio-wave exposure).
11) Equipment compatibility issues (now and in future).

State public utility commissions are addressing the health and privacy issues. After receiving numerous complaints about health and privacy concerns with the wireless, digital devices, Maine's Public Utility Commission voted to allow customers to opt out of the meters, at a cost of $12 per month. Also, on January 19, 2012, the American Academy of Environmental Medicine called for the California Public Utility

Commission to place an immediate moratorium on advanced meter installation and to hold hearings on advanced meter health impacts.

TABLE 1. BENEFITS OF ADVANCED METERING SYSTEMS

STAKEHOLDER	BENEFITS
Utility Customers	Timely access and control of their water use data Early leak detection More accurate water rates and timely billing Improved service and reliability Reduced costs from improved water efficiency Reduced costs from lower service fees Greater privacy (remote readings eliminate access issues)
Utility Management and Field Operations	Accurate meter reading, no more estimates Reduced cost of meter reading Elimination of handheld meter reading equipment Reduced call center transactions Reduced collections and connects/disconnects Early detection of meter tampering and theft Reduced billing errors Reduced employee safety incidents Increased customer satisfaction (cost savings & self control)

FUTURE DEMAND

In 2009, Oracle conducted a survey to determine future demand (Oracle Utilities, 2010). Over 300 water utility managers were surveyed to determine their perception of, and future plans for, advanced metering systems. The results of the survey are:

- 68 percent of water utility managers believe it is critical that water utilities adopt advanced metering systems.
- 83 percent of water utility managers that have completed a cost-benefit analysis support the adoption of advanced metering technology.
- 33 percent of water utility managers are currently considering or implementing advanced metering systems.

The survey concludes that the majority of water utility managers would like to replace their existing meters with advanced metering systems; however, only half of them (roughly speaking) are currently considering or doing it. The reason many utilities are not considering it at this time (i.e., in 2009 just prior to ARRA funding) is because of the upfront water utility expenses required and the lack of cost recovery/measurable ROI.

According to Pike Research[4], the global-installed base of advanced and advanced-enabled water meters will surge to 31.8 million by 2016, up from 5.2 million in 2009 (Dignan, 2010). Advanced water meters will ultimately account for 31 percent of all new water meter shipments. The research notes that water shortages will affect half the world's population by 2030, and in the United States, 36 states will see water shortages by 2013. Thus, the quest for more-efficient use of water is believed to be contributing to the surge in demand along with the need to replace an aging system infrastructure.

According to TechNavio[5], the market for advanced water meters is forecast to reach $508.1 million in 2012, up from $244.0 million in 2008. By 2020, it is estimated to be a $16.3 billion dollar industry (Heimbuch, 2012).

III. VENDOR-PROVIDED INFORMATION

INTRODUCTION

Datamatic is the vendor of the advanced metering technology used in this case study. Datamatic is a small, privately owned company headquartered in Plano, Texas. In 1980, Datamatic installed the first electronic meter reading system at the Texas Electric Service Company. From the development of this first handheld meter reading system to today's AMI technology, Datamatic's focus has been on providing innovative and economical field data collection systems to help utilities better manage assets and conserve water (Datamatic Ltd., 2012). In this section, vendor-supplied information is used to describe the product and ARRA-funding impacts on product and business development.

MOSAIC AMI

MOSAIC is the name of the advanced metering system product developed by Datamatic. It is a mesh hybrid AMI system that is compatible with any water meter (Datamatic, Ltd, 2006). Meters are read using walk-by, mobile and mesh network collection platforms. Full two-way communication is used to transmit the data (e.g., interval data requests, firmware updates and monitoring schedules) to and from the meters via the network. Water conservation monitoring is achieved with acoustic leak detection equipment, and also scheduling software that monitors usage and threshold exceedances (e.g., watering on a restricted day).

The MOSAIC AMI mesh network automatically delivers metering data without user intervention. The communications are directional within the mesh network with transmission moving purposefully toward

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[4] Pike Research is a market research and consulting firm that provides in-depth analysis of global clean technology markets. The company's research methodology combines supply-side industry analysis, end-user primary research and demand assessment, and deep examination of technology trends to provide a comprehensive view of these industry sectors.

[5] Technavio is the research platform of Infiniti Research. Infiniti Research provides actionable market, strategic, competitive and customer intelligence to leading companies worldwide. A team of 120 analysts with specialization in different sectors conduct research in more than 50 countries (including all OECD and extended BRIC countries), and in more than 20 languages (including French, German, Mandarin, Japanese, Korean, Spanish, Portuguese and Hindi).

the primary collector, not indiscriminately throughout the network. The mesh is designed to reroute around hazards, such as mountains, buildings, and difficult terrain. If the shortest route becomes unavailable, the transmission simply arrives by one of its other redundant routes, effectively 'healing' itself (Milburn, 2008).

The MOSAIC network uses software and hardware equipment to collect and relay metering data. The major components of the system are Firefly Meter Interface Units (Firefly MIUs), Gateway receivers and the RouteSTAR meter reading application. Firefly MIUs attach to the water meters and use radio frequency to transmit readings to handheld, mobile and fixed network AMI platforms. Firefly MIUs are compatible with all types and brands of water meters, making it the first universally compatible AMI system in the industry (Datamatic Ltd., 2012). A Firefly MIU installs in minutes and activates after the meter into which it is physically installed is inserted into the meter socket. When used with a mesh fixed network, the Firefly MIU receives a message from a Firefly MIU neighbor upon activation that tells it the primary gateway collector to which it should be communicating in the mesh network. Subsequently, the Firefly MIU wakes up and communicates for 6 seconds every 20 minutes. Between these transmissions, the Firefly MIU remains in a low power state, conserving battery life. It can store 240 days of usage profile data with the utility determining how often it wants readings transmitted. The Firefly MIU also functions as a repeater for the transmission of other Firefly MIUs around it, able to relay not only its own data to the gateway collector, but also the data from neighboring meters.

Gateway receivers collect data transmitted from the FireFly MIUs. Gateway receivers have compact, weather-resistant enclosures containing a backup power source, so they can continue collecting and communicating data to the server even during power outages. The RouteSTAR meter reading application receives uploaded data from the Gateway receivers. It delivers customizable reporting features and manages the information transfer to and from the utility billing system.

Permalog+ Leak Noise Loggers are an optional feature of the MOSAIC AMI system. Permalog+ Leak Noise Loggers find and repair leaks in water pipes. The loggers attach magnetically to valves throughout the distribution system. Sophisticated algorithms distinguish the sound of normal operations from the distinct acoustic signature produced by a leak. When integrated with a Firefly MIU, the Permalog+ Leak Noise Loggers transmit data to the office daily via the MOSAIC mesh network. A Digital Correllator analyzes the leak data to provide accurate location information.

Remote shutoff valves are another optional feature of the MOSAIC AMI system. Remote shutoff valves make it possible to perform shutoffs and reconnections remotely. A shutoff signal is transmitted via the MOSAIC mesh network. When the remote shutoff valve receives the signal, an internal ball valve is rotated to cut off the flow of water. The same process performs reconnections. The remote shutoff valves allow utilities to disconnect delinquent and inactive accounts.

INTERVIEW WITH MR. RICHARD SANDERS

In June 2012, Mr. Sanders, Vice President of Sales and Business Development for Datamatic, provided his perspective on how ARRA funding affected product and business development. This section summarizes his responses to questions concerning the local and national impact ARRA funding had on the advanced metering technology business sector.

OPPORTUNITY PROVIDED BY ARRA-FUNDED PROJECTS

Datamatic supplied AMI products on two ARRA-funded projects: the WVAW pilot study and a smaller project in Wasco, CA. The rural mountainous terrain of the WVAW pilot study provided an excellent opportunity for Datamatic to field demonstrate the strengths of the MOSAIC mesh fixed network AMI technology, which provides continuous connections and reconfigurations around blocked pathways. Unlike the line-of-site AMI fixed network technology supplied by most other vendors, the MOSAIC mesh fixed network AMI technology is reliable in rural mountainous terrain. Thus, this project provided Datamatic with the opportunity to accomplish something the balance of the industry could not accomplish and created a new market option for the company.

EFFECTS OF ARRA FUNDING ON COMPANY DEVELOPMENT

ARRA funds affected Datamatic product sales. The two ARRA-funded projects added direct value via incremental revenue. The effect was especially felt because the sales occurred during the recession. ARRA funding was helpful because it enabled utilities to push projects forward that would not have otherwise been funded during recessionary times.

The large production requirement of the ARRA-funded projects allowed Datamatic to change its manufacturing approach. Datamatic closed down some of its overseas production plants and expanded its United States-based production plant. This operational change transferred production jobs from overseas to the United States during the recession. Datamatic assessed whether increased product quality control of United States-based production offset production cost increases. They learned that the extra cost of manufacturing in the United States is offset by not having to cope with the product quality issues they experienced with overseas production. Now Datamatic intends to expand U.S. manufacturing as it reduces its overseas manufacturing.

ARRA funds did not create a temporary funding shock condition (i.e., funding bubble). Production levels of Datamatic products have been maintained since ARRA funding ended.

DRAWBACK OF ARRA FUNDING

Funding recipients experienced difficulty obtaining the ARRA funding, which may have dampened the technology adoption. The difficulty was associated with onerous paperwork requirements. Datamatic would have benefited from additional ARRA-funded projects, if some of the utilities had not abandoned their efforts to secure this funding. Funding provided by the State Revolving Fund (SRF) was less difficult to obtain.

IMPACT OF ARRA FUNDING ON NATIONAL MARKETS FOR AMI SYSTEMS

ARRA funding had a measurable impact on the water and electric AMI system markets. Although electric utilities received more ARRA funding than water utilities, both sides moved forward with investments in AMI systems. The electric utilities are farther along with the transition to AMI than the water utilities. Thus ARRA funding to the electric utilities accelerated the deployment of the AMI technology, whereas the ARRA funding to the water utilities opened up the market, especially by demonstrating the benefits of leak detection. On both sides, ARRA funding mitigated industry and employee suffering during the recession and saved many jobs.

Among water utilities, ARRA funding shifted the AMI technology adoption trend. Many utilities would not have tried the AMI technology without ARRA money. ARRA-funded projects led to greater interest in AMI products. Overall, ARRA funding helped the industry by increasing exposure and giving credibility to the technology. Although Mr. Sanders could not estimate the relative growth in the AMI market because of ARRA-funded projects, he would guess that less than 15 percent of large utilities have deployed AMI, whereas without ARRA funding, the percentage would only have been 7 to 8 percent of the market.

FUTURE BENEFITS FROM ARRA FUNDING

The ARRA-funded WVAW pilot study has most likely opened the door for follow-on work. Mr. Sanders anticipates that additional WVAW study phases will occur in the future.

Additional exposure from the ARRA-funded WVAW pilot study will most likely help with future Datamatic product sales. The utility industry tends to be risk adverse, and utilities prefer to see successfully completed examples of new technologies before investing. ARRA funding provided the means for Datamatic to get the MOSAIC mesh fixed network AMI technology installed and show the utility industry that AMI technology can control its assets and provide a return on investment. Thus, the ARRA-funded WVAW pilot study supplied Datamatic with the opportunity to complete a successful AMI field demonstration to present to the utility industry.

SUMMARY

The WVAW pilot study provided an excellent opportunity for Datamatic to field demonstrate the strengths of the MOSAIC mesh fixed network AMI technology. The ARRA funds positively affected Datamatic’s product sales and manufacturing approach, allowing it to close down some of its overseas production plants and expand its United States-based production plant. On a national scale, ARRA funding to the water utilities opened up the AMI technology market and shifted the adoption trend. Datamatic expects follow-on work from the ARRA-funded WVAW pilot study and has benefited from the additional product exposure it has provided.

IV. FUNDING RECIPIENT-PROVIDED INFORMATION

INTRODUCTION

In June 2012, Mr. Brent Morgan, Direction of Engineering for WVAW, provided his perspective on the performance of the Datamatic AMI technology and the impact ARRA funding had on the pilot study. This section summarizes his responses to questions about the pilot study and ARRA funding impact.

IMPACT OF ARRA FUNDING ON PILOT STUDY

As mentioned previously, the study was funded by three sources: ARRA, DWSRF and WVAW. The government-funded portion of the pilot study totaled $3,850,000 with $1,925,000 provided by ARRA and $1,925,000 provided by DWSRF. WVAW provided an additional $847,734 to meet the total project cost of

$4,697,734. Thus, the government funding accounted for 82 percent of the total funding for the pilot study. Mr. Morgan commented that WVAW would not have invested $4.7 million in the evaluation of the AMI technology without government funding.

Prior to the availability of government funding, WVAW was planning a pilot study of the AMI technology on a smaller scale (in the range of 500 to 1,000 customers). As a result of the ARRA and DWSRF funding, WVAW expanded the pilot study to include 12,000 customers. Thus, ARRA funding contributed to the expansion of the size of the pilot study.

SELECTION OF AMI TECHNOLOGY

AMI EQUIPMENT EVALUATION AND VENDOR SELECTION PROCESS

WVAW evaluated the available AMI communication options and selected a mesh fixed network AMI system to install in the Fayette County study area. As described in Section 2, a mesh fixed network AMI system uses meters as repeaters to pass data to nearby meters until it is relayed to a collector point. A mesh fixed network approach reduces the number of collection points that are usually needed in mountainous areas.

WVAW consulted with AMI experts and vendors prior to selecting the mesh fixed network approach. The equipment for this type of AMI system is manufactured by several vendors, and after evaluation, WVAW concluded that the vendor products were similar and were all viable options for the study. They prepared draft specifications that identified the project needs and then asked vendors to determine the equipment requirements based on their needs. WVAW invited five vendors to submit bids for a lump-sum system (i.e., unit price equipment by site). Two vendors responded to the request. The winning vendor (Datamatic Ltd.) was the low-price bidder.

MESH NETWORK SYSTEM COMPONENTS

WVAW purchased new AMI equipment to supplement the existing metering equipment in the Fayette County study area. The existing meters (mostly Neptune products) were retained as part of the new AMI system when they were in good condition. New Elster meters replaced older meters. WVAW added the Datamatic MOSAIC equipment (MIUs, repeaters, acoustic noise detectors and collectors) to the metering equipment to gather and transmit data from the field to a server. **Table 2** summarizes the equipment components that WVAW purchased for the new mesh fixed network system (Morgan, 2012).

TABLE 2. EQUIPMENT PURCHASED FOR THE MESH FIXED NETWORK SYSTEM

EQUIPMENT TYPE	NUMBER OF UNITS
MIUs (Fireflys manufactured by Datamatic)	13,011
Firefly Repeaters (manufactured by Datamatic)	1,191
ACER (AC Enhanced Repeaters)	50
BER (Battery Enhanced Repeaters)	200
Gateway collectors (manufactured by Datamatic)	17
Permalog Acoustic Monitors (manufactured by Datamatic)	1,255
Roadrunners (hand-held units manufactured by Datamatic)	6

A key feature of the new mesh fixed network system is its ability to detect leaks. The infrastructure in the Fayette County study area is deteriorating. Prior to installing the AMI system, nonrevenue water (NRW) accounted for 55 percent of produced water. NRW is water that is not delivered through a metered service and, most likely, reflects leaking pipes and valves in the water distribution system.

WVAW purchased acoustic monitors to provide 100 percent leak monitoring of the water distribution system. WVAW selected Datamatic's Permalog Acoustic Monitors for this purpose. The design required the purchase of 1,255 Permalog monitors to achieve the desired 100 percent monitoring coverage of the study area. Nightly, the Permalog monitors ’listen for’ leak-like noise and transmit a ’leak or no leak condition‘ through the mesh fixed network communication system. WVAW can review the Permalog monitoring transmissions on a daily basis, and if needed, send personnel to the site location for further investigation. WVAW can review the data stored on site to determine the probability of a leak's existence and estimate its volume. Small leaks often make more ’noise‘ than larger leaks.

WVAW did not select the Datamatic remote shutoff valve feature for the new mesh network system. Remote shutoff valves allow the utility to remotely control water flow to the customer (e.g., disconnect delinquent and inactive accounts). Although this feature would be useful, WVAW considers it to be too expensive as compared to the benefit. WVAW will reconsider the addition of remote shutoff valves to the mesh fixed network system if the price declines.

INSTALLATION OF THE AMI SYSTEM

SETTING

The snowy, mountainous terrain of Fayette County provides a challenging environment for the installation of an AMI system. The 333-square mile service area is located in south central West Virginia, which rises from the valleys in the northwest to the Allegheny Mountains in the east. The elevation change is approximately 2,800 feet. Annual snowfall ranges from 35 to 55 inches. This mountainous terrain makes signal transmission of AMI data difficult to relay from the meters to the data collector units. For this reason, WVAW considered this area to be a good test of the effectiveness of the AMI technology, and thus, selected it for the pilot study.

RESPONSIBILITIES

WVAW hired the engineering firm of Hatch Mott MacDonald to provide resident project management and GIS location for the pilot study. WVAW considers this approach to be one of the things that it did right.

Datamatic was responsible for the design, installation and startup operation of the mesh fixed network AMI system. This process generally went well. The equipment supplied by Datamatic and Elster Group functioned as advertised (i.e., defective equipment rate was not problematic). During installation, approximately 98 to 99 percent of the mesh transmission sites operated on startup.

ISSUES

A few issues occurred during the installation of the mesh fixed network AMI system. First, the wiring and retrofitting of meters was problematic in a few small parts of the acquisition territory. A trial-and-error solution to the wiring issue was required in these areas because of incompatibility with older metering systems. Second, data entry errors by installers caused delays during the connection of some new meters and MIUs. This was a human error issue created by onerous data entry requirements (i.e., each meter connected to the system required manual entry of a 35-digit identification number). And lastly, Datamatic struggled with establishing mesh communication on the last 1 to 2 percent of the transmission sites. These problematic sites are still not connected to the AMI system (e.g., WVAW manually reads 20 meters per day due to this issue).

The time associated with ARRA funding acquisition and weather impacted the schedule of the pilot study. WVAW commented that the schedule was slowed down because the ARRA application requirements changed part way through the process. In addition, there were unfamiliar performance and reporting requirements (e.g., Buy American and Davis Bacon). The paperwork was more than they would otherwise complete, and thus caused delays. Snow in the study area also delayed the start of the project by four months (from November to February).

SYSTEM PERFORMANCE

WVAW is satisfied with the performance of the mesh fixed network AMI system. At this point, the system is transmitting data from 98 to 99 percent of the connected meters within the pilot study area. There are still 100 to 150 meters (out of 12,000) that have problems, but WVAW does not expect the system to transmit readings from 100 percent of the meters every day.

WVAW is also very satisfied with the performance of the Datamatic Permalog acoustic monitoring equipment. It is fully functional. WVAW is currently detecting 80 to 100 leaks at a time. During the first month of operation, the initial benchmark 55 percent NRW dropped to 38 percent. Although this percentage drop is representative of the first month change only and will change with time, it provides an initial indication of the product effectiveness.

WVAW would recommend this type of AMI system to its industry peers. WVAW commented that it has been a good experience working with Datamatic and using its AMI system. Mr. Morgan also communicated this feedback in a slide-show presentation at an American Water Works Association (AWWA) conference in West Virginia.

SYSTEM BENEFITS

An important benefit of the AMI system is a reduction in water loss. This reduction is realized because the Permalog monitors detect leaks and transmit reports to the WVAW office on a daily basis. During the planning phase of the pilot study, WVAW projected a 30 percentage-point reduction in water loss over time due to the installation of the Permalog monitors within the pilot study area. This reduction is equivalent to a 25 percent NRW (down from the pre-installation rate of 55 percent). WVAW believes this reduction in water loss will be achieved in time. How quickly this rate will be achieved depends on how quickly they can detect and fix the 'big' leaks; the rate of repair or replacement depends on availability of funds. WVAW plans to address the main water loss problems within the next one to two years. WVAW also plans to use the data from the Permalog monitors to guide its capital investment decisions for main replacement and repairs.

Another important benefit of the AMI system is its efficiency in collecting and processing the meter reading data. More than 98 percent of meters are being read daily and automatically billed monthly. This system has reduced the number of meters read in the field from 600 per day to less than 20 per day. Prior to installation of the AMI system, four full-time meter readers were required to complete the job. Following the installation of the system, one person can do the same job as four full-time meter readers in 60 minutes. This improvement in efficiency has resulted in a permanent reduction in the meter reader work force, enabling WVAW to reassign meter readers to other functions such as distribution system maintenance. An additional benefit is a significant reduction in the size of the vehicle fleet, which has been reduced from six vehicles to one vehicle.

LESSONS LEARNED

WVAW learned the value of using a phased approach for migration to a mesh fixed network AMI system. If given the opportunity to conduct the pilot study again, WVAW would install a drive-by meter reading system as a first step and transition to a mesh fixed network system over time. This approach adds a greater degree of control during the installation phase of the project. If a utility installs the system using its in-house meter reader forces (without contractors), the system does not have to be installed all at once. Thus, the utility can focus on a smaller area and install the meters and MIUs for drive-by data collection first. After the meters are correctly transmitting signals to a mobile data collection device, WVAW can add the collection bases and switch the signal from the mobile device to the collectors. Unfortunately, this phased approach was not possible under the constraints of an installation contract.

In addition, WVAW learned lessons from the few other issues that they encountered during installation of the mesh fixed network AMI system. To avoid debugging delays, the installers should be familiar with the meter lids within the system; the output formats of the existing meters within the system; and the time settings on the acoustic monitors. Installers should also use handheld devices with GPS and bar code reading capabilities to avoid data entry errors.

SUMMARY

WVAW used ARRA funding to successfully install a mesh fixed network AMI system servicing 12,000 water utility customers in Fayette County, West Virginia. The mesh fixed network AMI technology has proven to be 98 to 99 percent effective in transmitting meter reading and acoustic monitoring data remotely to the

WVAW utility office despite challenging conditions (i.e., mountainous terrain). The green infrastructure benefits include a substantial reduction in water loss (i.e., an initial drop in NRW from 55 to 38 percent), and energy savings (i.e., reduction in vehicle use). WVAW is satisfied with the performance of the mesh fixed network AMI system and has recommended it to its industry peers.

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APPENDIX 2: PAX WATER TECHNOLOGIES^{TM} ACTIVE TANK MIXER CASE STUDY

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SUMMARY

Under a work assignment issued by the EPA Office of the Chief Financial Officer (OCFO), SAIC is gathering information regarding new or expanded industries or markets that were fostered as a result of ARRA spending. SAIC screened the Office of Water databases for drinking water and clean water projects to identify technologies considered innovative. In consultation with the EPA Office of Water, SAIC selected two drinking water technologies for case studies: Automated Meter Reading (AMR)/Advanced Metering Infrastructure (AMI) and solar-powered active tank mixers.

This case study focuses on the use of the solar-powered active tank mixer technology by the Town of Holly Springs Public Utility Department (Holly Springs), the recipient of the ARRA funding. For this report, SAIC obtained information both from Holly Springs and PAX Water Technologies™ Incorporated (PAX Water), the manufacturer of the innovative PAX Water active tank mixing technology.

Holly Springs purchased a PAX Water mixer to test its ability to eliminate thermal stratification and reduce disinfection byproducts (DBPs) in one of its potable water storage tanks. The active PAX Water mixer is an innovative alternative to the use of traditional passive tank mixing systems. Holly Springs received ARRA funding to assist in the purchase of the solar mixer, as did 13 other counties and cities within the state of North Carolina. Holly Springs installed the PAX Water mixer in the fall of 2009. PAX Water is a small privately owned company that manufactures the innovative tank-mixing product in Richmond, California.

The ARRA funding made the immediate purchase of the solar-powered tank mixers possible for Holly Springs. The PAX Water mixer is successfully reducing stratification and the generation of DBPs within the potable water tank. The green infrastructure benefits include energy savings (i.e., self-generated solar power) and improved water quality (i.e., reduction in DBPs). Holly Springs is satisfied with the performance of the PAX Water solar-powered mixer and has recommended it to its industry peers.

PAX Water benefited from ARRA-funded product orders received during the recession. In 2009, roughly 30 percent of PAX Water's product sales were ARRA-funded, which came at a critical moment and was a 'shot in the arm' for the company. The ARRA-funded product orders kept R&D efforts moving forward and helped PAX Water grow. ARRA funding led to improvements in the solar-powered feature of the PAX Water tank-mixer design. Exposure created by the completion of ARRA-funded projects also played a significant role in the launch of PAX Water's second project, the innovative THM (Trihalomethane) Removal System technology. ARRA funding created a boom of business for PAX Water in North Carolina that has led to follow-on work opportunities and new customers.

CASE STUDY OF SOLAR-POWERED MIXING IN POTABLE WATER TANKS

This document presents the case study conducted by SAIC. Section 1 contains a brief description of the project. Section 2 describes the potable water storage tank mixing technology including its innovative aspects and benefits. Section 3 presents information and lessons learned from the technology vendor (PAX Water Technologies™ Incorporated), and Section 4 presents information and lessons learned from the recipient of the ARRA funds (Town of Holly Springs Utility Department).

I. PROJECT DESCRIPTION

The Town of Holly Springs Public Utility Department (Holly Springs) purchased a PAX Water solar-powered mixer to test its ability to eliminate thermal stratification and reduce disinfection byproducts (DBPs) in one of its potable water storage tanks. The active PAX Water mixer is an innovative alternative to the use of traditional passive tank mixing systems. Holly Springs received ARRA funding to assist in the purchase of the solar mixer, as did 13 other counties and cities within the state of North Carolina. PAX Water is a small privately owned company that manufactures the innovative tank-mixing product in Richmond, California.

Forty-foot holly trees tower over freshwater springs in the small town of Holly Springs. Located 20 miles southwest of Raleigh, North Carolina, the Town encompasses a 15-square mile area. The town adopted the motto of “the fastest growing town in North Carolina” when its population increased from less than 1,000 just two decades ago (in 1990) to more than 25,000 today (U.S. Census Bureau, 2010). The construction of a wastewater treatment plant in 1985 spurred an influx of businesses to fuel growth, such as textile manufacturer, Warp Technologies, and pharmaceutical giant, Novartis. CNN Money ranked Holly Springs “the 22nd best small town to live in” in its 2007 evaluation (Holly Springs, 2012).

Holly Springs received $81,600 of Green Infrastructure ARRA funding for the purchase of one PAX Water tank mixer, as distributed by the Drinking Water State Revolving Fund (DWSRF). The funding conditions stipulated a 50 percent principal forgiveness and zero percent interest on the remaining 50 percent with a 20-year payback schedule. In the fall of 2009, the tank mixer was successfully installed.

II. POTABLE WATER STORAGE TANK MIXING TECHNOLOGY

INTRODUCTION

The potable water storage tank mixing technology circulates water contained in storage tanks. It is not a new technology; however, recent design innovations have improved its effectiveness and energy efficiency. The following sections provide a description of the technology along with its innovative aspects and benefits.

HOW POTABLE WATER STORAGE TANK MIXERS WORK

Potable water storage tank mixers are either passive or active. Passive mixing relies on the turbulence created by the tank inlet velocity to mix the water with no additional energy added; thus mixing only occurs during the fill cycle. Separate inlet/outlet pipes create the turbulence. The effectiveness of the mixing depends on the inlet/outlet location and the rate of water usage. If water usage rates are moderate to low, the effectiveness is reduced.

Active tank mixing imparts mechanical energy to the water using a motor and impeller device. The motor and impeller configuration continuously circulates and homogenizes the tank contents. Hydraulic modeling techniques can design an effective mixing process prior to installation. The mixing device is small enough for insertion through an existing opening in the tank to avoid a service disruption. The active mixer motor can use either solar energy or grid-based power.

BENEFITS OF ACTIVE TANK MIXING

Seventy percent of potable water storage tanks suffer from poor mixing (Bleth, 2012). As cool, dense water enters from the inlet pipe, it settles on the bottom of the tank while the warmer, more buoyant water already present in the tank rises to the top. This temperature difference, called thermal stratification, prevents natural mixing. Thermal stratification occurs with as little as one-degree difference between the bottom and top water temperatures.

Thermal stratification degrades water quality. This happens because the temperature of the water near the surface is increased, causing residual disinfectant loss and bacterial growth. In chloraminated systems, the warmer temperatures lead to both disinfectant loss and ammonia buildup, creating nitrification (i.e., where naturally occurring microbes convert ammonia to nitrate). Also, in cold climates, the cold temperatures and lack of circulation near the bottom of the tank can cause ice to form, damaging the tank coatings and internal hardware, and in severe cases rupturing the tank.

Thorough mixing of potable water storage tanks eliminates thermal stratification and ensures uniform conditions, which lowers overall disinfectant residual demand and reduces the risk of nitrification. Additionally, mixing protects and preserves tank assets by preventing the formation of ice, as well as lowering summertime headspace temperatures.

Eliminating thermal stratification also helps utilities comply with the more stringent requirements of the EPA Stage 2 DBP rule. This rule requires utilities to achieve disinfection goals while reducing DBP formation. DBPs such as trihalomethanes (THM) form when chlorine reacts with organic matter that naturally occurs in water. Disinfectant use may be higher in tanks with stratification problems because the disinfectant is not uniformly dispersed in the water. Therefore, minimizing stratification can reduce the disinfectant dose, which reduces the risk of DBP formation.

NEW AND INNOVATIVE ASPECTS OF THE ACTIVE TANK MIXING TECHNOLOGY

The introduction of active mixing in potable water storage tanks is relatively new and innovative, even though it has been used in many other industries for a long time. The inability of a passive mixing system to completely circulate tank water provided the catalyst to create the active mixing technology. The active mixing technology designs use innovative equipment or adapt established fan, impeller and pump equipment to the new constraints of storage tanks. Thus, active tank mixers on the market today can either be classified as an innovative technology or as an innovative use of existing technology.

