ODOR ABATEMENT & COLD PLASMA TECHNOLOGY: REVOLUTIONARY APPROACH SERVES PUBLIC WELL

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ABSTRACT

Palm Valley Wastewater Reclamation Facility (PVWRF) in Goodyear, Arizona faced odor complaints at its 4.1 million of gallons per day (MGD) facility. Proposals from engineering consultants recommended adding two more chemical scrubbers to the two already installed.

McBride Engineering Solutions (MES) recommended a new approach to odor control that eliminated odors and saved over 40% in capital costs and nearly $1,000,000 in total costs over five (5) years.

MES recommended the Aerisa WaveFour™ Ionization Technology products for the headworks and solids buildings (120,000 ft3), leaving the existing scrubbers to address the basins. This resulted in a reduced workload and chemical costs on the installed scrubbers and an energy savings of 80% by using the Aerisa system over chemical scrubbing solutions.

MES's focus on both process and odor abatement increased efficiencies at the plant, reduced stultifying odors up to 90% prior to installation of additional odor control and reduced the capital investment for odor control equipment.

KEYWORDS

Odor Control, WaveFour™, Bipolar Ionization, Chemical Scrubber, Carbon Filter, Bio Filter

THE PROBLEM

The Palm Valley Water Reclamation Facility (PVWRF) is a wastewater treatment facility owned by the Litchfield Park Service Company (LSPCO) and located in Goodyear, Arizona. The plant utilizes a sequential batch reactor (SBR) technology that is designed to produce Arizona A.R.S. Title 18 "Class A-plus" quality effluent for various reuse applications. The rated treatment capacity of the plant is 4.1 million gallons per day (MGD) on an annual-average-day basis and 11.1 MGD on a peak-flow basis. The facility was designed to utilize a minimal footprint by constructing the process equipment and administration buildings on top of the below-grade process basins.

The odor control system for the PVWRF originally consisted of two three-stage wet chemical scrubbers: one 10,000 CFM unit for the Headworks Building and Process Basins, and one 6,000 CFM unit for the Solids Dewatering Building and Digester Basins. Due to performance issues resulting in public complaints, in early 2007, a 16,000 SCFM carbon media scrubber was added to polish the exhaust streams of the two original scrubbers. The configuration of the odor control system prior to this project is represented in the following figure:

