Orange County Sanitation District

Research Report
2013-2016

2013 - 2016
OCSD Research Report

Compiled by
Engineering Planning

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Acknowledgments

Oversight of the research program is provided by the Research Technical Advisory Group (RTAG), a staff technical committee charged with evaluating proposals for new research projects, monitoring the progress of existing projects, and disseminating the results of projects to interested parties inside and outside OCSD. The RTAG membership provides scientific and engineering expertise and reflects the wide-ranging occurrence of research activities throughout the agency.

The RTAG members in 2015-16 were:

- Jeff Brown
- Kim Christensen
- Carla Dillon
- Margil Jimenez
- Tom Meregillano
- Christopher Stacklin
- MarcoPolo Velasco

Abbreviations and Acronyms

ADG	Anaerobic digester gas
AQMD / SCAQMD	South Coast Air Quality Management District
BMP	Biological methane potential
COD	Chemical oxygen demand
CGS	Central (Power) Generation System
DPR	Direct potable reuse
EBRT	Empty bed residence time
MRL	Method reporting limit
NG	Natural gas
NO_x	Nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
OAV	Odor activity value
OTC	Odor threshold concentration
PSA	Pressure swing adsorption
SCCWRP	Southern California Coastal Water Research Project
SCR	Selective catalytic reduction
SCWO	Supercritical water oxidation
SO_x	Sulfur oxides
TAG	Technology Approval Group
TS	Total solids
TSS	Total suspended solids
TWAS	Thickened waste activated sludge
UCLA	University of California, Los Angeles
VOC	Volatile organic compound
VS	Volatile solids
VSR	Volatile solids reduction

Part 1

Introduction and Overview

Part 1

Introduction and Overview

This document is a report of OCSD research activities after June 30, 2013, which is the ending date for the most recent previous annual research report (for FY 2012-13). This report provides updates for projects that were in progress at that time and also includes projects that were started in FY 2013-14, 2014-15, or 2015-16. The project activities were carried out by various divisions in the Engineering, Operations & Maintenance, and Environmental Services departments. The funding sources included research-specific allocations (SP-125 projects) and departmental funds.

The activities during these years addressed a range of topics, with notable efforts in odor control activities and treatment process improvements. Two master planning projects, for odor control and biosolids operations, were begun. There also were cooperative projects with wastewater industry research organizations.

Several major projects are continuing, and new research projects will be undertaken in response to OCSD's current and future needs. Toward this end, OCSD is a member of Isle Utilities' TAG (Technology Approval Group), an international consortium of wastewater agencies, to facilitate identifying and evaluating emerging technologies from around the world that could be beneficial for OCSD. The research program will continue to be proactive in bringing improvements to OCSD's activities to reduce costs, improve efficiency, and promote environmental protection.

Part 2

Detailed Project Information

Project Category:

Air Quality

2015-16 Project Description

Project Title:

Central Generation System (CGS) Engines Air Emissions Compliance (Project J-79)

Process Related Special Project

Central Power Generation

Contact: Lisa Rothbart, Engineering

Purpose: Evaluate catalytic emissions reduction systems for CGS engines

Description:

CGS engines are the largest sources of air pollution at OCSD. They emit both criteria pollutants (NO_x, CO, VOC, particulates, SO_x) and substances identified as air toxics.

The goal of the J-79 project is to evaluate and test technologies to reduce emissions from the CGS engines to address AQMD Rules 1110.2, 1401, and 1402. Several identified technologies that reduce NOx, CO, and VOC emissions were evaluated in detail based on technical and economic factors such as proven performance, availability, long-term performance, commercial application, site specific constraints, and cost. Based on the results of this evaluation, a pilot test of a Selective Catalytic Reduction (SCR)/Catalytic Oxidizer System is being conducted on one CGS engine at Plant 1. This selected post-combustion technology has been proven effective for controlling NOx, CO, and VOC emissions from combustion units using natural gas. However, the CGS engines run on digester gas, which can lead to fouling or rapid performance degradation of catalytic oxidizers. Therefore, a digester gas cleaning system is also included as part of the pilot testing program.

The design of the pilot testing program includes one full-scale platform-mounted SCR/catalytic oxidizer system that has been installed on Engine #1. Based on pilot testing previously performed at Plant 2, the digester gas cleaning system has proven successful in removing contaminants such as siloxane and hydrogen sulfide from the digester gas, making the catalyst life comparable to an IC engine installation operating on natural gas. The pilot testing will use one layer of catalyst in the catalytic oxidizer housing and two layers of catalyst in the SCR housing to collect data for compliance with upcoming (year 2012) emission limits. The digester gas cleaning system will use specially designed carbon adsorption to clean all digester gas produced at Plant 1.

2015-16 Project Description

Results:

The pilot testing program assessed the performance of NO_x, CO, and VOC removal by the SCR/catalytic oxidizer system and provided information for use in full-scale design. The monitoring requirements for the program included the following:

- Testing the catalytic oxidizers while running the engines on 90 to 100 percent digester gas.
- Performing source testing once during the initial start-up of the system using CARB approved sampling methods for NO_x, CO, and total VOCs and using CARB Method 430 or EPA Method 323 for formaldehyde and other aldehydes.
- Performing periodic monitoring of NO_x and CO performance at the inlet and two outlets of the two catalytic oxidizers using hand-held analyzers.
- Performing quarterly source testing of VOCs using SCAQMD Method 25.1 and formaldehyde using modified CARB Method 430 and EPA Method 323 at the inlet and outlet of the catalytic oxidizer.
- Performing bi-weekly source testing of specified organics (air toxics) and sulfur compounds at the inlet and outlet of the fuel gas cleaning system and the inlet and outlet of the catalyst system utilizing EPA Method TO-15 and SCAQMD Method 307-91.
- Performing quarterly testing of siloxane removal using MS/FID.

The catalytic oxidizer reduces carbon monoxide and air toxics (e.g., formaldehyde, acrolein) emissions from the engine exhaust. Urea is injected into the engine exhaust ductwork between the catalytic oxidizer and the SCR catalyst to reduce NO_x emissions. The digester gas cleaning system is filled with activated carbon media to remove siloxanes and other compounds that could potentially foul the oxidative and SCR catalysts.

The projected cost for the pilot testing was $530,000 for the SCR/catalytic oxidizer and digester gas cleaning system and $2.4 million for construction and related expenses during the test. Equipment for full-scale installations on the remaining seven CGS engines was projected to cost approximately $31 million.

Status:

Engineering services for the J-79 Project were provided by Malcolm Pirnie, Inc. (MPI). Olsson Construction provided installation services for the earlier catalytic oxidizer pilot test at Plant 2 and installed the pilot testing equipment at Plant 1. The construction began in October 2009 and was completed in February 2010. Testing activities began in late March 2010 and continued through March 2011. A research report was prepared by MPI, with the final report submitted to South Coast AQMD in August 2011.

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The results of the successful research showed significant reductions in NO_x, CO, VOCs, and air toxics emissions. The South Coast AQMD rule limits for CO and VOC were consistently achieved. The rule limit for NO_x was achieved for 99% of the data collected during the one-year monitoring period. NO_x limit exceedances, which occurred in 1% of the data, were experienced during times of high engine load (> 100% load) and also when the natural gas / digester gas fuel ratio changed. In its research report, MPI recommended further research to optimize the urea injection rates to improve NO_x removal during different engine operating scenarios.

In response to MPI's recommendations, adjustments were made in late 2011 to the urea injection system by Johnson-Matthey. Continuous emissions data were recorded and sent to MPI for analysis. These optimization efforts continued until the system was temporarily shut down in February 2012 due to a sudden decrease in performance of the oxidative catalyst, which was caused by contaminant breakthrough in the digester gas cleaning system and was unrelated to the urea optimization work. The oxidative catalyst was removed, samples were sent out for analysis, and the catalyst was regenerated to the extent possible. Optimization efforts and data monitoring restarted once the oxidative catalyst was put back into service.

MPI stopped their data review and analysis during 2012. OCSD Environmental Compliance staff began performing data review in-house. Research also continued on identifying an indicator of contaminant breakthrough that could be analyzed quickly. Siloxane analyses by an outside laboratory had a one-week delay, which was not desirable for process control. OCSD eventually procured laboratory equipment to perform onsite siloxane analyses.

The oxidative catalyst continued to meet the compliance limits. Implementation of this technology on all eight Central Power Generation System engines was completed under CIP Project J-111. The SCAQMD extended the compliance date from 2016 until January 1, 2018 for OCSD.

Project Category:

Biosolids

2015-16 Project Description

Project Title:

Biosolids Master Plan (Project PS-15-01)

Solids Handling & Digestion

Strategic & Master Planning

Contact: Sharon Yin, Engineering
Tom Meregillano, Environmental Services

Purpose: Develop a 20-year Biosolids Master Plan

Description:

This project will develop a Biosolids Master Plan (Plan) that will meet one of the goals in OCSD's 2013 Five (5)-year Strategic Plan, which is to recommend future biosolids management options and capital facilities improvements for a 20-year planning period. The Plan will identify offsite biosolids management alternatives for OCSD to generate biosolids product(s) that meet a sustainable beneficial use market. In addition, the Plan will include an evaluation of the existing OCSD solids handling facilities, study solids treatment alternatives, and make recommendations for future capital facilities improvements.

In 2003, OCSD’s Long-Range Management Plan established guidelines for diversifying biosolids products, contractors, and markets to create a sustainable biosolids program. OCSD has been implementing a diversified program that reflects these goals.

Looking forward, there will be significant changes in the biosolids quality and quantity within several years. OCSD’s biosolids management contract with Synagro expires in December 2016. In 2017, the Irvine Ranch Water District (IRWD) will stop sending solids to OCSD. In addition, OCSD’s dewatering centrifuges will be online after the completion of Projects P1-101 and P2-92. With these changes, the biosolids production will be reduced by approximately one-third in the next few years.

Furthermore, the age and vulnerable condition of the Plant 2 digesters generate the need for their rehabilitation or replacement. The 18 digesters were built between 1959 and 1979. No major structural rehabilitation has been done since the digesters were built. A recent planning study, SP-186 Plant 2 Digesters and Tunnels Seismic Evaluation, determined that all Plant 2 digesters have a high risk of structural failure in the event of soil liquefaction or other major seismic events. Major ground improvements and structural improvements will

2015-16 Project Description

be needed to reduce the risk of structural failure and make the digesters compliant with the current seismic code.

The Biosolids Master Plan (Project No. PS-15-01) will study mid- and long-term strategies for biosolids management and will identify onsite and offsite facility options to generate biosolids product(s) that could meet future regulations for a sustainable biosolids beneficial use market.

In July 2015 OCSD issued an RFP for a Biosolids Master Plan consultant. Black & Veatch was awarded the professional service agreement for an NTE fee of $2,965,556 plus a 10% contingency.

	Major Milestones	Proposed Date
1	Draft Technical Memorandum 1 – OCSD Solids Facilities Summary and Design Bases	March 15, 2016
2	Draft Technical Memorandum 2 – Review OCSD's Biosolids Program and Summarize the Current State, Trends and Outlook of Biosolids Management	March 15, 2016
3	Draft Technical Memorandum 3 - Offsite Biosolids Management Alternatives Evaluation	June 7, 2016
4	Draft Technical Memorandum 4 - Plant No. 2 Digestion and Post-Dewatering Technologies Evaluation	November 1, 2016
5	Draft Technical Memorandum 5 – High Strength Organic Waste Co-Digestion Evaluation	November 15, 2016
6	Draft Technical Memorandum 6 – CIP Project Development for Plant No. 2 Solids Handling Facilities	December 13, 2016
7	Draft Technical Memorandum 7 – CIP Project Development for Plant No. 1 Solids Handling Facilities	January 10, 2017
8	Draft Technical Memorandum 8 – Biosolids Management Plan	February 7, 2017
9	Draft Biosolids Master Plan	March 14, 2017
10	Final Biosolids Master Plan	May 9, 2017
11	Prepare Initial Study and Notice of Preparation	June 6, 2017

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	Major Milestones	Proposed Date
12	Finalize IS/NOP	July 4, 2017
13	Prepare First Administrative Draft EIR	September 26, 2017
14	Prepare Second Administrative Draft EIR	November 7, 2017
15	Finalize Draft EIR	December 19, 2017
16	Prepare Final EIR and Response to Comments	February 20, 2018
17	Submit Administrative Final EIR, Resolution of Findings, Statement of Overriding Consideration, Mitigation Monitoring & documentation to OCSD	March 20, 2018
18	Finalize Final EIR, Resolution of Findings, Statement of Overriding Consideration, Mitigation Monitoring & Reporting Program, and related documentation of OCSD	April 17, 2018

Results: In Progress

Status: The project is on schedule as of the end of FY 2015-16.

Project Category:

Odor and Corrosion Control

2015-16 Project Description

Project Title:

Odor Control Master Plan (Project SP-166)

Odor Control

Process Related Special Project

Contact: Ted Vitko, Engineering

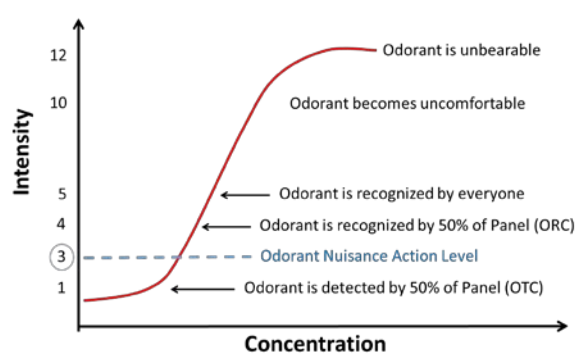
Purpose: Determine the most cost-effective odor abatement technology or technology combination to control odors from each plant process area

Description:

Each plant process area (wastehauler station, headworks, primary treatment, activated sludge, trickling filter, dissolved air flotation, dewatering, biosolids truck loading, and Central Generation engines) has a distinct smell, so the odorants (the mixture of chemical compounds that cause a particular smell) would be assumed to be particular to each process area. However, there are hundreds of potential odorants, and Phase I of this project focused on discovering which odorants were more prevalent and which methodologies could be used to quantify them.

Odorants can be determined by analytical and sensory methods. Standard analytical methods, such as those to determine reduced sulfur compounds, amines, and carboxylic acids, are not adequate for the complex smells perceived in wastewater treatment plants. But by using a combination of analytical and sensory methods, these smells can be analyzed.

However, all analytical methods have a limit beyond which odorants cannot be quantified. This is called the Method Reporting Limit (MRL). The human nose can detect certain key odorants at concentrations much below the MRL. That level of detection is called the Odor Threshold Concentration (OTC). Any odorant that exists at a concentration below its MRL can only be quantified by sensory methods.



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The sense of smell quantifies stimuli on a scale of odor intensity. Using the Weber-Fechner law, it is possible to determine the approximate concentration of an odorant based on its perceived odor intensity.

Once the odorants causing the different smells at each plant process area were identified, Phase II sought to determine (1) the nuisance concentration at the plant fence line for each odorant, (2) the extent of odor abatement needed at each plant process area by conducting air dispersion modeling, (3) the odor abatement technologies that are able to reduce the identified odorants, and (4) a conceptual design and cost estimate of the required odor treatment system for each plant process area to achieve a particular level of odor control.

Results:

The odors that characterize each plant process area are caused by a handful of "most detectable" odorants. However, some of these odorants require special analytical methodologies not done in typical laboratories. (This is addressed in Project SP-125-18, "Odorants Standard Analytical Protocols.")

Testing conducted in 2015 and 2016 obtained the following results.

Odorant/Process	MM	H_2S	DMDS	DMS	NH_3	MIB	IPMP	Skatole	Indole
Odor	Rotten Vegetable	Rotten Egg	Rotten Garlic	Canned Corn	Ammonia	Musty	Earthy	Fecal	Sewery
MRL (ppbV)	5.0	5.0	2.5	5.0	0.26	0.04	0.1	0.15	0.25
OTC[1] (ppbV)	0.077	0.51	0.22	3.0	1,300	0.020	0.004	0.04[2]	0.5
Nuisance (ppbV)	0.22	1.3	0.77	7.9	4,900	0.060	0.035	0.037	1.1
Dominant Odorants at Plant 1 per Process Area									
Wastehauler	X	X						X	
Headworks	X	X	X				X	X	
Primaries	X	X				X		X	
Trickling Filters	X	X				X	X		
Activated Sludge	X					X	X	X	
DAFTs						X		X	
Dewatering						X	X	X	
Truckloading	X		X	X	X	X	X	X	
Dominant Odorants at Plant 2 per Process Area									
Trunklines	X	X	X				X		
Headworks	X	X	X				X	X	
Primaries	X	X						X	
Trickling Filters	X	X				X		X	
TF Reactors	X					X	X	X	
TF Mixed Liquor	X		X				X	X	
Activated Sludge	X	X				X	X	X	
DAFTs	X	X						X	

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Odorant/Process	MM	H_2S	DMDS	DMS	NH_3	MIB	IPMP	Skatole	Indole
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Nuisance (ppbV)	0.22	1.3	0.77	7.9	4,900	0.060	0.035	0.037	1.1
Dewatering		X					X	X	
Truckloading	X	X		X	X		X	X	

[1] Suffet, *et. al.* (July 24, 2015) performed at OCSD. [2] *Addendum* (April 2016).
MM = Methyl Mercaptan, H_2S = Hydrogen Sulfide, DMDS = Dimethyl Disulfide, DMS = Dimethyl Sulfide, NH_3 = Ammonia, MIB = 2-Methyl Isoborneol, IPMP = 2-Isopropyl-3-Methoxy-Pyrazine.