In 2007, PAX Water introduced an active tank mixing technology with an innovative design. The PAX Water mixing technology offers a transformational leap in the otherwise mature markets of fans, impellers and pumps, which have changed only incrementally in the past 150 plus years (PAX, 2012). The innovative component of the PAX Water's mixing technology is the highly efficient and powerful Lily impeller, which is a biomimetic technology (see Figure 1). A PAX Water engineer developed the Lily impeller after studying fluid flow efficiencies in natural systems, such as air and ocean currents. He observed that nature never moves in a straight line, but instead tends to flow in a spiraling path (referred to as nature's streamlining principle). The Lily impeller's design mimics this natural spiraling flow path.

FIGURE 1. PAX MIXER LILY IMPELLER DESIGN

The PAX Water active tank mixer provides efficient mixing performance with green advantages. With this natural design, the PAX Water mixer circulates up to 10 million gallons with the same energy footprint as three 100-watt light bulbs (PAX, 2012). The logarithmic spiral-shaped impeller device reduces energy requirements from 15 to 30 percent, with solar energy being an option for meeting the energy requirements. In addition, the small size of the device reduces material demand and cost. Noise is also reduced by up to 75 percent over conventional motors.

The PAX Water tank-mixing technology continues to evolve. In 2010, PAX Water added a second innovative technology to its product line that removes THMs from potable water tanks in a controlled manner. The THM Removal System combines aeration with modeling to deliver targeted levels of THM reduction. The system's pumped circulation loop utilizes sprayers and other air handling equipment to optimize removal efficiency and energy consumption. The THM Removal System technology is a natural extension of the tank mixing technology. It can be used separately or together with active mixing and disinfectant control to synergistically provide water quality management.

III. EFFECTIVENESS OF THE PAX WATER MIXING TECHNOLOGY

PAX Water uses computational fluid dynamics (CFD) calculations to ensure the performance of its mixer for any tank configuration. CFD is an effective modeling technique for estimating fluid dynamics within water tanks when an appropriate mesh resolution is used to simulate the fluid flow conditions in the tank. Because of the large volume of water involved in storage tanks (typically several million gallons), the CFD simulation requires millions of mesh elements, and thus millions of computations requiring several days of dedicated calculation time on high-end parallel supercomputers. Also, as with all models, accuracy can only be assured through the modeling verification and calibration process.

In 2009, scientists at PAX Water, Stanford University, and operators at Redwood City Water (Redwood, California) collaborated to obtain high-quality experimental data for CFD modeling verification and calibration purposes. The team suspended a network of temperature probes inside a 500,000-gallon tank. The probes measured the time required to take the thermally stratified tank to a condition of uniform temperature. Cycles of tank mixing and non-mixing were repeated 10 times over a one-month period. Researchers calibrated and verified the CFD model by comparing experimental data to the CFD model simulations and adjusting the CFD model parameters and mesh size to match the experimental data. Thus, PAX Water has an accurate means of simulating pumping rates and tank flow patterns. PAX Water uses the calibrated CFD model to determine optimal mixing conditions prior to installing its product in each tank.

IV. VENDOR-PROVIDED INFORMATION

INTRODUCTION

PAX Water is the vendor of the potable water tank mixing technology. PAX Water is a PAX Company, which is a group of engineering research and development firms that translate nature's efficiencies into innovative technology applications. In 1997, the first company, PAX Scientific, was founded in San Rafael, California. Today there are three additional PAX companies (PAX Water, PAX Mixer and PAX Fans) that have been formed to develop, license and manufacture technologies in a variety of markets. The company's founder, Mr. Jay Harmon, formed the companies with the vision of developing tools that use less energy and materials while simultaneously offering greater productivity and control (PAX, 2012b).

PAX Water was founded in 2006 to develop and market energy-efficient mixing systems based on PAX Scientific's Lily impeller technology for potable water applications. The small privately held company is located in Richmond, California, where 16 employees assemble two products (i.e., the PAX Water mixer and the THM Removal System). The company is growing its business with the vision of creating a world where high quality drinking water is sustainably produced, efficiently distributed and universally valued as a life-giving foundation for healthy communities (PAX, 2012b). In 2009 through 2012, the Artemis Project selected PAX Water for its "Top 50" list of the world's most innovative water technology companies (Artemis, 2012).

INTERVIEW WITH MR. PETER FISKE

In June 2012, Mr. Fiske, Chief Executive Officer (CEO) of PAX Water, provided his perspective on how ARRA funding affected product and business development. Mr. Fiske also responded to questions concerning the drawbacks and future benefits of ARRA funding.

EFFECTS OF ARRA FUNDING ON COMPANY DEVELOPMENT

ARRA funding significantly affected product sales. In 2009, when the recession caused a significant downturn in business activity across the United States, PAX Water was just starting to grow. According to Mr. Fiske, the influx of ARRA-funded projects at that moment in time was very fortunate. He estimates that 13 tank-mixer sales were associated with ARRA-funded projects in North Carolina, which was a significant fraction of PAX Water's 2009 total annual sales (roughly 30 percent).

ARRA-funded product orders supported PAX Water's R&D efforts. Each order supports all aspects of the business, from product assembly to marketing to R&D. A steady supply of orders forms the revenue that is the basis of the company's survival. At PAX Water, 20 percent of the revenue is reserved for R&D.

Because ARRA-funded projects continued to generate product orders during the recession, PAX Water continued to develop its products. Without a steady supply of orders, R&D activities would have stopped.

ARRA-funded project orders helped PAX Water grow. The 2009 increase in direct sales created the opportunity for PAX Water to grow and market its tank-mixing product more widely across the United States. The additional marketing effort accelerated exposure and acceptance of the PAX Water tank mixer. According to Mr. Fiske, “the stimulus money came at a critical moment for us; it was a real shot in the arm.” Without the ARRA-funded projects, PAX Water would still be in business, but the company would be significantly smaller. PAX Water has continued to grow, experiencing substantial increases in revenue every year since 2009.

EFFECTS OF ARRA FUNDING ON PRODUCT DEVELOPMENT

ARRA funding led to improvements in the solar-powered feature of the PAX Water tank-mixer design. North Carolina Department of Environment and Natural Resources (NCDENR) required ARRA-funded tank mixers to be solar-powered, which is an optional feature of the PAX Water tank mixer. The sale of 13 solar-powered mixers enabled PAX Water to perfect the design and fabrication of its tank mixer’s solar-power component.

Exposure created by the completion of ARRA-funded projects played an important role in the launch of PAX Water’s second product, the THM Removal System (TRS). In 2009, Stanly County North Carolina installed an ARRA-funded solar-powered tank mixer to assist in reducing THM concentrations. Subsequently, in 2011 through ’word of mouth‘ marketing, Stanly County became aware of PAX Water’s innovative TRS technology, designed to lower THM levels in a controlled manner. At this point, PAX Water had only demonstrated its newly developed TRS technology in one tank and needed additional installations to verify its effectiveness.

Stanly County’s inquiry about the new TRS product propelled PAX Water to offer a free-of-charge demonstration, which was a spectacular success. According to Mr. Fiske, the demonstration led to enormous interest in the TRS technology throughout North Carolina and South Carolina. The demonstration also led to direct improvements in the TRS technology design based on lessons learned from an actual installation. Indirectly, improvements in marketing strategy occurred because the demonstration provided a marquee example with as-built data that PAX Water could share with other prospective buyers. Thus, PAX Water’s participation in ARRA-funded projects in North Carolina helped to launch its second innovative product, the TRS technology.

DRAWBACK OF ARRA FUNDING

PAX Water did not experience drawbacks associated with the ARRA funding. The Buy American and Davis Bacon provisions did not affect sales. According to Mr. Fiske, PAX Water’s tank-mixing product did not require an exemption from the Buy American provision. Completing ARRA-funding paper work required additional effort, but that was the only effect.

FUTURE BENEFITS FROM ARRA FUNDING

ARRA-funded projects created follow-on work opportunities and new customers for PAX Water. In 2009, the release of ARRA funds created a boom of business for PAX Water in North Carolina. The new business gave PAX Water the opportunity to demonstrate the effectiveness of its potable tank mixing technology at municipalities that were previously unfamiliar with its product. After completion of the ARRA-funded installations, the sales of tank mixers have continued to grow in North Carolina; it is one of its top sales states. A portion of these sales is most likely repeat business and the result of 'word of mouth' marketing exposure from ARRA funding recipients.

SUMMARY

PAX Water benefited from ARRA-funded product orders received during the recession. In 2009, roughly 30 percent of PAX Water's product sales were ARRA-funded, which came at a critical moment and was a 'shot in the arm' for the company. The ARRA-funded product orders kept R&D efforts moving forward and helped PAX Water grow. ARRA funding led to improvements in the solar-powered feature of the PAX Water tank-mixer design. Exposure created by the completion of ARRA-funded projects also played a significant role in the launch of PAX Water's second project, the innovative TRS technology. ARRA funding created a boom of business for PAX Water in North Carolina that has led to follow-on work opportunities and new customers.

V. FUNDING RECIPIENT-PROVIDED INFORMATION

INTRODUCTION

The Town of Holly Springs (Holly Springs) buys treated drinking water from two sources: Harnett County and the City of Raleigh. Holly Springs purchases 2 million gallons daily from Harnett County with the ability to obtain an additional 1 million gallons for a total of 3 million gallons per day. Water reaches Holly Springs through a 36-inch diameter pipe that can carry up to 10 million gallons a day. The City of Raleigh delivers up to 1.2 million gallons daily of treated water through a 16-inch diameter pipeline.

Holly Springs stores the purchased water in three water towers with a total storage capacity of 2.3 million gallons (two at 1 million gallons and one at 300,000 gallons). The town does not have the ability to add chlorine or provide other treatment for the delivered water. The first tank to receive water (i.e., nearest to the entry point to the Holly Springs distribution system from the water provider) has a one-million gallon capacity and is located in a less populated area of town. In 2009, Holly Springs was concerned about maintaining chlorine residual levels during the long residence time in this tank due to the slower water turnover rate, and about rising THM concentrations during the summer months. The remaining two tanks are centrally located in more densely populated areas of town, and therefore, water quality issues associated with maintaining chlorine residual were of less concern.

INTERVIEW WITH TOWN OF HOLLY SPRINGS MANAGEMENT

During a teleconference conducted in October 2012, Ms. Stephanie Sudano (Director of Engineering), Mr. Seann Byrd (Director of Public Utilities), Mr. Luncie McNeil (Director of Public Works), Mr. Wayne Wilhelm (Supervisor of Public Works) and Ms. Amy Moore (Public Utilities Lab Supervisor) provided their perspective on the acquisition and performance of the ARRA-funded PAX Water potable tank mixer. This section summarizes their responses to questions about the system performance and ARRA funding impact.

IMPACT OF ARRA FUNDING

ARRA funding accelerated the purchase of the solar-powered tank mixer. In 2009, when ARRA funding became available, Holly Springs was considering the purchase of a tank mixer to solve its water quality concerns. Holly Springs is a rapidly growing community and meeting the growing demand for water supply is its highest priority. However, due to budget constraints, Holly Springs would have delayed purchasing the tank mixer had ARRA funding not become available. The release of ARRA funds made its purchase possible during the 2009 fiscal year, and in the process, alleviated its water quality concerns sooner.

SELECTION OF MIXING TECHNOLOGY

Holly Springs selected the PAX Water active tank mixer. Prior to selection, the town explored several approaches for improving water quality in its potable water storage system. For example, Holly Springs evaluated the benefits of adding a biofilm treatment to its regular maintenance schedule of draining and cleaning each tank biannually. Biofilm treatment is a special cleaning technique designed to reduce bacterial growth. Biofilm treatment costs less than tank mixing; however, it does not address temperature stratification, and thus residual loss, in tanks. Following an evaluation of the site-specific conditions, Holly Springs considered biofilm treatment to be an acceptable solution for two of the three tanks.

For the third tank, Holly Springs evaluated the features and benefits of two active tank-mixing products (SolarBee® and PAX Water). Both products provided a solar panel feature, which was important to Holly Springs even though electric power was available at the tank. Holly Springs wanted the solar panels to save on energy consumption. From a design perspective, Holly Springs preferred the small footprint of the PAX Water mixer. Also, as part of the evaluation, Holly Springs performed reference checks on the two vendors and consulted with fellow industry users to determine their degree of satisfaction with the products and Utility Services Company, the contractor installer.

SYSTEM INSTALLATION

The installation schedule slipped because of ARRA's Buy American requirement. Holly Springs initially received Chinese-manufactured solar panels as part of the PAX Water mixer system. Utility Services Company returned the panels and replaced them with a U.S. manufactured product prior to installation. Because Utility Services Company handled the exchange, Mr. Fiske at PAX Water was unaware of this issue. The exchange resulted in a schedule delay of approximately two to three weeks.

Holly Spring's contractor, Utility Services Company, installed the PAX Water mixer in the fall of 2009. The PAX Water mixer was an off-the-shelf product designed to mix a one-million gallon tank. The installation went well with the exception of a minor telemetry hook-up problem. Utility Services Company resolved this issue quickly. Holly Springs uses a telemetry system to monitor the operation of the PAX Water mixer. Because the tank is elevated, visual monitoring of the system is not possible. The telemetry system remedies this situation by monitoring the mixer and signaling the user (via alarm) when the mixer is not running.

SYSTEM PERFORMANCE

Holly Springs collects tank water samples monthly to evaluate the performance of the PAX Water mixer. Tank water is diverted into a series of tubes suspended at various heights along the tank's inside wall. The diverted water flows through the tubes to a sampling station at the base of the tank. The samples are analyzed for chlorine concentration. The PAX Water mixer is considered to be performing well when consistent chlorine concentrations are obtained from all collection points within the tank.

The PAX Water mixer is performing well. According to Ms. Moore, chlorine sample results are "very consistent." Results from quarterly sampling of THMs also indicate the PAX Water mixer has taken care of the water quality issues. Since 2009, Holly Springs has collected THM data with results showing acceptable levels despite variations in the weather. Steady population growth in the vicinity of the tank, and thus a shorter residence time, is also likely to be contributing to the acceptable THM levels.

Holly Springs is very satisfied with the PAX Water mixer. According to Ms. Sudano, "we like the design, the way it operates and how it is integrated into the tank." If making the technology selection decision today, Ms. Sudano would select the PAX Water mixer. She has recommended it to her industry peers.

SUMMARY

Holly Springs used ARRA funding to successfully install a PAX Water solar-powered mixer in one of its elevated potable water storage tanks. The ARRA funding made the immediate purchase of the PAX Water solar-powered tank mixer possible. The PAX Water mixer is successfully reducing stratification and the generation of DBPs within the potable water tank. The green infrastructure benefits include energy savings (i.e., self-generated solar power) and improved water quality (i.e., reduction of DBPs such as THM). Holly Springs is satisfied with the performance of the solar-powered mixer and has recommended it to its industry peers.

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APPENDIX 3: SOLARBEE® ACTIVE TANK MIXER CASE STUDY

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SUMMARY

Under a work assignment issued by the EPA Office of the Chief Financial Officer (OCFO), SAIC is gathering information regarding new or expanded industries or markets that were fostered as a result of ARRA spending. SAIC screened the Office of Water databases for drinking water and clean water projects to identify technologies considered innovative. In consultation with the EPA Office of Water, SAIC selected two drinking water technologies for case studies: Automated Meter Reading (AMR)/Advanced Metering Infrastructure (AMI) and solar-powered active tank mixers.

This case study focuses on the use of the solar-powered active tank mixer technology by the Stanly County Utility Department (Stanly County), the recipient of the ARRA funding. For this report, SAIC obtained information both from Stanly County and Medora Corporation (Medora), the manufacturer of the innovative SolarBee® active tank mixing technology.

Stanly County purchased five SolarBee® mixers to test their ability to eliminate thermal stratification and reduce disinfection byproducts (DBPs) such as total trihalomethanes (TTHM) in potable water storage tanks. The active SolarBee® mixers are an innovative alternative to the use of traditional passive tank mixing systems. Stanly County received ARRA funding to assist in the purchase of the solar mixers, as did 13 other counties and cities within the state of North Carolina. In the spring of 2010, the five tank mixers were successfully installed. In 2012, Stanly County used ARRA contingency funds to purchase a supervisory control and data acquisition (SCADA) system that remotely monitors the effectiveness of the tank mixers.

The ARRA funding made the immediate purchase of the solar-powered tank mixers manageable and affordable. The SolarBee® solar-powered mixers have proven to be effective in eliminating stratification and reducing the generation of DBPs within the five Stanly County potable water tanks. The green infrastructure benefits include energy savings (i.e., self-generated solar power), lower chemical use (i.e., reduction in secondary chlorination), and improved public relations (i.e., elimination of the TTHM noncompliance issue). Stanly County is satisfied with the performance of the solar-powered mixers and has recommended them to its industry peers.

ARRA funding has positively impacted the local and national markets for active potable water tank mixing systems. Medora benefited from $2 million per year in additional revenue, which helped to keep the company operating during the recession. With ARRA-funding assistance, Medora was able to expand, improve and refine its product line, and also expand its international market reach. In the future, Medora will most likely benefit both nationally and internationally from the additional exposure provided by the ARRA-funded projects. Thus, ARRA funding has helped the potable water active tank mixing technology to move forward and grow.

CASE STUDY OF SOLAR-POWERED MIXING IN POTABLE WATER TANKS

This document presents the case study conducted by SAIC. Section 1 contains a brief description of the project. Section 2 describes the potable water storage tank mixing technology including its innovative aspects and benefits. Section 3 presents information and lessons learned from the technology vendor (Medora Corporation), and Section 4 presents information and lessons learned from the recipient of the ARRA funds (Stanly County Utility Department).

I. PROJECT DESCRIPTION

The Stanly County Utility Department (Stanly County) purchased five SolarBee® mixers to test their ability to eliminate thermal stratification and reduce disinfection byproducts (DBPs) in potable water storage tanks. The active SolarBee® mixers are an innovative alternative to the use of traditional passive tank mixing systems. Stanly County received ARRA funding to assist in the purchase of the solar mixers, as did 13 other counties and cities within the state of North Carolina. Medora Corporation (Medora) manufactures the innovative tank-mixing product. They are a small privately owned company headquartered in North Dakota.

Nestled in the foothills of the Uwharrie Mountains, Stanly County encompasses a 404-square mile area in central North Carolina. In 2010, the County's population was 60,585 people in 23,589 households (United States Census Bureau, 2010). Approximately 26 percent of the County population resides within the centrally located city of Albemarle. This area was known for its textile manufacturing industry.

Stanly County received $270,946 of Green Infrastructure ARRA funding for the purchase of the five SolarBee® tank mixers, as distributed by the Drinking Water State Revolving Fund (DWSRF). The funding conditions stipulated a 50 percent principal forgiveness and zero percent interest on the remaining 50 percent with a 20-year payback schedule. In the spring of 2010, the five tank mixers were successfully installed. In 2012, Stanly County used ARRA contingency funds to purchase a supervisory control and data acquisition (SCADA) system that remotely monitors the effectiveness of the tank mixers.

II. POTABLE WATER STORAGE TANK MIXING TECHNOLOGY

INTRODUCTION

The potable water storage tank mixing technology circulates water contained in storage tanks. It is not a new technology; however, recent design innovations have improved its effectiveness and energy efficiency. The following sections provide a description of the technology along with its innovative aspects and benefits.

HOW POTABLE WATER STORAGE TANK MIXERS WORK

Potable water storage tank mixers are either passive or active. Passive mixing relies on the turbulence created by the tank inlet velocity to mix the water with no additional energy added; thus mixing only occurs during the fill cycle. Separate inlet/outlet pipes create the turbulence. The effectiveness of the mixing depends on the inlet/outlet location and the rate of water usage. If water usage rates are moderate to low, the effectiveness is reduced.

Active tank mixing imparts mechanical energy to the water using a motor and impeller device. The motor and impeller configuration continuously circulates and homogenizes the tank contents. Hydraulic modeling techniques can design an effective mixing process prior to installation. The mixing device is small enough for insertion through an existing opening in the tank to avoid a service disruption. The active mixer motor can use either solar energy or grid-based power.

BENEFITS OF ACTIVE TANK MIXING

Seventy percent of potable water storage tanks suffer from poor mixing (Bleth, 2012). As cool, dense water enters from the inlet pipe, it settles on the bottom of the tank while the warmer, more buoyant water already present in the tank rises to the top. This temperature difference, called thermal stratification, prevents natural mixing. Thermal stratification occurs with as little as one-degree difference between the bottom and top water temperatures.

Thermal stratification degrades water quality. This happens because the temperature of the water near the surface is increased, causing residual disinfectant loss and bacterial growth. In chloraminated systems, the warmer temperatures lead to both disinfectant loss and ammonia buildup, creating nitrification (i.e., where naturally occurring microbes convert ammonia to nitrate). Also, in cold climates, the cold temperatures and lack of circulation near the bottom of the tank can cause ice to form, damaging the tank coatings and internal hardware, and in severe cases rupturing the tank.

Thorough mixing of potable water storage tanks eliminates thermal stratification and ensures uniform conditions, which lowers overall disinfectant residual demand and reduces the risk of nitrification. Additionally, mixing protects and preserves tank assets by preventing the formation of ice, as well as lowering summertime headspace temperatures.

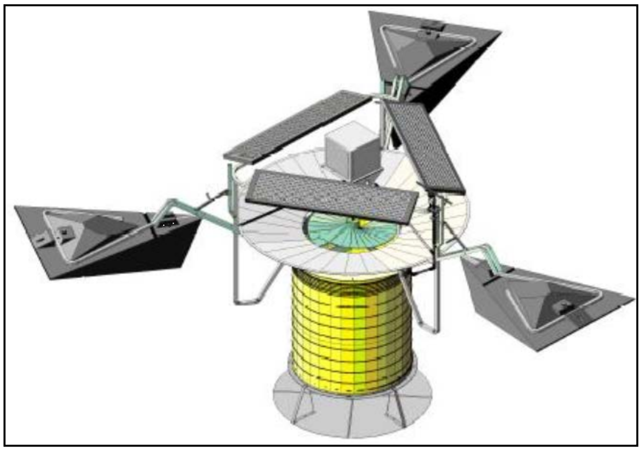
Eliminating thermal stratification also helps utilities comply with the more stringent requirements of the EPA Stage 2 DBP rule. This rule requires utilities to achieve better disinfection while reducing DBPs. DBPs, such as TTHM, form when chlorine reacts with organic materials found in water. Disinfectant use may be higher in tanks with stratification problems because the disinfectant is not uniformly dispersed in the water. Therefore, minimizing stratification can reduce the disinfectant dose, which reduces the risk of DBP formation.

NEW AND INNOVATIVE ASPECTS OF THE ACTIVE TANK MIXING TECHNOLOGY

The introduction of active mixing in potable water storage tanks is relatively new and innovative, even though it has been used in many other industries for a long time. The inability of a passive mixing system to completely circulate tank water provided the catalyst to create the active mixing technology. The active mixing technology designs use innovative equipment or adapt established fan, impeller and pump equipment to the new constraints of storage tanks. Thus, active tank mixers on the market today can either be classified as an innovative technology or as an innovative use of existing technology.

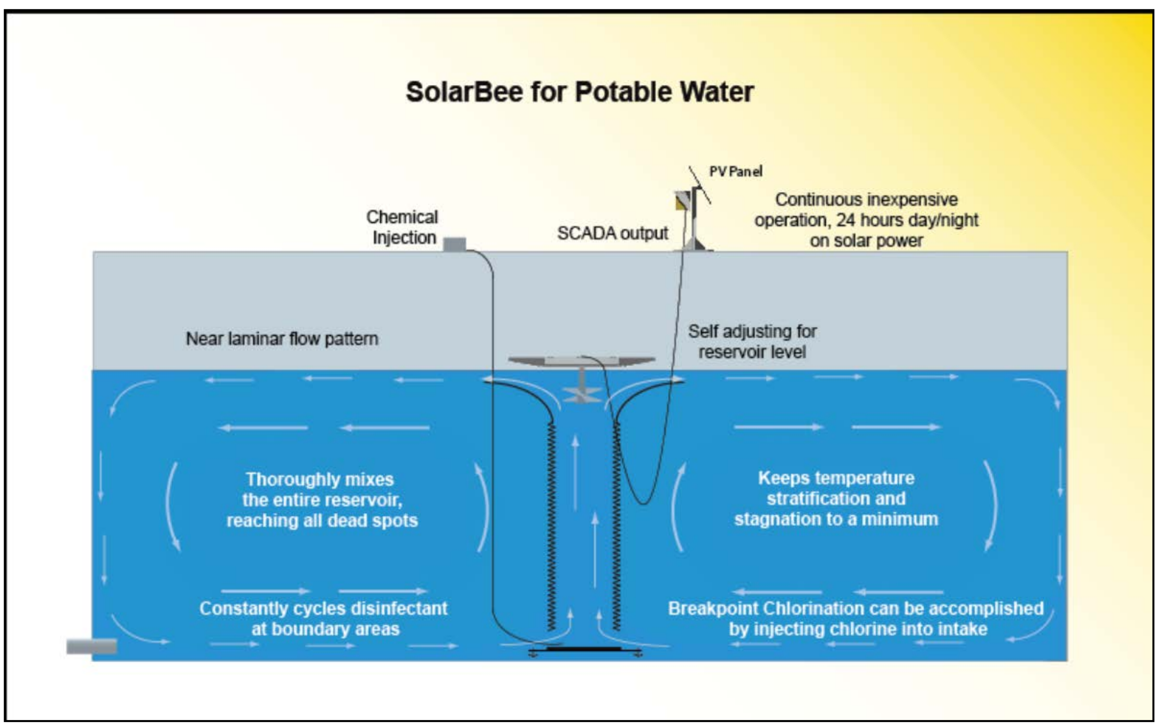
In 2003, Medora introduced an active potable tank-mixing product that is an innovative use of existing technology. The existing technology is the SolarBee® reservoir mixer, which is a floating platform with a pumping system powered by solar panels (see Figure 1). The existing technology was developed to produce radial long-distance circulation in ponds and reservoirs. Medora patented innovative components of its reservoir mixer pertaining to its equipment motor and drive system, digital power management system, run time algorithms, impeller, intakes and high wave kit.

FIGURE 1. SOLARBEE RESERVOIR MIXER



Medora adapted the reservoir mixer to potable water tanks by scaling down the system components, so the product fits through potable water tank hatches as small as 18 inches by 18 inches. The potable tank mixer can circulate water at rates of up to 10,000 gallons per minute while maintaining near laminar flow conditions. The mixer is designed to float on top of the water and gently draw it up from below (see Figure 2). The surface water travels a long distance because it is essentially powered by gravity and experiences little resistance, which makes it possible to mix the water throughout the entire water column, from the bottom of the tank to the outer walls and everywhere in between.

FIGURE 2. SOLARBEE® POTABLE WATER TANK MIXER

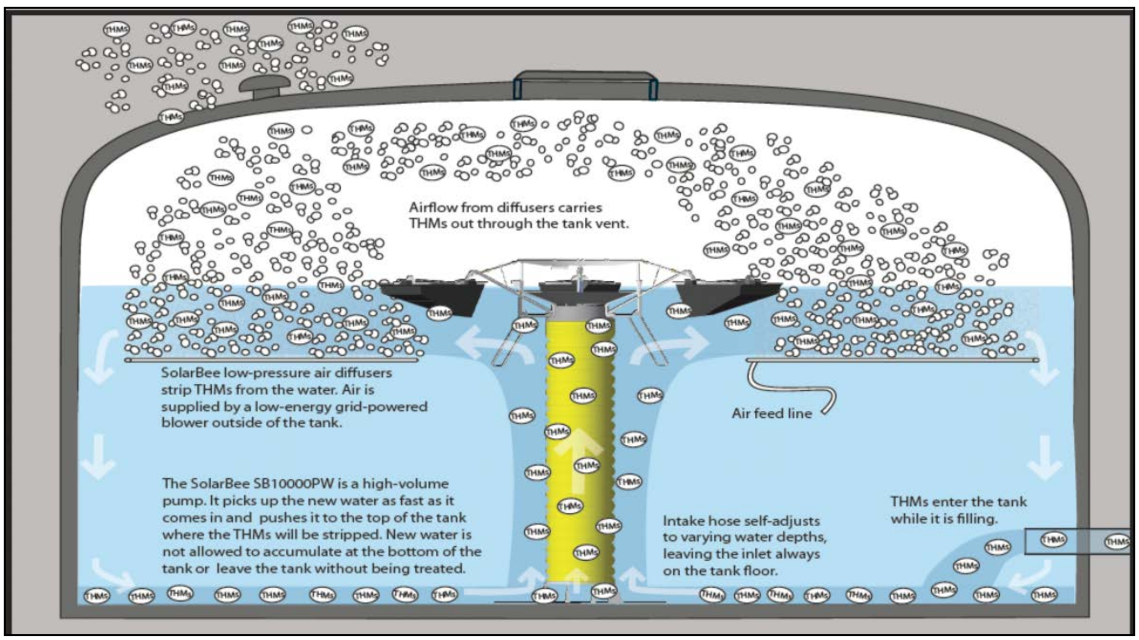


Source is http://www.nysawwa.org/documents/Water%20Storage%20Tank%20Mixing.pdf

The SolarBee® active tank mixer provides efficient mixing performance with green advantages. It requires little power due to the minimal head, or lift, in the up-flow pump design. It is driven by an electronically-controlled direct current (DC) motor that is significantly more efficient than induction motors typically used on turbulent mixers. The low-power requirement allows it to be powered by 80- to 300-watt solar photovoltaic arrays combined with a deep-cycle storage battery. The solar power source is installed on the tank roof.

The SolarBee® tank mixing products are continuing to evolve. In response to the 2006 EPA Stage 2 DBP rule, SolarBee® tank mixers can more thoroughly remove total trihalomethanes (TTHMs) from potable water tanks with the addition of an air diffuser system. This product is called the TTHM Removal System with floating air diffusers (see Figure 3). In this system, new inflow water is brought up from the bottom of the tank using the SolarBee® tank mixer. The up-flowing water passes through floating air diffusers that are placed in the tank at a depth of 24 inches. The air from the air diffuser system strips the volatile TTHMs out of the water, moving the gases to the tank headspace and into the atmosphere, eliminating the need for a separate headspace ventilation system.