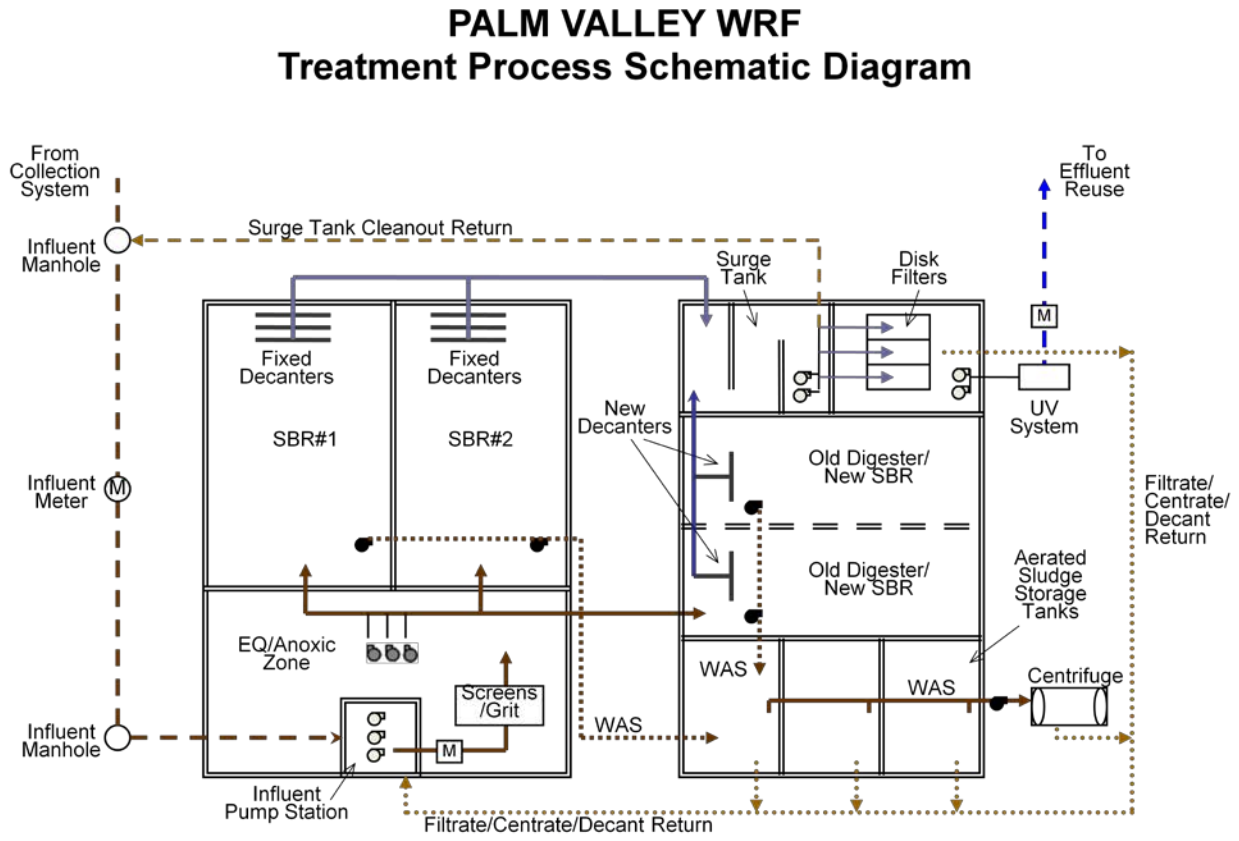

Figure #1: Odor Control Configuration

Based on the air space volumes in the odor-controlled buildings and tanks, it appears that the system was designed to provide approximately 10 to 12 air changes per hour for each of the odor-controlled equipment rooms. It is apparent that the design was based on drawing air in series from the process and digester basins *through* the odor-controlled rooms. But once the facility was constructed it turned out that input air could be drawn from various areas (e.g., the process air blowers, the evaporative cooling units, and infiltration through openings in each building), the entire volume of all air space was effectively drawn through the system in parallel, significantly reducing the air changes per hour. Therefore the effective air change rate for the system as a whole was less than optimal. In addition, there were no automatic or manual dampers on either the odor control duct lines or the buildings, which meant that there was no way of balancing the air in and out of the system.

In addition to the ongoing odor complaints from nearby residents and businesses, the inefficiency of the odor control system also had detrimental effects on equipment within the facility. Because

the odor control system drew foul air from the process basins through the odor-controlled rooms, the equipment and fixtures in the rooms had prolonged exposure to moisture-laden air with highly corrosive constituents. The effects of this could be readily observed in the Headworks room, where a layer of corrosion was present on most of the susceptible equipment and condensed moisture was visible on the windows and most hard surfaces.

Another negative effect of drawing the foul air from the process basins through the buildings was that it created an extremely uncomfortable environment for operators working within the odor-controlled rooms. Although the air within the rooms was kept within safe parameters, the hot, humid, and odorous conditions made the working space difficult to bear and often resulted in entry or rollup doors being kept open in an attempt to improve conditions. Open doors further diminished the effectiveness of the odor control system and led to even more complaints.

GOALS AND OBJECTIVES:

MES worked with Algonquin Water Systems (AWS,) PVWRF's parent company, to find a solution to create efficiencies in the plant's waste processes. As important, MES sought to find a solution that would maximize odor abatement while reducing costs for operations. The most important objective was to reduce odor complaints to zero. Specifically, the plant had to pass a very subjective smell test – no undesirable smells to be detected by any of their neighbors.