It is the proportion of "most detectable" odorants rather than a different mix of odorants that causes the different and characteristic smells throughout the wastewater treatment process. The most important odorants at each plant process area were determined by comparing odor activity values (OAV). OAV is the ratio of the concentration of an odorant (C) and its OTC. The higher the ratio, the more important that odorant is for that odor source. OAVs are useful for prioritizing the odorants to target for monitoring and treatment system design.

Status:

Tests have started of a pilot unit that allows the simultaneous evaluation of nine different odor abatement technologies (biological and physical) that are fed the same foul air. These technologies were picked after a thorough analysis of available options in the market with respect to the target odorants. The biological technologies will be tested at different empty bed residence times (EBRT) to determine the ideal conditions for the removal of the "most detectable" odorants.

Work in the upcoming year will include:

- Test the pilot unit with trunkline and trickling filter air sources and determine particular odorant removal rates for each technology;
- Conduct air dispersion modeling with the worst-case odorant conditions and worst-case weather conditions;
- Determine the level of treatment (type of technology and EBRT) needed to reduce odorants to below-nuisance levels (targeting odor concentrations at their sources);
- Compare the level of treatment needed with the odorant removal capability of each technology to determine its ability to meet the target odor concentration;

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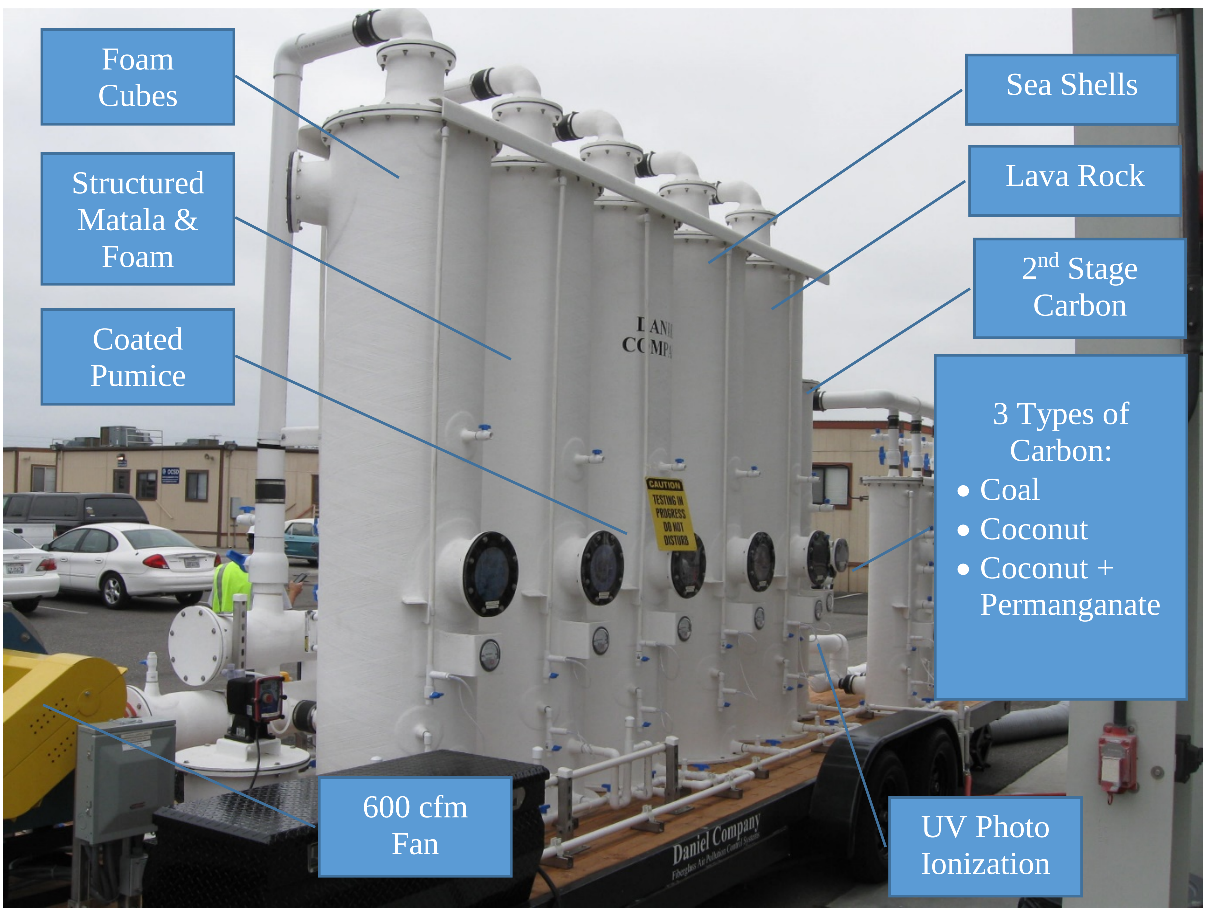
- Prepare realistic preliminary designs for treatment systems for each plant process area and associated costs for the following conditions:
  - Status quo (current system)
  - Best single stage technology
  - Best multiple stage technologies.

The project budget is $ 1,900,000. Expenditures have totaled $ 1,238,000 as of 6/30/16.

Pilot Equipment for Simultaneously Testing Multiple Odor Control Technologies



2015-16 Project Description

Project Title:

Odorants Standard Analytical Protocols (Project SP-125-18)

Contact: Ted Vitko, Engineering

Purpose: Develop standard gas chromatography/mass spectrometry (GC/MS) analytical protocols with appropriate quality assurance for 2-Methyl Isoborneol (MIB) and skatole in air samples and develop Weber-Fechner curves for all "most detectable" odorants.

Description:

During Phase I of Project SP-166 (Odor Control Master Plan), foul air samples were analyzed by broad spectrum sensory gas chromatography (GC) and mass spectrometry (MS). These analyses pointed to the presence of MIB and skatole in certain OCSD foul air samples. However, the standard analytical methods for determining these compounds are for water samples, not air samples. The methodologies used were adaptations of the standard methods to air samples, so the results obtained were estimates, and analytical interferences were evident. This project was undertaken to (1) develop standard analytical methods to remove these interferences for MIB and skatole, (2) determine the recovery and detection limits for MIB and skatole, and (3) develop Weber-Fechner intensity-concentration curves for all identified "most detectable" odorants (methyl mercaptan, hydrogen sulfide, dimethyl sulfide, dimethyl disulfide, ammonia, MIB, and skatole).

Results:

The first two tasks were performed cooperatively with UCLA researchers, and the third task was performed at OCSD using an olfactometer and an expanded odor assessment group (consumer panel) of 14 panelists of various ages chosen to resemble the general public.

In the process of developing the standard analytical methodologies, it was found that MIB was typically paired with 2-Isopropyl-3-methoxypyrazine (IPMP) to describe the earthy, musty, and moldy smells associated with wastewater treatment. Also, in a similar manner,

2015-16 Project Description

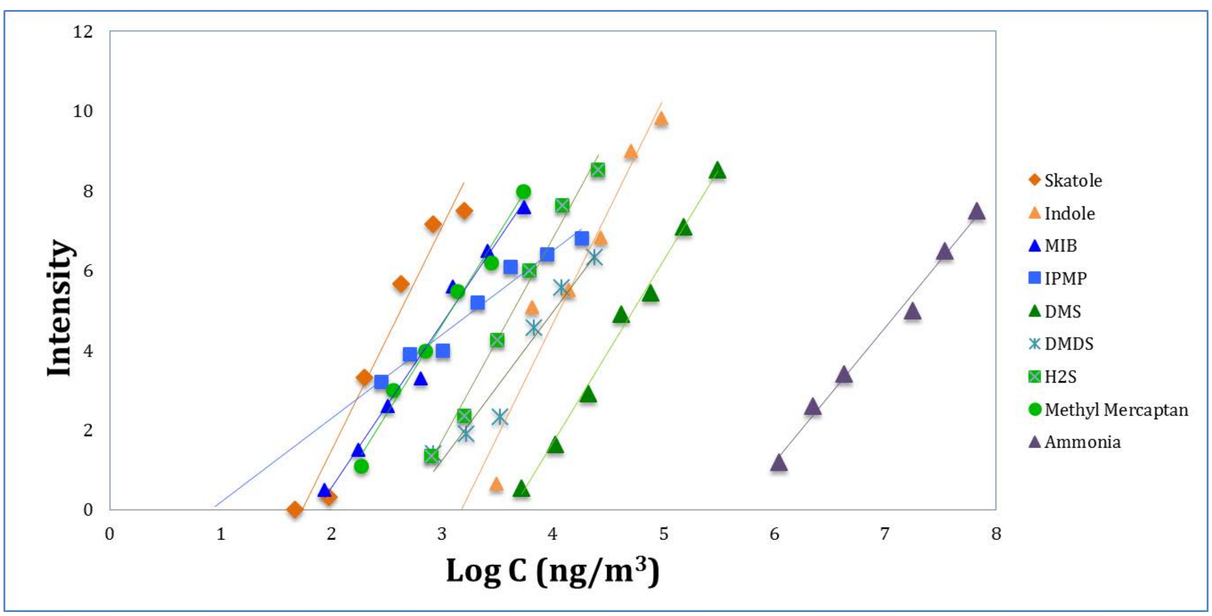
skatole (fecal/manure smells) was paired with indole (fecal/rubbery smells), bringing the total "most detectable" odorants to nine.

Odorant	Odor Threshold Concentration (OTC)	Method Reporting Limit (MRL)	Percent Odorant Recovery
MIB	0.02	0.04	
IPMP	0.004	0.1	
Skatole	0.02*	0.15	78 ± 4.4%
Indole	0.5	0.25	73 ± 5.6%

**later changed to 0.04; see text for explanation*

The methodology developed for MIB and IPMP consisted of subjecting the sample to gas adsorbent glass bead traps, a heat desorption system, a helium gas purge, and an ion MS trap. The methodology developed for skatole and indole consisted of subjecting the sample to a set of two liquid-gas impinger systems, concentrator tubes, a tube heater, and selective ion GC/MS analysis.

The odorant's intensity-concentration curves were developed with a consumer panel of six males and two females in the 18-29 age group, two males and one female in the 30-49 age group, and three females in the 50-64 age group. The OTCs for "most detectable" odorants were determined as well as the perceived odor intensities for samples presented from standards of known concentrations. This work resulted in the Weber-Fechner curves, which will facilitate defining target concentrations for specific odorants at their particular nuisance levels.



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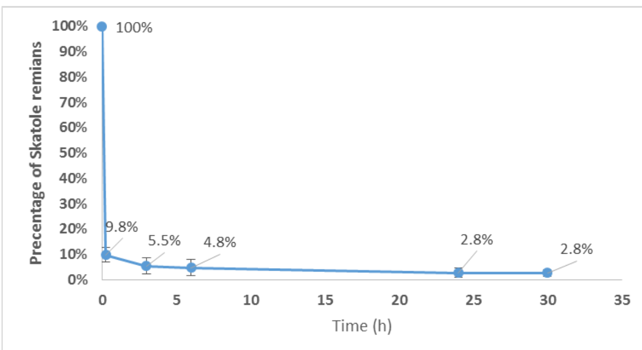
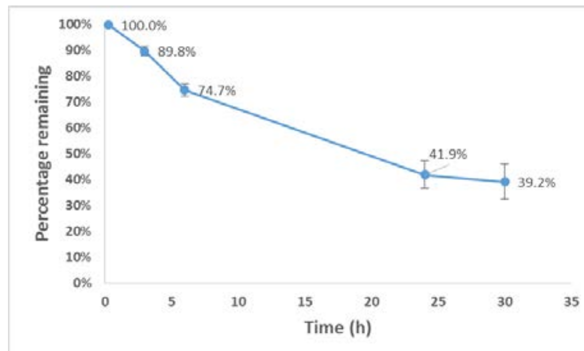
As the project was nearing completion, other research conducted by Boeker, *et. al.* (2014) indicated that skatole is almost totally adsorbed by the Tedlar bags typically used for sampling foul air. This finding prompted a search for an alternative bag material. Based on test results from UCLA, it was determined that Teflon bags were an acceptable replacement. As a result, the scope of this project was amended to include comparisons of Tedlar bags and Teflon bags.

Tedlar



Teflon



This study indicated that if skatole is analyzed from a Tedlar bag within 24 hours (a typical holding time), only 2.8% of the original skatole would remain. Conversely, with Teflon bags, 41.9% of the skatole would remain. It was recommended that all analyses for skatole use Teflon bags and that analyses be done as soon as possible, preferably within six hours (resulting in about 25% loss), which can be accounted for with the use of a correction factor.

Also, a new OTC for skatole was determined (OTC = 0.04) to correct the one determined previously (OTC = 0.02). All other prior conclusions were found to be correct.

Status:

This project has been completed and no further work on it is planned. The results are important for Phase II of Project SP-166 (Odor Control Master Plan). UCLA has published a paper with the findings for the benefit of other odor control investigations of this type.

This project, in conjunction with Phase I of Project SP-166, received an Honor Award for Research from the American Academy of Environmental Engineers and Scientists.

The project budget was $ 60,000. The project expenditures were $ 59,967.50 as of 6/30/16.

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Project Title:

SeweX Sulfide Generation Modeling

Contact: MarcoPolo Velasco, Operations and Maintenance

Purpose: Evaluate the SeweX sulfide generation model using a representative section of OCSD's collections system

Description:

SeweX (from Sewex.com in Australia) is a dynamic sulfide generation computer model for sewer networks. The model provides dynamic predictions of dissolved sulfide and sulfate, COD, pH, and dissolved oxygen over a specified period of time (ranging from eight hours to five days). The model can be run to provide baseline profiles or to simulate chemical dosing conditions for sulfide control (using magnesium hydroxide, iron or nitrate salts, or oxygen injection). The simulations provide profiles of the parameters, taking into account biological and chemical reactions and physical processes taking place in the sewer wall biofilm and in the bulk liquid phase. This dynamic model relies on input data specific to the network being modeled (wastewater and hydraulic data), and the coefficients for sulfide production rely on many different model processes and kinetic expressions. Most steady state models, in contrast, provide only an average or upper/lower estimates and rely on a single field measurement.

OCSD's Baker-Main Trunk Sewer System (BMTSS) provides service for the cities of Costa Mesa, Tustin, Santa Ana, and Irvine. The BMTSS consist of five primary segments serving the major tributary areas: the Baker-Gisler Interceptor, the Fairview Road Trunk, the Fairview Relief Trunk, the Main Street Trunk, and the Von Karman Trunk.

The sewer network consists of trunk sewers that connect the Main Street Pump Station (PS) to OCSD's Plant 1 near the Greenville-Banning channel. The system has two pump stations

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(at Main Street and College Avenue), two force main sewers, and a number of gravity sewers as shown in Figure 1.