FIGURE 3. SOLARBEE® TTHM REMOVAL SYSTEM WITH FLOATING AIR DIFFUSERS



Source is http://potablewater.medoraco.com/tthm/floating-air-diffusers

III. VENDOR-PROVIDED INFORMATION

INTRODUCTION

Medora is the vendor of the SolarBee® potable water tank mixing technology. Joel Bleth and Willard Tormaschy founded the company under the name of Pump Systems, Inc. In 1998, Pump Systems, Inc. tested the first radial long distance solar-powered circulator, which led to the launch of the SolarBee® Inc. brand of circulators in 2001. Subsequently, SolarBee® Inc. evolved the technology and expanded its product line. Notably in 2003, SolarBee® Inc. entered the potable tank active mixing market. In 2006, the company was reorganized, and Pump Systems, Inc. was sold so the founders could focus on reservoir treatment technology. Medora is now the parent company for two wholly-owned subsidiaries, Medora Corporation (formerly SolarBee® Inc.) and Medora Transport Corporation (formerly SolarBee® Transport Corp.).

Medora is a small, privately owned business that has been recognized for its technology potential and business performance. Medora's home office is in Dickinson, North Dakota. The company's 70 employees include scientists, engineers, manufacturing personnel and factory-trained service technicians. In 2008, its founders, Joel Bleth and Willard Tormaschy, received the North Dakota Entrepreneur of the Year Award. In 2009, Medora (as SolarBee® Inc.) was on the Artemis Project's list of "Top 50" water companies worldwide. In February 2012, Medora accepted an invitation from the White House and U.S. Department of Agriculture to attend the "Manufacturing Success in Rural America" event.

INTERVIEW WITH MR. JOEL BLETH

In June 2012, Mr. Bleth, co-founder, president and Chief Executive Officer (CEO) of Medora, provided his perspective on how ARRA funding affected product and business development. This section provides a summary of his responses to questions concerning the local and national impact ARRA funding had on the potable tank active mixing technology business sector.

EFFECTS OF ARRA FUNDING ON COMPANY DEVELOPMENT

ARRA funding had a significant effect on product sales and overall business operation. In 2009, when the industry was paralyzed and Medora's revenue was dropping, it received 20 to 50 nation-wide requests for solar mixers that were purchased with ARRA funds. The ARRA-funded projects added $2 million per year in revenue to this $12 million per year business. Thus, the ARRA-funded projects were very important to keeping this small company operating during the recession.

Additional revenue generated from ARRA-funded projects kept production moving, which assisted the international marketing effort. Medora exports mixers to 15 countries. They are currently working on providing mixers for very large water storage tanks (100 million gallons) in the Middle East.

EFFECTS OF ARRA FUNDING ON PRODUCT DEVELOPMENT

ARRA funding allowed Medora to expand its product line to take advantage of a wider variety of power conditions. Because half of the potable tanks in the country are near electric power sources, solar power is not a necessity. Thus, Medora developed tank mixer versions to take advantage of this portion of the market.

Medora continued to improve and refine its tank mixer product line during the recession. The tighter industry budgets provided the incentive for Medora to develop lower cost solutions, enabling customers to continue to purchase its mixers.

DRAWBACK OF ARRA FUNDING

Medora's assistance to the North Carolina Department of Environmental and Natural Resources (NCDENR) was costly. Some NCDENR officials wanted to use ARRA-funding to install solar-powered mixers in tanks within 300 cities statewide. Medora responded to a request to develop standard price quotations; the response involved 15 staff members working full time for a week at an expense of roughly $50,000. Medora was uncompensated for this effort, and ultimately provided tank mixers for only 14 ARRA-funded projects. Fewer projects received ARRA funding because water quality upgrade projects on the DWSRF list took precedence over new technology installation projects.

Additional rules for ARRA funding complicated implementation. The Buy American provision worked in some jurisdictions, but not others, resulting in payment delays of up to eight months. Also, Medora spokespeople said the Green Project Reserve Program (GPR) requirements were changed so that many more types of projects were considered 'green', and thus the SolarBee® solar-powered mixers lost preference afforded by its solar-powered feature.

IMPACT OF ARRA FUNDING ON NATIONAL MARKETS

ARRA funding had a measurable impact on the market for potable water tank mixing systems. Projects went forward that would not have otherwise been funded. Tank mixing solves problems with loss of residual chlorine level, which is a minor problem compared to other issues, such as lack of capacity or broken pipes. During a recession, only major problems are normally addressed. Thus, the potable tank mixer market would have been substantially impacted in a negative way without the influx of ARRA-funded projects.

FUTURE BENEFITS FROM ARRA FUNDING

In the future, Medora will most likely experience benefits from ARRA funding in the form of follow-on work with the utilities. New technology is often first implemented to solve the worst-case circumstance (i.e., the tank with the biggest water quality issues). After the utilities become familiar with the effectiveness of the new technology, they often install it in their additional tanks. At this point, the SolarBee® potable water mixers have been installed in hundreds of tanks; but thousands more can benefit from active mixing. Because of the ARRA funding, Medora was given the opportunity to demonstrate the effectiveness of its potable tank mixing technology at utilities that were previously unfamiliar with the product; which will most likely result in additional product orders.

Medora will most likely experience future benefits from ARRA funding in the form of new customers. The water utility industry is a small community where participants regularly share experiences at conferences and meetings. This exposure provides the opportunity for a new technology to spread nationwide and beyond.

ARRA funding has also helped the industry to move forward and grow. The company's sales force has recently heard from large cities in several states, including Tennessee, Kentucky and California, that "we've been watching this mixing and now we're going to go forward with mixing all of our tanks."

SUMMARY

ARRA-funding positively impacted the local and national markets for active potable water tank mixing systems. Medora benefited from $2 million per year in additional revenue, which helped to keep the company operating during the recession. With ARRA-funding assistance, Medora was able to expand, improve and refine its product line, and also expand its international market reach. In the future, Medora will most likely benefit both nationally and internationally from the additional exposure provided by the ARRA-funded projects. ARRA funding has helped the potable water active tank mixing technology to move forward and grow.

IV. FUNDING RECIPIENT-PROVIDED INFORMATION

INTRODUCTION

Stanly County purchases its water from the City of Albemarle and distributes it to nearly 5,000 customers within its rural service area. In the 1980s, the City of Albemarle built a second water treatment plant to support the community's thriving textile manufacturing industry. The two plants have a combined capacity of 14 to 18 million gallons per day (MGD). Unfortunately, in the last few decades, offshoring of U.S. textile manufacturing has resulted in textile mill closures in the area, which has reduced customer demand to 7 MGD (roughly half of the design capacity). The excess capacity results in water remaining in some portions of the distribution system for longer periods than originally planned. Longer distribution system residence times can lead to higher DBP formation. This is particularly true of the water sold to Stanly County.

Stanly County has struggled with water quality compliance related to TTHM levels in its system. The County service area radiates from several spurs off the Albemarle distribution system, which spans 175 linear miles. On these spurs of the system, approximately 3 MG of water are stored in seven elevated tanks, five of which are owned by Stanly County. Adding the long residence times in this portion of the distribution system to the long residence times within the city of Albemarle results in even older water, perhaps 7-14 days old. The result is TTHM levels that have exceeded the Stage 1 maximum contaminant level (MCL) in at least one of the Stanly County Utilities systems 87 percent of the time over an 8-year period (Davis, 2012).

INTERVIEW WITH MS. DONNA DAVIS

In September 2012, Ms. Donna Davis, Director of Stanly County Utilities Department, provided her perspective on the acquisition and performance of the five SolarBee® potable tank mixers that were purchased with ARRA funds. This section summarizes her responses to questions about the system performance and ARRA funding impact.

IMPACT OF ARRA FUNDING

ARRA funding made the immediate purchase of the solar-powered tank mixers manageable and affordable. In 2009, when ARRA funding became available, Stanly County was searching for a solution to the high TTHM levels in its water, but did not have the resources to purchase tank mixers or any other technology capable of addressing the issue. The terms of the ARRA funds made it possible to immediately install tank mixers in all five of its County-owned storage tanks.

ARRA funding changed the scheduling and magnitude of the purchase. Without ARRA funding, Stanly County would likely have purchased fewer mixers. Alternatively, Stanly County might have purchased the same number of mixers, but in a more extended time frame (i.e., fewer mixers purchased per year). Budget constraints would have dictated the purchasing approach. As with many communities in the current economy, operational funds were limited and extreme caution was exercised, particularly if borrowing funds was necessary.

SELECTION OF MIXING TECHNOLOGY

The technology selection process was standardized within the state of North Carolina for the ARRA-funding program. NCDENR was responsible for approving vendors (equipment manufacturers) of the mixing technology and the program bidding process. NCDENR hired a consulting engineering firm to develop site-specific plans and technical specifications; prepare public bidding documents; and manage the bidding process including the selection of an installation contractor. Within the state of North Carolina, vendors must have a licensed installation contractor. The installation contractor entered into a service agreement with the funding recipient. The installation contractor was responsible for reviewing the vendor bids; making the recommendation to the funding recipient on which vendor to use; and installing the tank mixers. If more than one vendor's product met the requirements of the technical specifications, the low bidder was selected.

Early in the ARRA funding process, the state-approved vendor list contained only one vendor for the tank mixing technology - Medora. Later in the ARRA funding process, a second vendor (PAX Water) gave a presentation to the state to demonstrate its product's effectiveness, as well as its innovative and green features. Subsequently, the state added PAX Water to the vendor list. As a result, the process of selecting a vendor required additional effort on the part of the consulting engineering firms and installation contractors.

In the case of Stanly County, Walker Contracting Group (the installation contractor) recommended Medora as the vendor. Stanly County reviewed and approved the recommendation, purchasing five identical SolarBee® tank mixers that are appropriate for tank sizes in the range of 250,000 to 500,000 gallons. The Walker Contracting Group installed the mixers without any major issues.

SYSTEM PERFORMANCE

The SolarBee® mixers are performing well. The mixers appeared to be working well from the start; however, their performance has only recently been confirmed by the addition of a remote monitoring system. To determine the operational status without remote monitoring requires visually monitoring a light located on top of the tank. Because the five Stanly County tanks are elevated, observation of the light is not feasible. The remote monitoring system remedies this situation by monitoring the mixers via laptop computer at ground level on the tank site. The County used ARRA funding to purchase the monitoring system this year (i.e., using the ARRA contingency budget). Recent monitoring confirms the mixers are working well to eliminate stratification and reduce DBPs.

"The mixers are a success" according to Ms. Davis. She is satisfied with their performance and would recommend them to her peers. She is also satisfied with the customer service provided by Medora, who has been very responsive to the County's requests. If a new tank is purchased, Ms. Davis will most likely install a SolarBee® mixer. She believes product consistency is important.

SYSTEM BENEFITS

Stanly County experienced improvements in public relations with its utility customers because the TTHM noncompliance issue disappeared following installation of the SolarBee® tank mixers, and subsequently, the addition of the PAX aeration system for one of its tanks, which was added to further assist in the reduction of TTHM. Stanly County is now in compliance with the TTHM MCL regulatory requirements throughout its water systems. Thus, the County no longer has to distribute water quality notifications to its customers concerning the TTHM noncompliance issues. Consumers have greater confidence in the water system because of this positive change.

Stanly County experienced economic benefits from the installation of ARRA-funded tank mixers. The tank flushing requirements are lower, resulting in lower maintenance costs and less system down time. Secondary chlorination requirements dropped with the elimination of stratification, resulting in lower chemical supply costs. Mailing expenses are lower because distributing water quality notifications to its customers are no longer required. In addition, the County realized minor economic benefits from the influx of tank mixer installers, who stayed in local hotels for a week. Ms. Davis also believes there will be a future economic impact as new businesses or industries and the general public consider Stanly County water system as a provider based on the improved water quality and compliance with TTHM requirements.

SUMMARY

The Stanly County Utility Department used ARRA funding to successfully install SolarBee® solar-powered mixers in all five of its elevated potable water storage tanks. The ARRA funding made the immediate purchase of the solar-powered tank mixers manageable and affordable. The SolarBee® mixers have proven to be effective in eliminating stratification and reducing the generation of DBPs within the five Stanly County potable water tanks. The green infrastructure benefits include energy savings (i.e., self-generated solar power), lower chemical use (i.e., reduction in secondary chlorination), and improved public relations (i.e., elimination of the TTHM noncompliance issue). Stanly County is satisfied with the performance of the solar-powered mixers and has recommended them to its industry peers.

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APPENDIX 4: COMAG ™ BALLASTED HIGH-RATE CLARIFICATION CASE STUDY

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SUMMARY

Under a work assignment issued by the EPA Office of the Chief Financial Officer, SAIC is gathering information regarding new or expanded industries or markets that were fostered as a result of ARRA spending. SAIC screened the Office of Water databases for drinking water and clean water projects to identify technologies considered innovative. In consultation with the EPA Office of Water, SAIC selected five clean water technologies for case studies: reactive filtration, high-gradient magnetic separation, integrated fixed-film activated sludge systems, compressible media filtration, and Class "B" residuals treatment. SAIC identified a sixth clean water technology, the SAFL Baffle hydrodynamic separator, as part of a stormwater project implemented under the Brownfields Program.

This case study focuses on the use of the ballasted high-rate clarification technology by the Town of Billerica Public Works Department (Billerica), the recipient of the ARRA funding. For this report, SAIC obtained information both from Billerica and Cambridge Water Technology (CWT), the manufacturer of the ballasted high-rate clarification technology.

Billerica purchased a CoMag ballasted high-rate clarification system (CoMag) as part of its wastewater treatment facility upgrade to meet new stringent phosphorus water quality standards. The innovative CoMag technology uses magnetite to remove phosphorus and other suspended solids from secondary wastewater effluent. Billerica received ARRA funding to assist in the purchase of the CoMag system and associated upgrades for its wastewater treatment facility. CWT is the original vendor of the CoMag technology; however, Siemens Water Technologies (Siemens) is the current vendor, having acquired CWT in 2012.

ARRA funding benefited Billerica citizens by reducing the fee burden associated with the construction of their wastewater facility upgrades. The $1.3 million principal forgiveness supported the purchase of the CoMag technology, which is successfully reducing phosphorus and aluminum levels in wastewater effluent to meet stringent NPDES (national pollutant discharge elimination system) permit limits. The green infrastructure benefits include improvements in stream water quality (i.e. reduced phosphorus and aluminum levels discharged to the Concord River), less infrastructure (i.e. smaller reaction and solids separation tanks), smaller footprint (i.e. no filter requirement) and energy savings (i.e. reduced electricity consumption). Billerica is very satisfied with the performance of the CoMag technology and is recommending it to its industry peers.

ARRA funding provided CWT with the opportunity to install its innovative clarification products in five municipal wastewater treatment facilities. With the influx of ARRA funding, CWT's product sales and project scheduling significantly increased (i.e., up by 30 percent). The ARRA-funded project installations created greater product exposure in the market place, which helped CWT establish credibility within the engineering and wastewater clarification communities at a quicker pace. The additional product exposure afforded by the ARRA-funded projects is helping the company expand into markets outside of Massachusetts (e.g., Chesapeake Bay, Connecticut, Virginia, West Virginia, Maryland and Pennsylvania).

CASE STUDY OF COMAG BALLASTED HIGH-RATE CLARIFICATION TECHNOLOGY IN WASTEWATER SYSTEMS

This document presents the case study conducted by SAIC. Section 1 contains a brief description of the project. Section 2 describes the ballasted high-rate clarification system technology including its innovative aspects and benefits. Section 3 presents information and lessons learned from the technology vendor (Cambridge Water Technology or CWT), and Section 4 presents information and lessons learned from the recipient of the ARRA funds (Town of Billerica Public Works Department).

I. PROJECT DESCRIPTION

The Town of Billerica Public Works Department (Billerica) purchased a CoMag ballasted high-rate clarification system (CoMag) as part of its wastewater treatment facility upgrade to meet new stringent phosphorus NPDES permit limits. The innovative CoMag technology uses magnetite to remove phosphorus and other suspended solids from secondary wastewater effluent. Billerica received ARRA funding to assist in the purchase of the CoMag system and associated upgrades for its wastewater treatment facility. Cambridge Water Technology (CWT) is the original vendor of the CoMag technology; however, Siemens Water Technologies (Siemens) is the current vendor, having acquired CWT in 2012.

Billerica is a small town in Middlesex County, Massachusetts. The town is located 22 miles north-northwest of Boston. It encompasses a total area of 26.4 square miles with a population of 40,243 people (U.S. Census Bureau, 2010). Founded in 1655, the town is proud of its famous resident, Thomas Ditson, who was tarred and feathered by the British and paraded through the streets of Boston in 1775. It is this incident that is said to be the source for the tune ‘Yankee Doodle Dandy’. More recently in 2005, the Town drew attention when Sports Illustrated Magazine named it “Sports Town of the Year” (Billerica, 2010).

With the help of ARRA funds, Billerica upgraded its wastewater treatment facility. The upgrades to the facility include the conversion of sludge holding tanks into settling tanks; the construction of a Vactor truck uploading area and a 16.5 million gallon per day (MGD) peak flow pump station; and the purchase of new concrete reaction tanks, chemical storage and feed systems, a magnetite separation system, two 30-foot diameter gravity thickeners and a new SCADA system. Billerica received a total of $10.8 million in low-interest ARRA loans with $1.3 million in principal forgiveness to help fund the facility upgrades.

II. COMAG BALLASTED HIGH-RATE CLARIFICATION TECHNOLOGY

INTRODUCTION

The CoMag technology removes phosphorus and other solid pollutants from wastewater. It is a physical/chemical treatment technology that uses an innovative magnetic separation approach to achieve very low phosphorus levels in wastewater effluent. In the following sections, an explanation of the technology is presented along with its innovative aspects and benefits.

PHOSPHORUS REMOVAL FROM WASTEWATER EFFLUENT

Wastewater treatment utilizes one or more of the following processes: preliminary, primary, secondary and advanced (also known as tertiary treatment). Wastewater passes through the processes sequentially starting with preliminary treatment, which removes grit and screens out large debris. Next is primary treatment, which removes solids in the wastewater using gravity-settling tanks. Adding chemicals to the settling tanks is a common practice to enhance performance by precipitating phosphorus and capturing and flocculating smaller solid particles. Secondary treatment follows primary treatment with the removal of colloidal and soluble organic matter by biological processes. Effluent disinfection is often included in the secondary treatment process.

As an additional step, the wastewater often passes through an advanced wastewater treatment (AWT) process, which is classified by EPA as "a level of treatment that is more stringent than secondary or produces a significant reduction in conventional, non-conventional, or toxic pollutants present in the wastewater" (EPA, 2009). Typically, chemical, biological and/or physical treatment processes are used to consistently and reliably meet standard AWT limits for phosphorus removal.

PHYSICAL/CHEMICAL TREATMENT PROCESSES

Physical and chemical treatment processes are defined as treatment technologies that do not include any biomass in the process to achieve the treatment objective. Physical treatment processes remove solids from wastewater by gravity settling (clarification) or filtration. Chemical treatment processes add coagulants to create changes in the wastewater pollutants. Coagulants are chemicals that create a larger, heavier particle mass (floc). Because chemicals improve removal of wastewater pollutants by physical treatment processes, chemical addition and physical processes are usually employed together to provide treatment. One example of a physical/chemical treatment process is chemical precipitation.

Chemical precipitation for phosphorus removal is a reliable, time-tested, wastewater treatment method that has not drastically changed over the years. To achieve removal, chemical aids are added to wastewater. The aids react with soluble phosphates to form precipitates. Typically, precipitation is accomplished using either lime or a metal salt such as aluminum sulfate (alum) or ferric chloride. The addition of polymers and other substances can further enhance floc formation and solids settling.

The effectiveness of phosphorus removal by chemical addition is highly dependent on the physical process following chemical precipitation. Direct addition of metal salts followed by conventional clarification (settling) can typically remove phosphorus to effluent levels between 0.5 and 1.0 milligrams per liter (mg/L) (Bott et al., 2007). To drop effluent levels to very low (< 0.1 mg/L) levels, AWT processes using tertiary clarifiers are needed. The CoMag technology is an example of a physical/chemical AWT technology with an innovative physical process that achieves very low phosphorus levels in wastewater effluent.

HOW THE COMAG BALLASTED HIGH-RATE CLARIFICATION TECHNOLOGY WORKS

The CoMag technology is a high-rate clarification process. It removes phosphorus and other solids from secondary wastewater effluent using three physical/chemical treatment steps:

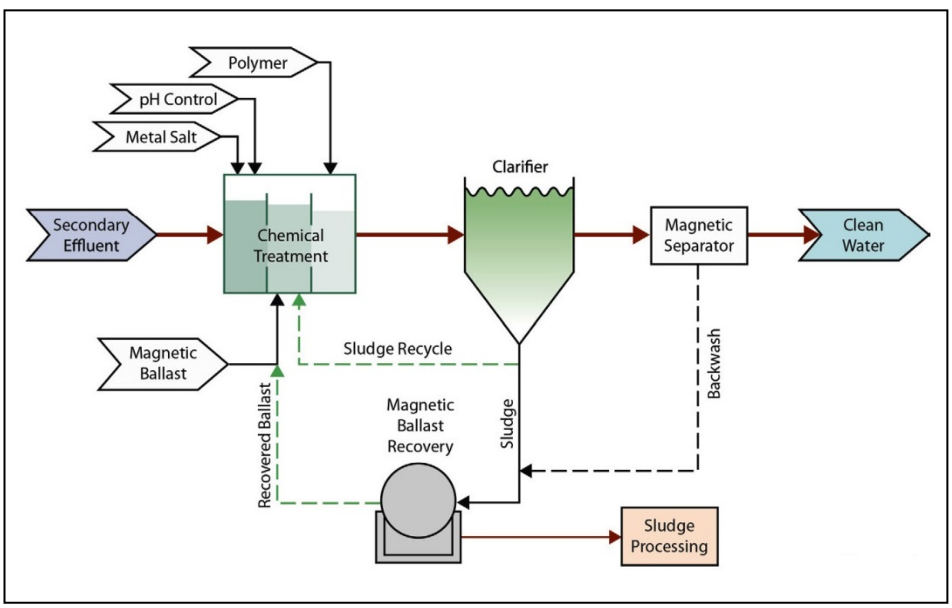
- Chemical precipitation in reaction tanks,

- Magnetite-enhanced settling in traditional clarifiers, and
- Polishing with a magnetic separator.

Figure 1 shows a flow diagram of the CoMag process. On the left hand side of the diagram, secondary wastewater effluent enters the chemical treatment reaction tank through an inlet pipe. Inside the tank, lime and metal salts (alum and/or ferric chloride) are added to the influent wastewater to adjust pH and form precipitates (i.e., floc). The treated wastewater is mixed with fine magnetic ballast to increase floc density. The tiny magnetic particles, with a specific gravity of approximately 5.2, are enmeshed into the floc and function as magnetic handles and weighting agents. Polymer is subsequently added to enhance floc formation before the wastewater leaves the reaction tank and travels to a small clarifier. Due to its high density, the magnetite-ballasted floc settles rapidly in the clarifier. The clarified wastewater effluent passes through a magnetic separator in a final polishing stage to remove flocs that escaped the clarifier. The clean water is discharged from the system.

Most of the settled solids from the clarifier are re-circulated to the chemical treatment reaction tank. The remainder of the solids move from the clarifier via a waste sludge line to an in-line, high-speed sheer mixer where the magnetite is liberated from the floc. The resulting two-part slurry is passed under a recovery drum. Permanent and stationary magnets inside the drum capture 99 percent of the magnetite and deposit it back to the reactor tank. The phosphorus-containing sludge, minus the magnetite, is removed from the system at the magnetic drum and ultimately disposed with the rest of the plant's sludge.

FIGURE 1. COMAG BALLASTED HIGH-RATE CLARIFICATION TECHNOLOGY FLOW DIAGRAM



Source: Tozer, 2008.

NEW AND INNOVATIVE ASPECTS OF THE COMAG TECHNOLOGY:

CoMag is the first product to use high-gradient magnetic separation (HGMS) in the treatment of wastewater. The basic principal of HGMS is the use of magnetic properties to separate particles from flowing streams of water. Use of magnetic gradients to remove particulates down to the micron scale is well established in the mineral processing industry (Winkler, 1998). Thus, the CoMag system is an innovative use of an existing technology.

CoMag uses magnetite, which has several physical properties that assist the HGMS process of particle separation. Magnetite is denser than sand, so it creates a heavy floc that settles rapidly in a small clarifier. It naturally bonds with chemical floc due to its hydrophobic property. It is fully oxidized and insoluble, which prevents it from rusting, degrading or dissolving like some other ballasting agents. It will not erode equipment components because it is non-abrasive. Its attraction to magnets, and not compounds, make it easy to recover and reuse, and lastly, it is inexpensive. It is a readily available commodity that helps keep operational costs low.

BENEFITS OF THE COMAG TECHNOLOGY

Lower levels of phosphorus and fine solids in wastewater effluent are achievable with the CoMag system. CoMag produces an effluent far superior to conventional alternatives at lower life-cycle costs. It has been proven at municipal and industrial facilities to remove phosphorus to levels of less than 0.05 mg/L, as well as fine solids, such as metals (i.e. copper, aluminum, zinc and arsenic). Other advantages are lower turbidity and reductions in pathogens and oil and grease (Siemens, 2012).

Settling rates are 20 to 40 times faster than conventional treatment. The high-density, magnetite ballasted floc settles rapidly and reliably in a conventional clarifier. This high-rate clarification treats larger quantities of wastewater in a shorter period of time. Thus, a much smaller clarifier is required, substantially reducing capital costs in new facilities or expansions and providing a particularly effective solution for sites with a small footprint. With the CoMag system, clarifiers can be reduced to one-tenth the size of a traditional clarifier footprint with minimal power consumption as an added benefit.

The CoMag system is reliable, robust, flexible, simple and compact. No media filters are part of the CoMag system, which reduces the risk of upsets. Conventional media filters, such as sand, require backwashing to clean and prevent plugging and fouling. CoMag achieves comparable contaminant removal performance without the filters, and therefore with greater operational stability. Also, without the constraints of a filtering system, CoMag is more flexible in handling variable solids loading, flows and coagulant types. Thus, CoMag can reliably handle a wider range of flows and loads.

CoMag provides quality pre-treatment for UV systems. It significantly reduces effluent bacteria and further reduces BOD with increases in UV transmittance of greater than 75 percent. This high transmissivity of the system effluent reduces energy and operating costs of final purification. Thus, full-scale UV disinfection systems can be smaller due to the high quality of the CoMag system effluent.

In 2008, CoMag received the highest scores in an evaluation of five phosphorus removal processes (i.e. CoMag, Actiflo, DensaDeg, Dualsand filter and membrane microfiltration) capable of meeting a very low phosphorus effluent limit (<0.05 mg/L) (Tozer, 2008). A team of senior engineers and plant operators assessed the processes for circumstances and issues associated with the Concord Massachusetts wastewater treatment facility. The team used four criteria categories in the assessment: safety factors; reliability factors (process flexibility, process reliability and commercial technology); implementation factors (impact on other processes, ease of implementation, space needs, ease of construction and phased implementation); and operational factors (staffing requirements and community impacts). The team ranked CoMag as the most flexible process because of its demonstrated ability to treat widely fluctuating flows and loads during the pilot study. CoMag scored high marks on process reliability due to the high solids separation efficiency without reliance on sand filtration. The team gave CoMag a high score on space requirements because it did not use sand filters, which require large amounts of space. Also, CoMag excelled in the operational factors category due to the relative simplicity of the process.

III. VENDOR-PROVIDED INFORMATION

INTRODUCTION

This section focuses on ARRA impacts experienced by CWT while marketing its innovative products in 2009 and 2010. CWT is the inventor and original vendor of the CoMag technology; however, Siemens is the current vendor, having acquired CWT in February 2012. Prior to purchase, CWT was a small, privately held company headquartered in Massachusetts. With its purchase, Siemens acquired the CWT patents, personnel and technologies.

CWT was founded in 2006 to commercialize its two innovative technologies: CoMag and BioMag. The BioMag technology is similar to CoMag in its use of magnetite; however, BioMag enhances biological wastewater treatment processes by using magnetite to ballast biological floc. In the early years, CWT focused on research and development. CWT conducted a long-term pilot study of the CoMag technology at a wastewater facility in Concord, Massachusetts. The pilot study was a 100,000 gallons per day (GPD) demonstration that ran for six years. The demonstration verified the effectiveness of the CoMag technology and launched the business.

INTERVIEW WITH MR. ROBERT BACKMAN

In November 2012, Mr. Backman, Vice President of Sales and Marketing for Siemens Industry, Incorporated (Siemens) and formally Manager of Sales at CWT, provided his perspective on how ARRA funding affected product and business development. This section summarizes his responses to questions concerning the impact ARRA funding had on the wastewater clarification business sector.

OPPORTUNITY PROVIDED BY ARRA-FUNDED PROJECTS

ARRA funding provided CWT with the opportunity to install its innovative clarification products in five municipal wastewater treatment facilities (i.e., four municipalities in Massachusetts and one municipality in New Hampshire). The Massachusetts municipalities of Billerica, Charleston and Maynard selected the CoMag products to lower phosphorus levels in effluent at their wastewater facilities. These ARRA-funded requests were driven by regulatory compliance (i.e., the requirement to lower NPDES permit phosphorus and aluminum levels). The ARRA-funded request for the BioMag system in Allentown, New Hampshire was driven by its need to increase wastewater effluent capacity. Sturbridge, Massachusetts requested the CoMag and BioMag systems to both increase capacity and lower phosphorus levels.