THE SOLUTION

The initial solution proposed by an engineering consultant was to increase the size of the existing wet scrubber system from 16,000 SCFM to approximately 45,000 SCFM, at a cost of approximately $2.7 million. Because of the capital costs and the anticipated increase in chemical usage and O&M costs, in late 2006 AWS asked MES to investigate the proposed system to see if an alternate solution could be developed.

What MES found was that the facility was producing extraordinarily high levels of odorous compounds due to some specific process equipment issues, and that these issues would need to be addressed before modifications to the odor control system could be implemented in a cost-effective manner. Based on MES's recommendations, PVWRF made some process modifications including installing a surge-tank recycle line and a higher-capacity dewatering centrifuge. These changes brought the average concentration of the constituents in the foul air down to a more manageable level and enabled the cost-effective implementation of a new odor control configuration as described below.

Based on their analysis of the existing odor control system, MES determined that since wet scrubbers tend to be most efficient under low-flow, high concentration conditions, one alternative for improving the system would be to seal off the basins from the equipment rooms and dedicate the existing scrubber system to the process basins alone. At the same time, a room-dedicated system could be installed to provide the full 12 air changes per hour for the headworks and solids dewatering rooms. MES proposed that in addition to eliminating the need for more wet scrubbers, a significant benefit of this alternative would be that the wet and corrosive air from the tanks would not be drawn through the equipment rooms.

ODOR TECHNOLOGY SELECTION

Several alternatives for the room-dedicated system were investigated and based on their analysis MES recommended that the Aerisa WaveFour™ technology be installed. The reasons for this recommendation included the following:

- Relatively low capital cost compared to other alternatives
- Significantly lower O&M costs compared to other alternatives
- No chemicals or expendable media are required
- Potential for design, procurement, installation and startup within 3 months
- System would include the Administration and Disinfection Buildings
- Reduction or elimination of corrosive conditions in equipment areas
- Uses building/basin interiors as reaction chambers improving working environment

At the time that MES was investigating the Aerisa system for PVWRF, there were no existing installations of the Aerisa system at a wastewater facility in the United States. Therefore MES investigated the European wastewater facility references for the manufacturer and its system and researched the performance of the system in animal kennels, meat rendering plants, and casinos in the U.S.

Once it was determined that the system was successful in these applications, MES coordinated a site visit to the local Fort McDowell Casino where it was being installed to purify the air in a large cigarette smoke-filled hall within the casino. The success of the system in that challenging application was apparent during the site visit, so MES recommended that PVWRF go forward with the installation of the new odor control configuration utilizing the Aerisa system.

AERISA ODOR CONTROL TECHNOLOGY: DIFFERENT APPROACH, BETTER RESULTS

There are three key differences in the way Aerisa's WaveFour™ cold plasma technology solves odor issues versus traditional technologies:

1. Contaminated air is cleaned inside the building, basin or station. The traditional solutions pull air from the building leaving a contaminated area.
2. No chemicals, water or bio agents are required. No special handling of the equipment other than the AerGen tubes is required.
3. The solution is ecologically beneficial, using less energy, requiring no special waste disposal and leaving a clean atmosphere for workers

Treat Air in the Building:

Most solutions attempt to pull air from an odorous environment into a large silo, cleansing the air, and then releasing the exhaust into the environment. This leaves the building filled with contaminants.

In contrast, treating the air inside the building reduces hydrogen sulfide inside producing a healthier work environment. Aerisa's cold plasma solution also reduces other contaminants and

pathogens. These include viruses, bacteria, molds, particulates, and volatile organic compounds (VOCs.) VOCs include methane, formaldehyde, toluene and a long list of others.

No Chemicals, Water or Bio Agents Required:

As the world becomes more and more environmentally conscious, introduction of potentially hazardous agents into the water or air, face greater and greater public scrutiny. Cold plasma technology requires no chemicals, no hazardous disposal, no water and no extensive management, such as transport of hazardous materials, to assure successful mitigation of odor.