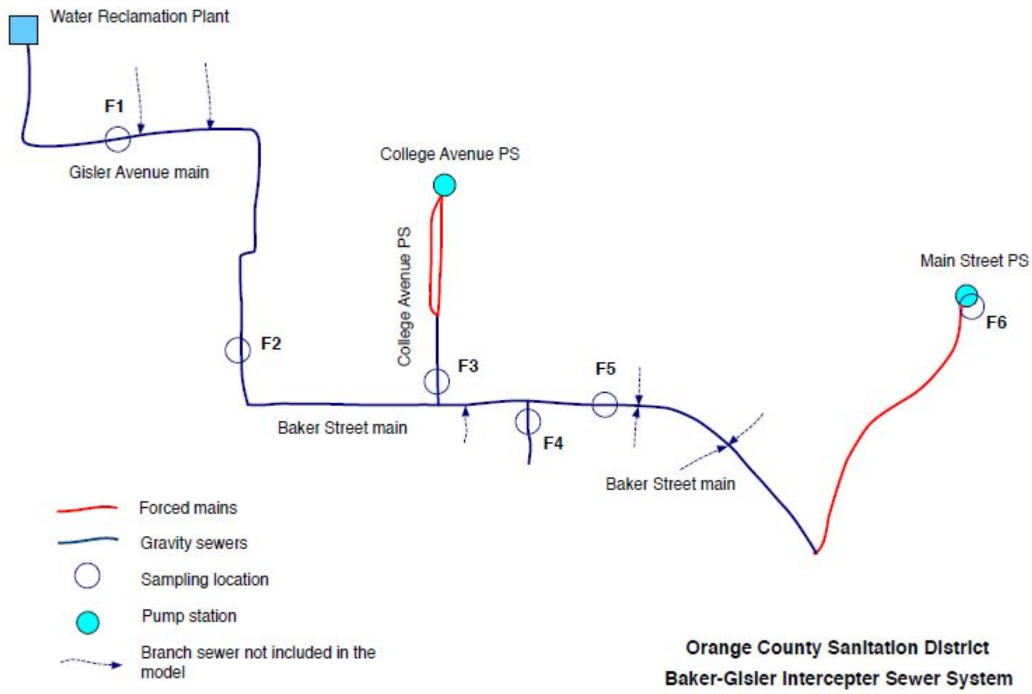

Figure 1. Schematic of the sewer network

For this project, the BMTSS was modeled in SeweX and various chemical dosing scenarios were simulated. (OCSD applies chemicals in various locations throughout its service area to reduce odors.) The sulfide levels (both dissolved and in the sewer headspace) were examined in each simulation case to evaluate the effectiveness of the chemical dosing.

2015-16 Project Description

Chemical dosing options evaluated in this study

Option	Chemical Used	Mechanism of Action	Dosing Details*
1	Calcium nitrate	Preventing anaerobic conditions in sewer; biological oxidation of hydrogen sulfide	Continuous dosing u/s of Main Street PS
2	Oxygen	Preventing anaerobic conditions in sewer; biological and chemical oxidation of hydrogen sulfide	Continuous dosing u/s of Main Street PS and 1.25 km d/s of Main Street PS
3	Ferrous chloride	Precipitation of hydrogen sulfide produced in sewer and removal of sulfide as insoluble iron sulfide precipitate	Continuous dosing u/s of Main Street PS
4	Magnesium hydroxide	Elevation of pH, thereby preventing the release of H_2S to sewer headspace; pH inhibition of sulfate reduction	Continuous dosing u/s of Main Street PS
5	Free nitrous acid (FNA)	Deactivation/detachment of biofilm	Intermittent dosing u/s of Main Street PS
6	Sodium hydroxide for pH shock	Deactivation/detachment of biofilm	Intermittent dosing u/s of Main Street PS

* u/s = upstream; d/s = downstream

Results:

All chemical options considered in this study except oxygen dosing were predicted to achieve the target of maintaining the dissolved sulfide concentration in the wastewater below 1.0 mg S/L most of the time with an average level below 0.5 mg S/L. Similarly, the dosing options were able to achieve the average headspace H_2S levels below 10 ppm. However, there were some possible reliability issues using FNA or sodium hydroxide as the dosing in both the cases would be intermittent, and the sulfide production rate gradually increased after the dosing was stopped.

The estimated operating cost and Net Present Value (NPV) for each chemical dosing option are summarized in the table below. Note that capital costs are excluded in this analysis.

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The estimated costs include the following:

- Operating costs include chemical and delivery costs, rental charges for dosing equipment provided by the chemical supplier, electricity, routine inspection / maintenance / spare parts. (Capital costs are not included.)
- NPV is based on a 5% discount rate, a return period of 25 years, and replacement of mechanical and electrical equipment after 15 years.

Ferrous chloride had the lowest annual chemical cost and NPV among the options. This is because of the low level of dissolved sulfide in the system. (Ferrous dosing requirements are very dependent on the sulfide level.) Although sodium hydroxide was the second least expensive option, there were concerns about its performance reliability since the chemical is dosed intermittently and biofilm regrows during the non-dosing periods, allowing the sulfide production to increase.

Chemical	Magnesium Hydroxide	Oxygen	Calcium Nitrate	Ferrous Chloride	Sodium Hydroxide	FNA
Chemical dosing rate (gal/day)	1190	342,370	3260	815	686 (intermittent)	1040 ($NaNO_2$), 65 (10 M HCl)
Chemical ($/yr)	$ 679,400	$ 331,100	$ 2,733,000	$ 345,500	$ 408,400	$ 1,310,200
O&M ($/yr)	$ 701,800	$ 397,800	$ 2,755,300	$ 367,900	$ 430,800	$ 1,332,600
Net Present Value (NPV)	$ 11,224,000	$ 6,983,000	$ 44,181,000	$ 5,866,000	$ 6,874,000	$ 21,348,000
Relative ranking based on cost	4	3	6	1	2	5
Reliability of performance	Good	Poor	Good	Good	Poor	Moderate

Status:

This project has been completed. Possible future work could include modeling a larger section of the sewer network, which could give more opportunities for identifying new dosing locations to provide improved odor control, but there are no current plans for that.

The project budget was $110,186. The project expenditures totaled $81,883.

Project Category:

Process Alternatives or Improvement

2015-16 Project Description

Project Title:

Supercritical Water Oxidation (AquaCritox®) Evaluation (Project SP-125-17)

Solids Handling & Digestion

Research & Development

Contact: Jeff Brown, Engineering

Purpose: Evaluate Supercritical Water Oxidation (SCWO) for solids treatment

Description:

Supercritical Water Oxidation (SCWO), also known as Hydrothermal Oxidation, is a highly efficient process for converting the energy potential of organic compounds from wastewater treatment into useful heat or electricity. It has a low carbon footprint, is environmentally sustainable, and can improve the energy efficiency of the conventional wastewater treatment plant by replacing the energy-intensive unit processes of anaerobic digestion, biogas cleaning/compression/storage, and residual solids dewatering, in addition to removing the need for onsite or offsite biosolids management.

Wastewater sludges, while high in water, still contain embedded chemical energy that is difficult to access in a manner that recovers useful energy. The impediment has been that the energy required to evaporate the water from the solids is equal to or greater than the energy present within the solids. This thermal energy is lost through the latent heat of evaporation.

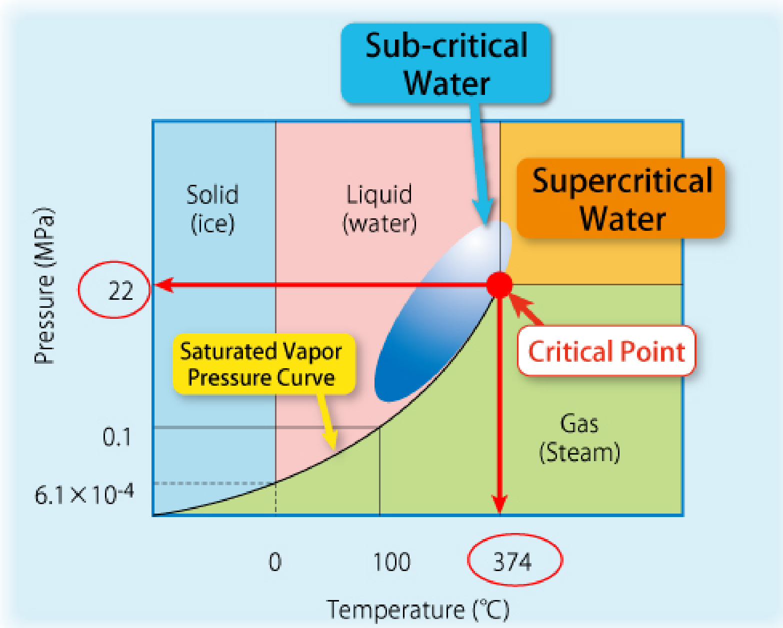
SCWO specifically intended for wastewater treatment solids (pre- or post-digestion) is embodied in the AquaCritox process developed by SCFI Group Ltd. (Cork, Ireland). AquaCritox is able to recover nearly all of the energy chemically bound within the biosolids because the latent heat of evaporation is not lost from the system. The AquaCritox process utilizes water and oxygen at elevated temperature and pressure to completely destroy organic wastes, with no harmful emissions to either air or water.

The process is totally enclosed and can achieve destruction efficiencies of close to 100% in less than 60 seconds' residence time. Primary, mixed, and digested biosolids can be

2015-16 Project Description

processed autothermally from feed streams with 12% to 16% dry solids. Because AquaCritox does not require water to be evaporated, the energy loss associated with the latent heat of evaporation is avoided, rendering this process substantially more efficient for energy recovery and power generation from wet biofuels.

The organics destruction is achieved by oxidation of the organic feed components at conditions above the supercritical point of water. Water enters the supercritical region when it is heated above 705 °F (374 °C) at a minimum of 3200 psi (22 MPa) pressure.



Phase Diagram for Water

On entering this phase, the physical properties change dramatically. In the supercritical region, organics, oxygen, and water become completely miscible, thus eliminating mass transfer constraints. The reaction rate is very fast, enabling complete oxidation within 30 to 60 seconds and achieving over 99.99% destruction efficiency in an exothermic reaction regardless of the nature of the organic reactants.

Supercritical water has a high diffusivity akin to a gas, while its density is like that of a liquid. Supercritical water acts like a low polarity solvent, so it becomes a solvent to all organics. Oxygen becomes a very powerful oxidant under supercritical conditions and is completely miscible in all ratios with the supercritical water.

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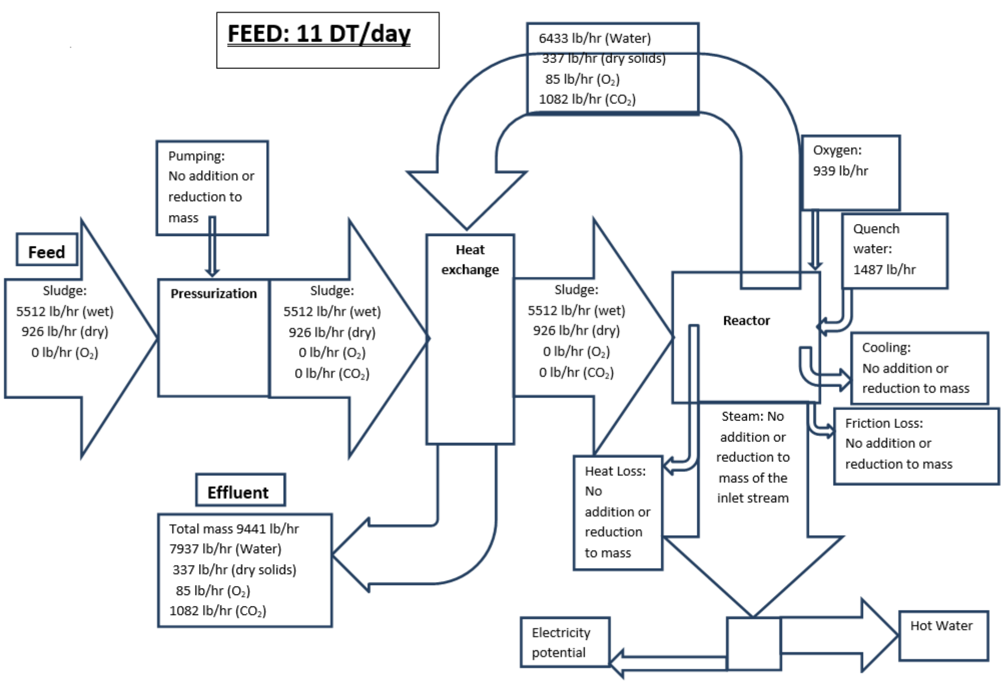
Results:

OCSD began investigating AquaCritox SCWO seriously in 2011 because it seemed to be a solids processing technology that offered substantial benefits over the current practices. With a higher system energy efficiency, no biogas production, and no residual biosolids remaining, it addressed the most troublesome aspects of conventional solids treatment and produced large amounts of recoverable heat that could be used for generating electricity in a steam turbine or as process heat if that were needed elsewhere.

After various informal evaluations of AquaCritox using OCSD-specific data produced promising results, SCFI was contracted in July 2015 (project SP-125-17, $311K/$423K for SCFI/total budget) to do a preliminary engineering study to define the process equipment, evaluate the expected performance and costs, and do site-specific planning for an AquaCritox installation. The final report, delivered in June 2016, addressed two possible AquaCritox facilities, a model A-30 (3,968 dry tons of feed annually) and a model A-100 (13,228 dry tons annually).

Sankey mass and heat balance diagrams representative of the A-30 system are shown below.

<u>Mass balance:</u>



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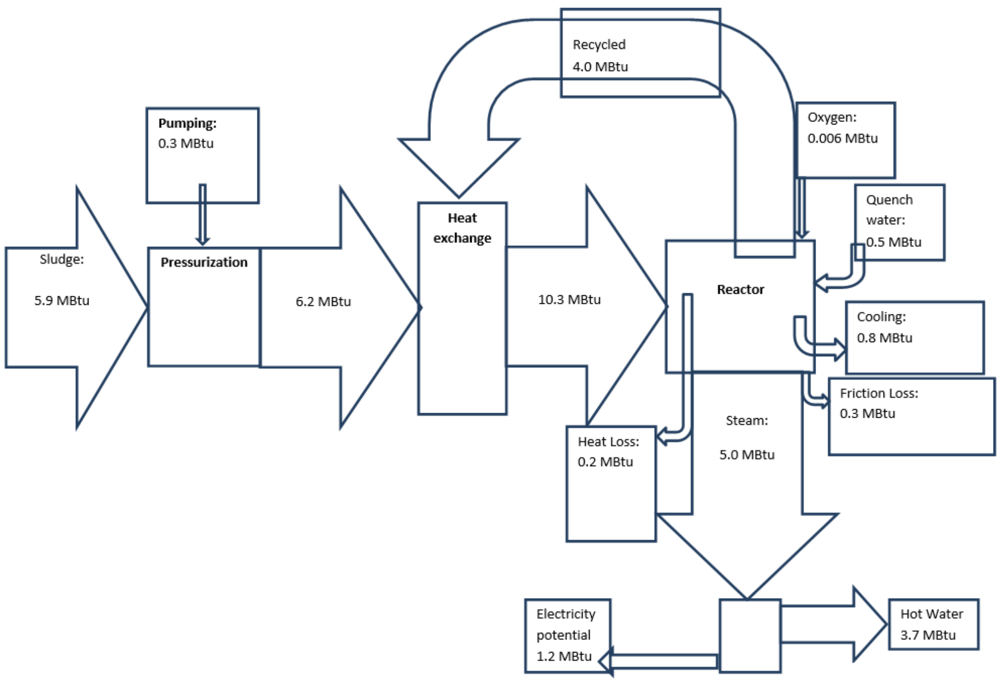
<u>Heat balance:</u>



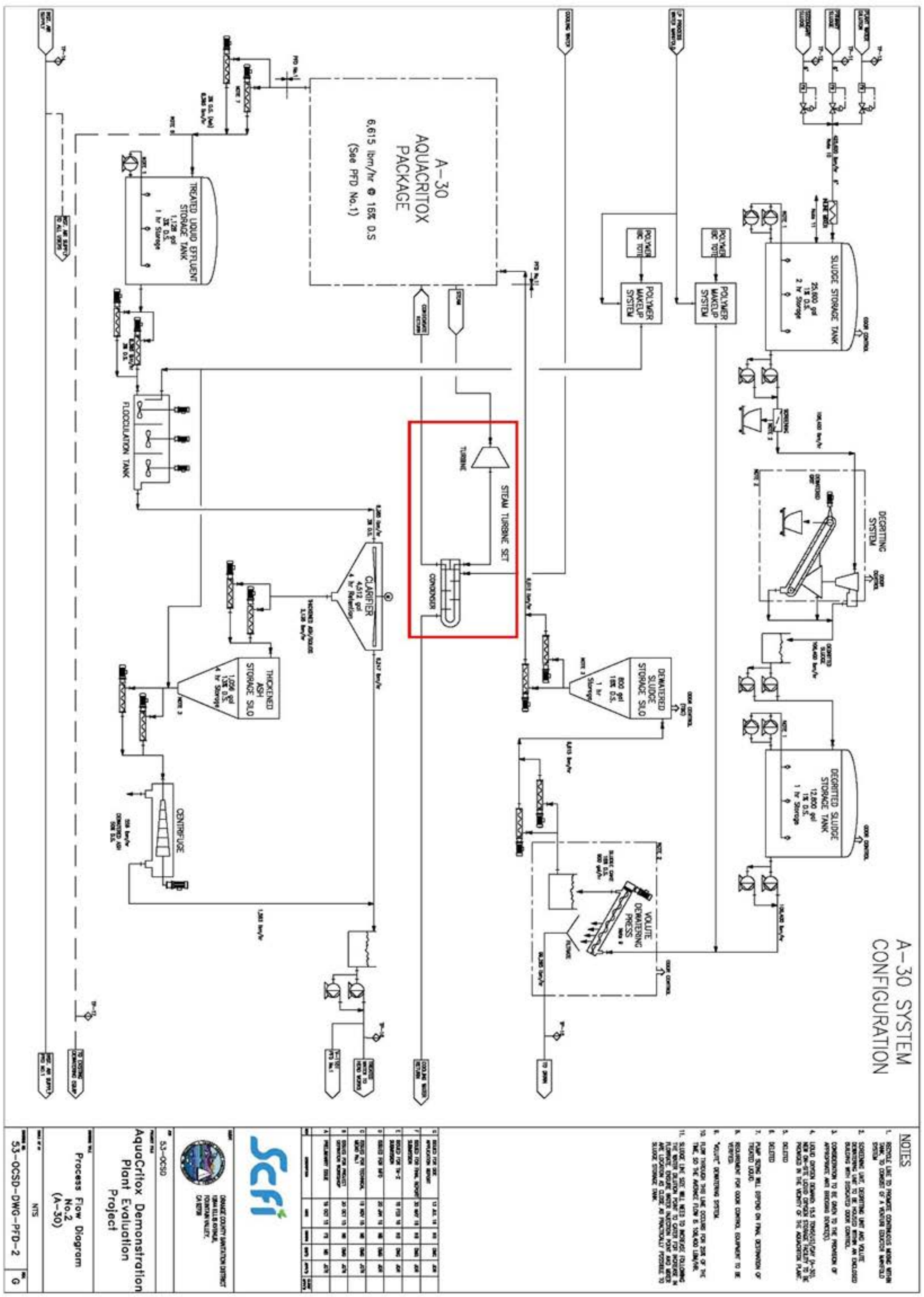
As electrical power producers, the A-100 facility could generate 1.6 MW (primary solids feed) or 1.0 MW (secondary solids feed), and the A-30 facility could generate about 30% as much. The capital costs were estimated at $26.50M (A-30) and $49.19M (A-100) including a steam turbine/electrical generator for the A-100 but not for the A-30. These costs include feed pre-processing, the proprietary AquaCritox elements, liquid oxygen facilities, heat recovery, post-processing of the mineral residue stream, and all site work and power distribution equipment. The operating cost savings (considering only current residual solids dewatering costs for electricity and polymer and current trucking costs for the dewatered biosolids) were estimated at $0.961-1.041M/yr (A-30) and $3.276-3.648M/yr (A-100).