ARRA funding spurred the use of an innovative technology. The Allentown, New Hampshire municipality was evaluating technologies to increase its capacity at the time the ARRA funding was announced. They were evaluating conventional technology options, as well as the innovative BioMag technology. The BioMag technology could double the plant’s capacity without increasing its footprint, so the Allentown municipality was very interested in it. However, Allentown was hesitant to move forward with the purchase of the innovative BioMag technology due to its capital cost. With the award of ARRA funding, Allentown overcame the capital cost hurdle and purchased the BioMag technology. According to Mr. Backman, “it was because of the ARRA funding that Allentown was able to make a decision to move forward with a newer technology, which they normally wouldn’t have done.”

ARRA funding accelerated adoption of the two CWT products (CoMag and BioMag). The availability of ARRA funds enabled municipalities to purchase and install systems earlier than anticipated by CWT. These early installations broadened CWT’s marketing plan at a quicker pace.

ARRA funding impacted the local market for clarification products. The installation of ARRA-funded projects created greater exposure of the CWT products in the market place. The exposure helped CWT establish credibility within the engineering and wastewater clarification communities and fast tracked its products. According to Mr. Backman, “CWT could have gone to private equity funding to achieve this goal, but ARRA did it for us.”

Mr. Backman anticipates there will be new customers as a result of the ARRA-funded project sales. ’Word of mouth‘ exposure led to new marketing opportunities, especially outside of Massachusetts (e.g., Chesapeake Bay, Connecticut, Virginia, West Virginia, Maryland and Pennsylvania).

EFFECTS OF ARRA FUNDING ON COMPANY DEVELOPMENT

ARRA funding significantly increased sales. According to Mr. Backman, “ARRA allowed us to see a significant increase in sales opportunities during that two-year period.” One example is CWT’s sale of the BioMag system to the Allentown municipality. In an attempt to quantify the increase, Mr. Backman estimated project scheduling was up 30 percent. Thus, CWT’s business was stable during the recession, partly due to the increased number of ARRA-funded sale opportunities.

ARRA-funded sales did not affect production. CWT is structured with a core group of staff and the ability to outsource as needed to meet flexible demand. CWT outsources its engineering support services and manufacturing capability. CWT products are composed of outsourced product pieces that are integrated together. The pieces are manufactured in U.S. facilities, so meeting the Buy American provision was not a major concern. After checking, CWT did have to change a few minor source materials, such as valves; but the impact was minimal.

CWT benefited from its purchase by Siemens in early 2012. Mr. Backman cannot say whether the exposure from ARRA-funding projects better positioned CWT for its sale to Siemens; however, the sale did benefit CWT. It allowed CWT to increase its market share. Because Siemens is a large company with greater financial resources, it is capable of improving product sales from a technical resource, marketing, order execution and sales network standpoint. Thus, CWT products are experiencing a faster growth rate due to its purchase by Siemens.

CWT did not experience a decline in sales after the influx of ARRA-funded money tapered off. CWT’s sale to Siemens may have offset any post-ARRA impact. However, the tapering-off issue is on Siemen’s ’radar screen.’ According to Mr. Backman, “there is a sense out there that infrastructure spending is lower than expected because there is a drag on finances.” This condition is not uniform across the country; instead there are pockets where movement is very slow, while in other areas of the country, the movement is at the "typical snail pace" of municipal projects.

SUMMARY

ARRA funding provided CWT with the opportunity to install its innovative clarification products in five municipal wastewater treatment facilities. With the influx of ARRA funding, CWT's product sales and project scheduling significantly increased (i.e., up by 30 percent). The ARRA-funded project installations created greater product exposure in the market place, which helped CWT establish credibility within the engineering and wastewater clarification communities at a quicker pace. The additional product exposure afforded by the ARRA-funded projects is helping the company expand into markets outside of Massachusetts (e.g., Chesapeake Bay, Connecticut, Virginia, West Virginia, Maryland and Pennsylvania).

IV. FUNDING RECIPIENT-PROVIDED INFORMATION

INTRODUCTION

The Concord River receives wastewater effluent from Billerica's wastewater treatment facility. It has a Class B, 'fishable and swimmable' water quality classification, although it does not meet this classification at present. The river is overloaded with nutrients, particularly phosphorus, which encourage plant growth in the warm summer months, leading to green blankets of algae and duck weed on the surface. This detracts from the beauty and recreational activities on the river, but more importantly it depletes the amount of oxygen in the water, which fish and other aquatic organisms need to live. Later in the summer and fall when the plants begin to decay, they create a bad odor (RSC, 2012).

Billerica struggled to meet NPDES permit limits on pollutants in its discharges into the Concord River using the treatment processes in its aging wastewater facility. In 2007, the Town was fined $250,000 for discharges exceeding allowable effluent limits for phosphorus, fecal coliform bacteria, pH and ammonia nitrogen. The discharges created an overabundance of nutrients that directly contributed to excessive aquatic plant growth in the river (Environmental News Service, 2007).

The Massachusetts Department of Environmental Protection and EPA jointly issued a new NPDES permit requiring the municipality to remove phosphorus from its wastewater effluent down to a level of 0.2 mg/L by September 15, 2009. After receiving the new NPDES permit, Billerica designed a plant upgrade to meet the new permit requirements, as well as provide flexibility in meeting even lower limits in the future. The Town selected the CoMag system to meet the new limits and make the desired flexibility possible.

INTERVIEW WITH TOWN OF BILLERICA MANAGEMENT

In November 2012, Mr. Abdul Alkhatib (Director of Public Works), Ms. Lauren Sanders (Wastewater Treatment Plant Supervisor) and Mr. Jeff Kalmes (Wastewater Treatment Plant Operator) provided their perspective on the selection and performance of the CoMag technology. This section summarizes their responses to questions about the technology selection process, system performance and impact of ARRA funding.

SELECTION OF THE COMAG TECHNOLOGY

Billerica retained Woodard & Curran, an integrated engineering, science and operations company, to design upgrades to its 5.4 MGD municipal wastewater treatment facility. Woodard & Curran engineers worked closely with state and federal regulators to craft a design capable of meeting all permit needs and complying with the regulatory compliance schedule. During the planning process, Woodard & Curran engineers evaluated many phosphorus removal strategies.

Woodard & Curran engineers selected CoMag as the best fit for addressing the municipality's design constraints. CoMag treats a large flow of wastewater in a small volume of tanks, thereby reducing the process footprint and costs. The small footprint feature was critical to the municipality due to the very limited availability of space. In addition to its small footprint feature, the CoMag system allowed reuse of existing structures. The system also provided flexibility with an add-on electromagnetic filter, capable of reaching lower effluent phosphorus levels in the future, if required. Last, but not least, the CoMag system provided a cost-effective solution.

Billerica took a chance by selecting the CoMag system. The CoMag system was new and unknown when the town was planning the facility upgrade. On paper, it appeared to be the most viable option for meeting the permit limits; however, CWT had demonstrated the CoMag system at only one wastewater treatment plant (Concord). The Concord wastewater treatment plant provided limited operating experience and process data for evaluation purposes. Ultimately, the benefits of the CoMag system outweighed its shortcomings (i.e., unproven long-term operation capability), and Billerica selected it.

SYSTEM PERFORMANCE

CWT pilot tested the CoMag technology at Billerica's wastewater facility. The pilot test ran for three months. CWT evaluated two metal salt options (i.e., alum and ferric chloride), which were added to the pilot test's wastewater influent to precipitate particles. Throughout the test, CWT sampled the wastewater effluent to determine the total phosphorus and ortho phosphorus concentrations. Evaluation of test results revealed alum to be the best performer; alum was also more cost effective than ferric chloride because it was already in use at the plant. Most importantly, the pilot test demonstrated the system's capability to reduce phosphorus levels to below the regulatory requirement. According to Mr. Alkhatib, CWT was very involved in the pilot test process (i.e., committed to proving the technology and selling the system).

Billerica's construction contractor installed the CoMag system according to the plan. The construction contract was awarded to Waterline Industries from Madison, New Hampshire. Waterline Industries installed the system on schedule without notable difficulties. According to Mr. Alkhatib, "Waterline Industries was a good contractor that made the job easy."

The CoMag system is performing well. In accordance with the permit, the municipality is collecting effluent samples on a monthly basis. The municipality sends the samples to a laboratory for phosphorus and aluminum analysis. The sampling results are demonstrating compliance with the permit requirement of 0.2 mg/L for phosphorus. Effluent discharges are consistently in the range of 0.05 to 0.17 mg/L.

Billerica wastewater facility operators are very satisfied with the CoMag technology. The system is working as advertised. Mr. Alkhatib thinks the municipality made the right technology choice and would "absolutely" make the same technology selection decision today. Mr. Alkhatib frequently conducts tours of the newly upgraded facility and recommends the CoMag system to his United States and international visitors, as well as his industry peers.

IMPACT OF ARRA FUNDING

ARRA funding benefited Billerica citizens by reducing the fee burden associated with the construction of its wastewater facility upgrades. Mr. Alkhatib considers the ARRA funding to be "supplemental money" having little impact on the project other than helping to lower fees. Because ARRA was announced at the tail end of the design process, the availability of ARRA funding did not play a role in the selection of the CoMag technology; nor did it impact the detailed design plans. Without ARRA funding, Billerica would have completed the project on the same timetable because it was driven by regulatory compliance. Likewise, ARRA provisions, such as the Buy American and Davis Bacon clauses, did not impact the project schedule.

SUMMARY

ARRA funding benefited Billerica citizens by reducing the fee burden associated with the construction of its wastewater facility upgrades. The $1.3 million principal forgiveness supported the purchase of the CoMag technology, which is successfully reducing phosphorus and aluminum levels in wastewater effluent to meet stringent permit limits. The green infrastructure benefits include improvements in stream water quality (i.e., reduced phosphorus and aluminum levels discharged to the Concord River), less infrastructure (i.e., smaller reaction and solids separation tanks), smaller footprint (i.e. no filter requirement) and energy savings (i.e., reduced electricity consumption). Billerica is very satisfied with the performance of the CoMag technology and is recommending it to its industry peers.

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APPENDIX 5: FUZZY FILTER® CASE STUDY

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SUMMARY

Under a work assignment issued by the EPA Office of the Chief Financial Officer (OCFO), SAIC is gathering information regarding new or expanded industries or markets that were fostered as a result of ARRA spending. SAIC screened the Office of Water databases for drinking water and clean water projects to identify technologies considered innovative. In consultation with the EPA Office of Water, SAIC selected five clean water technologies for case studies: reactive filtration, high-gradient magnetic separation, integrated fixed-film activated sludge systems, compressible media filtration, and Class "B" residuals treatment. SAIC identified a sixth clean water technology, the SAFL Baffle hydrodynamic separator, as part of a stormwater project implemented under the Brownfields Program.

This case study focuses on the use of the Fuzzy Filter® compressible media filtration technology by the Linda County Water District (District) in California, the recipient of the ARRA funding. For this report, SAIC obtained information both from the District's engineering design and construction management contractor, Kennedy/Jenks Consultants (Kennedy/Jenks), and Schreiber LLC (Schreiber), the manufacturer of the innovative technology.

The District purchased a Fuzzy Filter® as part of its wastewater treatment facility upgrade to meet new stringent National Pollutant Discharge Elimination System (NPDES) permit limits. The innovative Fuzzy Filter® enhances filtration capability for removal of suspended solids with a unique compressible media. The District received ARRA funding to assist in the purchase of the Fuzzy Filter® and other upgrades for its wastewater and water treatment facilities. Schreiber manufactures the Fuzzy Filter® in Birmingham, Alabama.

ARRA funding provided Schreiber with the opportunity to install the Fuzzy Filter® in the District's expanded and updated wastewater treatment facility, which significantly affected Schreiber's product sales in 2008. In addition, the District project helped Schreiber fine tune its operation for compliance with unrestricted water reuse regulations under Title 22 of the California Code of Regulations. The District project will most likely create new customers for Schreiber due to its central location and 'word of mouth' marketing exposure.

ARRA funding made the purchase of the Fuzzy Filter® and other upgrades to the District wastewater facility a reality. The Fuzzy Filter® is successfully reducing suspended solids to low levels in the facility's wastewater discharge, exceeding the reductions needed to comply with upcoming stringent NPDES permit limits. The green infrastructure benefits include improvements in stream water quality (i.e., reduced suspended solid levels discharged to the Lower Feather River), large space savings (i.e., small footprint) and energy savings (i.e., reduced electricity consumption). The District is very satisfied with the performance of the Fuzzy Filter® and recommends it to its industry peers.

CASE STUDY OF COMPRESSIBLE MEDIA FILTRATION TECHNOLOGY IN WASTEWATER SYSTEMS

This document presents the case study conducted by SAIC. Section 1 contains a brief description of the project. Section 2 describes the compressible medium filter technology including its innovative aspects and benefits. Section 3 presents information and lessons learned from the technology vendor (Schreiber LLC), and Section 4 presents information and lessons learned from the recipient of the ARRA funds (Linda County Water District).

I. PROJECT DESCRIPTION

The Linda County Water District (District) in California received ARRA funds to upgrade and expand its wastewater treatment facility. To comply with new regulatory provisions and effluent limitations, the District selected an innovative compressible media filter technology to incorporate into the upgrade. The innovative technology is referred to as the Fuzzy Filter®. Its enhanced filtration capability provides operators unprecedented flexibility in removal of suspended solids. Schreiber LLC (Schreiber) manufactures the Fuzzy Filter® in Birmingham, Alabama.

The District is a private company that operates under the California State water code to provide domestic water service to both businesses and residences. The District serves an unincorporated area near Olivehurst, California which is 38 miles north of Sacramento. During the Great Depression, citizens escaping the dust bowl in Oklahoma migrated to Olivehurst, looking for fertile ground, job opportunities and a better future. The economy is largely focused on agriculture, with some work in the mill and manufacturing sectors. According to the 2010 census, there are 13,656 residents in Olivehurst (U.S. Census Bureau, 2010).

The District received $18,368,130 of ARRA funding for the expansion and upgrade of its 1.8 million gallon per day (MGD) wastewater treatment plant, as distributed by the Clean Water State Revolving Fund. The funding conditions stipulated $10 million in principal forgiveness and 1 percent interest on the remaining portion with a 30-year payback schedule. The agreement was executed in August 2009.

II. COMPRESSIBLE MEDIA FILTRATION TECHNOLOGY

INTRODUCTION

The Fuzzy Filter® technology removes suspended solid pollutants from wastewater. It is a physical/chemical treatment technology that uses an innovative compressible filtration approach to achieve a high rate of solids removal in wastewater effluent. In the following sections, an explanation of the technology is presented along with its innovative aspects and benefits.

SOLIDS REMOVAL FROM WASTEWATER EFFLUENT

Wastewater treatment utilizes the following processes: preliminary, primary, secondary, and sometimes advanced (also known as tertiary treatment). Wastewater passes through the processes sequentially starting with preliminary treatment, which removes grit and screens out large debris. Next is primary treatment, which removes solids in the wastewater using gravity-settling tanks. Adding chemicals to the settling tanks is a common practice to enhance performance by capturing and flocculating smaller solid particles. Secondary treatment follows primary treatment with the removal of colloidal and soluble organic matter by biological processes. Effluent disinfection is often included in the secondary treatment process.

As an additional step, the wastewater sometimes passes through an advanced wastewater treatment (AWT) process, which is classified by EPA as "a level of treatment that is more stringent than secondary or produces a significant reduction in conventional, non-conventional, or toxic pollutants present in the wastewater" (USEPA, 2008). Typically, chemical and/or physical treatment processes are used to consistently and reliably meet standard AWT limits for suspended solids removal.

PHYSICAL/CHEMICAL TREATMENT PROCESSES

Physical and chemical treatment processes are defined as treatment technologies that do not include any biomass in the process to achieve the treatment objective. Physical treatment processes remove solids from wastewater by gravity settling (clarification) or filtration. Chemical treatment processes add coagulants to create changes in the wastewater pollutants. Coagulants are chemicals that create a larger, heavier particle mass (floc). Because chemicals improve removal of wastewater pollutants by physical treatment processes, chemical addition and physical processes are usually employed together to provide treatment. The physical process of clarification and/or filtration follows the chemical treatment prior to disinfection and discharge. When particles in wastewater are too small to remove by clarification alone, filtration is used to eliminate the precipitated particles and flocs remaining after clarification. The filtration process removes suspended solids, organics, nitrogen, phosphorus and pathogenic bacteria and viruses.

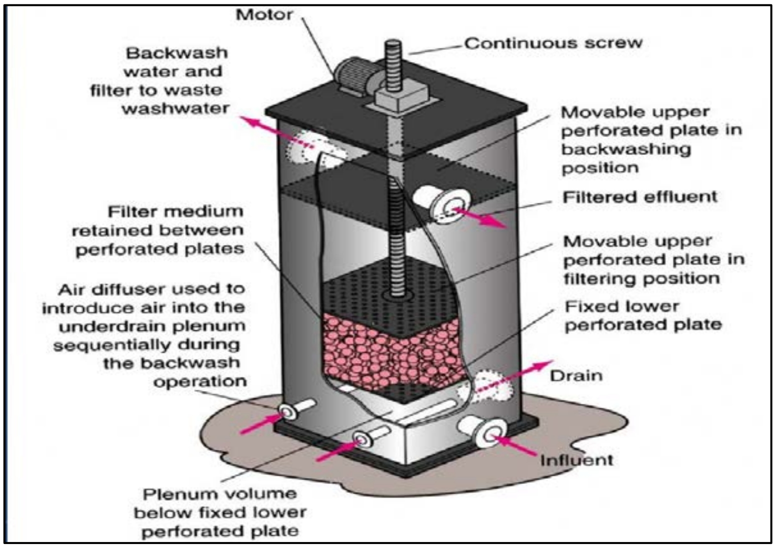
Filtration separates suspended solids from wastewater by passing it through a porous medium, such as sand and anthracite. Under the force of gravity, often by a combination of positive head and suction from underneath, water passes downward through the medium. Optimum filtration occurs when impurities in the water neither pass through the bed nor are all strained out on the surface, but instead are removed throughout the entire depth of the filter. Particle removal is accomplished only when the particles make physical contact with the surface of the filter medium (e.g., trapped or attached by straining, flocculation and sedimentation). When the medium becomes filled or solids break through, the filter bed is cleaned by backwashing, a process where upward flow fluidizes the media and conveys away the impurities that have accumulated in the bed.

HOW THE FUZZY FILTER® COMPRESSIBLE MEDIA FILTRATION TECHNOLOGY WORKS

A schematic of the Fuzzy Filter® is shown in Figure 1. The major components of the system are a media bed and two horizontal flat plates, which are contained in a concrete or steel structure. The media bed is confined in a chamber between the two plates. It is filled with small balls made of compressible synthetic fibers. The two plates are perforated to allow filtered liquid to move through them, as well as through the media bed. The upper plate is movable. Lowering the upper plate compresses the media against the lower plate, which is fixed. The space below the lower plate is referred to as the plenum area. The function of the plenum area is to improve flow distribution through the media bed.

The Fuzzy Filter® filters wastewater influent in an upflow pattern during its filtration cycle, as shown in Figure 2. The upper plate is positioned to optimize capture of the suspended solids. Influent wastewater enters the Fuzzy Filter® system at the bottom of the chamber (in the plenum area). The influent fills the plenum area, flows up through the media bed and discharges from the top of the structure. The operator alters the properties of the media bed (i.e., collector size, porosity and depth) by adjusting the position of the upper movable plate. For effective filtration, a media bed depth of at least 30 inches is recommended.

FIGURE 1. SCHEMATIC OF FUZZY FILTER® SYSTEM



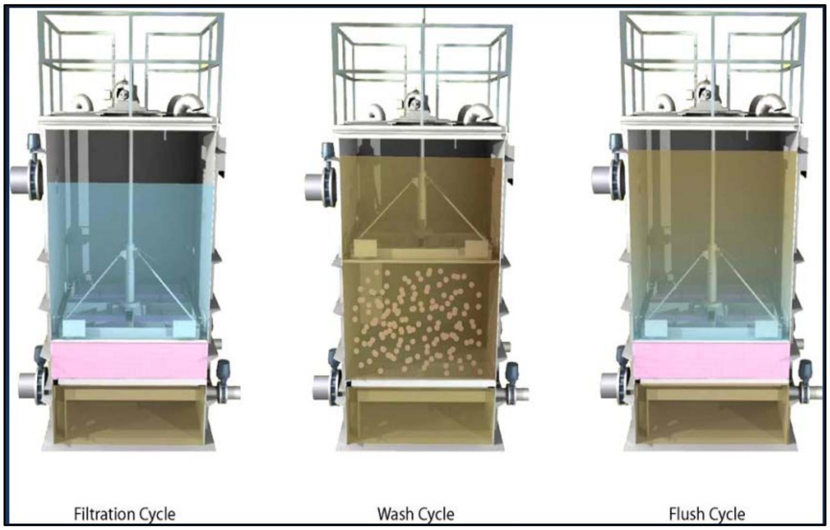
Source: Caliskaner, 2011

The filter media is backwashed in its wash cycle. The Fuzzy Filter® transitions from the filtration cycle to the wash cycle by redirecting the filtered effluent to the backwash water line exit (see upper left arrow in Figure 1). In this cycle, the upper plate is raised to allow room for washing, while compressed air enters the bottom of the unit (see wash cycle in Figure 2). The compressed air creates turbulence and shear forces as it moves up through the expanded media bed, which helps to scour and remove accumulated material from the filter media. The backwash water exiting the structure is returned to the secondary biological treatment unit.

As a final step following the wash cycle, the Fuzzy Filter® enters its short flush cycle (see Flush Cycle in Figure 2). At the start of the cycle, the upper plate lowers to its original filtration position. The influent flow continues to move up through the media bed and out the backwash water line exit, removing any dirty water before returning the unit to filtration service. The filter is typically flushed to waste for one minute; however, the flushing period can be adjusted to the specific application (e.g., influent wastewater characteristics, effluent quality requirements or filter bed detention time).

The Fuzzy Filter® filtration cycle is interrupted at least once a day for backwashing of the filter media. In addition, the wash cycle starts when head loss through the filter media reaches a preset maximum allowable level (i.e., terminal head loss) or effluent quality deteriorates to an unacceptable level (e.g., >2.0 nephelometric turbidity units). The complete backwash cycle takes approximately 30 minutes. Chlorine is added to the wash cycle once every 12 to 18 months to kill any bacterial growth. Detergent can also be added to remove any grease buildup that may occur.

FIGURE 2. OPERATION CYCLES OF FUZZY FILTER®



Source: Caliskaner, 2011

NEW AND INNOVATIVE ASPECTS OF THE FUZZY FILTER® COMPRESSIBLE MEDIA FILTRATION TECHNOLOGY

The Fuzzy Filter® is the only filtration process to use a compressible media. The Fuzzy Filter® media are small, pink, spherical balls of synthetic fibers. The fibers are bound together at the center of each ball by a metal binder clip. Each ball, in its uncompressed state, is about 1.25 inches in diameter and is highly porous (89 percent) with a density that is slightly greater than water.

The Fuzzy Filter® media bed is innovative for two reasons. First, influent liquid flows through the media as opposed to around it, as in conventional sand and anthracite filters. This feature greatly increases its ability to capture suspended solids. Second, the porosity of the media adjusts to suit influent characteristics and maximize solids capture due to its low density and high compressibility. This feature permits higher hydraulic loadings of up to 40 gallons per minute per square foot of media as opposed to other filtration systems, which permit only 2 to 6 gallons per minute per square foot of media.

BENEFITS OF THE FUZZY FILTER® COMPRESSIBLE MEDIA FILTRATION TECHNOLOGY

The Fuzzy Filter® offers significant advantages over traditional non-compressible media filters (Schreiber, 2012). Although originally designed for AWT, it is extremely versatile for a wide range of other applications including water reuse, peak wet weather flows, combined sewer overflows, process water conditioning, and pre-filtration for reverse osmosis. In all applications, the Fuzzy Filter® offers significant benefits. The five principal benefits of the Fuzzy Filter® are described below.

IMPROVED FILTRATION CAPACITY

The Fuzzy Filter® handles flux rates of 30 to 40 gallons per minute per square foot of media, which is 6 to 8 times higher than traditional granular filters. Even at these high flux rates, the Fuzzy Filter® effectively removes particles 4 microns and larger with removal rates of over 80 percent. High flux rates translate into large space savings (i.e., small footprint). For example, a typical granular media filter requires the space of an entire football field including both end zones to process a flow of 230 MGD, whereas a Fuzzy Filter® processes the same flow in a space of one end zone (i.e., a space savings of 90 percent).

EASILY SCALABLE

The Fuzzy Filter® handles small flows, as well as huge flows, by adding units. The systems are modular and quick to install. Fuzzy Filters® are available in a variety of sizes (from 2.25 to 64 square feet) for a variety of flow rates (ranging from 0.13 MGD to 3.68 MGD).

EXTREMELY LOW MAINTENANCE

The Fuzzy Filter® is a low maintenance product for two reasons. First, the media is not consumed or lost. With a nominal life of 10 years, the media requires infrequent replacement. Second, instead of being recharged and replaced, the Fuzzy Filter® is automatically washed with effluent at a reduced flux rate of 10 gallons per minute per square foot of media, eliminating the need for costly storage tanks. The approach also completely eliminates the need for underdrains. A little lubrication and occasional detergent media washing are all that are typically required to keep the Fuzzy Filter® operating reliably.

SIMPLE INSTALLATION

The Fuzzy Filter® installs in three simple steps. First, the Fuzzy Filter® steel vessel is placed on a concrete pad. Second, piping is attached. Third, the electrical supply is attached and the power is switched on. This installation process is quick and simple.

FLEXIBILITY

The adjustability of the Fuzzy Filter® filter bed provides operators with unprecedented flexibility. The adjustable filter bed allows operators to change the porosity of the media to suit their facility-specific influent characteristics and maximize solids capture. Because the media is compressed from the top down, the resulting porosity gradient allows the Fuzzy Filter® to act like a multimedia depth filter (i.e., upflow allows larger particles to be captured in the larger openings in the lower parts of the media bed with the smaller particles passing deeper into the bed where they are captured by progressively smaller openings). This porosity gradient minimizes buildup on the surface and the blockage of flow that is created by a lack of depth in many other conventional filters.

III. VENDOR-PROVIDED INFORMATION

INTRODUCTION

Schreiber is the vendor of the innovative Fuzzy Filter® described in this case study. Schreiber is a small privately owned business that employs 52 employees in Birmingham, Alabama. The company offers individual wastewater components, complete systems and a wide range of energy efficient and innovative wastewater treatment equipment options, including headwork screens, aeration devices, continuously sequencing reactors, clarifiers and filters. In 1995, Schreiber installed the first Fuzzy Filter® in Columbus, Georgia.

INTERVIEW WITH MR. THACHER WORTHEN

In October 2012, Mr. Thacher Worthen, President and Chief Executive Officer of Schreiber, provided his perspective on how ARRA funding affected product and business development. Also, Mr. Worthen responded to questions concerning the ARRA-funding impact on the company's business operation and product sales.

OPPORTUNITY PROVIDED BY ARRA-FUNDED PROJECTS

ARRA funding provided Schreiber with the opportunity to install a Fuzzy Filter® in the District's expanded and upgraded wastewater treatment facility. The District contacted Schreiber about the project in early 2005. Schreiber invested a substantial amount of time completing the Fuzzy Filter® design; however, the project was shelved as a closed opportunity due to a lack of funding. In 2009, ARRA changed the project status by providing the District with funding required to move the project forward, which in turn allowed Schreiber to benefit from the sale and installation of a Fuzzy Filter®.

Schreiber participated in only one ARRA-funded project (i.e., the District wastewater facility upgrade project). According to Mr. Worthen, the reason for its limited participation is the ARRA 'shovel-ready' provision. Small equipment suppliers (e.g., pipe suppliers) benefited greatly from ARRA; whereas large equipment suppliers, such as Schreiber, did not benefit as much because they could not meet the ARRA timeline. A new municipal project takes two to three years for planning, design and contracting, and therefore could not meet the completion date stipulated by ARRA.

EFFECTS OF ARRA FUNDING ON MARKET ADOPTION RATE

ARRA did not alter the market adoption rate for the Fuzzy Filter® technology. In 2009, the Fuzzy Filter® was not widely adopted, even though it was developed in 1995. According to Mr. Worthen, new technologies that are developed by small businesses typically take 10 years to gain any momentum in the wastewater business. By the late 2000s, several Fuzzy Filters® were installed in U.S. wastewater treatment facilities; however, the Fuzzy Filter® was still considered a new technology. The Water Environment Federation Technical Exhibition and Conference innovation award to Fuzzy Filter® in 2005 is an indication of its new and innovative status at that time. Today the Fuzzy Filter® is more widely adopted with installations in at least 60 wastewater treatment facilities. Unfortunately, participating in only one ARRA-funded project did not make a difference in the Fuzzy Filter®'s adoption rate.

EFFECTS OF ARRA FUNDING ON PRODUCT SALES

ARRA funding significantly affected product sales in 2008. According to Mr. Worthen, the District project was a "good" project. It was slightly larger than average, and because Schreiber is a small company, the ARRA-funded District project was large enough to have an effect on product sales during the one year. It did not have an on-going effect.

EFFECTS OF ARRA FUNDING ON BUSINESS OPERATION

The ARRA-funded District project helped Schreiber fine tune its operations for compliance with unrestricted water reuse under Title 22, Chapter 4 of the California Code of Regulations. Under Title 22 unrestricted water reuse regulations, effluent must be treated with AWT processes, specifically filtration (such as the Fuzzy Filter®) and disinfection. For equipment manufacturers, Title 22 adds complexity to projects because of the stringent demonstration, treatment and monitoring requirements. The manufacturers must study the Title 22 regulatory requirements and establish procedures to test, adjust and monitor the filtration process. A pilot study must be completed and approved by the California Department of Health Services. Additionally, the treatment process must be adjusted to comply with specific equipment criteria (e.g., filter media height and backwash specifications). Schreiber gained experience with the Title 22 process by working on the ARRA-funded District project. The experience resulted in minor adjustments to its operational procedures. According to Mr. Worthen, there were no "ground breaking" changes, but adjustments were made.