Environmentally Beneficial

Energy costs are a growing concern both for the consumer and industry. As energy costs rise, the impact on a wastewater plant's budget is becoming an increasingly large line item. As much as 12% of energy costs are for odor control alone. Because Aerisa technology uses the building/basin/station as a reaction chamber instead of a very small silo, the pressure drop for Aerisa solutions is very low compared to competing solutions. In most cases, Aerisa's energy costs are one-fifth of traditional solutions.

Given the EPA's recent growing focus on chemicals and their handling, and transportation, as regulations increase the cost of maintaining chemical scrubber solutions will increase.

AERISA CONFIGURATION AND IMPLEMENTATION

PVWRF Configuration

The PVWRF utilized a Sequential Batch Reactor (SBR) for its 4.1 MGD facility. The basins are housed below the headworks, solids building, controller building and administration. The headworks measure about 72,000 cubic feet and the solids building about 55,000 cubic feet. The predominance of odors was produced in these buildings.

The potential advantages of the Aerisa approach, as well as the demonstrated success in other severe odor applications, convinced AWS and MES to commence a fast track implementation of the system. Given the short timeframe, close coordination was required between MES and Aerisa engineers to develop a solution that could mitigate the odor issues, require as little as possible modification to the existing building and associated infrastructure and provide equipment redundancy while at the same time satisfying the demanding project schedule.

In designing the system, three factors were central to the correct configuration for each site i.e., the contamination factor for H2S, the volume of space to be saturated by the cold plasma generators, and the required density of superoxide ions to cleanse the air. After a site survey, the final configuration of supply units, scrubbers, and air distribution systems was determined and detailed engineering commenced.

The final solution combined three of Aerisa offerings to provide a comprehensive solution to the odor issues. The design for <u>each</u> building contained:

- One AerFlow – 12000 -15

Aerisa AerFlow is a scalable air handler with four basic cabinet sizes that produce from 100 to 15,000 CFM. Custom air handlers can be designed up to 200,000 CFM depending on customer requirements.

AerFlow draws in ambient air and moves it over AerWave 5550 cold plasma generators that are racked inside the AerFlow cabinet. The WaveFour™ conditioned air flows into the building and begins decomposing contaminants in the air.

Figure #2: AerFlow 12000 – 15

Two AerScrubber – 6000 – 4

The AerScrubber takes air from the building into the unit where it is mixed with fresh WaveFour™ conditioned air. A specially designed mixing manifold takes both air flows and mixes them to increase contact ratios. The result is nearly contaminant-free air. The AerScrubber can also be used as a backup or redundant solution.

Figure #3: AerScrubber 6000 – 4

- AerDuct

AerDuct assures an even distribution of WaveFour™ conditioned air throughout the contaminated area. AerDuct is not your typical air conditioning/heating duct, which is both expensive and ineffective for wastewater applications. Most HVAC solutions blow air through a few vents is each room. This is fine for heating and cooling but ineffective in areas that are highly contaminated with odorous gases.

Figure #4: AerDuct

Cleansing the air is a two step process. First, clean air is feed into the building using the AerFlow and the associated AerDuct distribution network. The embedded WaveFour technology create clusters of highly activated superoxide molecules which, due to their high reactivity, decompose H2S, volatile organic compounds and sulfur compounds into their constituent inert components.

The second step, which pulls highly cleansed air from the building into AerScrubbers, allows one more air clarification before release into the atmosphere. This second step satisfies two requirements 1) providing an additional air clarification for sites that have stringent odor requirements and 2) satisfying state or local building codes that require a specified number of air changes in the building per hour.