A process flow diagram for a complete A-30 facility at Plant 2 is shown on the following page. (The steam turbine is existing, but underutilized, equipment at Plant 2.)

Status:

The next step, if approved by OCSD's Board of Directors, will be contracting for final design and construction of an AquaCritox facility based on the preliminary engineering study's recommendations.

2015-16 Project Description



2015-16 Project Description

Project Title:

Biogas Scrubbing:
Carollo / OCSD Process
(Project SP-125-16)

Solids Handling & Digestion

Process Related Special Project

Contact: Jeff Brown, Engineering

Purpose: Evaluate a chemical-free process for removing contaminants from digester gas

Description:

Biogas from digesters contains chemicals, including odorous hydrogen sulfide (H_2S) and silicon compounds (siloxanes), that must be removed before the gas can be used in the Central Generation engines. Currently, this is done with liquid ferric chloride and columns of granular activated carbon. These processes are expensive and require a continuous chemical supply. In addition, since ferric chloride is used sequentially for both primary treatment and digester sulfide control, some potential primary treatment improvements using other additives are not possible as long as both process steps are tied to using this chemical.

OCSD started working with Carollo Engineers (Carollo) in 2013 to test, develop, and optimize Carollo's new proprietary gas scrubbing process that uses only water to remove sulfides and siloxanes from biogas. OCSD obtained a royalty-free perpetual license to use the technology and holds a 20% ownership stake in the intellectual property of this invention.

The biogas scrubbing process uses venturi mixers to promote contact between biogas and pressurized scrubbing water [which does not need to be of potable quality, so plant water (chlorinated secondary effluent) was used by OCSD]. The flowing water creates a vacuum in the venturi apparatus that draws in low pressure biogas. The gas and water are mixed, transferring contaminants that are highly water soluble from the gas to the water. As the table below shows, both hydrogen sulfide and carbon dioxide are much more soluble than methane, suggesting that these contaminants could be scrubbed from biogas with only minimal simultaneous methane loss.

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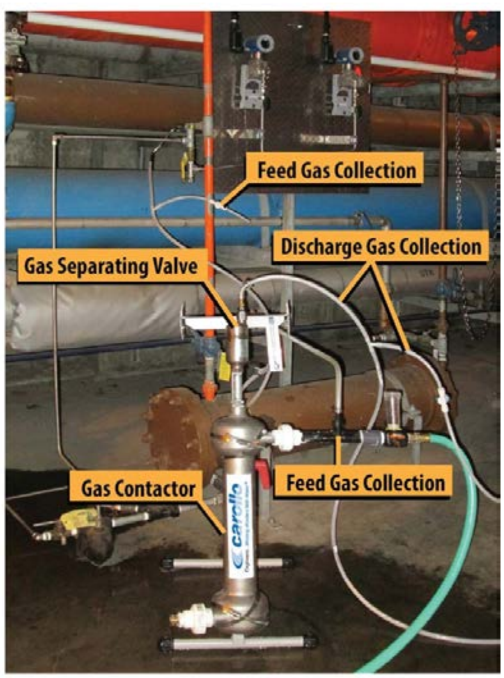
Compound	Solubility [(1)]	Ratio
CH_4 (methane)	4	-
H_2S (hydrogen sulfide)	300	73 : 1
CO_2 (carbon dioxide)	256	64 : 1

(1) ft^3 gas per 1000 gal water

Results:

Proof-of-concept testing was conducted twice in 2013 (June 12 and December 11) at Plant 1 using Carollo's test equipment (pictured below). This set-up uses a single venturi mixer ("gas contactor") and a gas/liquid separating valve with rudimentary manual controls and sampling ports at appropriate locations. The wash water is once-through (i.e., with no recirculation).



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Typical results are summarized in the table below. Hydrogen sulfide (and also other reduced sulfur compounds) was completely removed from the biogas, and both carbon dioxide and a range of siloxanes were almost completely removed. The carbon dioxide was replaced by nitrogen and oxygen, presumably from air dissolved in the scrubbing (plant) water.

Gas Scrubbing Pilot Results (12/11/13)

Component	Inlet Gas Quality[(1)]	Outlet Gas Quality[(1)]	Removal
Methane (CH_4)[(4)]	61.7%	58.6%	4.9%
Carbon Dioxide (CO_2)[(4)]	36.5%	2.2%	94.1%
Hydrogen Sulfide (H_2S)[(5)]	7.7 ppm	0.00[(2)]	100%
Siloxanes[(5)]	3.3 ppm	0.09 ppm	97.3%
Nitrogen (N_2)[(4)]	1.2%	30.0%	-
Oxygen (O_2)[(4)]	0.3%	8.7%	-

Notes:

(1) Values based on averages of samples analyzed by independent and OCSD laboratories.
(2) H_2S levels were below the detection limit for both laboratories.
(3) Nitrogen and oxygen gained during the scrubbing pilot came from dissolved air leaving the scrubbing water and transferring into the biogas. This impact may change based on the water used for scrubbing and the number of recirculation cycles used.
(4) Values reported are percent by volume.
(5) Values reported are parts per million by mass.

Based on these test results, a feasibility study was undertaken to evaluate the impacts of using the biogas scrubbing system in a full-scale application. This study considered the impacts on other plant equipment, developed a conceptual full-scale design and cost estimate, calculated the resulting biogas treatment costs, and identified areas of uncertainty that would require additional testing and analysis to resolve.

The gas scrubbing would be done on low pressure biogas after it left the anaerobic digesters. Although nitrogen and oxygen would replace the carbon dioxide that would be removed by scrubbing, the total volume of gas would be reduced about 25%. This would reduce the energy needed to compress the gas, resulting in proportional operating cost savings.

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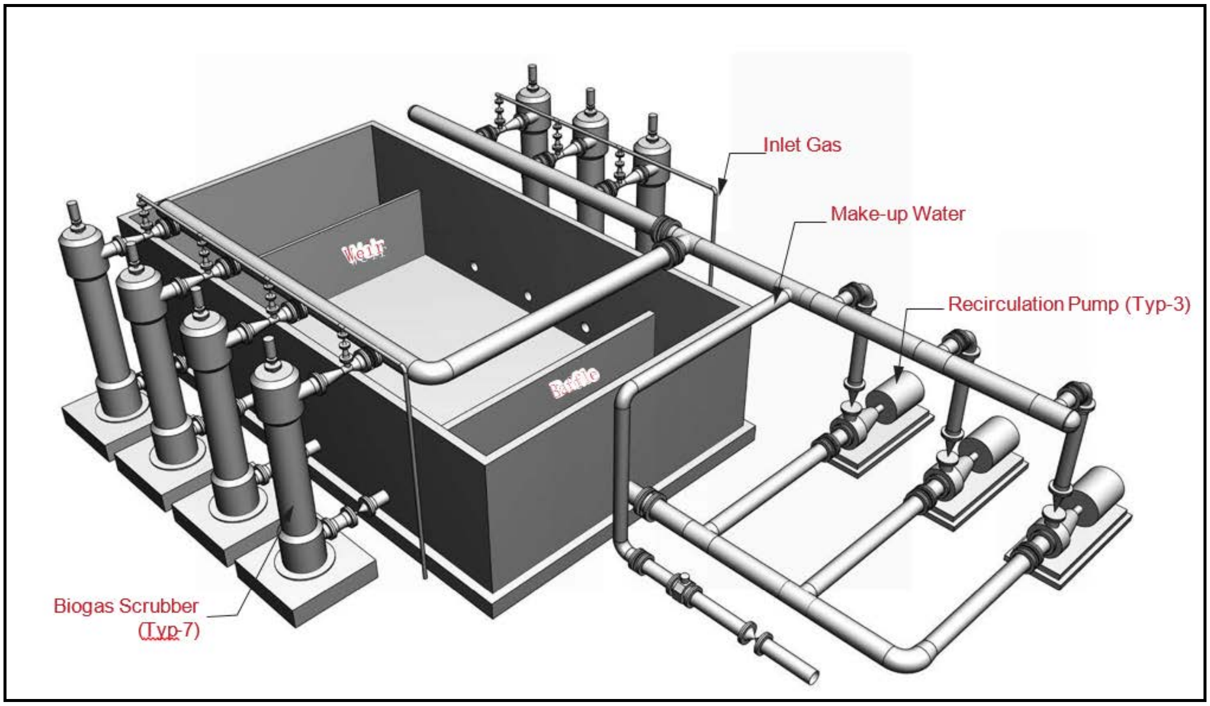
A conceptual design for a full-size installation is illustrated below. The actual number of scrubbers would depend on the diameter of the venturi mixers used; they are available in a wide variety of sizes and flow capacities. Similarly, the central tank would allow the scrubbing water to be recirculated, but its size would depend on the number of times the water could be reused before the increasing carbon dioxide or sulfide concentrations would unacceptably reduce the driving force for absorption of the contaminants from the biogas.

Conceptual Design of Full-Scale Biogas Scrubbing System



The cost analyses indicated that biogas scrubbing might be cost-effective compared to OCSD's current practices, depending on the assumptions that are made about capital costs, scrubbing water recirculation cycles, and chemical savings when ferric chloride no longer is used for digester sulfide control.

The number of recirculation cycles impacts both the capital cost and the operating costs. This was identified as an important area of uncertainty that could not be resolved without having more extensive operating data.

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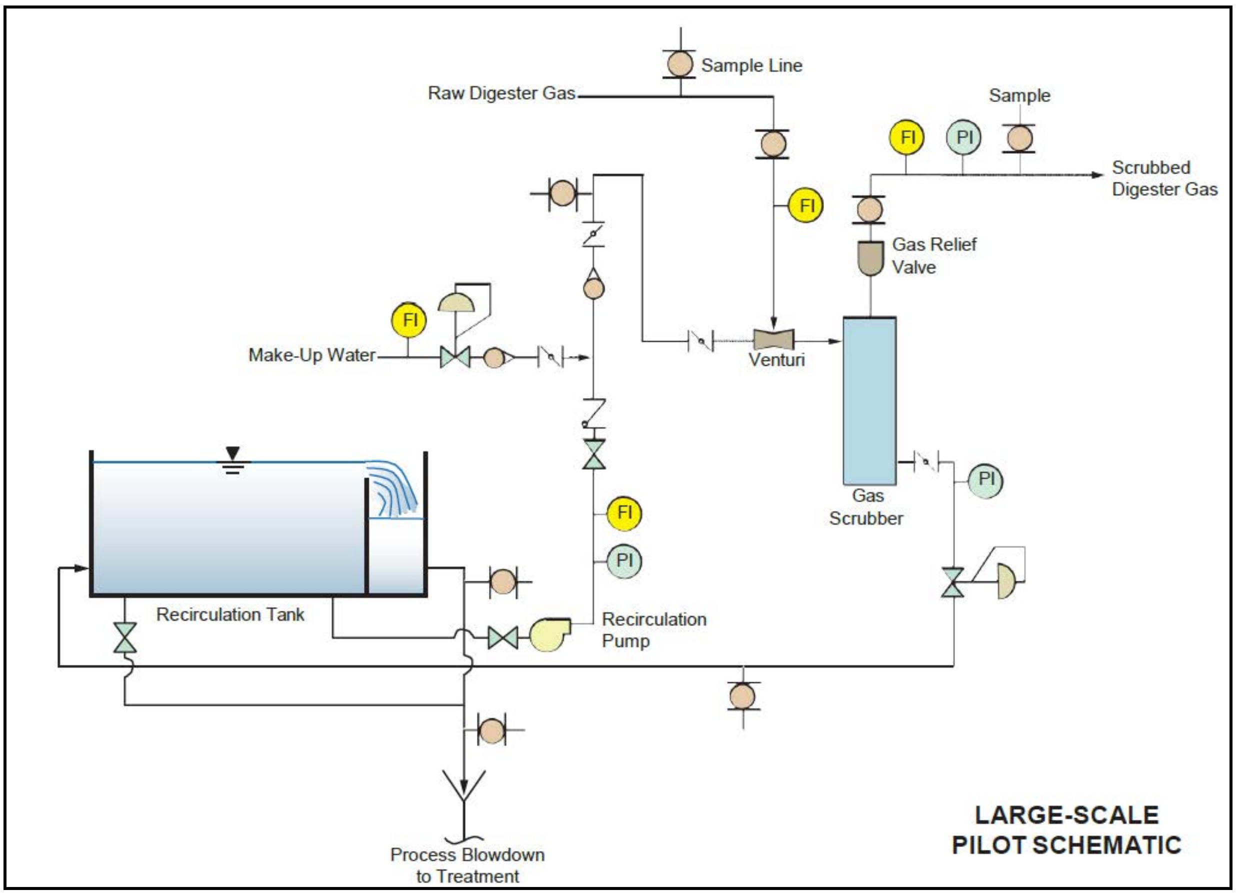
Status:

Extensive large-scale testing is planned for FY 2016-17 using a purpose-built pilot facility similar to the schematic shown below. This will be used to evaluate the effects of various recirculation cycle strategies, optimize the process performance, reduce methane losses, and investigate the control options for responding to changes in the incoming biogas flow.



The project budget for SP-125-16 was $122,140. The actual expenditures were about $121,600 through 6/30/16.

2015-16 Project Description

Project Title:

Fuel Cell Demonstration for Energy and Hydrogen Production (Project SP-125-4)

Central Power Generation

Research & Development

Contact: Jeff Brown, Engineering

Purpose: Demonstrate a fuel cell power plant using digester gas as fuel and producing hydrogen for vehicle fuel and electricity for onsite use

Description:

A fuel cell is an electrochemical device to generate electricity. Its fuel is a carbon source, such as digester gas, and its operation produces only water, waste heat, and trace gaseous emissions as byproducts. The electrochemical process occurring in a fuel cell is a direct form of fuel conversion that is much more efficient than conventional combustion-based electricity generation. Compared to combustion processes, fuel cell operation results in dramatically reduced emissions of such pollutants as nitrogen oxides (NO_x), sulfur oxides (SO_x), and carbon dioxide (CO_2).

OCSD is the host site for a public / private collaborative demonstration with the University of California, Irvine (UCI), U.S. Department of Energy, California Air Resources Board (CARB), South Coast Air Quality Management District, Air Products and Chemicals (APCI), and FuelCell Energy (FCE). A 300 kW fuel cell is installed at Plant No. 1 to use a portion of the treatment plant's digester gas to generate electricity for on-site use. In addition, hydrogen gas is produced and compressed for fueling vehicles at a publicly accessible fueling station as part of the California "Hydrogen Highway."