FUTURE BENEFITS FROM ARRA FUNDING

The ARRA-funded project will most likely create new customers for Schreiber. The District project gave Schreiber the opportunity to successfully demonstrate the effectiveness of its Fuzzy Filter® for a water reuse application. Mr. Worthen commented that "the location of the District's wastewater treatment facility is good, and the District does not mind showing off the plant." Thus, the ARRA-funded District project's central location should create marketing exposure, which should lead to new customers. The municipality's discussion of the project with its industry peers should also provide Schreiber with 'word of mouth' marketing exposure.

SUMMARY

ARRA funding provided Schreiber with the opportunity to install the Fuzzy Filter® in the District's expanded and updated wastewater treatment facility, which significantly affected Schreiber's product sales in 2008. The District project helped Schreiber fine tune its operation for compliance with unrestricted water reuse regulations under Title 22 of the California Code of Regulations. In addition, the District project will most likely create new customers for Schreiber due to its location and 'word of mouth' marketing exposure.

IV. FUNDING RECIPIENT-PROVIDED INFORMATION

INTRODUCTION

In 2006, the District designed an upgrade for its wastewater treatment facility. The design would expand the facility and add features to achieve more stringent NPDES permit limitations for a number of parameters including ammonia, nitrogen, biochemical oxygen demand, suspended solids and coliform. Looking forward, the District selected features that were also capable of meeting Title 22 water reuse requirements, despite a current lack of market for recycled water. At the completion of the design phase, the District shelved the project because funding resources for the necessary upgrades and expansion were not available. ARRA changed the situation in 2009, and the project began construction.

The District completed the expansion and update of its wastewater treatment facilities in January 2012. The project expanded the facility treatment capacity from 1.8 to 5.0 MGD. The facility upgrades replaced the front end of the existing plant with new preliminary, primary, secondary and AWT processes. In the upgraded facility, wastewater flowing into the primary treatment tank runs through a coarse bubble aeration system with flight and chain collector mechanisms. The primary effluent continues through an activated sludge biological treatment unit, then passes through two clarifiers. Secondary effluent from the two clarifiers is pumped through a new filter pump station and injected with hypochlorite, polymer and coagulants to aid in removal of suspended solids before AWT filtration with Fuzzy Filters®. Following filtration, the effluent re-enters the existing plant, where it runs through the chlorine contact basin and pump station prior to discharge into infiltration basins within the floodplain of the Feather River.

INTERVIEW WITH MR. BRIAN DAVIS

In December 2012, Mr. Brian Davis, Project Manager with Kennedy/Jenks Consultants (Kennedy/Jenks), provided his perspective on the selection and performance of the Fuzzy Filter® technology. Kennedy/Jenks is a consulting business providing engineering design and construction management services to the water and wastewater industry. Mr. Davis and his staff at Kennedy/Jenks supported the District in the design and construction management of its upgraded wastewater and water treatment facilities. This section summarizes his responses to questions about the technology selection process, system performance and impact of ARRA funding.

SELECTION OF THE FUZZY FILTER® COMPRESSIBLE MEDIA FILTRATION TECHNOLOGY

Kennedy/Jenks selected the District wastewater treatment plant upgrades to comply with the upcoming stringent NPDES permit limits. As a first step, they reviewed a variety of AWT technologies including several filtration alternatives. Following the review, Kennedy/Jenks completed an alternatives evaluation to thoroughly identify the benefits and drawbacks of the available filtration technologies. The evaluation included disc filters, sand filters, membrane bioreactors and compressible media filters.

Kennedy/Jenks selected the Fuzzy Filter® innovative system for two reasons. First, the Fuzzy Filter® changes media properties 'on the fly.' Kennedy/Jenks wanted the flexibility to change the media properties, most importantly compressibility ratio, to accommodate uncertain flow and influent characteristics. Due to a tight timeframe, Kennedy/Jenks did not have the luxury of pilot testing the plant features, so the composition of the secondary effluent was uncertain. Seasonal variations in flow and effluent characteristics also added to the uncertainty of the effluent composition and made the flexibility of the Fuzzy Filter® desirable.

Second, Kennedy/Jenks selected the Fuzzy Filter® because it uses less water in the backwash cycle. The Fuzzy Filter® uses 2 percent of the wastewater effluent for backwashing as compared to 8 to 10 percent used by conventional sand filters. The reduction in wastewater effluent use translates to a 5 percent reduction in production costs. The wastewater effluent reduction creates huge energy savings because the lower flow requires less pumping, which is energy intensive.

Schreiber did not conduct pilot testing of the Fuzzy Filter®. Pilot testing was not possible because of financial and time constraints. The District was on a tight time schedule to complete the construction as required for compliance with the NPDES permit. The District was also constrained financially.

Kennedy/Jenks was not overly concerned about the lack of pilot testing because it was familiar with the product, having completed Fuzzy Filter® pilot testing on other projects.

SYSTEM PERFORMANCE

The installation of the Fuzzy Filter® went well. The programmable logic controller (PLC) programming only had a 'hiccup or two' that took a month to fix. The delay was inconsequential to the plant construction schedule. The delay occurred because the Fuzzy Filter® PLC system was programmed to enter the backwash cycle daily at midnight, which is too low of a flow condition at the facility. The operator wanted the system to enter the backwash cycle during peak flow conditions because the low flow condition was inadequate to service both the Fuzzy Filter® and the disinfection system.

The Fuzzy Filter® is performing well. The District collects effluent samples to assess compliance with the NPDES permit limits. The District analyzes the samples for turbidity and suspended solids. The performance data indicate the Fuzzy Filter® is performing well by consistently discharging effluent below the permit limit requirements.

Kennedy/Jenks and the District wastewater facility operators are very satisfied with the Fuzzy Filter®. Mr. Davis would select the Fuzzy Filter® technology again, assuming it is appropriate for site-specific facility conditions. Mr. Davis also recommends the Fuzzy Filter® system to his industry peers.

SYSTEM BENEFITS

The District wastewater treatment plant is located in the Feather Watershed, "the water supply breadbasket for municipal and agricultural uses in central and southern California" (Sacramento River Watershed Program, 2012). The Feather River runs through the watershed from its headwaters in the Sierra Nevada downstream to the Sacramento River confluence. It is divided into an upper watershed and lower watershed by the 3.5 million-acre-foot Oroville Reservoir (the keystone of the State Water Project). In the lower watershed, the Feather River meanders through lush valley agricultural lands dominated by orchards, rice and other irrigated row crops. Yuba City and Marysville are the rapidly expanding, major urban centers in the watershed area.

The Lower Feather River is 303(d) listed as water quality–impaired from mercury, polychlorinated biphenyls (PCBs) and agricultural chemicals. Important management issues in the watershed are protection and improvement of aquatic habitat conditions required for propagation of salmon and steelhead that migrate through the Lower Feather River, and riparian habitat along the river corridor that supports a variety of important wildlife species.

The upgrade to the District's wastewater treatment facility benefits the Lower Feather River watershed. With the upgrade, the effluent discharges to the river are lower in ammonia, nitrogen, biochemical oxygen demand, coliform and suspended solids (including many metal and organic constituents). Without ARRA funding, the upgrade with Fuzzy Filter® might not have happened. According to Mr. Davis, the District "might have gone back to the Regional Control Board and renegotiated the NPDES permit limits; so it is fair to say the filters would not have been purchased without ARRA funding."

DRAWBACKS OF ARRA FUNDING

The Buy American provision was a "significant headache" and caused scheduling delays. According to Mr. Davis, a specialty industry like wastewater treatment does not produce everything locally; therefore, many suppliers had to rush to the United States to open production here to meet the Buy American requirements. Also, the District had to order alternative products.

According to Mr. Davis, the Davis Bacon provision was an unnecessary duplication of the "prevailing wage" California statute. Compared to the California prevailing wage statute, only one Davis Bacon classification was higher (i.e., paid a higher wage than required under the California law). Although the Davis Bacon provision did not slow down the process, the impact cost the County money it did not need to spend.

IMPACT OF ARRA FUNDING

ARRA funding made the necessary upgrades to the District wastewater treatment plant a reality. Without ARRA funding, the District would not have started construction in 2009 because a funding source was not available. Also, due to the economic downturn, the District asked Kennedy/Jenks to reduce the scope of the original design. Significant changes occurred, but none related to the Fuzzy Filter®. The ARRA funding allowed the District to keep the original Fuzzy Filter® size while cutbacks occurred elsewhere.

SUMMARY

ARRA funding made the purchase of the Fuzzy Filter® and other upgrades to the District wastewater facility a reality. The Fuzzy Filter® is successfully reducing suspended solids to low levels in the facility's wastewater discharge, exceeding the reductions needed to comply with upcoming stringent NPDES permit limits. The green infrastructure benefits include improvements in stream water quality (i.e., reduced suspended solid levels discharged to the Lower Feather River), significant space savings (i.e., small footprint), and energy savings (i.e., reduced electricity consumption). The District is very satisfied with the performance of the Fuzzy Filter® and recommends it to its industry peers.

V. REFERENCES

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APPENDIX 6: HYBAS^{TM} INTEGRATED FIXED-FILM ACTIVATED SLUDGE SYSTEM CASE STUDY

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SUMMARY

Under a work assignment issued by the EPA Office of the Chief Financial Officer (OCFO), SAIC is gathering information regarding new or expanded industries or markets that were fostered as a result of ARRA spending. SAIC screened the Office of Water databases for drinking water and clean water projects to identify technologies considered innovative. In consultation with the EPA Office of Water, SAIC selected five clean water technologies for case studies: reactive filtration, high-gradient magnetic separation, integrated fixed-film activated sludge systems, compressible media filtration, and Class “B” residuals treatment. SAIC identified a sixth clean water technology, the SAFL Baffle hydrodynamic separator, as part of a stormwater project implemented under the Brownfields Program.

This case study focuses on the use of the HYBAS™ integrated fixed-film activated sludge technology by the Town of Georgetown, Colorado (Georgetown), the recipient of the ARRA funding. For this report, SAIC obtained information both from Frachetti Engineering Incorporated (FEI), Georgetown’s engineering design and construction contractor, and I. Kruger, Inc. (Kruger), the manufacturer of the innovative technology.

Georgetown purchased a HYBAS™ integrated fixed-film activated sludge system as part of its wastewater treatment facility upgrade to meet new stringent National Pollutant Discharge Elimination System (NPDES) permit limits. The innovative HYBAS™ integrated fixed-film activated sludge system combines conventional activated sludge and fixed-film technologies to enhance biological nutrient removal in wastewater effluent. Georgetown received ARRA funding to assist in the purchase of the HYBAS™ system and other upgrades for its wastewater and water treatment facilities. Kruger manufactures the HYBAS™ system. Kruger is a wholly owned subsidiary of Veolia Water Solutions and Technology, a large public company. Kruger is headquartered in North Carolina and is solely focused on the U.S. water market.

The ARRA-funded Georgetown project provided Kruger with the opportunity to install the HYBAS™ system. In addition, ARRA funding provided Kruger with the opportunity to install quite a few of its other advanced/innovative technologies on other ARRA-funded projects. ARRA funding significantly affected product sales and led to minor improvements in some of its products. The Buy American provision provided the incentive for Kruger to make a permanent change from offshore to onshore material sourcing.

ARRA funding made the purchase of the HYBAS™ integrated fixed-film activated sludge system and other upgrades to the Georgetown wastewater facility a reality. Kruger’s HYBAS™ system is successfully reducing nutrient levels to low levels in the facility’s wastewater discharge, exceeding the nutrient reductions needed to comply with upcoming stringent NPDES permit limits. The green infrastructure benefits include improvements in stream water quality (i.e., reduced nutrient levels discharged to Upper Clear Creek), reduction in waste products (i.e., less sludge production), and energy savings (i.e., reduced electricity consumption). Georgetown is very satisfied with the performance of the HYBAS™ system and recommends it to its industry peers.

CASE STUDY OF INTEGRATED FIXED-FILM ACTIVATED SLUDGE TECHNOLOGY IN WASTEWATER SYSTEMS

This document presents the case study conducted by SAIC. Section 1 contains a brief description of the project. Section 2 describes the integrated fixed-film activated sludge technology including its innovative aspects and benefits. Section 3 presents information and lessons learned from the technology vendor I. Kruger, Inc. (Kruger), and Section 4 presents information and lessons learned from the funding recipient's engineering design and construction services consultant to the utility industry (Frachetti Engineering, Inc. or FEI).

I. PROJECT DESCRIPTION

The Town of Georgetown (Georgetown) purchased a HYBAS™ integrated fixed-film activated sludge (IFAS) system as part of its wastewater treatment facility upgrade to meet new stringent National Pollutant Discharge Elimination System (NPDES) permit limits. The innovative HYBAS™ system combines conventional activated sludge and fixed-film technologies to enhance biological nutrient removal in wastewater effluent. Georgetown received ARRA funding to assist in the purchase of the HYBAS™ system and other upgrades for its wastewater and water treatment facilities. I. Kruger, Inc. (Kruger) manufactures the HYBAS™ system. Kruger is a wholly owned subsidiary of Veolia Water Solutions and Technology, a large public company that is headquartered in North Carolina and is solely focused on the U.S. water market.

Georgetown is located in Clear Creek County, Colorado. The town sits at an elevation of 8,530 feet, nestled in the mountains west of Denver. It encompasses a total area of 1.0 square mile with a population of 1,034 people (U.S. Census Bureau, 2010). The town experienced its greatest growth and prosperity during the Colorado silver boom of the 1880s. Today, Georgetown is a National Historic Landmark District and was named a Preserve America Community by former First Lady Laura Bush.

With the help of ARRA-funded Clean Water State Revolving funds, Georgetown expanded its wastewater treatment facility capacity by almost 40 percent. The HYBAS™ system is one of several updated facility features, including a new continuous upflow sand filtration system, replacement of a secondary clarifier, construction of new biosolids storage tanks, and addition of septage receiving facilities. To fund the upgrades to the wastewater facility, as well as the water processing facility, Georgetown was awarded a total of $9.2 million in ARRA loans, consisting of $5 million in 0 percent interest loans and $4 million in principal forgiveness. This loan amount represents the second-largest ARRA award in the State of Colorado and the largest principal forgiveness awarded to a single Colorado community.

II. INTEGRATED FIXED-FILM ACTIVATED SLUDGE TECHNOLOGY

INTRODUCTION

The IFAS technology is an advanced biological nutrient removal process. It is not a new technology; however, recent design innovations have improved its effectiveness. In the following sections, an explanation of the technology is presented along with its innovative aspects and benefits.

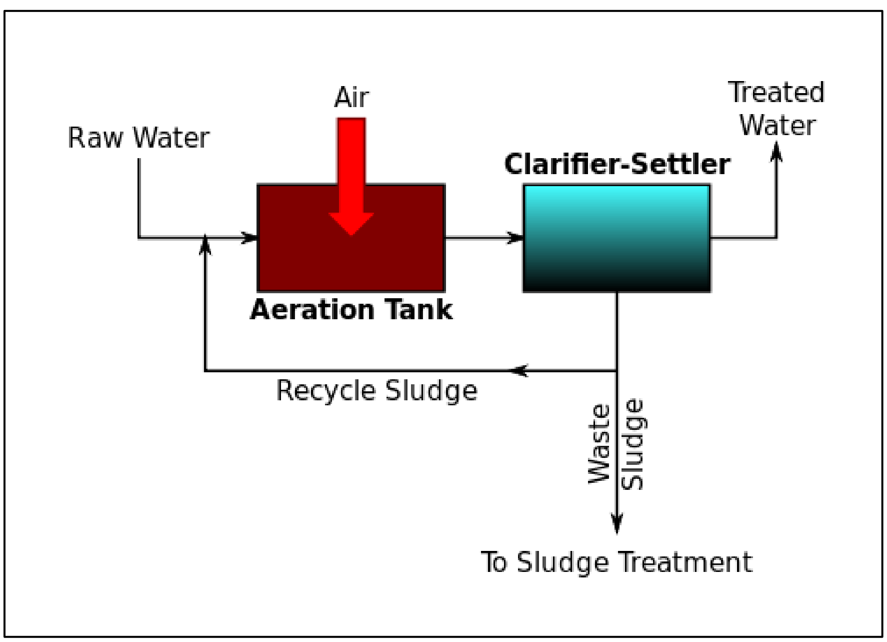
THE CONVENTIONAL ACTIVATED SLUDGE PROCESS

In accordance with the Clean Water Act, all municipal wastewater treatment plants in the country must provide secondary treatment at a minimum. Raw wastewater entering a wastewater treatment plant passes through secondary treatment after solids have been removed in the preliminary and primary treatment steps. Secondary treatment removes up to 90 percent of the organic matter in wastewater using biological treatment methods.

The activated sludge process is a conventional biological treatment method that is commonly used to achieve secondary treatment. The activated sludge process removes organic matter from wastewater by saturating it with air and microorganisms (i.e., aerobic bacteria and other small organisms). The microorganisms consume the organic matter in the wastewater, turning it into new bacterial cells, carbon dioxide and other solid by-products. The addition of oxygen to the wastewater is essential to the process, causing masses of microorganisms to live, grow, multiply and rapidly metabolize the organic pollutants. The biomass produced by the growth of microorganisms in the aerated wastewater is called 'activated sludge.' The term 'activated' is used because the particles (sludge) that settle out of the process are teeming with microorganisms.

The activated sludge process uses an aeration tank and a sedimentation tank (secondary clarifier) as shown in Figure 1. In the aeration tank, the wastewater is vigorously mixed with air and microorganisms in suspension for several hours to remove the organic matter. From the aeration tank, the treated wastewater flows to a sedimentation tank, where the excess microbial growth (biomass) is removed by settling. At this point, some of the biomass is recycled to the head end of the aeration tank, while the remainder is "wasted" from the system. The waste biomass and settled solids are treated before disposal or reuse as biosolids.

FIGURE 1. A GENERALIZED SCHEMATIC OF THE ACTIVATED SLUDGE PROCESS.



Source: Beychok (1967)

HOW THE INTEGRATED FIXED-FILM ACTIVATED SLUDGE TECHNOLOGY WORKS

IFAS systems combine two processes: fixed-film and activated sludge. In the fixed-film process, microorganisms grow on the surface of a mobile or fixed media that is added to the activated sludge process in the aeration tank. The mobile media are objects dispersed in the aeration tank. The fixed media are objects fixed-in-place in the aeration tank. Wastewater passes over the media along with air to provide oxygen. The microorganisms grow and multiply, forming a microbial growth or slime layer (biomass) on the mobile or fixed media in the tank. The addition of mobile or fixed media to the activated sludge tank increases the biomass in the system without increasing the footprint of the aeration tank to achieve higher rates of degradation.

IFAS systems use a variety of media materials. Mobile-media systems use porous sponges or plastic finned-cylinder shapes that are suspended or float (depending upon material density) in the activated sludge tank. Fixed-media systems use either flexible fabric media or polyvinyl chloride structured-sheet media. The flexible fabric materials are typically attached to rigid frames that are placed within the activated sludge tank. The media provides a large protected surface area for the biofilm and optimal conditions for biological activity when suspended in water. Media of different shapes and sizes are available to optimize treatment based on site-specific wastewater characteristics, discharge standards and available volumes.

Municipalities use the IFAS technology for both new construction and plant upgrades. In new plant design, IFAS requires smaller tanks than conventional activated sludge systems that are designed to incorporate fixed or mobile media, and in some cases additional auxiliary screens. In plant upgrades (retrofit applications), the existing aeration capacity and tank sizes are evaluated to determine if they can accommodate the fixed or mobile media systems.

NEW AND INNOVATIVE ASPECTS OF INTEGRATED FIXED-FILM ACTIVATED SLUDGE TECHNOLOGY

IFAS is an innovative use of the conventional activated sludge and fixed-film technologies. Two engineers discovered the activated sludge process in 1913 while conducting research at the Davyhulme Sewage Works in the United Kingdom (Beychok, 1967). The engineers produced highly treated effluent in a ’draw-and-fill‘ reactor, the precursor to the sequencing batch reactor. In the 1950s, the wastewater industry used fixed-film media for the first time in the ’contact aeration‘ process, which was a biological treatment process that used aeration (similar to the activated sludge processthat did not have return sludge capability. In the following decades, hundreds of installations employing fixed-film media were introduced internationally, although relatively little work was done in the U.S.

The innovation aspect of IFAS is combining the two conventional processes to create a new and improved process. Work on the integration of the fixed-film and activated sludge technologies began in the U.S. during the 1990s. The wastewater industry developed an interest in combining the technologies to address increasingly stringent effluent requirements, high cost of tank expansion and reduced funding options. Over the last 20 years, private companies have developed a variety of mobile-media IFAS products (e.g., AGAR®, Captor® and LINPOR®) and fixed-media IFAS products (e.g., CLEARTEC®, AccuWeb®, BioMatrix™, Hybas™, BioWeb™ and Ringlace®). Despite the prolonged period of development, EPA guidance on emerging technologies for wastewater treatment categorizes the IFAS technology's state of development as 'innovative," indicating adoption is progressing at a slow pace (EPA, 2008).

BENEFITS OF THE INTEGRATED FIXED-FILM ACTIVATED SLUDGE TECHNOLOGY

IFAS technology is an attractive solution for wastewater municipalities requiring additional treatment capacity or increased biological nutrient removal. It allows more rapid treatment in the same footprint without additional aeration basins. It adds stability (i.e., resistance to organic and hydraulic shock loadings) and produces a treated effluent quality equal to or better than the conventional activated-sludge process (Brentwood, 2012). Specifically, the IFAS technology has six process benefits, described below.

Enhanced Nitrification

The fixed biomass increases the volume of microorganisms in the tank, promoting better nitrification compared to conventional activated sludge systems. During cold weather and where lower compliance limits are imposed, the added biomass improves the performance of nitrifying plants, or even allows non-nitrifying plants to nitrify. Recent research indicates that autotrophic bacteria tend to grow more readily on fixed-film surfaces than in a suspended growth environment.

Resistance to Organic and Hydraulic Shock Loads

Biomass populations in IFAS aeration tanks are not susceptible to washout during hydraulic surges as they are in conventional activated sludge systems because they are fixed in place. Additionally, the fixed biomass acts as a source of seeding to help return the system to normal operations quickly after such a surge. System nitrification is also restored faster because a large mass of nitrifying bacteria is retained on the fixed-film. The fixed-film component continues to provide treatment while the suspended solids inventory in the wastewater/activated sludge mixture is rebuilding. This can mitigate or prevent permit excursions, depending upon the amount of fixed-film biomass in the system. The depth of biomass provided on fixed film also resists organic shocks better than suspended biomass in conventional activated sludge systems.

Improved Process Stability

By increasing the microorganism population with the fixed-film component for a given organic matter (food) loading, the food to microorganism (F/M) ratio is lowered. Alternatively, loadings may be increased while maintaining F/M ratios. Typically, lower F/M systems are more stable than higher F/M systems.

Improved Sludge Volume Index

The Sludge Volume Index (SVI) improves and has less variation when IFAS upgrades are implemented. The SVI is the volume of settled sludge in milliliters occupied by 1-gram of dry sludge solids after 30 minutes of settling in a 1000-milliliter graduated cylinder. The continual sloughing of the fixed-film component into the suspended growth environment is the key to this characteristic. Reductions in SVI values of 25 to 40 percent have been reported in the literature. Improved SVI values allow for a more concentrated return activated sludge, thereby reducing the return sludge flow requirements, saving power and improving process control.

Higher Suspended Solids in Wastewater/Activated Sludge Mixture without Higher Clarifier Loading

IFAS systems increase the suspended solids in an aeration tank by as much as 3000 mg/L. The additional biomass offsets the need for additional aeration tank capacity. IFAS systems are designed to specifically 'off-load' clarifiers by shifting an appropriate portion of the bacterial population to the fixed film. This is particularly effective in applications with limitation on the clarifier solids loading, which often limits the suspended solids wastewater/activated sludge mixture content of the aeration basins.

Reduced Sludge Production

IFAS systems reduce sludge production. Studies indicate that reduction in sludge production or wasting rates is expected when F/M ratios are reduced, or the waste sludge solids concentration is higher.

THE HYBAS™ IFAS TECHNOLOGY

The IFAS product purchased by Georgetown is called HYBAS™, which stands for Hybrid Biofilm Activated Sludge. In the HYBAS™ system, the aeration tank (called a reactor) contains both free-floating biomass (activated sludge flocs) and biomass attached to fixed media. The free-floating biomass passes through the reactor, is settled in a sedimentation tank, and then is recycled back to the reactor. The fixed media and attached biofilm remain in the reactor.

The HYBAS™ fixed media system is designed to provide a large protected surface area for the biofilm and optimal conditions for biological activity when suspended in water. The media are made from polyethylene and have a density slightly less than water. They do not require backwashing or cleaning. The media are retained within the reactor using stainless steel retention screens. A medium bubble aeration system generates air that passes through the media within the HYBAS™ reactor to supply oxygen to the microorganisms in the biofilm.

The HYBAS™ system is ideal in upgrading municipal treatment plants for nutrient removal. The process uses existing tankage for either maintaining nitrification at new higher flow rates or loads or upgrading a plant to meet new nitrification requirements. The HYBAS™ system includes the media, screen assemblies (to keep media in each reactor), medium bubble aeration grid assemblies, submersible mixers, and if required, instrumentation and controls.

III. VENDOR-PROVIDED INFORMATION

INTRODUCTION

Kruger is the vendor of the innovative HYBAS™ system described in this case study. Kruger is a wholly owned subsidiary of Veolia Water Solutions and Technology, a large public company with 135 business units around the world. Kruger is headquartered in North Carolina and is solely focused on the U.S. water market. It sells advanced/innovative water and wastewater treatment technologies to industrial companies and municipalities. In the biological treatment technology area, Kruger sells approximately 10 to 15 products including the AnoxKaldnes™ moving bed biofilm reactor, ANITA™ Anammox process, BIOSTYR™ biological aerated filter, NEOSEP™ immersed membrane bioreactor system and OASES™ high purity oxygen system.

INTERVIEW WITH MR. BRIAN FREWERD

In November 2012, Mr. Brian Frewerd, Vice President of Strategic Planning for Kruger, provided his perspective on how ARRA funding affected product and business development. Mr. Frewerd also provided responses to questions concerning the impact of ARRA-funding on the company's business operation and product sales.

OPPORTUNITY PROVIDED BY ARRA-FUNDED PROJECTS

The ARRA-funded Georgetown project provided Kruger with the opportunity to install the HYBAS™ system as one of its wastewater treatment facility upgrades. The HYBAS™ technology is a unique technology that has not been widely adopted. Although the technology was developed decades ago, only 20 systems have been installed to date. It is well suited to facilities upgrading within an existing footprint, and also to facilities located in cold climates, where it is difficult to achieve good nitrification.

Quite a few ARRA-funded projects received technologies supplied by Kruger. Mr. Frewerd did not have data readily available to discuss the specific number of projects and types of technologies requested; however, he mentioned that Kruger supplied a variety of technologies to funding recipients. There were not a significant number of requests for any one particular technology (i.e., no focal point technology), and the requests were from municipalities located across the United States (i.e., not concentrated in a particular region).

EFFECTS OF ARRA FUNDING ON PRODUCT AND COMPANY DEVELOPMENT

ARRA funding did not change market diffusion strategies or have a measurable impact on local or national markets for the IFAS technology. At the time ARRA funding was announced, many of the projects were either under contract or under construction because there is typically a two-year lead time prior to the bidding process. In other words, the ARRA-funded projects were already in the pipeline. The arrival of ARRA funding accelerated the schedule on some projects, but it did not create new project opportunities.

ARRA-funded projects led to improvements in some of Kruger's advanced biological treatment products; however, the modifications were not substantial.

EFFECTS OF ARRA FUNDING ON PRODUCT SALES

ARRA funding significantly affected product sales. In 2009 and 2010, Kruger saw a large increase in product sales. Unfortunately, the surge in product sales was not sustained; with 2011 being Kruger's worst sales year on record. Mr. Frewerd explained that its projects got moved up and there were not any projects to follow them (i.e., the pipeline was accelerated and emptied). Without ARRA funding, Mr. Freward believes sales would have been slower in both 2009 and 2010 due to the recession. In 2011, the continuing municipal fiscal crisis and an empty pipeline combined to create a very slow sales year. At this point, Mr. Freward believes sales have bottomed out and some recovery is occurring.

EFFECTS OF ARRA FUNDING ON BUSINESS OPERATION

Kruger made a permanent change from offshore to onshore sourcing. Kruger does not have a production facility. It outsources the fabrication of the HYBAS™ system to a third party in the United States; however, in 2009 not all of the system components were manufactured onshore. For example, the plastic media was mass-produced in Korea. To comply with the Buy American provision, Kruger had to find a fabricator in the United States to replace its offshore plastic media source. The change to onshore sourcing was difficult, time-consuming and expensive (i.e., time spent to find a fabricator, establish quality assurance/quality control procedures and validate the manufacturer), but Kruger knew it needed to be done and the process did not delay the project. Kruger made the change to onshore sourcing permanent because they found it easier to control product quality from its headquarters in North Carolina and it lowered shipping costs. Kruger's HYBAS™ system is now a 100 percent U.S. product with components manufactured in Wisconsin, Pennsylvania, Alabama and New Jersey. Today Kruger realizes the long-term benefits of onshore sourcing and has switched to onshore sourcing for all of its technology needs.

FUTURE BENEFITS FROM ARRA FUNDING

The ARRA-funded project will most likely create new customers for Kruger. The Georgetown project gave Kruger the opportunity to successfully demonstrate the effectiveness of its HYBAS™ system. Mr. Frewerd noted that a successful installation helps build your reputation and helps others envision how the technology can be used in their application, which leads to new customers. A successful installation also creates marketing exposure. Kruger's successful installation of the HYBAS™ system at the Georgetown wastewater facility was widely discussed in wastewater industry publications and conferences due to the project's award-winning status (FEI received recognition through two American Council of Engineering Companies (ACEC) awards for the Georgetown facility.) The municipality's discussion of the project with its industry peers also provided Kruger with 'word of mouth' marketing exposure.