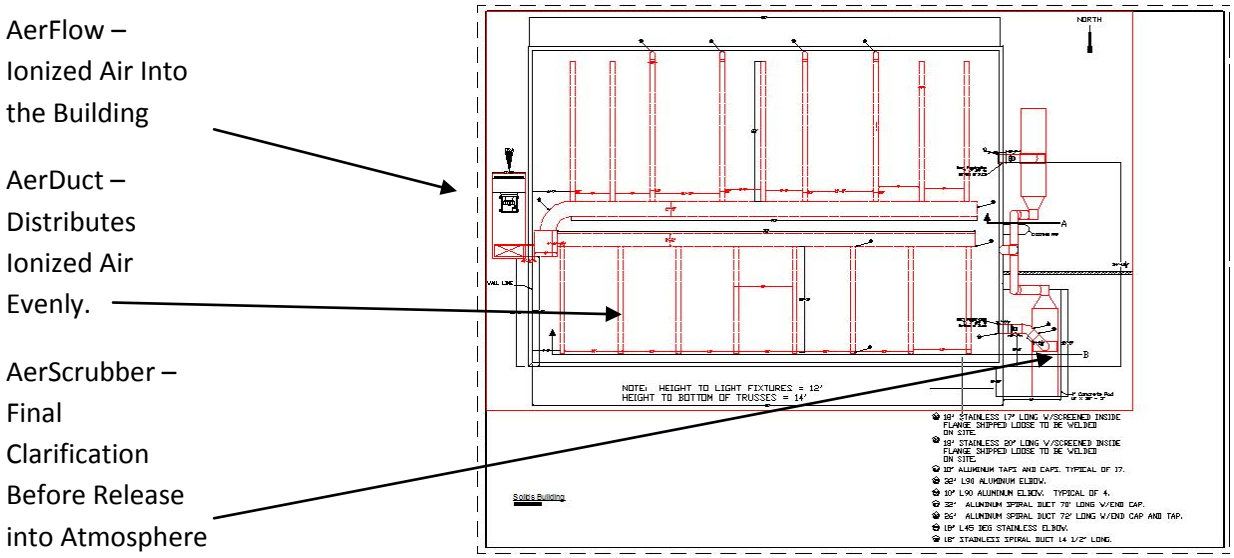

Figure #5: Aerisa Configuration for Solids Building

THE PHYSICS OF WAVEFOUR™ TECHNOLOGY

Oxygen is nature's agent for change in the world of chemicals and elements. Its abundance in ambient air, about 21 percent, makes it natures most effective oxidizer. In its atomic state, oxygen contains 8 proton, 8 neutrons, and 8 electrons.

The electrons are the key to reactivity for atoms and molecules. Electrons are held in 'shells' around the nucleus. For oxygen, the first shell contains 2 electrons, and the second shell which can hold 8 electrons holds the additional six, with a total of eight for the atom. Having a shell with fewer electrons than the shell's total capacity make the element 'reactive.' Oxygen is looking for something to react with to fill the outer shell's empty electron slots.

In ambient air its most reliable 'reaction' partner is another atom of oxygen, which forms a molecule of O2. In its molecular state, four electrons orbit each oxygen atom and eight of its electrons are shared via four covalent bonds. No matter which state it is in, or for that matter any element or compound, the electrons are the key to reactivity.

Individual oxygen atoms will always pair up and naturally exist as a molecule. When oxygen atoms pair up (O2), they share electrons with a covalent bond. As an atom, oxygen is very reactive. It is also reactive as a molecule, and even more reactive as a positively or negatively charged ion.