The specific fuel cell technology selected for this project has qualified for several environmental certifications, such as the Leadership in Energy and Environmental Design (LEED) program and the Renewable Energy Standards (RES). It also qualifies as an "ultra-clean" technology by exceeding all CARB emission standards.

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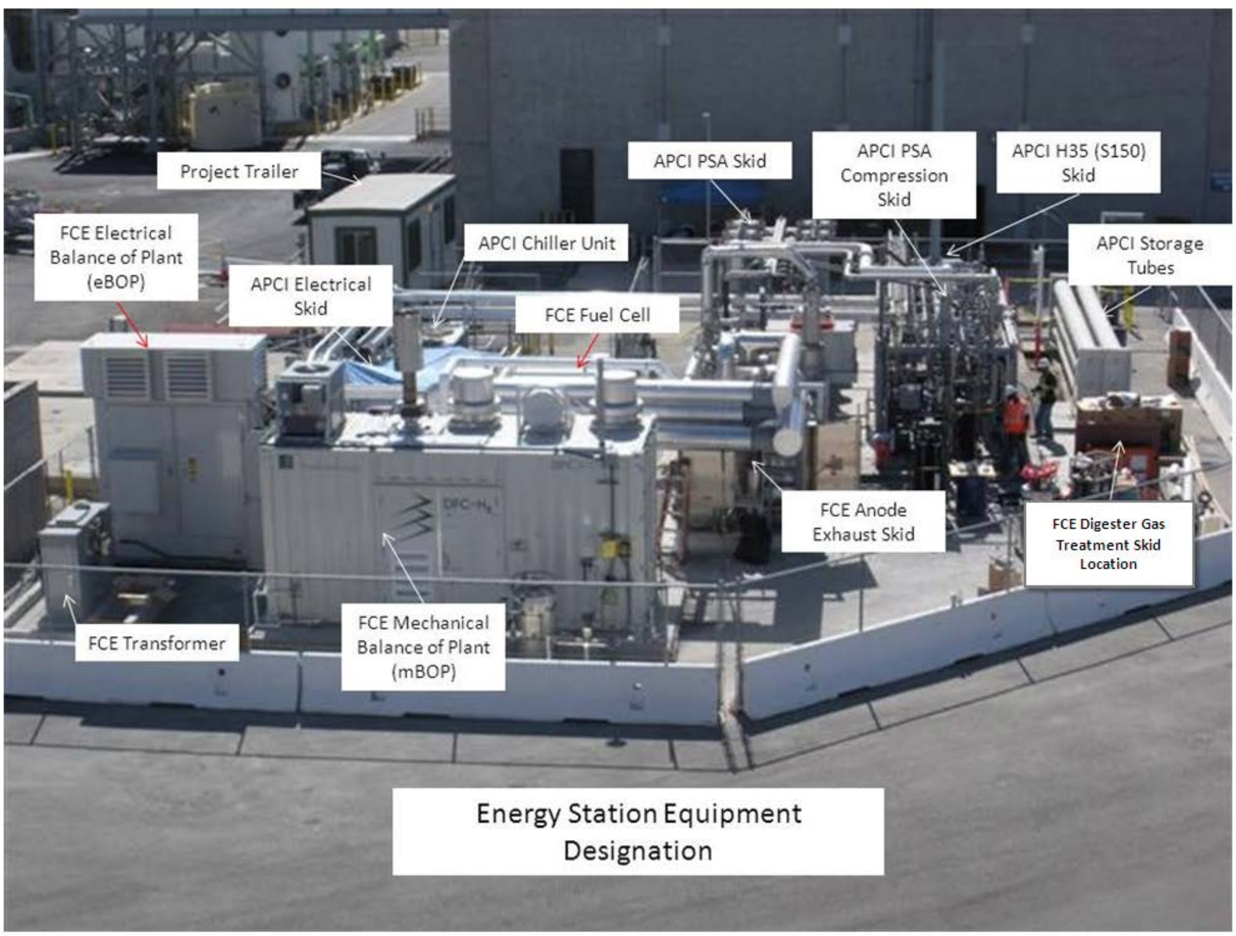
The project calls for APCI and FCE to design, install, operate, and maintain the fuel cell system and UCI's National Fuel Cell Research Center to operate the fueling station. The entire installation is expected to operate for three years (starting in mid-2011).

The elements of this project that are included under the general goal of "demonstrating the fuel cell power plant operation" include determining the amount of digester gas cleaning that is needed to make it a suitable fuel, documenting the operating efficiency of the power plant and its component processes, determining the maintenance requirements for the system, and verifying the expected lack of air pollutant emissions. Appropriate samples will be collected throughout the test program by the participating organizations, and all test results and operating records will be reviewed by OCSD and the other participants.



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Since digester gas is considered a renewable energy source, this project has received significant financial incentives, including $2.7 million from CARB. OCSD was responsible for preparing the site and installing the utilities needed for the project. OCSD's share of this $8 million project is $500,000 plus project oversight costs during the test period.

Results:

Following commissioning activities (such as leak checking and system purging with nitrogen), the initial operation of the fuel cell plant (Hydrogen Energy Station) on natural gas began on September 13, 2010. The following early results were realized:

- Initial power operations, including power conditioning of the fuel cell, resulting in an increase in power output of 40 kW/day for 7 days, reaching 300 kW net AC on September 20, 2010, with excess electricity exported to the OCSD in-plant grid.

- Following initial power operation, the water-gas shift, water removal, and PSA feed compressor systems were placed into service.

- Initial integration with the PSA system at 50% feed gas rates took place on September 23, 2010. There was a system trip shortly after integration which demonstrated the performance of the deintegration process in the field.

During the months of October and November 2010, the fuel cell was operated at various loads on natural gas, and the hydrogen purification system was operated periodically to test the integration/deintegration of the two systems. During this initial operating period, the Power Conditioning Unit (PCU/Inverter) associated with the fuel cell had difficulty maintaining its connection with the local electrical grid. Experts from FuelCell Energy characterized the grid quality and identified changes required to the power conditioning system to match the highly inductive power factor (0.6 to 0.8) and larger voltage sags (5% to 10%). Troubleshooting efforts began in early December. On December 14, a module within the inverter was damaged by an electrical fault.

During the period through December 31, 2010, over 1,000 hours of operation in "electricity only" and "electricity + hydrogen" modes were completed. During the period from January to March 2011, the inverter was repaired, and the fuel cell operated for one month at 100 kW power output and one month at 200 kW power output. The total on-stream time producing power was 93.4% (excluding inverter repair time).

The hydrogen quality was checked and met all performance specifications. Hydrogen was vented locally pending completion of commissioning of the hydrogen refueling station.

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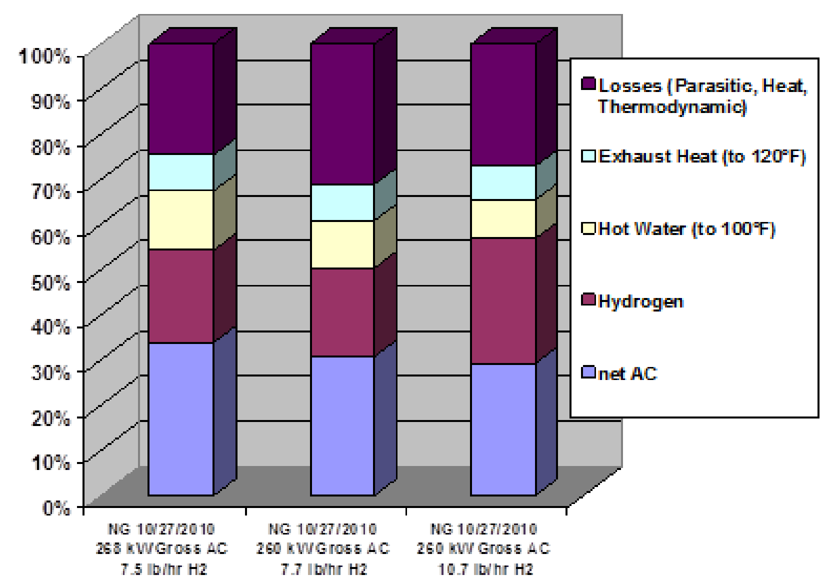
During the period from April to June 2011, the major activities were the installation and commissioning of the ADG (anaerobic digester gas) clean-up system. ADG was first introduced to the fuel cell system on May 25, 2011, and the operating parameters were tuned to allow for natural gas to be supplied automatically in case of a decrease or interruption of the ADG supply.

The formal opening of the fuel cell (Energy Station) and hydrogen fueling station was held on August 16, 2011 with 140 invited guests in attendance.

During the period from July to September 2011, the fuel cell produced a total of 334,933 kWh of electricity. A total of 195,018 kWh was exported to the local grid, with the remaining power being consumed by the fuel cell, digester gas clean-up, and hydrogen purification systems. The hydrogen purification system was operated as needed to supply hydrogen to storage. Independent of any fueling station usage, a portion of the hydrogen is sent from storage to the ADG clean-up system to assist in removing sulfur compounds. The remaining hydrogen now can be routed back to the fuel cell rather than being vented as was the case during the initial operation in 2010.

The fuel cell continued to experience operational issues related to the power quality. A total of 115 off-line trips (excluding trips less than 15 minutes apart) were experienced during this three-month period (July to September 2011). These trips limited hydrogen production since the system was programmed to deintegrate the hydrogen purification system each time the fuel cell power production was interrupted. Operating limitations due to power quality issues continued through the end of 2011. After modifications within the power grid at OCSD, no trips related to power quality have occurred since January 31, 2012.

During operation on ADG, a detailed heat and material balance was performed to determine the overall efficiency of the fuel cell energy station. The calculated efficiency of 53.3% (electricity plus hydrogen) exceeded the program target of 50%. The components of the energy balance are shown in the bar graph to the right.



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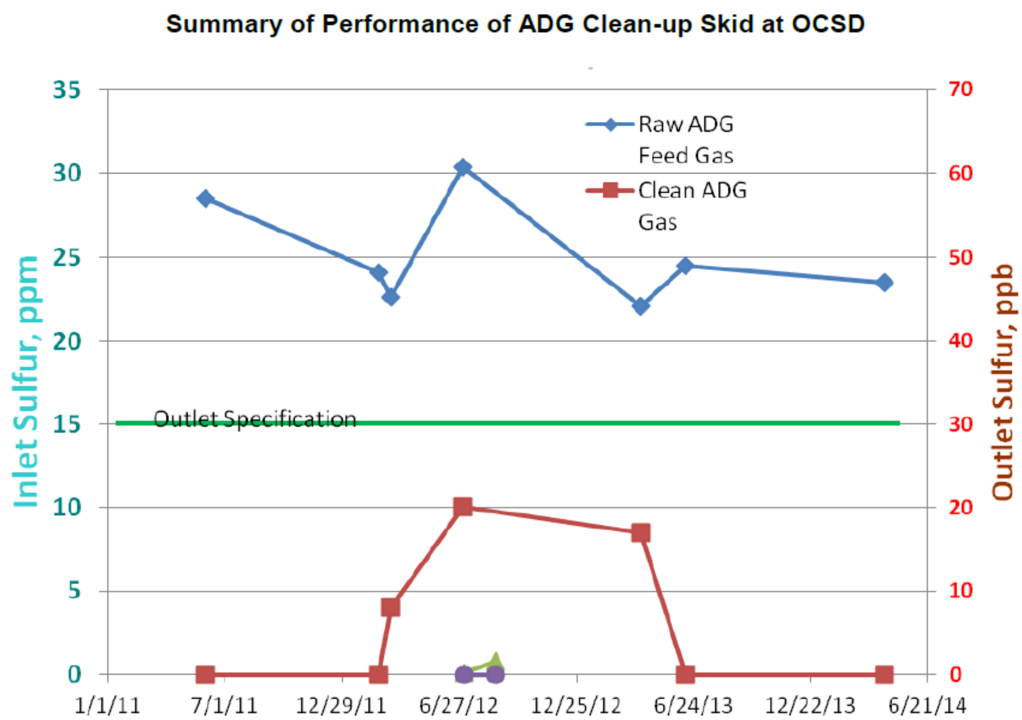
The sulfur content of the raw and cleaned ADG was measured periodically to track the operating performance of the gas cleanup skid. The raw gas contained 20-30 ppm sulfur, and the cleaned gas consistently was below the required maximum limit of 30 ppb sulfur as shown in the following figure.



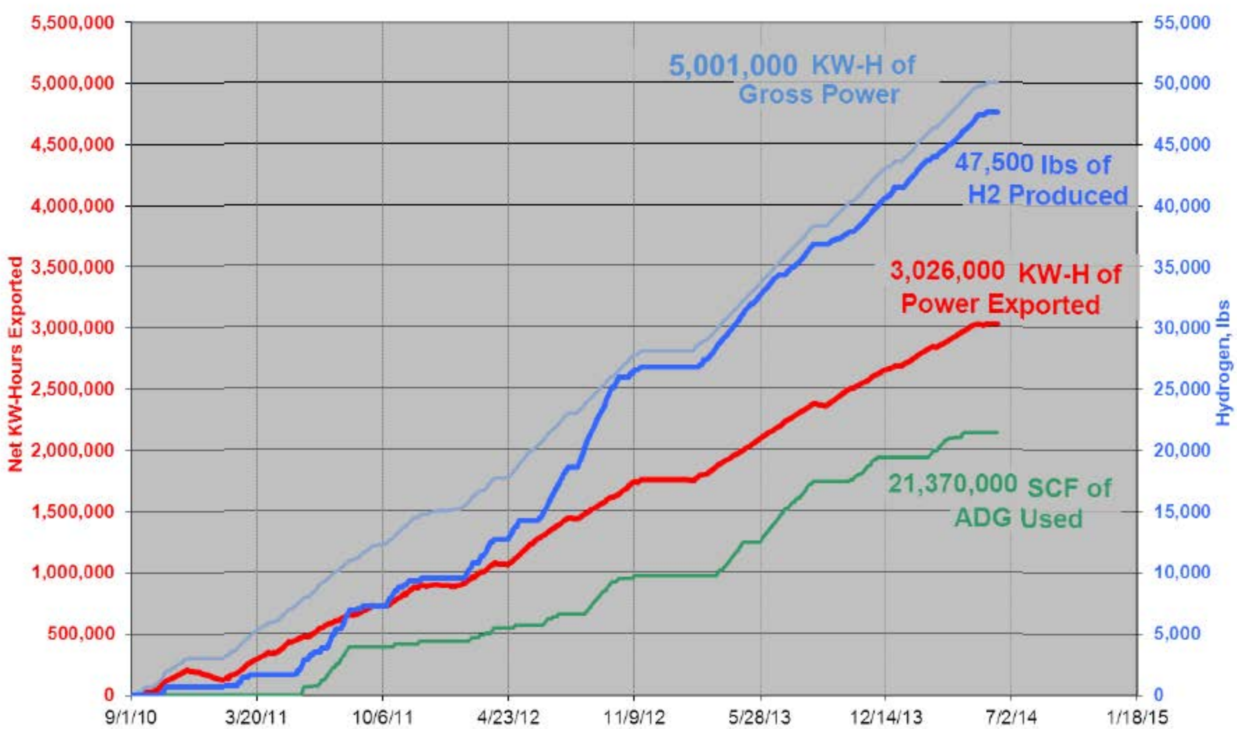
The air emissions around the fuel cell were measured on August 22, 2012. As shown in the following figure, the emissions were typically 0.1 ppm NO_x and nondetectable (ND) for SO_x and CO when operating on either natural gas (NG) or digester gas (ADG) and for various operating conditions.

Air Emissions from Fuel Cell Equipment

Date: August 22, 2012				INSTRUMENTS						
				APNA-370			APSA-370	PG-250		
Time	Fuel	Condition	Position	NO[ppm]	NO2[ppm]	NOx[ppm]	SO2[ppm]	CO[ppm]	CO2[vol%]	O2[vol%]
10:30	NG	"Normal"	After CO Polisher	0.087	0.013	0.100	ND	ND	3.907	14.217
10:55	NG	Anode DP = 4.5 inH2O	After CO Polisher	0.056	0.013	0.069	ND	1.088	2.229	17.093
11:25	NG	Anode DP= "Low"	After CO Polisher	0.094	0.016	0.110	ND	ND	4.184	13.809
11:50	NG	"Normal"	After CO Polisher	0.096	0.012	0.108	ND	ND	4.273	13.695
15:50	NG	Anode DP = 1.5 inH2O	Before CO Polisher	0.118	0.005	0.123	ND	7.508	4.673	12.925
16:30	NG	Anode DP = 3 inH2O	Before CO Polisher	0.107	0.003	0.110	ND	10.676	4.152	13.859
17:00	NG	Anode DP = 4.5 inH2O	Before CO Polisher	0.100	0.006	0.106	ND	15.849	4.104	13.926
17:27	NG	Anode DP = 0 inH2O	Before CO Polisher	0.107	0.008	0.115	ND	3.284	4.080	13.753
18:40	ADG	"Normal"	Before CO Polisher	0.095	0.002	0.096	ND	6.076	6.008	13.493
18:50	ADG	"Normal"	After CO Polisher	0.080	0.001	0.083	ND	ND	4.894	14.906

An overall operations summary of the fuel cell energy station is shown in the figure below. About 21.4 million standard cubic feet of ADG were processed, about 3 million kWh of electricity were exported to the OCSD grid, and 47,500 lb of hydrogen were produced.