SUMMARY

The ARRA-funded Georgetown project provided Kruger with the opportunity to install the HYBAS™ system, an integrated fixed-film activated sludge technology. In addition, ARRA funding provided Kruger with the opportunity to install quite a few of its other advanced/innovative technologies on other ARRA-funded projects. ARRA funding significantly affected product sales and led to minor improvements in some of its products. The Buy American provision provided the incentive for Kruger to make a permanent change from offshore to onshore material sourcing.

IV. FUNDING RECIPIENT-PROVIDED INFORMATION

INTRODUCTION

In 2009, Georgetown's wastewater treatment facility was barely functional (ENR, 2011). Major components were failing at the aged facility, which was constructed in 1967. At the same time, the town's water treatment plant, originally installed in 1964, was in similar condition. Meeting discharge standards was challenging with the failing infrastructure. Financial resources for the necessary upgrades and replacements also posed a significant challenge due to the lack of funding resources available prior to ARRA.

Georgetown dedicated its newly updated wastewater treatment facilities on June 21, 2011. The project expanded the facility capacity by almost 40 percent. The HYBAS™ system is one of several updated facility features. Other updated features include a new continuous up-flow sand filtration system; replacement of a secondary clarifier; construction of new biosolids storage tanks; and the addition of septage receiving facilities.

INTERVIEW WITH MR. ROBERT FRACHETTI

In September 2012, Mr. Robert Frachetti, President of Frachetti Engineering, Inc. (FEI), provided his perspective on the selection and performance of the HYBAS™ integrated fixed-film activated sludge technology. Frachetti Engineering, Inc. is a small consulting business providing engineering design and construction services to the utility industry. Mr. Frachetti and his staff at FEI supported Georgetown in the design and construction of its upgraded wastewater and water treatment facilities. This section summarizes his responses to questions about the technology selection process, system performance and impact of ARRA funding.

SELECTION OF THE HYBAS™ REACTIVE FILTRATION TECHNOLOGY

FEI selected the Georgetown wastewater treatment plant upgrades required to meet the upcoming stringent NPDES permit limits. The new permit lowers the levels of nutrients in the wastewater effluent entering Upper Clear Creek. As a first step, FEI reviewed technologies that provide advanced biological nutrient removal treatment. As part of the process, FEI searched for ’innovative technologies’ in response to the ARRA innovative technology provision. For assistance in identifying technologies considered to be ‘innovative’ by the EPA, FEI referred to the EPA guidance document titled Emerging Technologies for Wastewater Treatment and In-Plant Wet Weather Management (EPA, 2008). Following the review, FEI completed an alternatives evaluation to thoroughly identify the benefits and drawbacks of the available technologies.

FEI selected the innovative HYBAS™ system for two reasons. First, HYBAS™ performs well in cold climates. Georgetown’s cold climate presents a challenge for biological treatment systems because microorganisms are extremely sensitive to temperature. Mr. Frachetti explained that the colder the climate, the slower the microorganisms work. When the microorganisms are working slowly, more are needed to breakdown organic matter in the wastewater and larger tanks are required to house them. Because there is significant cost associated with containing microorganisms, minimizing the tank size is an important consideration and is the second reason FEI selected the HYBAS™ system. Unlike conventional activated sludge processes, the HYBAS™ media retain the microorganisms in the tank. Adding media to the tank also greatly increases the surface area for the microorganisms to grow on, and thus greatly increases the number of organisms within an existing tank footprint. Due to Georgetown’s space constraints, using the existing footprint was an important consideration that the HYBAS™ was designed to achieve.

Kruger did not pilot test the HYBAS™ system. Although a pilot test demonstrates performance and reduces risk, FEI was not overly concerned about the lack of testing in this case. Mr. Frachetti explained that HYBAS™ was invented by Anox-Kaldness, the most experienced premier supplier of the integrated fixed-film activated sludge technology. Anox-Kaldness is a Swedish company with many cold climate

HYBAS™ installations. Although the HYBAS™ system is considered to be innovative, Mr. Frachetti did not consider it to be 'overly' innovative (i.e., having a high potential for failure for the Georgetown project).

SYSTEM PERFORMANCE

The HYBAS™ system is performing well. There were no unforeseen issues during installation. The Georgetown wastewater facility operators collect samples on a monthly basis to demonstrate compliance with the NPDES permit limits. Sampling results indicate the HYBAS™ system is performing well by consistently generating effluent nutrient concentrations well below the permit limits.

FEI and the Georgetown wastewater facility operators are very satisfied with the HYBAS™ system. According to Mr. Frachetti, "The system is doing a great job." FEI would select the HYBAS™ system technology again. FEI would also recommend the HYBAS™ system to industry peers.

SYSTEM BENEFITS

Clear Creek is a key Colorado stream that provides recreation and water supply to downstream agricultural and drinking water users. Its headwaters begin in an area rimmed by four 14,000-foot mountain peaks at the westernmost edge of the east side of the Continental Divide. The main stem flows eastward through several mountain and Colorado Front Range communities before converging with the South Platte River on the plains near Denver. It is the primary water supply source for six upper-watershed towns (including Georgetown) and the principle surface water source for industrial entities (e.g., Coors Brewing Company), agricultural users and reservoirs that provide potable water to more than 350,000 residents.

The upgrade to the City of Georgetown's wastewater treatment facility greatly improved the water quality in Clear Creek. At the top of the watershed, the Georgetown wastewater treatment facility discharges treated wastewater effluent into Upper Clear Creek. In 2009, the town's vintage treatment facility was unable to meet the upcoming stringent NPDES permit limits. The plant needed comprehensive improvements and innovations, but lacked the funding to implement them. The award of ARRA funds greatly benefited the town and the Upper Clear Creek watershed. Georgetown's promise to improve and protect water quality in the Upper Clear Creek Watershed was only made possible because of ARRA funding.

BENEFITS TO SMALL BUSINESS

FEI grew because of its willingness to seize the opportunity provided by ARRA. FEI's client, Georgetown, had a huge need. FEI also had a strong desire to please its client and grow the company. Thus, FEI accepted the challenge of designing the Georgetown wastewater and water treatment facility upgrades despite the severe time constraints imposed by ARRA and as a result FEI was able to hire employees during the economic downturn.

FEI's reputation benefited from the ARRA-funded Georgetown project. FEI received recognition for a job well done through two American Council of Engineering Companies (ACEC) awards. FEI became the ACEC State Engineering Excellence Honor Winner for the Georgetown Wastewater Treatment Systems Improvement Project. In addition, FEI was awarded the ACEC State Engineering Excellence Award for the

Georgetown Water Treatment Systems Improvement Project. FEI has new customers and business opportunities as an added benefit from participating in this ARRA funded project.

IMPACT OF ARRA FUNDING

ARRA funding accelerated the schedule. FEI has never been asked to complete a project in such an incredibly accelerated mode. In Colorado, ARRA-funded projects were required to be 'shovel-ready' by September 30, 2009 (i.e., seven months after President Obama's announcement of the plan). Mr. Frachetti stated, "To pull off as much engineering as we did in that time period and complete the state regulatory review process was nearly impossible." FEI's staff worked 16-hour days every day for three quarters of that year. In his words, it "over stimulated" them.

ARRA funding made the necessary upgrades to the Georgetown wastewater treatment plant a reality. Without ARRA funding, the town would have done nothing in 2009 because a funding source was not available. The existing facility would have operated in a sub-optimal manner until something failed and then the operators would have fixed the failed component of the system (i.e., not the entire system). This phased approach was the town's only option, which was tenuous at best in terms of meeting the upcoming stringent NPDES permit limits. According to Mr. Frachetti, "ARRA funding gave the town the ability to do things right the first time without having to piecemeal the plant together."

SUMMARY

ARRA funding made the purchase of the HYBAS™ system and other upgrades to the Georgetown wastewater facility a reality. Kruger's HYBAS™ system is successfully reducing nutrient levels to low levels in the facility's wastewater discharge, exceeding the nutrient reductions needed to comply with upcoming stringent NPDES permit limits. The green infrastructure benefits include improvements in stream water quality (i.e., reduced nutrient levels discharged to Upper Clear Creek), reduction in waste products (i.e., less sludge production), and energy savings (i.e., reduced electricity consumption). Georgetown is very satisfied with the performance of the HYBAS™ system and recommends it to its industry peers.

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APPENDIX 7: BLUE PRO® REACTIVE FILTRATION CASE STUDY

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SUMMARY

Under a work assignment issued by the EPA Office of the Chief Financial Officer (OCFO), SAIC is gathering information regarding new or expanded industries or markets that were fostered as a result of ARRA spending. SAIC screened the Office of Water databases for drinking water and clean water projects to identify technologies considered innovative. In consultation with the EPA Office of Water, SAIC selected five clean water technologies for case studies: reactive filtration, high-gradient magnetic separation, integrated fixed-film activated sludge systems, compressible media filtration, and Class "B" residuals treatment. SAIC identified a sixth clean water technology, the SAFL Baffle hydrodynamic separator, as part of a stormwater project implemented under the Brownfields Program.

This case study focuses on the use of the reactive filtration technology by the Town of Georgetown (Georgetown), the recipient of the ARRA funding. For this report, SAIC obtained information both from Frachetti Engineering Incorporated (FEI), Georgetown's engineering design and construction contractor, and Blue Water Technologies Incorporated (Blue Water), the manufacturer of the innovative reactive infiltration technology.

Georgetown purchased a Blue PRO® reactive filtration plant as part of its wastewater treatment facility upgrade to meet upcoming stringent phosphorus and zinc water quality standards. The innovative Blue PRO® reactive filtration technology combines filtration and adsorption technologies to achieve very low levels of phosphorus and metals in wastewater effluent. Georgetown received ARRA funding to assist in the purchase of Blue PRO® reactive filtration plant and other upgrades for its wastewater and water treatment facilities. Blue Water manufactures the Blue PRO technology. Blue Water is a small, privately held company headquartered in Hayden, Idaho.

The ARRA-funded Georgetown project provided Blue Water with the opportunity to install for the first time a Blue PRO® plant designed to remove metals from the wastewater, as well as phosphorus. Because the first installation is always the hardest to secure, the ARRA-funded Georgetown project played a significant role in helping Blue Water launch the Blue PRO® technology into the metals removal portion of the reactive filter technology business sector. Blue Water has also benefited from the additional product exposure afforded by the ARRA-funded Georgetown project, which is helping the company expand into foreign markets, as well as nationally.

ARRA funding made the purchase of the Blue PRO® technology and other upgrades to the Georgetown wastewater facility a reality. Blue Water's Blue PRO® technology is successfully reducing phosphorus and zinc levels in the facility's' wastewater discharge to levels that exceed the upcoming stringent water quality standards. The green infrastructure benefits include improvements in stream water quality (i.e. reduced zinc and phosphorus levels discharged to Clear Creek), lower chemical use (i.e., 30 percent less than used by other technologies), and energy savings (i.e., reduced electricity consumption). Georgetown plant operators are very satisfied with the performance of the Blue PRO® technology and will recommend it to their industry peers.

CASE STUDY OF REACTIVE FILTRATION TECHNOLOGY IN WASTEWATER SYSTEMS

This document presents the case study conducted by SAIC. Section 1 contains a brief description of the project. Section 2 describes the reactive filtration technology including its innovative aspects and benefits. Section 3 presents information and lessons learned from the technology vendor Blue Water Technologies, Inc, (Blue Water), and Section 4 presents information and lessons learned from the funding recipient's engineering design and construction services consultant to the utility industry (Frachetti Engineering, Inc. or FEI).

I. PROJECT DESCRIPTION

The Town of Georgetown (Georgetown) purchased a Blue PRO® reactive filtration plant as part of its wastewater treatment facility upgrade to meet new stringent phosphorus and zinc water quality standards. The innovative Blue PRO® reactive filtration technology combines filtration and adsorption technologies to achieve very low levels of phosphorus and metals in wastewater effluent. Georgetown received ARRA funding to assist in the purchase of Blue PRO® reactive filtration plant and other upgrades for its wastewater and water treatment facilities. Blue Water, a small, privately held company headquartered in Hayden, Idaho, manufactures the Blue PRO technology. .

Georgetown is located in Clear Creek County, Colorado. The town sits at an elevation of 8,530 feet nestled in the mountains west of Denver. It encompasses a total area of 1.0 square mile with a population of 1,034 people (United States Census Bureau, 2010). The town experienced its greatest growth and prosperity during the Colorado silver boom of the 1880s. Today Georgetown is a National Historic Landmark District and was named a Preserve America Community by former First Lady Laura Bush.

In 2009, Georgetown's wastewater treatment facility was barely functional (ENR, 2011). Major components were failing at the aged facility, which was constructed in 1967. At the same time, the town's water treatment plant, originally installed in 1964, was in similar condition. Meeting discharge standards was challenging with the failing infrastructure. Financial resources for the necessary upgrades and replacements also posed a significant challenge due to the lack of funding resources available prior to ARRA.

With the help of ARRA-funded Clean Water State Revolving funds, Georgetown expanded its wastewater treatment facility capacity by almost 40 percent. The Blue PRO® reactive filtration is one of several new facility features, including an upgrade to an integrated fixed film activated sludge process; replacement of a secondary clarifier; construction of new biosolids storage tanks; and addition of septage receiving facilities. To fund the upgrades to the wastewater facility, as well as the water processing facility, Georgetown was awarded a total of $9.2 million in ARRA loans, consisting of $5 million in zero percent interest loans and $4 million in principal forgiveness. This loan amount represents the second-largest ARRA award in the State of Colorado and the largest principal forgiveness awarded to a single Colorado community.

II. REACTIVE FILTRATION TECHNOLOGY

INTRODUCTION

The reactive filtration technology removes phosphorus from wastewater. It is not a new technology; however, recent design innovations have improved its effectiveness. The following sections present an explanation of the technology along with its innovative aspects and benefits.

PHOSPHORUS REMOVAL FROM WASTEWATER EFFLUENT

Wastewater treatment utilizes one or more of the following processes: preliminary, primary, secondary, and advanced (also known as tertiary treatment). Wastewater passes through the processes sequentially starting with preliminary treatment, which removes grit and screens out large debris. Next is primary treatment, which removes solids in the wastewater using gravity-settling tanks. Adding chemicals to the settling tanks is a common practice to enhance performance by precipitating phosphorus and capturing and flocculating smaller solid particles. Secondary treatment follows primary treatment with the removal of colloidal and soluble organic matter by biological processes. Effluent disinfection is often included in the secondary treatment process.

As an additional step, the wastewater often passes through an advanced wastewater treatment (AWT) process, which is classified by EPA as "a level of treatment that is more stringent than secondary or produces a significant reduction in conventional, non-conventional, or toxic pollutants present in the wastewater" (USEPA, 2009). Typically, chemical addition, biological treatment and/or filtration are used to consistently and reliably meet standard AWT limits for nutrient removal.

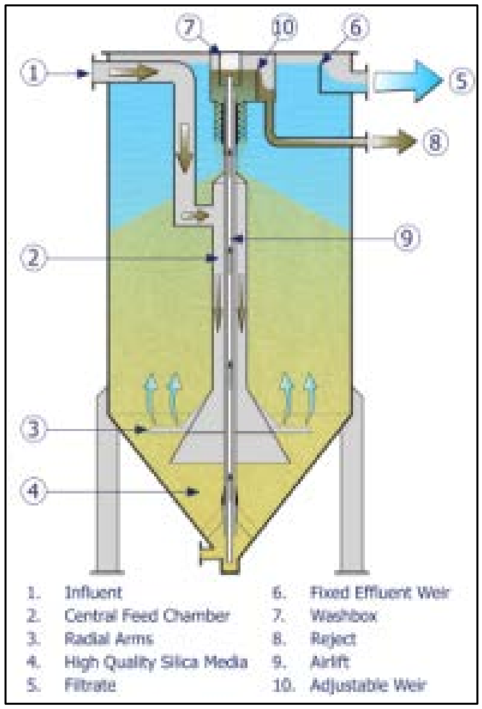
In accordance with the Clean Water Act (CWA), all municipal wastewater treatment plants in the country must provide secondary treatment at a minimum. However, approximately 44 percent of the municipal WWTPs go beyond the minimum requirement and provide some kind of AWT (USEPA, 2009). This percentage is on the rise because federal and state regulations related to water quality standards and total maximum daily loads are driving down wastewater effluent limits. These lower limits are increasingly becoming so low for nutrient removal that conventional AWT processes cannot reliably meet them, creating a need for innovative approaches.

Attaining low effluent limits for phosphorus is a difficult task. Residual total phosphorus (TP) in wastewater effluent is made up of orthophosphates and refractive dissolved organic phosphorus (rDON). rDON is the dominant phosphorus fraction in the effluent, with most contributions supplied from industrial sources and household wastewater. Unfortunately, little is known about the species that make up rDON, which makes removal challenging. One study determined that rDON only showed signs of removal with adsorption media processes (Liu et al. 2011). Despite this claim and other challenges, innovative approaches have been developed and are in use to achieve reliable compliance with low phosphorus effluent limits. One approach is the Blue PRO® technology.

HOW THE BLUE PRO® INNOVATIVE REACTIVE FILTRATION TECHNOLOGY WORKS

The Blue PRO® technology uses reactive filter media to reduce the level of phosphorus and other contaminants in wastewater effluent. Reactive filter media is any filter media with the additional capability of removing contaminants from wastewater through chemical processes such as adsorption (Figure 1). In the Blue PRO® process, the reactive filter media are sand coated with hydrous ferric oxide (HFO). The HFO coating is unusually adsorbent, taking phosphorus and other pollutants out of solution as wastewater flows through the media.

FIGURE 1. SCHEMATIC OF BLUE PRO FILTER PROCESS

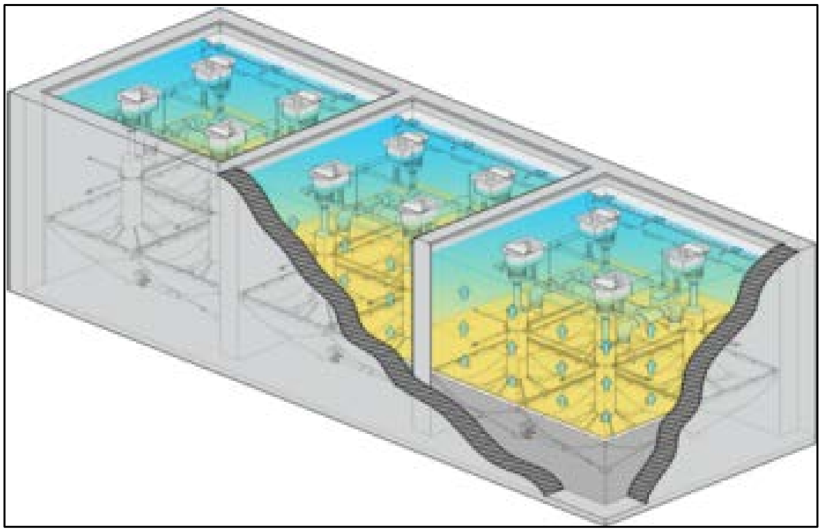


Source: http://www.blueh2o.net/products/bluepro.html

The Blue PRO® process uses a continuous backwashing filter process . During operation, wastewater and HFO enter the sand bed vessel through a central feed chamber. The wastewater and HFO solution is released into the vessel near its bottom where a set of radial arms evenly distributes it into the media bed. The wastewater flows upward through the sand bed. Phosphorus and other contaminants are retained in the media and adsorbed onto the HFO coating during this process. The purified filtrate fills the headspace above the media bed, flows over a fixed effluent weir at the top of the filter, and then flows out of the vessel. At the same time, the sand and trapped solids are drawn downward to the bottom center of the vessel and pulled by suction into an airlift pipe. As the sand travels up the airlift pipe, high-energy turbulence from the air scours the particles and separates the sand from the filtered solids before discharge into the washbox. The washbox is a baffled chamber where counter-current washing and gravity separate the filter media and lighter captured solids. The clean sand settles back onto the top of the filter bed and the solids are carried away into a reject line. The added HFO aids in coagulation and replaces the ferric coating that is abraded from the sand.

Blue PRO® technology can be installed above ground or below ground. Above ground circular filter vessels are available in either fiberglass reinforced plastic or stainless steel. Below ground, Blue PRO® technology is installed in rectangular concrete basins (see Figure 2).

FIGURE 2. BELOW GROUND INSTALLATION OF BLUE PRO® TECHNOLOGY



Source: http://www.blueh2o.net/products/tertiary.html

NEW AND INNOVATIVE ASPECTS OF THE BLUE PRO® TECHNOLOGY

The Blue PRO® process uses an innovative approach to chemical dosing. Its reactive filtration process overcomes a critical obstacle to achieving efficient phosphorus removal in bulk aqueous solutions by providing reactive surface sites within the media bed, resulting in forced contact of chemical species with high adsorptive capacity. As discussed above, the adsorptive reactive surface is a continuously regenerated HFO coating that forms on the sand media. The conventional processes, coagulation followed by filtration, cannot compare to the efficiency of adsorptive phosphorus removal (Blue Water Technologies, 2012). The reactive filtration was awarded a United States Patent in 2010 (Moller, 2010).

A recent innovation to the process is the addition of advanced oxidants for nitrogen removal. Because many plants requiring phosphorus mitigation also require nitrogen control, Blue Water has added the option to simultaneously denitrify in the same vessel. With slight modifications, Blue Water can provide a unique and efficient system for total nutrient reduction (Blue Water Technologies, 2012).

BENEFITS OF THE BLUE PRO® TECHNOLOGY

Blue PRO® technology is designed to meet low phosphorus permit limits in an efficient and cost-effective manner (Blue Water Technologies, 2012). The advantages of the process are:

- Simple operation and low chemical use.
- Low capital and operating and maintenance (O&M) costs.
- Continuous flow – no interruption for backwash or changing media.
- Modular design easily handles capacity increases.

Blue PRO® technology can meet permit limits as low as 0.05 milligram per litter (mg/L) with a chemical dose of only 10 mg/L as iron. This chemical dose is 30 percent less than the dose requirement of other technologies. No other chemical dosing is required in the plant to achieve the low phosphorus discharge requirements. This lower rate of chemical dose also has the advantage of lower sludge production.

Blue PRO® technology has low O&M costs because there are no mechanical moving parts in the process. The design uses gravity feed flow; therefore pumps, valves and complex control systems are not needed. The only operating cost is the air consumption of the airlift, which consumes between 1 and 3 cubic feet per minute at 40 pounds per square inch.

Blue PRO® technology is designed to maximize performance with continuous flow. The continuous backwashing filter process operates without interruptions for cleaning. In addition, the waste FHO helps with odor control and can reduce water content in biosolids.

Blue PRO® technology's module design makes system expansion possible with minimal effort. Its chemical control system can seamlessly integrate into an existing wastewater treatment system. It does not require change in the plant's sludge handling system.

III. VENDOR-PROVIDED INFORMATION

INTRODUCTION

Blue Water Technologies, Inc. (Blue Water) is the vendor of the innovative reactive filtration technology described in this case study. Blue Water is a small, privately held company headquartered in Hayden, Idaho. Blue Water's core business is new water treatment technology.

Blue Water was founded in 2003 to commercialize the reactive filtration process. After focusing on research and development, Blue Water completed full scale testing of the reactive filtration technology in 2005. Blue Water moved into full commercialization in 2007 and named its new product Blue PRO®. Blue PRO is an innovative technology that is effective at removing phosphorus, as well as many other contaminants, such as mercury, arsenic, chromium and uranium.

INTERVIEW WITH MR. MARK LOPP

In August 2012, Mr. Lopp, Regional Sales Manager for Blue Water, provided his perspective on how ARRA funding affected product and business development. This section summarizes his responses to questions concerning the impact ARRA funding had on the reactive filter technology business sector.

OPPORTUNITY PROVIDED BY ARRA-FUNDED PROJECTS

Blue Water supplied products for two ARRA-funded projects: the Georgetown WWTP upgrade and a smaller project in Westborough, Massachusetts; however, the Blue PRO® product was only supplied for the Georgetown project. The company supplied a rotating belt filter for the Westborough project, which is a product that Blue Water no longer sells.

The ARRA-funded Georgetown project provided Blue Water with the opportunity to install a Blue PRO® plant designed to remove metals from the wastewater, as well as phosphorus. Georgetown was the first wastewater facility to request metals removal as part of the Blue PRO® process. With this first installation up and running, Blue Water was able to collect operating data to share with its network in the wastewater business. By 'word of mouth,' engineers with similar needs have subsequently become aware of the Blue PRO® technology and contacted Blue Water. Today, Blue Water is working with the City of East Helena, Montana to remove copper, lead, zinc and phosphorus from its wastewater, and also with the Town of International Falls, Minnesota for the removal of mercury and phosphorus. Because the first installation is always the hardest to secure, the ARRA-funded Georgetown project has played a significant role in helping Blue Water launch the Blue PRO® technology into the metals removal portion of the reactive filter technology business sector.

EFFECTS OF ARRA FUNDING ON COMPANY DEVELOPMENT

The Blue PRO® process was originally developed to remove arsenic from drinking water. However, the market demand for arsenic removal dropped late in the product development stage when NPDES discharge limits for arsenic were revised upward from 5 parts per billion (ppb) to 10 ppb. Thus, the focus for the marketing of the Blue PRO® process shifted to take advantage of lower NPDES phosphorus limits required for point sources discharging to the Spokane River. Unfortunately, subsequent litigation prevented the lower limits from being adopted and point source generators are now operating under draft permits, a condition that is projected to continue until 2020. In response to the local lack of demand in phosphorus removal, Blue Water expanded its marketing of Blue PRO® technology's phosphorus removal capability to other areas of the country (e.g. the Chesapeake Bay area). The product exposure provided by the ARRA-funded Georgetown project assisted Blue Water in its marketing efforts.

The ARRA-funded Georgetown project's demonstrated ability to remove both phosphorus and zinc helped Blue Water market Blue PRO® technology internationally. South Korea is a good market for the Blue PRO® process because President Lee Myung-Bak acquired $6 billion of funding in 2010 to make clean water his legacy. To date, one- to two-dozen Blue PRO® plants have been installed in South Korea. These installations are only removing phosphorus; however, according to Mr. Lopp "metals removal is in the back of their minds." Europe is another market that is interested in the Blue PRO® process because of its metals removal capability in addition to phosphorus. Thus, Blue PRO® process' proven metals removal capability, as demonstrated by the Georgetown project, is helping the company expand into foreign markets.

DRAWBACK OF ARRA FUNDING

ARRA funding helped the Georgetown project move forward; however the announcement of ARRA funding also created delays for other projects. According to Mr. Lopp, many 'shovel-ready' projects were already funded at the time ARRA funding was announced, and because project managers wanted to take advantage of the ARRA subsidies, they delayed startup and shifted their attention to the ARRA-funding appropriation process. Additional information about 'shovel-ready' projects that were delayed by the ARRA-funding announcement was not provided.

SUMMARY

The ARRA-funded Georgetown project provided Blue Water with the opportunity to install for the first time a Blue PRO® plant designed to remove metals from wastewater, as well as phosphorus. Because the first installation is always the hardest to secure, the ARRA-funded Georgetown project played a significant role in helping Blue Water launch the Blue PRO® technology into the metals removal portion of the reactive filter technology business sector. Blue Water has also benefited from the additional product exposure afforded by the ARRA-funded Georgetown project, which is helping the company expand into foreign markets, as well as nationally.

IV. FUNDING RECIPIENT-PROVIDED INFORMATION

In September 2012, Mr. Bob Frachetti, President of Frachetti Engineering, Inc. (FEI), provided his perspective on the selection and performance of the Blue PRO® technology. Frachetti Engineering, Inc. is a small consulting business providing engineering design and construction services to the utility industry. Mr. Frachetti and his staff at FEI supported Georgetown in the design and construction of its new wastewater and water treatment facilities. This section summarizes his responses to questions about the technology selection process, system performance and impact of ARRA funding.

SELECTION OF THE REACTIVE FILTRATION TECHNOLOGY

FEI selected the Georgetown wastewater treatment plant upgrades required to meet the upcoming stringent water quality discharge standards. The new standards require removal of phosphorus and zinc to low concentration levels of 0.3 and 0.2 mg/L, respectively. As a first step, FEI reviewed filtration technologies to identify alternatives capable of removing both phosphorus and zinc to the low levels in the same filter. As part of the process, FEI searched for 'innovative technologies' in response to the ARRA innovative technology provision. For assistance in identifying technologies considered to be 'innovative' by the EPA, FEI referred to the EPA guidance document titled *Emerging Technologies for Wastewater Treatment and In-Plant Wet Weather Management* (EPA, 2008).

During the review process, two technologies emerged as viable options: the Parkson Dynasand® filter technology and the Blue PRO® reactive filtration technology. The Parkson Dynasand® filter is an established technology for removal of suspended solids using a continuous upflow granular media filter. Both technologies are continuous upflow granular media filters; however, only Blue PRO® technology adds adsorption capabilities. Following the review, FEI completed an alternatives evaluation to thoroughly identify the benefits and drawbacks of the two technologies.

FEI selected the innovative Blue PRO® technology for two reasons. First, Blue Water volunteered to pilot the reactive filter technology at no cost to the project, whereas Parkson Corporation was not willing to pilot its Dynasand® filter technology. Blue Water's willingness to pilot gave them a large advantage because it took the risk of using an innovative technology out of the equation and provided FEI with accurate design parameters, such as flow and chemical dose rates. During the pilot test, Blue Water optimized the chemistry to suit the site-specific conditions. Following the pilot test, Blue Water provided FEI with a detailed design report including performance data demonstrating the technology's ability to achieve the desired reduction in phosphorus and zinc concentrations. In addition, Blue Water provided a performance guarantee. Thus, Blue Water successfully removed all doubt concerning the use of an innovative technology causing FEI to select an innovative technology over a conventional one.

Second, FEI selected the Blue PRO® reactive filter technology because it was much less expensive than the Parkson Dynasand® filter. Equipment cost was an important discriminator because the budget was tight, even with the receipt of ARRA funding. According to Mr. Frachetti, FEI looked for every opportunity to complete the job efficiently.