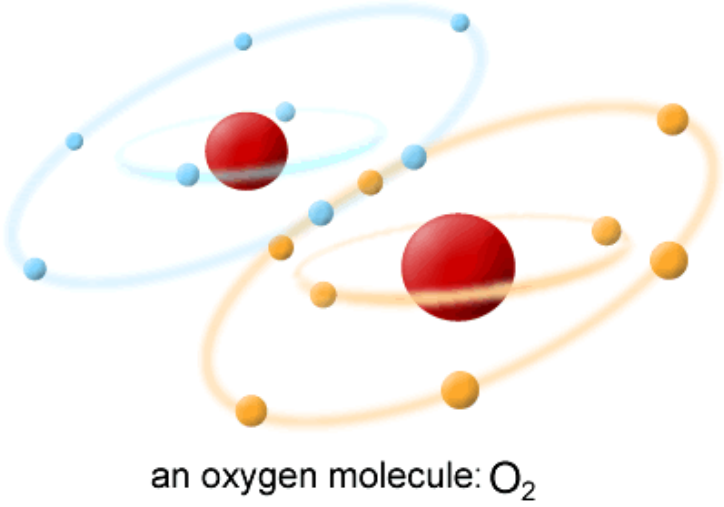

Figure #6: Oxygen Molecule with Covalent Bonding
http://www.terrific-scientific.co.uk/Pages/AtomicStructure/atomic_structure4.htm)

WaveFour™'s unique technology produces specific wavelengths of energy that either sends an electron out of the 'shell' creating a positive ion or adds one, creating a negative ion. The result is a superoxide molecule that has either a positive or negative charge and that is very reactive. In the case of the wastewater industry, hydrogen sulfide is a very suitable agent.

WaveFour's™ technology also provides additional kinetic energy to the conditioned superoxide molecule, increasing the chances for reacting with H2S as well as VOCs and mercaptans. This separates WaveFour™ from all other ionization technologies.

The amount of superoxide molecules is directly proportional to the area of the tube exposed to ambient air and the amount of air that flows over the tubes. The more tubes and the more airflow, the greater the amount of superoxide molecules distributed in the contaminated area.

It should be noted that Aerisa technology closely mimics ultraviolet radiation in the atmosphere. So, for instance, in the very clean mountaintop environment this radiation produces about 1500 ions per cubic centimeter. At lower elevations, in a city environment, this production is lower, generally around 100-200 ions per cubic centimeter. In a very contaminated environment such as a wastewater treatment plant, Aerisa systems are engineered to create an equilibrium of ions in the air at anywhere from 500 to 2,000 ions per cubic centimeter.

Oxidation in Gases

The oxidation of contaminants in the air that produce odor is not unlike what occurs in traditional wet scrubber solutions. Oxygen is the key component of any oxidation reduction reaction.

Chemically the reaction is written as:

$$H_2S + (5/2)\ 0_2^{+} = H_20 + S0_4$$

The derivatives of this gas reaction can be seen in a variety of bacteria, photosynthetic and other chemical reactions. Many chemicals compounds which include oxygen are used in chemical scrubbers including H2O2, NaOH, and iron ferrite. The result of these chemical reactions is to oxidize H2S.

Regarding the buildup of sulfates or sulfur atoms inside a plant; consider that most H2S contamination is between 5 and 100 ppm, the resultant sulfate falling to the floor in a year would not be noticeable.

RESULTS:

Before implementation of plant process efficiencies executed by MES, the Headworks H2S levels had routinely measured up to 20 ppm. Replacement of media in the influent process and acquiring new test instruments and improving procedures reduced these readings to under 1 ppm upwards to 11 ppm (see Figure #7).