Operations Summary at OCSD (through 31 May 2014)



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As of June 30, 2014, four automakers (Daimler, Honda, Hyundai, and Toyota) had agreements for using OCSD's hydrogen fueling facility for their fuel cell vehicles. A total of 275 vehicle fuelings were performed during April and May 2014, and a total of 1663 fuelings were performed between March 2012 and June 2014.

Status:

The fuel cell operation finished its three-year test schedule in May 2014 and was taken out of service. But the California Air Resources Board agreed to provide an additional year of funding to keep the hydrogen fueling station operating. During this period, standard tube trailers would be used to deliver hydrogen that would be compressed and dispensed to vehicles at the fueling station.

The overall budget for the tri-generation fuel cell test program was $8.5 million. OCSD's expenditures totaled about $600,000.

2015-16 Project Description

Project Title:

OpenCEL Process Evaluation (Project SP-125-6)

Solids Handling & Digestion

Process Related Special Project

Contact: Jeff Brown, Engineering

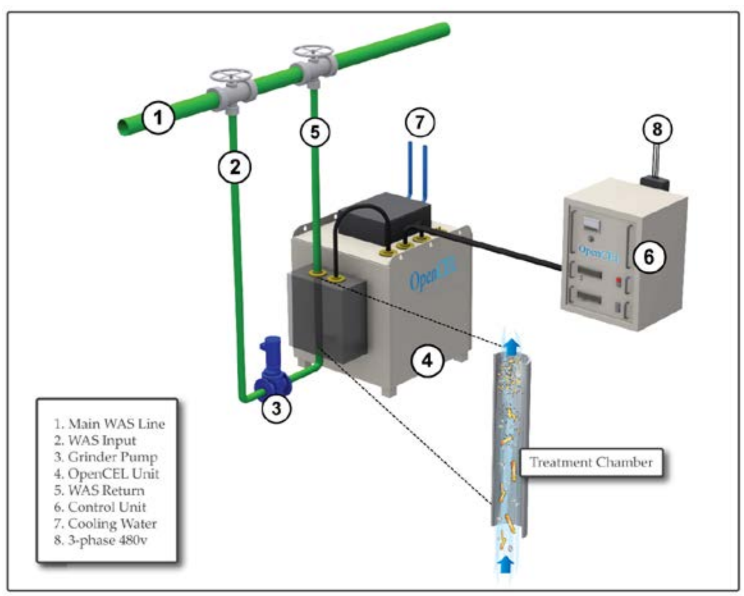
Purpose: Evaluate a process to improve digester efficiency and minimize residual solids

Description:

Anaerobic digesters convert volatile solids to methane gas, but their conversion efficiency is not 100%. Solids from secondary treatment (such as waste activated sludge or WAS) are particularly difficult to convert; a typical digestion cycle might convert only one-third of the available secondary volatile material.

Breaching the cellular membrane is the rate-limiting step for anaerobic digestion of WAS. Various methods of digestion pretreatment have been shown effective at laboratory scale since the late 1970's, but scalability problems, excessive power requirements, and other factors generally have kept them from achieving full-scale practical use.

The OpenCEL process is a proprietary Focused Pulsed (FP) treatment that creates reversible disruptive conditions within cellular membranes. These forces are generated by a rapid, pulsed electric field using high voltage, high frequency, microbursts of conditioned electricity. Applying enough electrical energy to the WAS results in irreversible opening and breaching of the cell membrane. This releases the intracellular material, making it readily available for further reaction and conversion to methane in the digester. The net result would be increased digester gas production and reduced amounts of residual biosolids.



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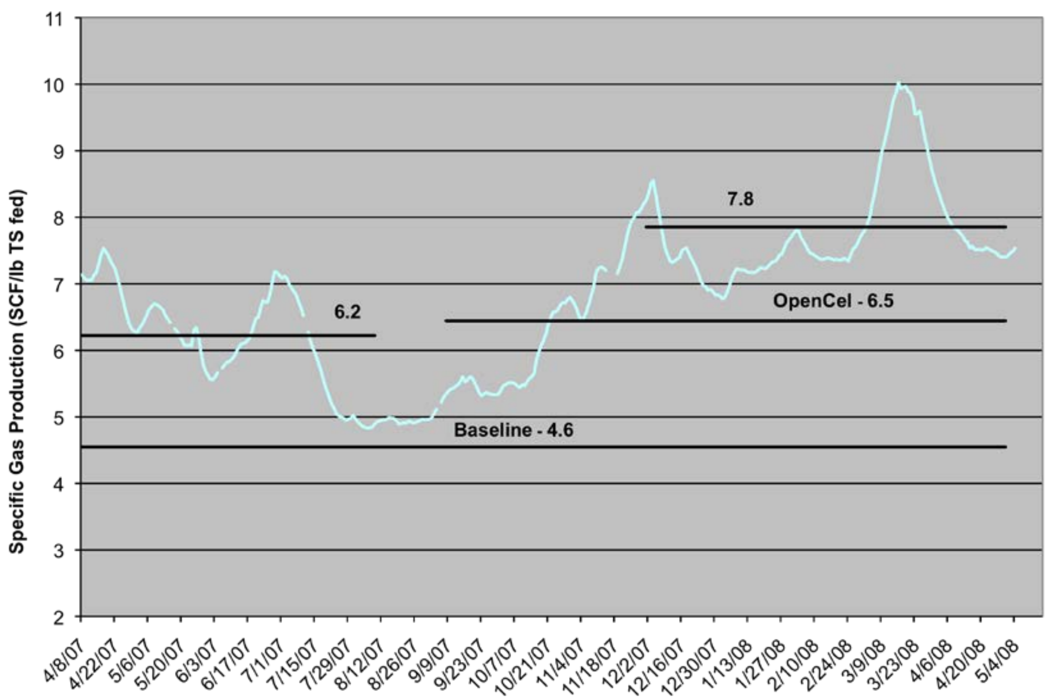
Results:

OpenCEL has been used in a full-scale commercial installation at the wastewater treatment plant in Mesa, AZ, since 2007 to treat a mixture of thickened primary solids and WAS. The results have been impressive: the WAS volatile solids reduction (VSR) has increased from about 30% VSR to about 70% VSR, and the biogas production has increased about 60%. Analyses of the digester microbial population showed increases in the relative abundance of acetate-utilizing methanogens, indicating the cell lysis caused by the treatment increased the availability of simple volatile acids.

Specific Gas Production (Mesa, AZ) with and without OpenCEL



Biological Methane Potential (BMP) tests in 2009 on OCSD's WAS by Arizona State University showed BMP increases after treatment that supported OpenCEL's expectations for successful performance. Preliminary cost analyses suggested that using OpenCEL could save OCSD on the order of $2-4 million/year at each plant (depending on the specifics of each plant's operation and the value placed on WAS heating). The equipment cost for full WAS treatment at each plant would be about $4 million.

A test program for an OpenCEL installation on digester 15 at Plant 1 was developed to compare the digester performance (e.g., biogas production and quality; VSR) with and without OpenCEL treatment. In addition, digester 16 without OpenCEL was designated as an experimental control so any changes in digester 15's performance could be correctly

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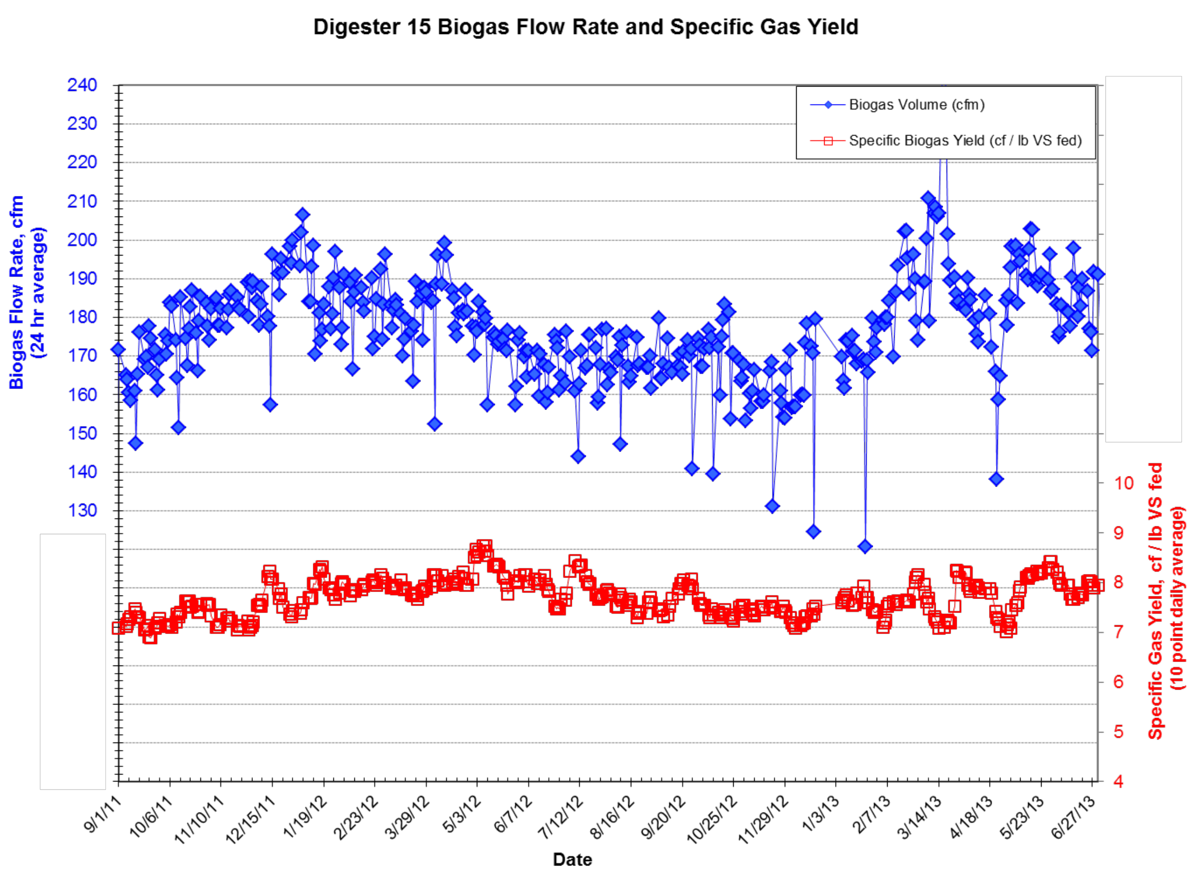
attributed to OpenCEL (affecting digester 15 only) or other factors (affecting other digesters as represented by digester 16).

The first necessary step was to establish the baseline digester performance at the test conditions without OpenCEL treatment. The secondary sludge (TWAS) feed proportion in digesters 15/16 was increased from about 23% to about 40% starting in October 2010, and the digesters were allowed to adjust to the new feed conditions. Gas flow meters were installed in the gas exit piping to measure the flow from both digesters individually and their combined flow (as a data quality control check). Usable readings were being recorded by the beginning of September 2011.

The figure below presents daily average biogas production and specific yield data for digester 15. The actual production or flow rate (ft^3/min) varied with changes in daily feed volume and possibly other factors. But the specific biogas yield (the amount of biogas produced per pound of volatile solids fed to the digester, ft^3/ lb VS) was relatively constant in the range of 7-8 ft^3/ lb VS, which is typical for mesophilic anaerobic digesters.



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The installation and startup of the OpenCEL equipment occurred during 2012-13. Operational problems believed to be related to unusually high TWAS conductivity and possibly to inadequate mixing in the OpenCEL treatment chamber delayed the transition to the project's test phase at the end of this period. It was expected that as soon as these problems were resolved, the performance test would begin and was expected to continue throughout 2013-14.

Before this could be done, OpenCEL discovered in 2012 that their test protocol for BMP determinations was in error, so earlier testing at OCSD and other sites did not measure the actual OpenCEL performance. By early 2013, this had been corrected. In addition, progress on process optimization at other OpenCEL installations led to plans to restart the OCSD activities by mid-2013.

During this time, project P1-100 to clean and rehabilitate the Plant 1 digesters was continuing. Early in 2014, the schedule for this project was changed so digesters 15 and 16 would be out of service starting in mid-2014 and continuing for 12-18 months. Accordingly, the OpenCEL activities were put on hold until the rehabilitation of these digesters was completed.

Early in 2015, US Peroxide (OpenCEL's parent company) notified OCSD of their decision not to continue with the test program at OCSD. Their results at other test sites during the previous year reportedly did not replicate the initial positive effects of OpenCEL treatment at Mesa, AZ. Accordingly, US Peroxide decided to withdraw OpenCEL as a commercial offering. In the future, a revamped process might be reintroduced to the market.

OCSD's OpenCEL process evaluation project was stopped in 2015, and arrangements were made for US Peroxide to retrieve their equipment.

Project SP-125-6 had a budget of $850,000. The actual project charges were $583,900.

2015-16 Project Description

Project Title:

Volute Dewatering Press (supplement to SP-125-17)

Solids Handling & Digestion

Process Related Special Project

Contact: Jeff Brown, Engineering

Purpose: Evaluate sludge dewatering using the Volute dewatering screw press

Description:

The organic feed stream to an AquaCritox supercritical water oxidation (SCWO) process (discussed separately) needs to have a solids content of about 10-16% TS for the process to operate autothermally. If the solids content is too low, the heat released by the oxidation reactions will not be sufficient to maintain the supercritical process temperatures without adding supplemental heat, which would negate a significant efficiency advantage SCWO has over conventional WWTP solids treatment. If the feed stream is typical primary or secondary sludge (~5% TS or less), it will require dewatering before entering the SCWO reactor.

Dewatering could be done with a conventional centrifuge, but the Volute screw press (originally developed in Japan and offered in the United States by Process Water Technologies LLC (PW Tech)) seemed to offer some notable advantages. The Volute press has a unique drum design surrounding the screw that employs alternating fixed and movable rings with spacers between them. This was claimed to be less prone to clogging than other presses (even for raw sludge) and could take sludge as dilute as 0.1% TS and produce a cake of over 20% TS.

Compared to centrifuges, a Volute press uses much less energy, does not have extended starting/stopping cycles, and may use less polymer. In addition, multiple independent screws can be housed in a single machine, potentially providing built-in redundancy that would require multiple centrifuges to achieve.

2015-16 Project Description

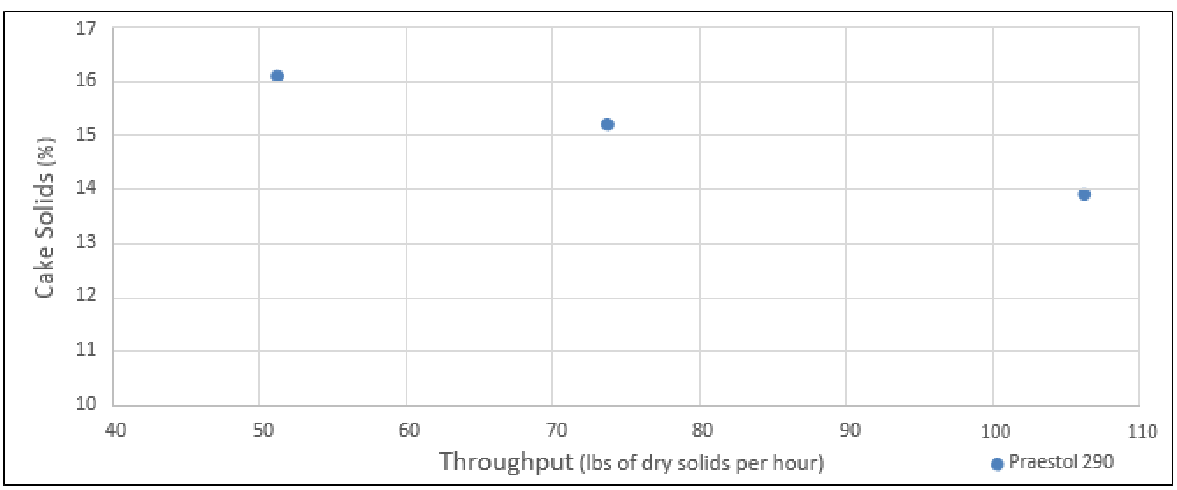
Results:

A test of a Volute Dewatering Press (and the similar Volute Thickener) was conducted at Plant 1 in April 2016. PW Tech has Volute equipment and auxiliary systems (e.g., polymer preparation) mounted in a trailer for such tests. The test results reported below were obtained through onsite analyses by PW Tech staff, but several parallel samples also were analyzed by the OCSD laboratory and showed good agreement with the onsite results.