SYSTEM PERFORMANCE

The installation of the Blue PRO® technology went well. There were no unforeseen issues, primarily because the pilot testing took the guesswork out of the process.

The Blue PRO® technology is performing well. Blue Water collected an initial round of samples following plant commissioning in the summer of 2011. The sampling results demonstrated compliance with the performance specifications. Blue Water will collect a second round of performance data in October in accordance with specification requirements.

FEI and the Georgetown wastewater facility operators are very satisfied with the Blue PRO® technology. Likewise they are satisfied with Blue Water, which FEI describes as very customer service oriented. According to Mr. Frachetti, "They've done a great job." FEI would select the Blue PRO technology again and would also recommend the Blue PRO® technology to its peers.

SYSTEM BENEFITS

Clear Creek is a key Colorado stream that provides recreation and water supply to downstream agricultural and drinking water users. Its headwaters begin in an area rimmed by four 14,000-foot mountain peaks at the western edge of the Continental Divide. The main stem flows eastward through several mountain and Colorado Front Range communities before converging with the South Platte River on the plains near Denver. It is the primary water supply source for six upper-watershed towns (including Georgetown) and the principle surface water source for industrial entities (e.g., Coors Brewing Company), agricultural users and reservoirs that provide potable water to more than 350,000 residents.

The upgrade to the City of Georgetown's wastewater treatment facility greatly improved the water quality in Clear Creek. At the top of the watershed, the Georgetown wastewater treatment facility discharges treated wastewater effluent into Upper Clear Creek. In 2009, the town's vintage treatment facility was unable to meet the upcoming stringent water quality standards. The plant needed comprehensive improvements and innovations, but lacked the funding to implement them. The award of ARRA funds greatly benefited the town and the Upper Clear Creek watershed. Georgetown's promise to improve and protect water quality in the Upper Clear Creek Watershed was only made possible because of ARRA funding.

BENEFITS TO SMALL BUSINESS

FEI grew because of its willingness to seize the opportunity provided by ARRA. FEI's client, Georgetown, had a huge need. FEI also had a strong desire to please its client and grow the company. Thus, FEI accepted the challenge of designing the Georgetown wastewater and water treatment facility upgrades despite the severe time constraints imposed by the Act and as a result FEI was able to hire employees during the economic downturn.

FEI's reputation benefited from the ARRA-funded Georgetown project. FEI received recognition for a job well done through two American Council of Engineering Companies (ACEC) awards. FEI became the ACEC

State Engineering Excellence Honor Winner for the Georgetown Wastewater Treatment Systems Improvement Project. In addition, FEI was awarded the ACEC State Engineering Excellence Award for the Georgetown Water Treatment Systems Improvement Project. FEI has new customers and business opportunities as an added benefit from participating in this ARRA funded project.

IMPACT OF ARRA FUNDING

ARRA funding accelerated the schedule. FEI has never been asked to complete a project in such an incredibly accelerated mode. In Colorado, ARRA-funded projects were required to be 'shovel-ready' by September 30, 2009 (i.e., seven months after President Obama's announcement of the plan). Mr. Frachetti stated, "To pull off as much engineering as we did in that time period and complete the State regulatory review process was nearly impossible." FEI's staff worked 16-hour days every day for three quarters of that year. In his words, it "over stimulated" them.

ARRA funding made the necessary upgrades to the Georgetown wastewater treatment plant a reality. Without ARRA funding, the town would have done nothing in 2009 because a funding source was not available. The existing facility would have operated in a sub-optimal manner until something failed and then the operators would have fixed the failed component of the system (i.e., not the entire system). This phased approach was the town's only option, which was tenuous at best in terms of meeting the upcoming stringent water quality standards. According to Mr. Frachetti, "ARRA funding gave the town the ability to do things right the first time without having to piecemeal the plant together."

SUMMARY

ARRA funding made the purchase of the Blue PRO® technology and other upgrades to the Georgetown wastewater facility a reality. Blue Water's Blue PRO® technology is successfully reducing phosphorus and zinc levels in the facility's wastewater discharge to levels that exceed the upcoming stringent water quality standards. The green infrastructure benefits include improvements in stream water quality (i.e., reduced zinc and phosphorus levels discharged to Clear Creek), lower chemical use (i.e., 30 percent less than the chemical requirements of other technologies), and energy savings (i.e., reduced electricity consumption). Georgetown plant operators are very satisfied with the performance of the Blue PRO® technology and will recommend it to their industry peers.

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APPENDIX 8: BCR CLEAN B^{TM} SYSTEM CASE STUDY

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SUMMARY

Under a work assignment issued by the EPA Office of the Chief Financial Officer (OCFO), SAIC is gathering information regarding new or expanded industries or markets that were fostered as a result ARRA spending. SAIC screened the Office of Water databases for drinking water and clean water projects to identify technologies considered innovative. In consultation with the EPA Office of Water, SAIC selected five clean water technologies for case studies: reactive filtration, high-gradient magnetic separation, integrated fixed-film activated sludge systems, compressible media filtration, and Class “B” residuals treatment. SAIC identified a sixth clean water technology, the SAFL Baffle hydrodynamic separator, as part of a stormwater project implemented under the Brownfields Program.

This case study focuses on the use of the waste activated sludge residuals treatment technology by the City of Alachua Wastewater Division (Alachua), the recipient of the ARRA funding. For this report, SAIC obtained information both from Alachua and BCR Environmental Corporation (BCR Environmental), the manufacturer of the innovative waste activated sludge residuals treatment technology.

Alachua received ARRA funds to construct a new wastewater treatment facility. To treat its sludge by-product, Alachua selected an innovative waste activated sludge residual treatment technology to incorporate into its new facility. It is referred to as the CleanB™ system. The energy-efficient CleanB™ system creates odorless Class “B” biosolids in less than an hour. BCR Environmental manufactures the CleanB™ system in Jacksonville, Florida.

Alachua built the new facility with innovative and automatic components to reduce operation and maintenance costs. The innovative CleanB™ system is successfully producing biosolids to Class “B” standards for reuse by farmers to amend soil conditions. The green infrastructure benefits of the CleanB™ system include energy savings (i.e., reduced electricity consumption), smaller carbon footprint (i.e. reduction in vehicle use), reduction in waste products (i.e., no landfill disposal), elimination of infrastructure (i.e. digesters, thickeners), odor reduction, and beneficial reuse of sludge. Alachua is satisfied with the performance of the CleanB™ system and routinely recommends it to its industry peers.

BCR Environmental benefited from the installation of the CleanB™ system on the ARRA-funded Alachua project. Alachua was the first municipality to purchase the CleanB™ system. As the initial adopter of the CleanB™ system, the Alachua project expanded the technology’s reference cases, accelerated its rate of adoption and created company growth. However, ARRA funding had a minimal effect on product sales and business operations, according to the vendor. The vendor compiled an extensive utility database, which it uses in targeted marketing. BCR Environmental also offers a range of services including financing to help utilities adopt innovative technologies. The vendor indicated that these strategies contribute to the success of the business and that ARRA funding did not affect sales or operations. Regardless, the ARRA-funded project will most likely create new customers for BCR Environmental.

CASE STUDY OF WASTE ACTIVATED SLUDGE RESIDUALS TREATMENT

This document presents the case study conducted by SAIC. Section 1 contains a brief description of the project. Section 2 describes the waste activated sludge residual treatment technology including its innovative aspects and benefits. Section 3 presents information and lessons learned from the technology vendor BCR Environmental Corporation (BCR Environmental), and Section 4 presents information and lessons learned from the recipient of the ARRA funds (City of Alachua Wastewater Division).

I. PROJECT DESCRIPTION

The City of Alachua Wastewater Division (Alachua) received ARRA funds to construct a new wastewater treatment facility. To treat its sludge by-product, Alachua selected an innovative waste activated sludge residual treatment technology to incorporate into its new facility. It is known as the CleanB™ system. The energy-efficient CleanB™ system creates odorless Class “B” biosolids in less than an hour. BCR Environmental manufactures the CleanB™ system in Jacksonville, Florida.

Alachua is an Indian word meaning “sink” depicting the layout of the land. Located just 13 miles north of Gainesville, Florida, Alachua encompasses a 29-square mile area in Alachua County, home of the University of Florida. It is a small town that is growing. According to the 2010 census, there are over 9,000 residents, an increase of 49 percent during the last decade (U.S. Census Bureau, 2010).

Alachua received $20,550,074 of ARRA funding for the construction of a new 1.5 million gallon per day (MGD) wastewater treatment plant, as distributed by the Clean Water State Revolving Fund (CWSRF). The funding conditions stipulated 50 percent principal forgiveness and a low interest rate on the remaining 50 percent with a 20-year payback schedule. The agreement was executed in June 2009.

II. BCR ENVIRONMENTAL CLEANB™ BIOSOLIDS TECHNOLOGY

INTRODUCTION

The CleanB™ system stabilizes biosolids to meet Class “B” standards. It uses an innovative approach that is fast, odorless, energy efficient and cost effective. The following sections discuss traditional wastewater process methods, EPA biosolids regulations and the CleanB™ system process including its innovative aspects and benefits.

TRADITIONAL WASTEWATER PROCESSING

Raw sewage wastewater enters a wastewater treatment plant at the headworks. The headworks act as a primary grit and foreign matter removal system. From the headworks, wastewater is transferred to a biological treatment unit (BTU) where nutrients are removed from the wastewater. The BTU subjects the wastewater to organisms in combination with aeration. Typically, the growth of microorganisms in the BTU during the biological nutrient removal step forms a biological floc, which allows separation of the solid and liquid components of the waste stream. The liquid component is filtered, disinfected and discharged to surface waters or reused.

The solid component leaving a BTU is referred to as waste activated sludge (WAS). It is traditionally transferred to a stabilization process, such as anaerobic or aerobic digestion. The digestion process reduces the number of disease-causing microorganisms and the amount of degradable organic matter in the WAS. In the process of anaerobic digestion, microorganisms break down the biodegradable material in the sludge in the absence of air. The end products of the biological degradation are stabilized biosolids and biogas, which is composed of methane and carbon dioxide. Under aerobic conditions (in the presence of air), bacteria rapidly consume organic matter and convert it into carbon dioxide.

Pretreatment processes are often used to degrade the WAS prior to digestion. WAS is composed of carbohydrates, lipids and proteins. While the carbohydrate and lipid components of sludge are easily degraded, the proteins are contained inside the cell walls, which must first be broken down to make the contents readily available as a nutrient for digestion. Several pretreatment processes exist, such as Cambi, Portous, Zimpro, OpenCei, and Disintegrater. These processes use thermal hydrolysis (high pressure steam) or high-voltage to disrupt the cell membranes and cell walls. The high-energy requirements of these processes result in high capital and operating costs.

Following stabilization, WAS is just 3 to 5 percent solids. Removal of the water from the material is essential to reducing weight and the cost of further treatment or disposal or reuse. A variety of technologies are employed to dewater WAS including belt presses, centrifuges and other devices. The resulting dewatered biosolids can be applied to the land for beneficial use (soil conditioner/fertilizer), deposited in a surface disposal site or fired in an incinerator.

EPA REGULATION OF BIOSOLIDS

As required by the Clean Water Act, USEPA developed the 40 CFR Part 503 Rule to protect public health and the environment from any reasonably anticipated adverse effects of certain pollutants that might be present in sewage sludge and biosolids (treated sewage sludge). As specified in Subpart D of 40 CFR Part 503, Class “B” biosolids are required to have pathogen concentrations of less than 2 million MPN (Most Probable Number) or CFU (Colony Forming Units) per gram of sludge solids based on the geometric mean of seven samples per event, OR using one of five approved processes to significantly reduce pathogens (PSRP). The PSRPs are:

- Aerobic Digestion: 40 days @ 20 degrees C (no less than 60 days @ 15 degrees C).
- Air Drying: 3 months with 2 months above 0 degrees C.
- Anaerobic Digestion: 15 days @ 35 to 55 degrees C (no less than 60 days at 20 degrees C).
- Composting: Minimum 40 degrees C for 5 days with minimum of 4 hours at 55 degrees C.
- Lime Stabilization: Add lime to raise pH to 12 after two hours of contact.
- Other as approved by the permitting authority.

The BCR Environmental CleanB™ system is a PSRP that falls in the ‘other as approved by the permitting authority’ category. The permitting authority is the Pathogen Equivalency Committee (PEC). It is a federally sponsored technical group created by the EPA that provides technical assistance and recommendations on process equivalencies for pathogen reduction in sewage sludge to government and industry. The PEC reviews and makes recommendations to relevant federal and/or state permitting authorities on the merits of applications proposing that innovative or alternative sewage sludge pathogen reduction processes are equivalent to the processes currently listed in the 40 CFR Part 503D regulation. The BCR Environmental CleanB™ system is currently going through the PEC approval process.

HOW THE BCR ENVIRONMENTAL CLEANB™ BIOSOLIDS TECHNOLOGY WORKS

The CleanB™ system chemically conditions WAS to produce Class "B" biosolids in less than 10 minutes. It is a simple, one-stage process that meets pathogen and vector attraction reduction requirements for Class "B" biosolids, as defined by Title 40 CRF Part 503. Every system is housed in a structure outfitted with a control system and monitoring devices to record process parameters and ensure consistent, repeatable biosolids treatment. The system has a small footprint that is modular and scalable.

The CleanB™ system acquires WAS directly from the BTU, which eliminates the need for standard digesters. The WAS is thickened prior to treatment to achieve a solids content of 3.5 to 4.0 percent solids. The thickened WAS is directed to a continuously mixed batched process tank where it is subjected to chemical treatment with chlorine dioxide. Chlorine dioxide is an oxidant that enhances digestion by two mechanisms. The first mechanism reduces the population of non-beneficial microorganisms prior to seeding with the specific organisms that are better suited to their function. The second mechanism alters the cell walls of the substrate material to cause or facilitate cell lysis (i.e. dissolution or destruction), thus making more nutrients available for the microorganisms. The thickened WAS is dosed with chlorine dioxide and held for one hour. After chemical treatment, the process tank is evacuated and the biosolids are dewatered.

The CleanB™ treatment oxidizes sulfides, sulfates and mercaptans (i.e. odor-producing chemicals) in the WAS to produce an odor-free Class "B" biosolids product that is safe for land application as set forth by Title 40 CFR Part 503. Treatment improves odors both at the wastewater treatment plant and the land application site.

BENEFITS OF THE BCR ENVIRONMENTAL CLEANB™ SYSTEM

The CleanB™ system is energy efficient and cost effective. It uses 95 percent less energy than alternative treatments such as digesters, dryers or incinerators, and lime stabilization. The system relies on simple chemistry rather than on energy intensive treatments such as thermal hydrolysis (high pressure steam) or high-voltage. Its energy efficient (fractional horsepower) equipment minimizes the need for electricity, which translates to low energy costs. The elimination of infrastructure (e.g., digesters, gravity belt thickeners, lime and polymers) reduces capital and operating and maintenance (O&M) costs by approximately 50 percent. These lower capital, energy and O&M costs give the CleanB™ system an obvious economic advantage over traditional technologies (BCR Environmental, 2012a).

Local environmental conditions are not impacted by the CleanB™ system. It is a 'zero-emissions' process that takes place within a climate-controlled building. The treated biosolids are disinfected and deodorized without exposure to the surrounding environment. Thus, the Clean B™ system can be installed in close proximity (<300 feet) to residential neighborhoods without a negative impact.

The CleanB™ system is a high volume treatment process that is highly scalable and fast. The system has no minimum or maximum capacity limitations, thus it can be used in any size wastewater treatment plant. Also, it creates Class "B" biosolids in minutes, instead of 30 to 40 days like conventional technologies. The fast and odorless features of the CleanB™ system dramatically increase the biosolids throughput at a wastewater facility, addressing capacity and storage constraints.

III. VENDOR-PROVIDED INFORMATION

INTRODUCTION

BCR Environmental is the vendor of the CleanB™ treatment technology. The company was founded in 2003 to conduct research and development in the wastewater treatment business sector. Its vision is “to be the best, most trusted company at converting wastewater residuals and organic waste streams into environmentally responsible products” (BCR Environmental, 2012b). In 2012, the Artemis Project selected BCR Environmental for its “Top 50” list of the world’s most innovative water technology companies (Artemis, 2012).

BCR Environmental is a small privately held company. Located in Jacksonville FL, BCR Environmental markets and fabricates three innovative products (i.e., Neutralizer, CleanB™, and CleanB-AC). The company is rapidly growing with 22 of its 30 employees hired in the last 18 months. BCR Environmental’s products are sold exclusively in Florida; however, the company is expanding to several neighboring states (e.g., Georgia, Alabama, South Carolina and North Carolina).

In 2006, BCR Environmental produced its first innovative product, Neutralizer, which is a two-step chemical process to produce Class “AEQ” biosolids. Between 2006 and 2009, BCR Environmental built three full-scale facilities to demonstrate Neutralizer, as required by EPA to achieve PSRP certification. In 2010, Neutralizer became the first new PSRP method to be approved in 20 years. Today BCR Environmental has six Neutralizer facilities operating with several more under contract. With PSRP certification complete, BCR Environmental believes the Neutralizer adoption cycle will be significantly compressed for its expansion outside of Florida.

In 2010, BCR Environmental introduced the CleanB™ system to the market. The CleanB™ system is currently in the PSRF approval process.

INTERVIEW WITH MR. AARON ZAHN

In November 2012, Mr. Aaron Zahn, President and Chief Executive Officer (CEO) of BCR Environmental, provided his perspective on how ARRA funding affected product and business development. Mr. Zahn also provided responses to questions concerning the drawbacks and future benefits of ARRA funding.

EFFECTS OF ARRA FUNDING ON PRODUCT AND COMPANY DEVELOPMENT

Alachua was the first municipality to purchase the CleanB™ system. As such, Alachua became the initial adopter of the BCR Environmental CleanB™ system. According to Mr. Zahn, finding an initial adopter is always a positive step for a new technology. It expands the technology’s reference cases, accelerates its rate of adoption and creates company growth. Thus, the ARRA-funded Alachua project played a significant role in the development of the CleanB™ system and BCR Environmental.

In the summer of 2012, BCR Environmental sold its second CleanB™ system to the U.S. Naval Air Station in Jacksonville, Florida. NAVFAC (Naval Facility Engineering Command) is conducting a three-year engineering review of the CleanB™ system, which may lead to the adoption of the CleanB™ system base wide (i.e. use at all of the Naval Air bases). Thus, it appears an ARRA-funded project helped create growth opportunities for the company.

DRAWBACKS OF ARRA FUNDING

BCR Environmental did not experience drawbacks associated with the ARRA funding. The Buy American and Davis Bacon provisions did not affect sales. BCR Environmental's CleanB™ system did not require an exemption from the Buy American provision.

ARRA's 'shovel-ready' requirement did not pose a challenge for BCR Environmental. BCR Environmental approached Alachua after the design stage was complete and six months into the construction stage of the project. At this point, Alachua management made the executive decision to stop construction to take advantage of the CleanB™ system's ability to meet the pending regulatory compliance requirements set forth by the State of Florida in FL 62-640. The new CleanB™ system approach upgraded Alachua's wastewater facilities end product quality to Class "B" biosolids for land application disposal. Due to the CleanB™ system's simple modular design, integrating it into the facility design was fast, delaying the construction schedule by only 15 to 30 days.

EFFECTS OF ARRA FUNDING ON PRODUCT SALES

ARRA funding had a minimal effect on product sales. Mr. Zahn is not aware of any ARRA-funded product sales other than the CleanB™ system sold to Alachua. Timing is potentially responsible for the lack of CleanB™ system ARRA-funded sales because the product was not introduced to the market until 2010. Although several Neutralizer systems (BCR Environmental's first innovative product) projects were funded through the State Revolving Fund (SRF), none were purchased with ARRA funds distributed through the SRF vehicle.

EFFECTS OF ARRA FUNDING ON BUSINESS OPERATION

ARRA funding did not affect BCR Environmental's business operation. BCR Environmental's use of a revised business strategy is responsible for the lack of effect. Mr. Zahn describes his company's unconventional business strategy as follows:

The 2008 recession drove a paradigm shift in traditional methods of delivery. Clients could no longer afford the current business model use of third party consulting engineering firms. BCR Environmental took advantage of the poor economic conditions by eliminating the third party consulting engineering firms, which substantially reduces the capital cost of projects. One BCR Environmental client saved upwards of $500,000 to $1 million in 'soft costs' on a $4 million project.

The business strategy is a 'solutions provider' approach to assisting its clients. According to Mr. Zahn, BCR Environmental does not just sell equipment. Instead BCR Environmental works with its clients to "design holistically advantageous biosolids management processes." First BCR Environmental assists its clients to integrate the CleanB™ system into the WWTP and then partners with the client "to establish a responsible and long-term transportation product management solution." For example, BCR Environmental marketed Alachua directly (not through a third party consulting firm); worked with Alachua to integrate the

CleanB™ system into its wastewater treatment facility design; and then signed a 20-year operating agreement with Alachua to monitor and manage its biosolids.

The business strategy uses a specific market segmentation approach. BCR Environmental targets customers that have similar pain points and economic profiles. The similar economic profile is wastewater facilities in the 0.5 to 15 MGD range (i.e. a large market with tight capital and operating budget constraints). Pain points refer to cost drivers or compliance requirements that influence technology selection decisions such as odors, energy consumption, operational complexity, carbon footprint and regulatory compliance (BCR Environmental, 2012c).

The business strategy requires extensive customer research. BCR Environmental identifies its potential customers through data mining and a direct sales force. The sales force goes door-to-door to collect wastewater treatment plant information. Over a two-year period, BCR Environmental developed a database on Florida wastewater utilities that is more detailed than is available through the EPA. In the database, BCR Environmental compiled operational and management information (e.g., compliance, size, processes, economic profiles and complaints).

The business strategy provides capital funding options. Either BCR Environmental or the municipality can provide the capital funding to purchase the CleanB™ system. In other words, a lack of capital funding is not an obstacle to installation of BCR Environmental's innovative technologies. If the municipality cannot afford a CleanB™ system, BCR Environmental incorporates the capital cost into its long-term service agreement, which helps the municipality manage the residual after it is treated. Thus, Mr. Zahn makes the point that although Alachua used ARRA funding to purchase the CleanB™ system, it was not required. Also, by incorporating the capital cost into the long-term service agreement, the immediate boost in revenue is not felt by BCR Environmental, marginalizing its effect on the business operation.

FUTURE BENEFITS FROM ARRA FUNDING

The ARRA-funded project will most likely create new customers for BCR Environmental because Alachua gave BCR Environmental the opportunity to demonstrate the effectiveness of its CleanB™ system. The successful demonstration and sale of the CleanB™ product provided the BCR Environmental marketing team with a reference case (i.e. a tool to assist them with future sales). Alachua's discussion of the project with its industry peers also provided BCR Environmental with 'word of mouth' marketing exposure.

SUMMARY

BCR Environmental benefited from the installation of the CleanB™ system on the ARRA-funded Alachua WWTP project. Alachua was the first municipality to purchase the CleanB™ system. As the initial adopter of the CleanB™ system, the Alachua project expanded the technology's reference cases, accelerated its rate of adoption and created company growth. However, ARRA funding had a minimal effect on product sales and business operations. BCR Environmental's use of progressive technologies and business strategies is responsible for the lack of effect in these areas. Regardless, the ARRA-funded project will most likely create new customers for BCR Environmental.

IV. FUNDING RECIPIENT-PROVIDED INFORMATION

INTRODUCTION

In December 2011, Alachua held a grand opening for its newly completed 1.5 MGD advanced water reclamation facility. The ceremony was the culmination of a project that was initiated more than 12 years ago, when the Alachua City Commission recognized its existing wastewater treatment plant was reaching capacity and becoming obsolete.

The new wastewater treatment facility addresses the concerns of the City Commission. It features highly effective biological carbon and nutrient removal, sand filtration, high-level disinfection, innovative biosolids treatment, state-of-the art instrumentation and control, bi-fuel auxiliary generation for backup power, and an administration building with dedicated operations, maintenance and laboratory areas. The facility is readily expandable to 3.0 MGD in the future. Treated effluent from the new facility is pristine, meeting drinking water standards; and thus is suitable for public access reuse water. The City plans to use 100 percent of the treated water in the community as reclaimed water (Alachua, 2012).

The new wastewater treatment facility uses the CleanB™ system to convert sludge from the biological treatment unit to biosolids. Historically, operations staff pumped the sludge to basins, where it was concentrated and stabilized over a 45 to 60 day period prior to disposal at the landfill. Today, the CleanB™ system replaces the basins and stabilizes the sludge to Class "B" standards in less than an hour. In accordance with a City agreement, local farmers can now use the stabilized sludge (i.e. biosolids) as a soil amendment on hay fields.

INTERVIEW WITH CITY OF ALACHUA MANAGEMENT

During a teleconference conducted in November 2012, Mr. John Swilley (Wastewater Treatment Facility Superintendent) provided his perspective on the acquisition and performance of the ARRA-funded CleanB™ system. This section summarizes his responses to questions about the system performance and ARRA funding impact. This section also includes information from a news article on Alachua's new plant.

IMPACT OF ARRA FUNDING

Alachua used ARRA funding to build a new wastewater treatment facility with innovative components to reduce operation and maintenance costs, increase capacity, and improve the quality of the treated water. According to Mr. Swilley, the new facility "makes beautiful water going out the back; it looks like spring water."

The new wastewater facility is a dramatic infrastructure improvement. In a news article, Mr. Mike New (Director of Public Works) stated the improvement in infrastructure "is like going from a bicycle to a new car." He explained, "The new facility is more energy efficient [and] has increased longevity and lower maintenance costs" (Alachua, 2012). For example, before the new treatment plant was operational, the expense associated with landfill disposal of the biosolids was double the current cost. The new approach of processing the biosolids with the CleanB™ system is saving Alachua money with lower shipping and power consumption expenses.

ARRA funding made the purchase of the CleanB™ technology possible. Alachua is a small town without substantial funding resources. Even though the CleanB™ system reduces operating costs and has the potential to be cost effective in the long run, Alachua did not have the upfront capital funds to purchase it. Thus, without ARRA funds, Mr. Swilley believes Alachua probably would have proceeded with a plan that did not include CleanB™ biosolids treatment.

ARRA funding made the beneficial reuse of wastewater and sludge a reality. The new treatment plant discharges effluent of drinking water quality that is suitable as public access reuse water. For the first time, 100 percent of the treated water can be used to benefit the community. Likewise the new treatment plant creates Class "B" biosolids, which are now beneficially reused by local farmers for soil amendment.

ARRA funding contributed to the sustainability and economic growth of the City of Alachua. According to a news article, Ms. Traci Cain, the City Manager, noted "The recent expansion of our wastewater treatment facility will attract future residents and businesses to our community while better serving our citizens. The sustainability and economic growth of our community is directly related to providing vital infrastructure" (Alachua, 2012).

SELECTION OF THE WASTE ACTIVATED SLUDGE RESIDUALS TREATMENT TECHNOLOGY

Alachua retained Eutaw Utilities of Tallahassee Florida (Eutaw Utilities) to lead the planning efforts for the new wastewater treatment facility project. Eutaw Utilities specializes in planning projects with Florida grant and loan funding. In addition, Alachua retained Jones, Edmunds, and Associates to produce the engineering design for the facilities. They focused on the inclusion of innovative and automatic components to reduce operation and maintenance costs.

Jones, Edmunds, and Associates did not consider waste activated sludge treatment during the design phase of the project. Most likely, they were not aware of the technology because it was in its infancy. At the time, only BCR Environmental's Neutralizer product was commercially available. BCR Environmental's CleanB™ system did not enter the market until 2010, approximately six months into the construction phase of the project.

BCR Environmental introduced its three products (Neutralizer, CleanB™, and CleanB-AC) to the Alachua design team in 2010. The City met with BCR Environmental several times on-site and at its offices in Jacksonville, Florida to discuss the design and robustness of the products. According to Mr. Swilley, the City considered the CleanB-AC product as an alternative to the CleanB™ product. The CleanB-AC product is a more comprehensive treatment option that produces Class "A" compost. Mr. Swilley refers to the CleanB-AC system as the "Cadillac" product, and commented that "its higher initial cost would have had too much impact on rate payers, so it was not selected." The Neutralizer product was also considered, but the lack of chlorine in the facilities sludge residual reduced the cost benefit of this product, so it was eliminated from further consideration.

SYSTEM INSTALLATION

The CleanB™ system is simple and easy to install. The stand-alone system is added to the tail end of the facility, where the sludge is normally discharged to the dewatering system. According to Mr. Swilley, adding the CleanB™ system was not complicated. They had to review the drawings and add the system modifications, which included pipe, two 1,000 gallon tanks and some electrical connections. The design modifications delayed construction by a few weeks. BCR Environmental was on-site for the initial start-up because it was the first CleanB™ installation. It went well; there were no unforeseen issues that caused delays.

The CleanB™ system was not pilot tested due to time constraints. Even though Alachua was the first municipality to purchase the CleanB™ system, they were not concerned about the lack of pilot testing. Mr. Swilley commented that CleanB™ is a pretty simple system for pathogen reduction and noted "some of the best things are simple." Also, the consequences from its failure were small. If the CleanB™ system did not work, the facility would still function normally and Alachua would just go back to sending the biosolids to the landfill.

ARRA's Buy American requirement did not impact the construction schedule. According to Mr. Swilley, some parts had to be returned to meet the Buy American requirement, such as a 69-cent wall receptacle; however "the contractors kept good track of things coming in and handled any problems." Mr. Swilley said the Buy American requirement did not affect the end product and the project stayed on schedule.

SYSTEM PERFORMANCE

The CleanB™ system is performing well. Alachua collects monthly fecal samples to evaluate its performance. The fecal count is running an average of 250,000 counts, which is well within the two million count limit. When the influent flow rate increases, it is easy to adjust the CleanB™ system chlorine dioxide feed rate (i.e. 60 parts per million injection rate) into sludge stream. The system is fully automated to respond to changes in the flow rate.