The primary goal of the tests was to determine whether primary and secondary (TWAS) sludges could be dewatered to approximately 15% TS. Preliminary cationic emulsion polymer jar tests were done to identify an acceptable polymer for each sludge, but there was no attempt to determine the "best" polymer. The polymers chosen for testing were Praestol 290 and Praestol 279. Thus, the results were expected to show whether the required dewatering could be done, but probably they would not show the optimized results (e.g., the lowest effective polymer dose).

The initial tests using TWAS established that polymer doses of 16-18 active pounds of polymer per ton of dry solids (lb/ton) using Praestol 290 achieved a sludge concentration of 15% TS. At this polymer dose, the effective throughput of the press was determined. As the graph below shows, as the throughput was increased from 50 lb/hr (60% rated capacity) to 106 lb/hr (130% capacity), the dewatered cake changed from 16% TS to 14% TS.

TWAS Feed: Cake Solids Variation with Throughput Changes (60-130% Rated Capacity)

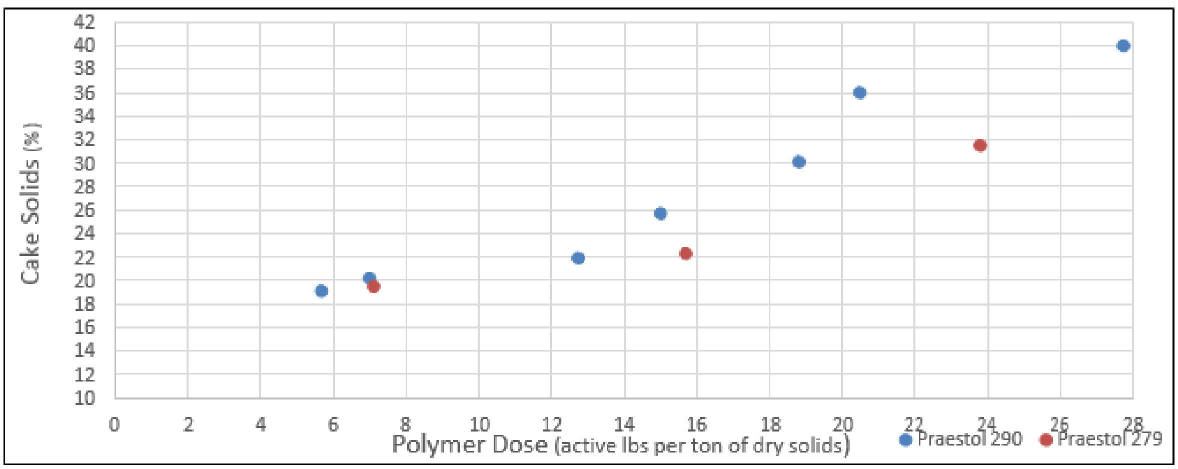


2015-16 Project Description

The solids capture rate was evaluated by measuring the solids (TSS) in the pressate (the liquid stream coming from the dewatering drum). Except for the initial runs with polymer dose rates below 15 lb/ton, the capture rate consistently was 98-99%. This indicated the press was removing water without losing large amounts of solids as well.

Primary sludge dewatering tests then were conducted. As shown in the following graph, the dewatered cake had 20-40% TS for moderate to high polymer doses (13-28 lb/ton). Reducing the polymer dose to 6 lb/ton still yielded cake solids of about 20% TS, but the capture rate deteriorated to 76%.

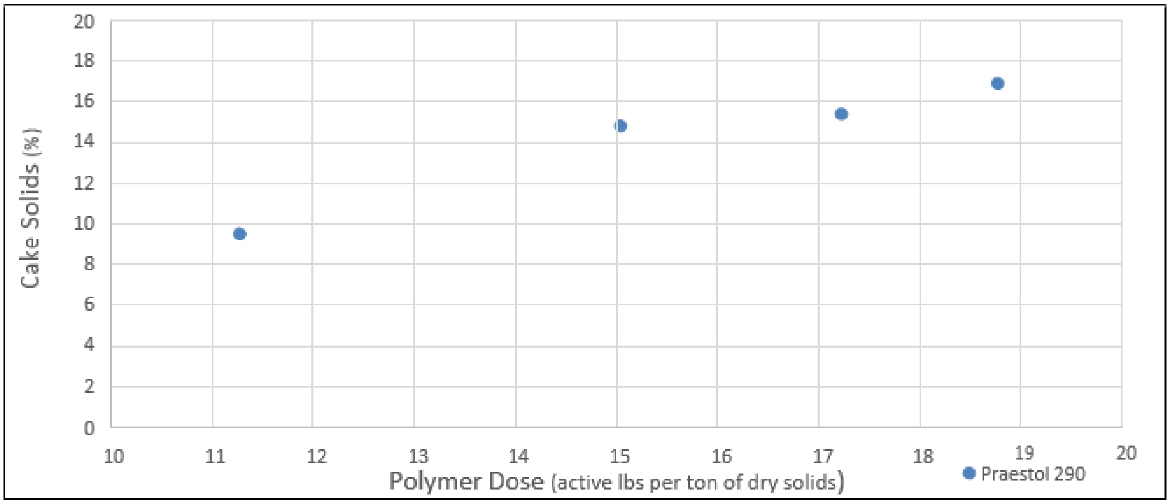
Primary Sludge Feed: Volute Press Cake Solids vs. Polymer Dose (at similar sludge throughput)



To achieve primary sludge cake solids of 15% TS, the testing switched to a Volute Thickener. This is similar to the Dewatering Press except it has a shorter retention time and higher throughput. As the following graph show, the target cake solids was achieved with the Thickener and polymer doses comparable to the TWAS tests.

2015-16 Project Description

Primary Sludge Feed: Volute Thickener Cake Solids vs. Polymer Dose (at similar sludge throughput)



Overall, the test results showed the Volute equipment was able to dewater primary sludge and TWAS (separately) to obtain a cake with 15% TS. The polymer dosing was not optimized but still was comparable to other dewatering processes. There was no indication of plugging in the screw drum with either feed sludge during more than 30 hours of operation over six days.

Status:

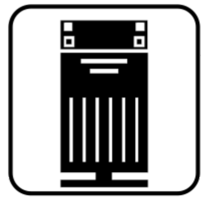
The tests were completed satisfactorily. The conclusion was that Volute dewatering equipment would be capable of meeting the requirements of an OCSD SCWO facility.

This testing did not involve a separate budget allocation or significant internal or external costs.

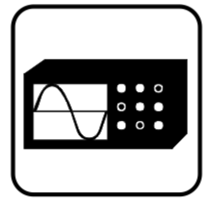
2015-16 Project Description

Project Title:

ZAPS Multi-Analyzer



Plant 1 & 2 Monitoring/ Control Systems



Research & Development

Contact: Kim Christensen, Environmental Services

Purpose: Test a continuous optical monitoring instrument for measuring chemistry parameters in wastewater

Description:

The ZAPS LiquID™ Station is a continuous monitoring instrument with all measurements made in a patented flow cell without any added reagents. Chemical concentrations are measured using absorption, fluorescence, and scattering measurements by applying Zero Angle Photo-Spectrometry (ZAPS) and the Hybrid Multispectral Analysis (HMA) approach developed by ZAPS Technologies. HMA is an optical approach for continuous monitoring and characterization of chemical bonding and molecular structure. Sample fluid enters the analyzer through a submerged pump in the wastewater field and flows through a single optical flow cell for multispectral analysis. Inside the flow cell, the sample is exposed to high intensity light at specific wavelengths (visible and invisible). The analyzer records absorption, fluorescence, and reflectance responses that indicate sample characteristics. Multiple parameters are determined, and new measurements are taken approximately every two minutes. The continual flow of measurement data is available for immediate analysis and response.

The following table of manufacturer's data shows the standard parameters the ZAPS instrument is capable of measuring. (An individual instrument will be configured to measure a selected subset of these parameters.)

ZAPS Standard Parameters

Parameter	Detection Range/Sensitivity	Accuracy
Ammonia Gas (NH_3)	0.2 to 100 mg-N/L	±8%
Biochemical Oxygen Demand (BOD)	0.2 to 700 mg/L	±8%
Carbonaceous BOD (cBOD)	0.05 to 600 mg/L	±8%
Chemical Oxygen Demand (COD)	0.7 to 1400 mg/L	±6%
Chloramine	0.01 to 11 mg/L	±5%
Chlorophyll α	0.3 to >100 μg/L	±5%
Chlorophyll β	3 to >100 μg/L	±5%
Color @440nm	2 to 1500 Pt/Co Unit	±5%
Dye (Fluorescent Dyes)	0.5 to >100 DFU	±5%
E. coli	0.1 to 2.3×107 MPN/100 ml	±10%
Fluid Temperature	-4 to 100 deg C	±3%
Fluorescent Dissolved Organic Matter (FDOM)	0.5 to >100 DFU	±5%
Free Chlorine (OCL^{2-} + $HOCL^{-}$)	0.01 to 11 mg/L	±5%
Nitrate + Nitrite (NO_2+NO_3)	0.03 to 50 mg-N/L	±9%
Phycobilin Chromophore	0.9 to >100 DFU	±5%
Oil – Refined Hydrocarbons	0.5 to >100 DFU	±5%
Specific UV Absorption (SUVA)	0.06 to 5 L/mg-C•m^{-1}	±10%
Total Kjeldahl Nitrogen (TKN)	0.2 to 100 mg-N/L	±8%
Total Organic Carbon (TOC)	0.02 to 100 mg/L	±5%
Total Organic Halide (TOX)	2 to 6000 μg/L	1 μg/L
Total Suspended Solids (TSS)	0.08 to 800 mg/L	±13%
Turbidity (ATU)	0.1 to 100 m^{-1}	±10%
Ultraviolet Absorbance (UVA)	0.1 to 100 m^{-1}	±5%
Ultraviolet Transmission (UVT)	0.2 to 100 %	±5%
Volatile Fatty Acids (VFA)	1 to 1000 mg/L	±10%

Results:

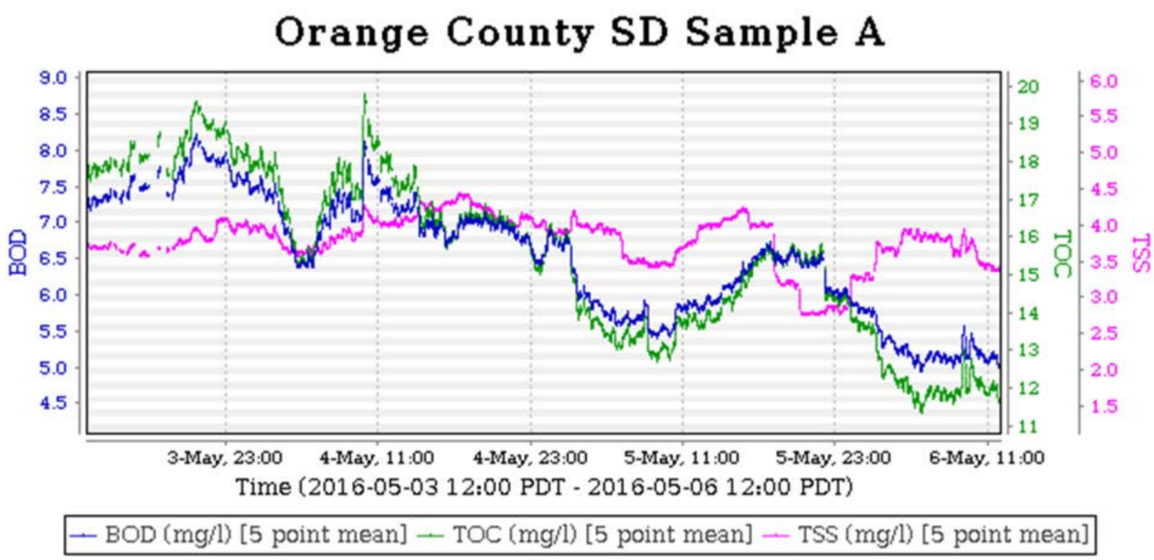
The OCSD instrument is configured to measure the following parameters: BOD, cBOD, COD, *E. coli*, ammonia, nitrate + nitrite, fluid temperature, TOC, TOX, chlorine, and TSS.

Installation and commissioning occurred in February and March 2015. Currently the instrument is installed at the secondary effluent discharge to the Groundwater

2015-16 Project Description

Replenishment System (GWRS) influent. Commissioning of the instrument allowed ZAPS Technologies' engineers to calibrate the readings with physical grab samples analyzed by OCSD's Environmental Laboratory. Overall, the laboratory staff have been very pleased with the ZAPS instrument's accuracy and reliability.

The following figure shows typical data obtained from the current location. The plotted values are rolling five-point averages of data points at two-minute intervals.



Status:

The ZAPS instrument has been at its current location for over one year. The installation has undergone changes to improve the submerged pump stability, the preventive maintenance scheduling, and the flow configuration. Maintaining the flush water supply required to clean the optics has been a problem with various temporary connections, but there are plans to install a permanent fix for this.

Future plans for this instrument include a test on OCSD's ocean research vessel *Nerissa* to see whether it will provide a better method for detecting and tracking the WWTP final effluent plume in the ocean.

Project Category:

Ocean Monitoring and General Topics

2015-16 Project Description

Project Title:

Southern California Bight Regional Monitoring Program 2013 (SCCWRP Cooperative Project)

Studies Research

Ocean Outfall Systems

Contact: Ron Coss and George Robertson, Environmental Services

Purpose: A multi-agency regional ocean monitoring program that samples waters in the Southern California Bight

Description:

This project (Bight ’13) is the fifth cooperative, multi-agency regional monitoring program that samples waters in the Southern California Bight (SCB) from Point Conception to the US-Mexico border and out to the Channel Islands. Begun in 1994, sampling occurs every five years, and the information obtained is used to assess cumulative impacts of contaminant inputs, evaluate relative risks among different environmental stressors, and serve as a regional baseline from which local dischargers can compare their individual monitoring data. The project involves over 60 agencies, with the Southern California Coastal Water Research Project (SCCWRP) acting as the coordinating agency.

Bight ’13 has five components as summarized below:

- Nutrients: Investigate the relative influence of anthropogenic nutrients on primary production and nutrient cycling in the SCB.

- Contaminant Impact Assessment (previously "Coastal Ecology"): Assess the condition of the benthic environment and the health of the biological resources in the SCB.

- Shoreline Microbiology: Assess the reliability of the rapid bacteria detection test method (qPCR) and the percentage of beach discharges with significant human fecal pollution.

2015-16 Project Description

- Marine Protected Area (MPAs)/Rocky Reef: Determine whether rocky reef status is more related to fishing or water quality pressure.

- Trash and Debris: Link marine debris abundance with the types and distributions found in coastal watersheds.

Status:

The field sampling work was completed in 2016 and the following reports have been finalized:

- Sediment Chemistry
- Sediment Toxicity

Reporting will continue through the fall of 2017.

Results:

A summary of the findings for Sediment Chemistry and Toxicity are:

- 68% of the SCB sediment have low levels of contamination;
- Less than 1% have high levels of contamination;
- These levels of sediment conditions have remained consistent over the past 10 years;
- Contamination was generally greater in embayments than offshore;
- Conditions in ports/harbors/marinas are improving;
- Overall levels of toxicity in the SCB were low (2%), but 17% of canyons were toxic;
- There has been a decrease in sediment toxicity since 2008.

Budget:

The estimated Bight ’13 budget is $15 million. The overall OCSD project budget is $355,000 with actual project expenditures of $138,000 as of June 30, 2016.

2015-16 Project Description

Project Title:

Nutrient Cycling Sampling (SCCWRP Cooperative Project; SP-125-15)

Studies Research

Ocean Outfall Systems

Contact: George Robertson, Environmental Services

Purpose: Understand the influence of effluent nitrogen on coastal waters and biologic communities.

Description:

The goal of this project is to understand the influence of effluent nitrogen on coastal waters and how the nature of this nitrogen affects the response of the biological community. The study objectives are:

1. Identify the relative contributions of different nitrogen sources that are being utilized by phytoplankton and bacteria in an effluent impacted area (Orange County) as well as a minimally-impacted area in Oceanside (i.e., mostly natural nutrient sources with only minor anthropogenic inputs).

2. Conduct process studies to determine key rates of primary production, respiration, nitrogen uptake, and nitrification in effluent impacted (Orange County) and minimally-impacted (Oceanside) regions.

Status:

Final field sampling and laboratory testing were completed in the spring of 2016. Data analysis and report writing are expected to commence in the fall of 2016 with a final report completed by the fall of 2017.

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Results:

None available at this time.

Budget:

The project budget is $95,000. The project expenditures were $38,000 as of June 30, 2016.

2015-16 Project Description

Project Title:

Orange County Spatial Variability of Ocean Sediments – Phase II

Ocean Outfall Systems

Research & Development

Contact: Jeffrey Armstrong, Environmental Services

Purpose: Strengthen OCSD's ability to detect changes in sediment quality in its receiving waters monitoring area and insure the accuracy of NPDES permit compliance assessments

Description:

Problem Statement:

Maps are an extremely effective data summary tool used to demonstrate the spatial extent and magnitude of environmental conditions. Maps help put information about contaminant gradients relative to sources into context over the entire area of interest. Maps of environmental conditions in the area of interest across multiple years help identify changes in spatial extent (e.g., is the outfall footprint expanding or shrinking over time?). However, the ability to create maps with scientific rigor is difficult and rarely accomplished as sampling grids are often too sparse to capture the necessary spatial variability for reliable predictions at unsampled locations. In addition, many tools used in map creation do not describe confidence in the mapping contours. OCSD publishes contour maps of pollutants and sediment physical parameters in the Marine Monitoring Annual Report. These maps are based on the placement of existing sediment sampling stations prescribed in the NPDES discharge permit. This sampling scheme is likely not optimal for accurately assessing the outfall footprint for contaminants discharged with the treated wastewater effluent.

Study Objective:

The objective of this study is to review OCSD's historical benthic sediment data to determine the optimal sediment station array for accurate map generation of OCSD's outfall footprint for sediment geochemistry analytes and benthic infaunal community metrics. Improved maps will ultimately provide better data for the determination of NPDES permit compliance and provide managers, regulators, and other stakeholders with the best available information on spatial and temporal trends of sediment impacts from wastewater discharge. As a result of this study, we will be able to answer the following questions: (1)

2015-16 Project Description

how representative is our existing station grid of the outfall area? (2) are we undersampling some areas and/or oversampling others? (3) what is the most cost-efficient grid spacing to provide accurate mapping contours? (4) how many additional stations are necessary to characterize spatial variance in the area around the discharge or other areas of influence (e.g., Santa Ana River); and (5) what analyses (e.g., chemical parameters, biological indices) will provide the best resolution for mapping the area?

This phase of the study will be conducted in five discrete tasks conducted serially, each with associated products (see Study Outline below). The specific products will include estimates of sample spacing and resulting spatial variability estimates from the current monitoring grid. In addition, an enhanced sample design will be created that will ensure quantifiable spatial variability estimates (also known as a “variogram”). A map of the station locations and a table of latitude/longitude will be created for sediment mapping sampling and analysis. The project will also include the transfer of mapping technology from SCCWRP to OCSD. Implementation of the sediment mapping study design will be evaluated at the conclusion of this study based upon a review of the results, the study value, and fiscal constraints.

Study Collaborators:

Dr. Kerry Ritter, Southern California Coastal Water Research Project (SCCWRP), supported the study with assistance in modeling the spatial variability (variograms), spatial statistics, and spatial designs. She currently is completing a comparable sediment mapping project with the City of San Diego.

Dr. Jeffrey Armstrong, the project leader, worked with Dr. Ritter to provide data and assist with statistical analyses as needed.

Phase II is scheduled to run from July 2010 to June 2013. It is an OCSD self-funded project. There is no estimated budget for this phase due to the unknown number of samples required. The number of additional sampling sites for Task 1 is 60, while the sampling sites for Task 4 are yet to be determined.

The study outline for Phase II is as follows.

TASK 1: Sample and analysis for variability assessment (to be completed by OCSD)

The goal of this task is implementation of the optimal sampling design created in Phase 1, Task 3. Implementation will include field sampling and laboratory analysis. At a

2015-16 Project Description

minimum, the indicators to be measured include sediment grain size, chemistry, and benthic infauna.

Products:
- Sampling to be completed by July 2010
- Chemistry analysis to be completed by Aug. 2010
- Benthic infaunal analysis completed by Dec 2010

TASK 2: Spatial variability assessment

This task will focus on analyzing the data collected during Task 1. Data analysis will include variogram modeling, spatial regression models for trends in spatial and temporal gradients, and the effects of unique spatial heterogeneity (i.e., outliers). Finally, an initial contour map, based on the results from Task 1, will be prepared. Based on kriging models, the contour map will focus on representative indicators and include estimates of confidence.

Products:
- Preliminary variogram modeling
- Initial contoured image maps of kriged values with estimates of kriging errors

TASK 3: Design cost-efficient mapping study / annual monitoring program

Based on the spatial variance calculated during Task 2, a cost efficiency curve will be generated that weighs prediction errors versus sample density. This cost efficiency curve will be used to create an optimal sample design for mapping that maximizes contour resolution and confidence for the minimum amount of resources. Several designs will be explored including uneven sample allocation and nested sample designs.

Products:
- Cost efficiency curve
- Written description of optimized sample design
- Map of station locations and table of latitudes and longitudes

TASK 4: Sample and analysis for final map (to be completed by OCSD)

The goal of this task is implementation of the cost-efficient sampling design created in Task 3. Implementation shall include field sampling and laboratory analysis. Indicators should be focused on monitored parameters currently collected by OCSD including sediment grain size, chemistry, and benthic infauna.

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Products:
- Sampling to be completed by July 2011
- Chemistry analysis to be completed by Aug. 2011
- Benthic infaunal analysis completed by Dec 2011

TASK 5: Production of final map

The goal of this task is to prepare the final maps for OCSD's Annual Report. A complete set of indicators can be evaluated. The contour maps will include kriged predictions and estimates of confidence. In addition, the map production capability and assessment will be transferred to OCSD for making future maps.

Products:
- Final contoured image maps of kriged values with estimates of kriging errors by June 2012
- Technical transfer of kriging techniques to OCSD staff by June 2012

Status:

Tasks 1 through 4 were completed. However, the project will have to be concluded as is. There has been no work on this project since 2014. The contractor is no longer available, and there are no other options for completion.

<u>Phase II Schedule</u>

TASK 1: Sample and analysis for variability assessment (OCSD) - Sampling (July – September 2010) - Laboratory analysis	7/10 – 12/10
TASK 2: Spatial variability assessment - Preliminary variogram modeling - Initial contoured image maps of kriged values with estimates of kriging errors	3/11
TASK 3: Design cost-efficient mapping study/ annual monitoring program - Cost efficiency curve - Written description of optimized sample design - Map of station locations and table of latitudes and longitudes	7/11
TASK 4: Sample and Analysis (OCSD) - Sampling - Laboratory analysis	7/11 – 6/14
TASK 5: Production of final map - Final contoured image maps of kriged values with estimates of kriging errors - Technical transfer of kriging techniques to OCSD	N/A

2015-16 Project Description

Project Title:

Risks from Ebola Discharge from Hospitals to Sewer Workers (WERF4C15)

Contact: Christopher Stacklin, Environmental Services
[WERF Ebola Research Advisory Committee, Technical Reviewer]

Purpose: Review risks of virus exposure to sewer workers and effectiveness of disinfectants

Description:

There are concerns over the potential for Ebola virus (EBOV) and other pathogen transmission to sewer workers. The concerns exist because the safety of nondisinfected disposal of EBOV-contaminated liquid wastes and the efficacy of disinfection approaches are unknown. To this end, this research had two goals:

- assess a sewer worker's potential risk of developing Ebola virus disease from inhalation exposure when performing standard occupational activities in a sewer line serving a hospital with Ebola patients where there is no pretreatment of the waste prior to discharge, and
- conduct a review of inactivation of Ebola and other highly infectious agents by various disinfectants.

Results:

The results of this study suggest that the potential risk that sewer workers face when operating in a wastewater collection system downstream from a hospital receiving Ebola

2015-16 Project Description

patients warrants further attention and that current WHO and CDC guidance for EBOV liquid waste disposal – to dispose in the sanitary sewer without further treatment – may be insufficiently protective of sewer worker safety.

As a result of these findings, workers may choose to exercise greater caution than policy requires when managing biologically contaminated liquid wastes that pose a health risk. Also, agencies may also choose to use these findings as a rationale for advocating for more stringent pretreatment procedures for highly infectious waste at hospitals.

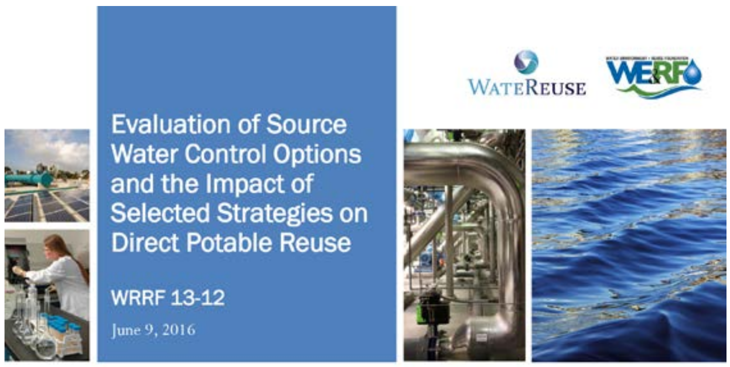
Status:

The WERF report was completed in March 2016. OCSD provided in-kind advisory and technical support valued at $15,000.

2015-16 Project Description

Project Title:

Evaluation of Source Water Control Options and the Impact of Selected Strategies on Direct Potable Reuse (WRRF-13-11)



Contact: Christopher Stacklin, Environmental Services
[Project Advisory Committee, Case Study Contributor]

Purpose: Evaluate various source water control strategies on direct potable reuse

Description:

Influent water is an important variable in the performance of a direct potable reuse (DPR) treatment process train. There are many factors that impact influent quality, including source control strategies in the collection system and upstream wastewater treatment process performance. In particular, membrane processes can play a key role in DPR treatment, and influent to the membrane process has a significant impact on process efficiency and reliability.

It is important to understand the source control strategies that are available and have been previously implemented for indirect reuse facilities - and treatment processes that will be used in indirect treatment - in order to better characterize source control management options that will ensure reliable and robust performance of DPR processes. This project is a desktop study that will inform regulators and designers of DPR processes of important considerations in selecting source water control strategies for fulfilling DPR performance requirements.

2015-16 Project Description

The goals are to evaluate upstream wastewater treatment impacts (e.g., industrial source control, nitrification / denitrification) on DPR source water quality and DPR processes, and to evaluate the impacts of hydraulic control mechanisms (e.g., flow equalization and source water storage buffers) on influent water quality and flow variations that stress the DPR process.

Results:

The final deliverables will include a guidance document for regulators and designers and a summary report.

Status:

The technical work on the project has been completed, as has the evaluation of the first draft of the Final Report. OCSD's in-kind costs have totaled $15,000; the total WRRF budget is $231,130.

2015-16 Project Description

Project Title:

From Collection System to Tap: Resiliency of Treatment Processes for Direct Potable Reuse (WRRF-14-13)

Contact: Christopher Stacklin, Environmental Services
[Project Advisory Committee, Case Study Contributor]

Purpose: Evaluate the effects of treatment process failures in the context of direct potable reuse treatment trains

Description:

Direct potable reuse (DPR) treatment is a complex and interdependent process. To assure the safety of the water produced through advanced treatment, the industry must address the impact of upstream water quality and upstream process failure on downstream process performance. Depending on where a process failure occurs in the DPR treatment train, it may have a domino effect on multiple treatment processes downstream of the failure. The analysis should focus on mapping the interdependency of unit treatment processes from sewershed to point of entry in a drinking water distribution system.

This project will assess the resiliency of unit treatment processes while mapping the interdependency of these processes to trace failures and impacts. Both potential acute and chronic impacts affecting performance reliability will be identified, including water quality and production capacity along with public health.

2015-16 Project Description

A design guide will be developed incorporating information from the wastewater source, wastewater treatment, and advanced water treatment assessments. This will identify the most practical design features, control systems, maintenance programs, and standard operating procedures.

Results:

The project is in progress, and the end date has not been determined. A design guide has not been issued yet.

Status:

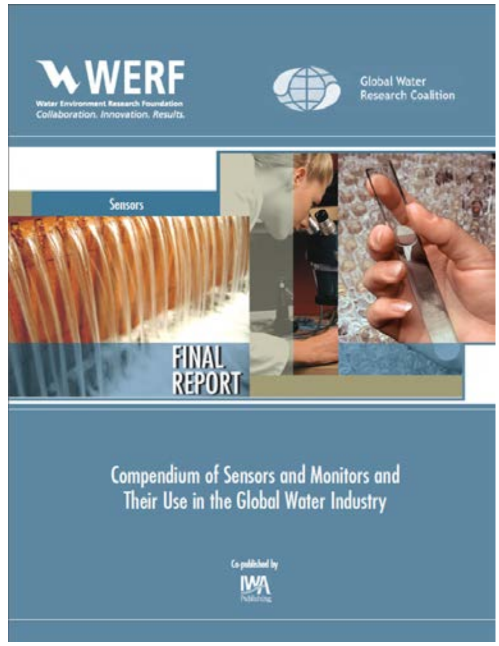
An award for this project was made in September 2015 to Sustainable Systems, LLC. Work during the first quarterly progress reporting period focused on a literature review and gap analysis to inform the draft utility surveys that will be used for the three DPR stages: wastewater source, wastewater treatment, and advanced water treatment. The literature review is ongoing.

OCSD has provided descriptions of our Source Control Program, mass balance approach, Wastewater Discharge Ordinance, and Ordinance Fact Sheet. The OCSD in-kind work to date is valued at $2,500 and may total $15,000 throughout the project. The total WRRF project budget is $200,000.

2015-16 Project Description

Project Title:

Compendium of Sensors and Monitors and Their Use in the Global Water Industry (SENG1C11)



Contact: Carla Dillon, Engineering Planning
[WERF Sensor Advisory Committee, Technical Reviewer, Case Study Participant]

Purpose: Identify and document information on sensors in the water/wastewater industry and create an on-line compendium

Description:

Online monitoring of water quality is a critical component in the proactive management of processes and assets and supports improvements in process performance and cost efficiency. Instrumentation for monitoring many water quality parameters is commercially available; however, the implementation of such equipment remains largely limited to a small number of basic parameters and is confined to key nodes in collection, treatment, and distribution systems.

An obstacle to greater utilization of online monitoring is the lack of publicly available information on system performance, key drivers, and technical, economic, and social barriers. This project helped to remove this obstacle. It involved research and case studies on sensors and monitors that culminated in the Compendium, available at www.wqsmc.org, and a final written report. The Compendium contains information on applications, capital and operating costs, and real-world experiences taken from literature, interviews with users, questionnaires, and a number of national and international workshops. The

2015-16 Project Description

Compendium database can be searched through a web-based interface, allowing users to conduct searches by application as well as technology. This provides industry stakeholders with a tool to select and operate real-time water quality monitoring solutions, enabling them to learn from the experiences of other end-users worldwide.

The online Compendium requires a login and password that can be obtained from Global Water Research Coalition (GWRC) member organizations. OCSD is a member of the Water Environment & Research Foundation, which is a member of GWRC

Results:

Many drivers were identified for online monitoring, including:

- Cost
- Rapid results
- Frequency of measurements
- Process control and optimization
- Regulatory needs
- Event detection and response
- Safety
- Asset protection
- Planning
- Maintenance

Through the case studies, common themes emerged. Monitoring is complex; all individual aspects might be simple, but the entire operation is not. There are over 250 manufacturers of automated online monitoring instruments for over 100 parameters. Implementations of sensing and monitoring are not just technical processes, but people need to learn to understand the how, and appreciate the why.

In addition, well-trained maintenance personnel are important for the successful implementation of sensors. Maintenance requirements will vary with the application; for instance, an instrument for real time control or compliance monitoring will require more frequent attention than an instrument for environmental monitoring. An often overlooked aspect is that the lifespans of instruments are limited. An expensive instrument may need to be replaced after five or ten years and may require servicing by the manufacturer during the lifespan as well.

2015-16 Project Description

The project identified global issues affecting the state of sensor and monitor usage in the water sector, including:

- There is a lack of skilled personnel and an overall lack of personnel.
- The current generation of sensors is capable but may not be suitable for large-scale use. (Capital and operating expenses are too high.)
- Legislation can be a driver but often is a barrier.
- Distribution of knowledge is problematic, even within an organization (often different sections do not talk to each other).
- Research is ad-hoc and uncoordinated, occurring mainly on a national level, although the demand is global. There is little cooperation among sectors.
- Market dynamics can be a hindrance.
- Contracts and policies for procurement may lead to limited continuity or different systems.

Status:

The WERF report was completed in August 2014. OCSD provided in-kind advisory support, technical support, and case study participation.

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