Alachua is satisfied with the performance of the CleanB™ system. It consistently creates biosolids that meet Class "B" standards. If asked to make a technology selection today, Mr. Swilley would make the same technology decision to purchase the CleanB™ system. Industry peers "are coming by to look at the CleanB™ system all the time," and he recommends it to them.

SUMMARY

Alachua built the new wastewater facility with innovative and automatic components to reduce operation and maintenance costs. The innovative CleanB™ system is successfully producing biosolids to Class "B" standards for reuse by farmers to amend soil conditions. The green infrastructure benefits of the system include energy savings (i.e. reduced electricity consumption), smaller carbon footprint (i.e. reduction in vehicle use), reduction in waste products (i.e., no landfill disposal), elimination of infrastructure (i.e. digesters, thickeners), odor reduction, and beneficial reuse of sludge. Alachua is satisfied with the performance of the CleanB™ system and routinely recommends it to its industry peers.

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APPENDIX 9: SAFL BAFFLE HYDRODYNAMIC SEPARATOR TECHNOLOGY

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SUMMARY

Under a work assignment issued by the EPA Office of the Chief Financial Officer (OCFO), SAIC is gathering information regarding new or expanded industries or markets that were fostered as a result of ARRA spending. SAIC screened the Office of Water databases for drinking water and clean water projects to identify technologies considered innovative. In consultation with the EPA Office of Water, SAIC selected five clean water technologies for case studies: reactive filtration, high-gradient magnetic separation, integrated fixed-film activated sludge systems, compressible media filtration, and Class “B” residuals treatment. SAIC identified a sixth clean water technology, the SAFL Baffle hydrodynamic separator, as part of a stormwater project implemented under the Brownfields Program.

This case study focuses on the use of the SAFL Baffle technology by the St. Paul Port Authority (SPPA), the recipient of the ARRA funding. For this report, SAIC obtained information both from Loucks Associates, the SPPA’s engineering design contractor, and Upstream Technologies, the vendor of the innovative technology.

The SPPA installed the SAFL Baffle in the ’Next Generation’ Storm Water Management System (NGSWMS) portion of the Beacon Bluff redevelopment project. The NGSWMS routes previously untreated stormwater through the SAFL Baffle and an infiltration basin prior to discharge into the Mississippi River. The innovative SAFL Baffle technology fits into an upgradient sump manhole to remove sediment from runoff before it enters the basin. The innovative SAFL Baffle technology is a product of Upstream Technologies, a small start-up business located in New Brighton, Minnesota.

ARRA funding made the construction of the NGSWMS a reality. Loucks Associates selected the SAFL Baffle innovative technology to include in the NGSWMS because of its simplicity and use of conventional maintenance equipment. According to Mr. Shopek, the SAFL Baffle is an easy to install and maintain product that most likely will be widely implemented in the future as a low-cost solution to sediment loss in stormwater sump manholes. Its green infrastructure benefit is an improvement in stream water quality (i.e., reduced suspended solid levels discharged to the Mississippi River).

The Beacon Bluff redevelopment project provided Upstream Technologies with its first opportunity to successfully demonstrate the effectiveness of the SAFL Baffle as a stormwater pretreatment technology. The successful demonstration opened the door to commercialization of the product and made the task of raising funds to launch the new start-up business (Upstream Technologies) less onerous. The demonstration also provided Upstream Technologies with a marketing tool that has helped it become a fast-growing company. Since its launch, Upstream Technologies has tripled in size, expanding its sales reach from Minnesota to eight additional states. Today, Upstream Technologies is marketing the SAFL Baffle both nationally and internationally and plans to launch the sale of a second innovative technology this year.

CASE STUDY OF SAFL BAFFLE HYDRODYNAMIC SEPARATOR TECHNOLOGY

This document presents the case study conducted by SAIC. Section 1 contains a brief description of the project. Section 2 describes the SAFL Baffle hydrodynamic separator technology including its innovative aspects and benefits. Section 3 presents information and lessons learned from the technology vendor (Upstream Technologies Inc.), and Section 4 presents information and lessons learned from Loucks Associates, the engineering design consultant of the funding recipient.

I. PROJECT DESCRIPTION

In 2009, the St. Paul Port Authority (SPPA) received $1.6 million of ARRA funding through EPA's Brownfields Grants Program. Most of the funding supported the Beacon Bluff redevelopment project located along Phalen Avenue in St. Paul, Minnesota. The project transformed the former 11.4-acre 3M manufacturing site into a construction-ready site for new businesses.

The SPPA serves the City of St. Paul by managing commodities transportation on the Mississippi River and redeveloping inland. It routinely acquires and cleans up brownfields sites that are 'shovel-ready' building sites suitable for developing new industrial or business centers to attract commercial and industrial investment to St. Paul. The SPPA's process also encourages green redevelopment efforts. The SPPA has redeveloped more than two square miles of St. Paul into productive and prosperous jobs centers. In 2010, the SPPA construction projects employed 924 people throughout St. Paul with an ultimate goal of improving the economic environment in the East Metro area (SPPA, 2013).

As part of the Beacon Bluff redevelopment project, the SPPA installed the 'Next Generation' Storm Water Management System (NGSWMS). The NGSWMS was a collaborative effort between the SPPA, the City of St. Paul, the Capitol Region Watershed District, Loucks Associates and the University of Minnesota. The system included several innovative approaches to reroute runoff through an infiltration basin prior to discharge into the Mississippi River. One innovative approach was the use of the SAFL Baffle, which captures sediment from stormwater runoff prior to entering the infiltration basin. The innovative SAFL Baffle technology is a product of Upstream Technologies, a small start-up business located in New Brighton, Minnesota.

II. SAFL BAFFLE TECHNOLOGY

INTRODUCTION

The SAFL Baffle is a pretreatment technology used in stormwater collection systems. This innovative devise is a porous grate that is inserted into a sump manhole. It prevents sediment captured during low flow conditions from washing out during intense storm events. In the following sections, the SAFL Baffle technology's innovative aspects and benefits are explained.

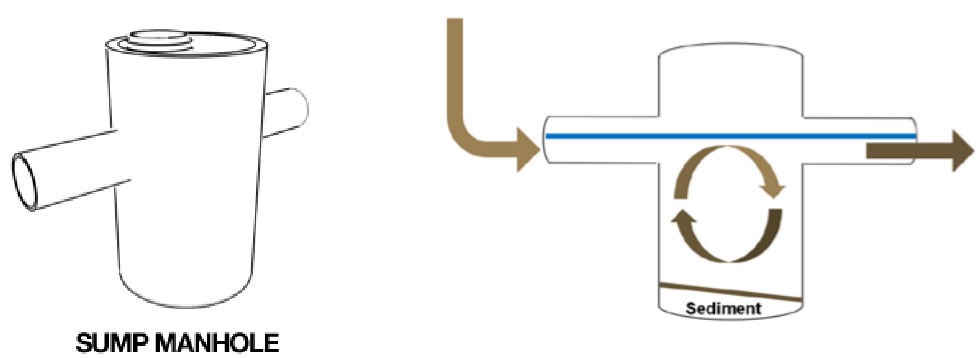
SUMP MANHOLES IN STORMWATER COLLECTION SYSTEMS

A sump within a manhole is a key component in stormwater infrastructure. It is a vertical cylindrical chamber with pipe connections on at least two sides (see Figure 1). Sumps provide a junction for the storm sewer pipes, as well as access points to allow inspection of the stormwater system by maintenance staff. Stormwater flow enters the sump through an inlet pipe and exits through an outlet pipe. The two pipes are typically oriented straight across from each other, with a slight drop from the inlet to the outlet; however, it is not uncommon to have more than one inlet and outlet at various locations within the sump.

Sumps capture a portion of the sediment and debris carried with stormwater influent due to their geometric configuration. The sump inlet and outlet pipe openings are usually a few feet above the bottom of the sump chamber; thus when stormwater fills the chamber during storms, it can only drain to the depth of the outlet pipe opening. The water in the sump below the level of the outlet pipe moves at a slower velocity, allowing time for some suspended sediment and debris to settle out.

Research indicates that suspended sediments are only captured in sumps during low flow conditions (Howard et al., 2011). During intense storm events (i.e., high flow conditions), the captured sediment is substantially scoured and washed out of the system. This is because water moving at high flow rates creates a circular flow pattern inside sumps, causing scour and resuspension of the previously captured sediment, as shown in Figure 1. The circular flow pattern consists of a downward flow due to the plunging of the incoming jet, a lateral flow near the sediment bed, and an upward flow at the upstream end of the standard sump enhancing the washout of previously deposited sediment at the bottom of the sump. The re-suspended sediment moves through the storm sewer pipes and enters receiving water bodies causing sedimentation problems, as well as contributing to other water quality problems when pollutants are attached to the sediment. The SAFL Baffle is an innovative hydrodynamic separator unit that addresses this issue.

FIGURE 1. SCHEMATICS OF A SUMP MANHOLE AND CIRCULAR FLOW PATTERN OF SEDIMENT WITHIN THE SUMP MANHOLE



Sources: Upstream Technologies, 2012 and Howard et al., 2011.

HYDRODYNAMIC SEPARATOR UNITS

Hydrodynamic separator units are flow-through structures with a settling or separation device to remove sediments and other pollutants from stormwater systems (USEPA, 1999). No outside power source is required, because a reduction in flowing water energy allows the sediments to efficiently settle. Separation techniques vary with the type of unit (e.g., swirl action or indirect filtration).

Hydrodynamic separator units are designed primarily to remove floatable and gritty materials. They do not remove dissolved pollutants or solids with poor settling ability (i.e., fine-grained particles) that are generally found in stormwater. Likewise, hydrodynamic separators will not significantly remove pollutants, such as nutrients, because they adhere to fine-grained particulates or are dissolved. The reported removal rates of sediments, floatables, and oil and grease differ depending on the vendor.

Hydrodynamic separator units require a minimum amount of maintenance, but lack of attention will lower their overall efficiency. The units do not have any moving parts, and are consequently not maintenance intensive. However, maintaining the system is very important in ensuring that it is operating as efficiently as possible. Proper maintenance involves frequent inspections. The unit must be cleaned out when it has reached capacity (i.e., typically when the sediment level comes within one foot of the unit's top). Cleanout is performed with a sump vacuum or vacuum truck, depending on the type of unit installed.

HOW THE SAFL BAFFLE TECHNOLOGY WORKS

A SAFL Baffle is a simplified hydrodynamic separator unit. The simplified design is composed of a porous metal grate that is oriented perpendicular to flow between the inlet and outlet pipes within a sump manhole (Figure 2). The grate angle and hole dimensions are varied to suit specific conditions within a given stormwater collection system. The particle size of the suspended sediment load and type of debris are key factors in determining the optimum configuration of openings and grate angle. Grate openings typically range from 3 to 5 inches in diameter. Grate angles typically range from 90 to 120 degrees with respect to the inlet pipe.

FIGURE 2. SAFL BAFFLE IN SUMP MANHOLE

Source: Shopek (2012).

The SAFL Baffle technology works on the head loss principle. Inlet pipe flow enters the sump manhole and collides with the porous grate. The portion of the flow that does not move through the grate openings is forced to change direction and spread out along the grate surface, distributing the flow evenly across the sump. The change in direction and even distribution of the flow creates a head loss, which is defined as energy dissipation due to friction. A reduction in flow velocity comes with the head loss, causing sediment to fall out of suspension and also prevent its resuspension.

Tests were performed to optimize the design of the SAFL Baffle. The St. Anthony Falls Laboratory staff at the University of Minnesota evaluated multiple SAFL Baffle configurations with varying percent open area and different angles of attack in a laboratory-scale model. The tests demonstrated that with the right baffle dimensions and porosity, nearly complete elimination of sediment scour is possible for flows up to the 10-year design storm of 4.2 inches for the Minneapolis, Minnesota area (Howard, 2009).

The SAFL Baffle is typically installed upgradient of other Best Management Practices (BMPs) to pre-treat stormwater (i.e., upgradient of an infiltration basin or detention pond). However, in many urban areas, the space required to install standard stormwater BMPs does not exist. Under these circumstances, hydrodynamic separators, such as the SAFL Baffle, are often the only stormwater BMP alternative, and therefore, are used as primary treatment.

INNOVATIVE ASPECTS OF THE SAFL BAFFLE TECHNOLOGY

The SAFL Baffle is innovative because it fits into existing sump manholes. Unlike other hydrodynamic separators, it is possible to retrofit a sump manhole with the SAFL Baffle. This ability to retrofit greatly simplifies the installation process. Instead of tearing up a street to remove an existing sump and replacing it with a new pre-fabricated hydrodynamic separator structure, the SAFL Baffle can be inserted into an existing sump and installed in less than 45 minutes. It is the SAFL Baffle’s simplicity that makes it innovative.

BENEFITS OF THE SAFL BAFFLE TECHNOLOGY

The SAFL Baffle offers significant advantages over traditional hydrodynamic separators. The principal benefits of the SAFL Baffle are described below (Upstream Technologies, 2012).

TOTAL SUSPENDED SOLIDS REDUCTION

The SAFL Baffle captures and retains debris, sand and silt sediments in stormwater systems. Four years of testing optimized its design, creating a technology that completely eliminates high-flow washout in sump manholes.

INEXPENSIVE

The SAFL Baffle is the most cost-effective hydrodynamic separator on the market today. The SAFL Baffle can capture roughly the same amount of suspended solids as other leading hydrodynamic separators on the market at a fraction of the cost. For retrofit projects, the cost of a SAFL Baffle is between $3,000 and $4,000 (i.e., approximately 1/10 the cost of other hydrodynamic separators). For new projects, costs will likely be between $8,000 and $12,000, including a new sump manhole, the SAFL Baffle, and installation (i.e., approximately 1/3 of the cost of other hydrodynamic separators).

SIMPLE DESIGN AND INSTALLATION

The SAFL Baffle is easy to install. Every piece of the SAFL Baffle fits through a standard manhole casting, allowing staff to easily perform retrofits. Installing a SAFL Baffle takes about 45 minutes with readily available equipment (i.e., hand drill, bubble level, and wrenches). No experience is required. Uninstalling the SAFL Baffle takes about five minutes.

LOW MAINTENANCE

SAFL Baffles are a low maintenance BMP. The only maintenance requirement is the removal of captured sediment with a vacuum truck. Because the SAFL Baffle takes up a small portion of the manhole, a vacuum truck reaches captured sediment easily. Typically, a sump requires sediment removal once or twice per year; however, more or less frequent maintenance may be required depending on watershed size and land use.

REDUCTION IN BMP MAINTENANCE COSTS

SAFL Baffles are an effective pretreatment BMP to lower maintenance costs. The SAFL Baffle inexpensively captures sands and silts upstream of other stormwater BMPs (e.g., stormwater ponds, infiltration basins and underground vaults). This pretreatment approach extends the life of the downstream BMPs, resulting in less frequent maintenance. Downstream BMP maintenance can be very expensive, on the order of hundreds of thousands of dollars. Pretreatment with the SAFL Baffle results in cost savings as high as 90 percent.

III. VENDOR-PROVIDED INFORMATION

INTRODUCTION

Upstream Technologies is the vendor of the innovative SAFL Baffle technology described in this case study. It is a small Minnesota-based business focused on the development of stormwater products. The company's mission is "to keep lakes, rivers, and oceans clean" (Upstream Technologies, 2012).

Founded in 2011, Upstream Technologies is a start-up business. The new company is a product of the University of Minnesota (UM) Office for Technology Commercialization (OTC), which assists university researchers with the patenting and commercializing of their innovative products. The UM retains the rights to one of two patents on the SAFL Baffle, and therefore, receives patent royalty income from Upstream Technologies. The UM uses the royalty income to foster additional innovation within the area of water quality.

INTERVIEW WITH MR. A.J. SCHWIDDER

In February 2013, Mr. A.J. Schwidder, Chief Executive Officer and Director of Upstream Technologies, provided his perspective on how ARRA funding affected product and business development. Also, Mr. Schwidder responded to questions concerning the ARRA-funding impact on product sales and future marketing benefits.

OPPORTUNITY PROVIDED BY ARRA-FUNDED PROJECTS

The Beacon Bluff redevelopment project provided the UM research team with its first opportunity to install the SAFL Baffle. By 2010, the UM team had completed over four years of laboratory testing on the SAFL Baffle and were prepared to start the field-testing phase of product development. With ARRA-funding support, the St. Paul Port Authority provided the UM team with the sought-after field demonstration opportunity. The Beacon Bluff project also provided the same opportunity to several other innovative technology developers.

The ARRA-funded Beacon Bluff field demonstration opened the door to commercialization of the SAFL Baffle product. During the planning phase of the demonstration, two UM professors (the inventors of the SAFL Baffle) submitted a U.S. patent application and prepared to commercialize the product. The effort resulted in the creation of Upstream Technologies. The professors selected Mr. Schwidder to launch the new company and manage the production and marketing of the product.

The ARRA-funded Beacon Bluff field installation made the task of raising funds less onerous. Mr. Schwidder needed monetary support to launch Upstream Technologies (e.g., cover SAFL Baffle manufacturing costs and build inventory). He turned to angel investors and asked for money to fill an existing order. The existing order was the SAFL Baffle for the Beacon Bluff project. According to Mr. Schwidder, having an order in hand made the investors much more receptive to funding the new SAFL Baffle product.

The ARRA-funded Beacon Bluff field demonstration generated monitoring data to help Upstream Technologies market the new SAFL Baffle project. Supported by the ARRA funds, researchers collected field-monitoring data following completion of the demonstration. According to Mr. Schwidder, the most important benefit of the ARRA-funded Beacon Bluff installation was the generation of actual field monitoring data, which he shares with clients and uses to verify the product's effectiveness. The ongoing monitoring at the Beacon Bluff redevelopment site provides Mr. Schwidder with the opportunity to keep existing customers up-to-date, as well as to strengthen the case for technology effectiveness to potential customers.

OPPORTUNITY TO FOSTER COMMERCIALIZATION OF INNOVATIVE PRODUCTS

Research labs, like the SAFL, have the potential to become engines for the creation of innovative technologies. When researchers work with agencies to solve real world problems, innovative technologies are often the result. This is how the SAFL Baffle was created. The two professors at the SAFL were funded by the Minnesota Department of Transportation (MnDOT) to develop standard testing protocols for hydrodynamic separators and the collection of sediment in sump manholes. This applied research led MnDOT to request a solution to the problem of sediment washout from sumps under high flow conditions. The SAFL researchers responded to the request with the creation of the SAFL Baffle. Unfortunately, according to Mr. Schwidder, there are few grant opportunities available to the SAFL researchers for applied research; most available funding is for basic research. Mr. Schwidder believes "You need to change how university research is funded before there will be more focus on applied research." Thus, funding from agencies interested in applied research, such as MnDOT, that moves along the applied research agenda. Perhaps if more funds were funneled through agencies, such as MnDOT more innovative technologies would be developed.

The UM Office for Technology Commercialization (OTC) is another engine that fosters the commercialization of innovative technologies. The OTC takes ideas and technology that stem from the UM research (intellectual property), prepares it for market, and in some cases, spins it out into new businesses. As part of the process, the OTC conducts a technology assessment of all disclosed intellectual property to determine its commercial potential and develop an appropriate commercial strategy. In a typical year, roughly 250 new UM technologies are reviewed and evaluated for patenting and commercializing. Of the 250 reviews, approximately five are approved according to Mr. Schwidder. If a technology is approved, the OTC evaluates whether it is best commercialized via a license to an existing company or through the creation of a new start-up company. Thus, the OTC provides a link between the development and commercialization of innovative technologies. Upstream Technologies is a good example of what the OTC is achieving.

The UM provides additional benefits to the new start-up businesses. It protects them against copyright infringement. For example, the biggest risk to Upstream Technologies is the SAFL Baffle's easy-to-copy design. Although two patents are in place to protect them, Upstream Technologies is a small business without the monetary means to defend against copyright infringement. The UM remedies this situation because it is a large entity with the resources to sue any copyright infringers, if necessary.

EFFECTS OF ARRA FUNDING ON COMPANY AND PRODUCT DEVELOPMENT

The ARRA-funded Beacon Bluff demonstration project helped Upstream Technologies develop into a fast growing company. In the launch year of 2011, Upstream Technologies sold 30 SAFL Baffles. In 2012, sales revenues grew to three times the 2011 revenues. The increasing sale revenues enabled Upstream Technologies to hire two additional employees to market its product. In addition, two full-time employees are manufacturing SAFL Baffles at another Minnesota company (i.e., Upstream Technologies outsources manufacturing).

The growth of Upstream Technologies is not waning from lack of ARRA-funded projects to support it (i.e., no ARRA funding bubble effect). Exposure and acceptance of the SAFL Baffle are driving continued sales to new customers, as well as to return customers with larger orders. Initially, clients ordered one or two SAFL Baffles to test in their stormwater systems. Now, according to Mr. Schwidder, customers are coming back with larger orders. For example, the cities of Golden Valley and Bloomington, Minnesota tried the SAFL Baffle and now have a five-year plan to buy twelve additional SAFL Baffles per year to retrofit in their sumps.

Upstream Technology expanded its sales reach beyond the State of Minnesota with help from product exposure on the ARRA-funded Beacon Bluff demonstration. In 2012, Upstream Technologies sold SAFL Baffles to clients in Oregon and Puerto Rico. New clients in Pennsylvania, New Jersey, New York, Illinois, North Carolina and Wisconsin have submitted sales orders for SAFL Baffle installations in the upcoming construction season. In addition, Upstream Technologies is pursuing sales in Australia.

Upstream Technologies continues to develop the SAFL Baffle and expand its product line. In 2012, Upstream Technologies developed a new software package to assist with the design of SAFL Baffles. This summer, Upstream Technologies will launch its second innovative product: a soil testing instrument (infiltrometer) designed to monitor rain gardens and infiltration basins. This innovative soil-testing instrument is another SAFL invention.

FUTURE BENEFITS FROM ARRA FUNDING

The ARRA-funded Beacon Bluff project created follow-on work and new customers for Upstream Technologies. Because the SPPA project gave Upstream Technologies the opportunity to successfully demonstrate the effectiveness of its SAFL Baffle for stormwater pretreatment, it provided them with a marketing tool to attract both follow-on and new customers. For example, its demonstrated success led the project's engineering design firm, Loucks Associates, to recommend the SAFL Baffle on several of its subsequent stormwater design projects. The successful demonstration also created a reference at SPPA, for whom Mr. Schwidder can refer prospective customers. In addition, the SPPA's discussion of the project with the media and industry peers provided Upstream Technologies with 'word of mouth' marketing exposure. Likewise the SAFL researchers' presentations at industry conferences provided additional marketing exposure that is likely to result in new customers.

SUMMARY

The ARRA-funded Beacon Bluff redevelopment project provided Upstream Technologies with its first opportunity to successfully demonstrate the effectiveness of the SAFL Baffle as a stormwater pretreatment technology. The successful demonstration opened the door to commercialization of the product and made the task of raising funds to launch the new start-up business (Upstream Technologies) less onerous. The demonstration also provided Upstream Technologies with a marketing tool that has helped it become a fast-growing company. Since its launch, Upstream Technologies has tripled in size, expanding its sales reach from Minnesota to an additional eight states. It is marketing the SAFL Baffle both nationally and internationally, and plans to launch the sale of a second innovative technology later this year.

IV. RECIPIENT-PROVIDED INFORMATION

INTRODUCTION

The first SAFL Baffle installation occurred at the Beacon Bluff redevelopment site in St. Paul, Minnesota. Prior to redevelopment, the site served as 3M's global headquarters and production facility, but supported other industries including a foundry over the past century. These industrial activities left the soils contaminated with hazardous substances. In addition, over 200,000 square feet of older on-site buildings were contaminated with lead paint and asbestos (SPPA, 2009). The SPPA acquired the property with the intent of removing the contaminated soils and structures and preparing the site for sale to commercial ventures.

As part of the Beacon Bluff redevelopment project, SPPA installed the NGSWMS. This storm water management system was a collaborative effort between SPPA, the City of St. Paul, the Capitol Region Watershed District (CRWD), Loucks Associates and the University of Minnesota (Enterprise Minnesota, 2010). It included several innovative approaches to constructing and monitoring an engineered infiltration basin that captures and treats stormwater runoff from the neighboring residential and brownfields areas, such as use of recycled materials to remove contaminants from stormwater as it percolates through the soil. For larger flows, the NGSWMS includes three ten-foot diameter culverts that convey stormwater underground, away from the site. A sump manhole that conveys water to the culverts contains the SAFL Baffle.

INTERVIEW WITH MR. JEFF SHOPEK

In February 2013, Mr. Jeff Shopek, President of Loucks Associates, provided his perspective on the selection of the SAFL Baffle technology for the NGSWMS and its performance. Loucks Associates is a consulting business providing engineering design services on stormwater and environmental projects. Mr. Shopek and his staff at Loucks Associates supported the SPPA in the planning and design of the NGSWMS. This section summarizes his responses to questions about the technology selection process, system performance and impact of ARRA funding.

SELECTION OF SAFL BAFFLE TECHNOLOGY

Loucks Associates focused the selection process on innovative, rather than conventional, technologies. This is because SPPA requested Loucks Associates to use “the next up-and-coming storm sewer device” on the Beacon Bluff redevelopment site. According to Mr. Shopek, “A builder or a developer doesn’t want to go out on a risky limb. They want everything to be cut and dry; whereas SPPA is looking for new and innovative ideas to help all of their projects.”

The SPPA’s request resulted in a search for an innovative storm sewer technology. The CRWD contacted the UM to inquire about innovative devices and was told about Dr. Gulliver’s research and testing of the SAFL Baffle. Mr. Shopek contacted Dr. Gulliver to explore the possibility of demonstrating the SAFL Baffle at the Beacon Bluff site. Following the discussions, Loucks Associates evaluated the features of the SAFL Baffle against conventional hydrodynamic separators.

Loucks Associates selected the SAFL Baffle innovative technology because of its simplicity and use of conventional maintenance equipment. Mr. Shopek knew the City of St. Paul did not want a conventional hydrodynamic separator, which has several undesirable features (i.e., complex design, difficult installation and non-standard equipment requirements for cleanout). The City cleaned all of its existing sumps using a vacuum truck and didn’t want to buy another type of cleanout device for a new sump. Because the SAFL Baffle avoided the pit falls of other hydrodynamic separators, it was selected for the Beacon Bluff project.

SYSTEM INSTALLATION

SPPA’s contractor installed the SAFL Baffle in a new sump manhole located between the existing stormwater sewer system and the new infiltration basin. As designed, the new diversion system routes roughly 50 percent of runoff from the 48-inch pipe of the main stormwater sewer system into a new 18-inch pipe that flows into the new sump and then outlets into the infiltration basin. The diversion system captures low flow events and the “first flush” of larger storm events, (i.e., initial runoff containing the most sediment).

The installation of the SAFL Baffle occurred in April 2011, which was roughly six months after the scheduled installation date of October 2010. The delay occurred because the SAFL Baffle was not available on the scheduled date. The UM required additional time to complete commercialization and manufacture of the SAFL Baffle product; however the delay did not affect the overall construction schedule for the Beacon Bluff project. The sump manhole was built on schedule, thus the contractor retrofitted the SAFL Baffle to the sump, which was a quick and easy process.

The installation of the SAFL Baffle went “very smoothly,” according to Mr. Shopek. An audience of 12 people watched the installation, including representatives from the SPPA, the UM and the manufacturing company. Upstream Technologies drilled four holes, inserted screws and attached the baffle. As advertised, the SAFL Baffle installation only took 45 minutes to complete.

SYSTEM PERFORMANCE

There are preliminary indications that the SAFL Baffle is performing well. In the summer of 2012, the City of St. Paul started monitoring the SAFL Baffle’s performance. Monitoring was delayed prior to 2012 due to a lack of funding. To date, the City has collected data from only two storm events because 2012 was a dry year. Mr. Shopek cannot say whether the SAFL Baffle is performing well based on the collected data, but when he observed the sump bottom, it was full of sediment (an indication the SAFL Baffle is performing well).

SYSTEM BENEFITS

The Beacon Bluff redevelopment project expanded a small site-specific BMP (i.e., detention pond) into a much larger regional BMP (i.e., NGSWMS) to benefit the community. The SPPA was in favor of the NGSWMS because it was a better use of land (i.e., an underground system that freed up surface area for future development). The City of St. Paul was in favor of the NGSWMS because it provided treatment to the neighboring watershed area, which was not in compliance with the CRWD requirement to treat stormwater prior to discharge to the Mississippi River. The neighboring watershed area was not in compliance because it was totally built out with residential houses and streets; therefore, no open space was available to construct the needed stormwater BMPs, such as detention ponds. The NGSWMS solved the problem. Thus, the installation of the NGSWMS benefited both the City of St. Paul and the SPPA.

IMPACT OF ARRA FUNDING

The ARRA funding made the construction of the NGSWMS a reality. According to Mr. Shopek, the SPPA would not have proceeded with the Beacon Bluff project without ARRA funding. Thus by association, ARRA funding fostered the development of a useful innovative technology. Mr. Shopek believes the SAFL Baffle is an easy to install and maintain product that will most likely be widely implemented in the future as a low cost solution to sediment loss in stormwater sump manholes.

SUMMARY

The ARRA funding made the construction of the NGSWMS a reality. Loucks Associates selected the SAFL Baffle innovative technology to include in the NGSWMS because of its simplicity and use of conventional maintenance equipment. According to Mr. Shopek, the installation of the SAFL Baffle went “very smoothly.” Since monitoring began in the summer of 2012, there are preliminary indications that the SAFL Baffle is performing well. Mr. Shopek believes the SAFL Baffle is an easy to install and maintain product that most likely will be widely implemented in the future as a low cost solution to sediment loss in stormwater sump manholes. Its green infrastructure benefit is an improvement in stream water quality (i.e., reduced suspended solid levels discharged to the Mississippi River).

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