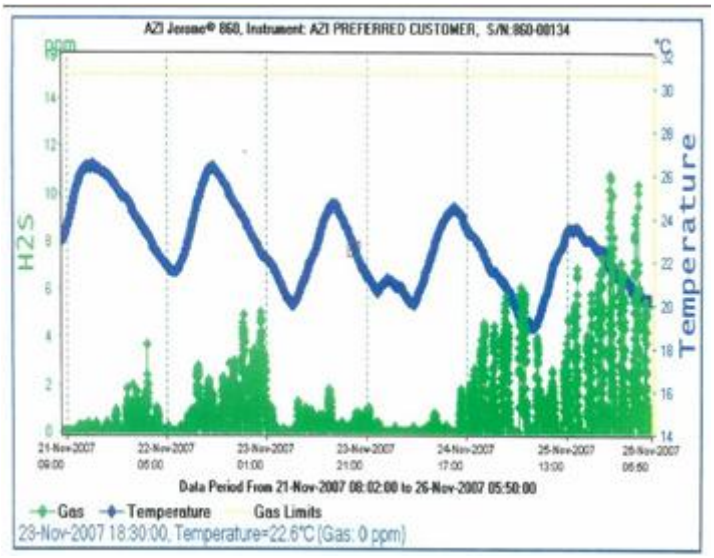

Figure #7: PVWRF Pre-Installation Testing

PVWRF and Aerisa performed testing that produced data that showed almost uniform zero levels of H2S remaining in both the Headworks and Solids Buildings. Although the results were great, the impression remained that the test instruments were not sensitive enough to provide accurate results, i.e. below 0.100 ppm.

An independent consultant was hired and further tests were conducted.

The testing is presented below in Figures #8 and #9. Over a five day period, there were five spikes inside the headworks building, the highest 0.09 ppm. Outside the headworks at the AerScrubber exhaust closest to the residential development, the highest reading was 0.01 ppm.

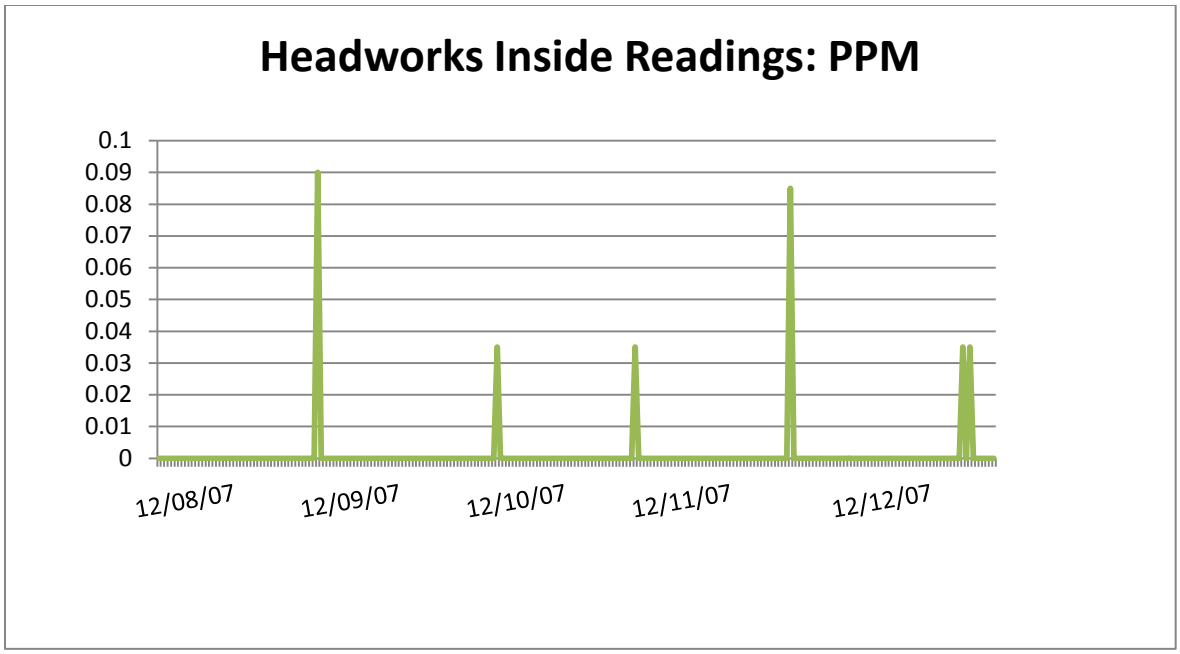

Figure #8: Independent Testing: Inside Headworks, Post Installation

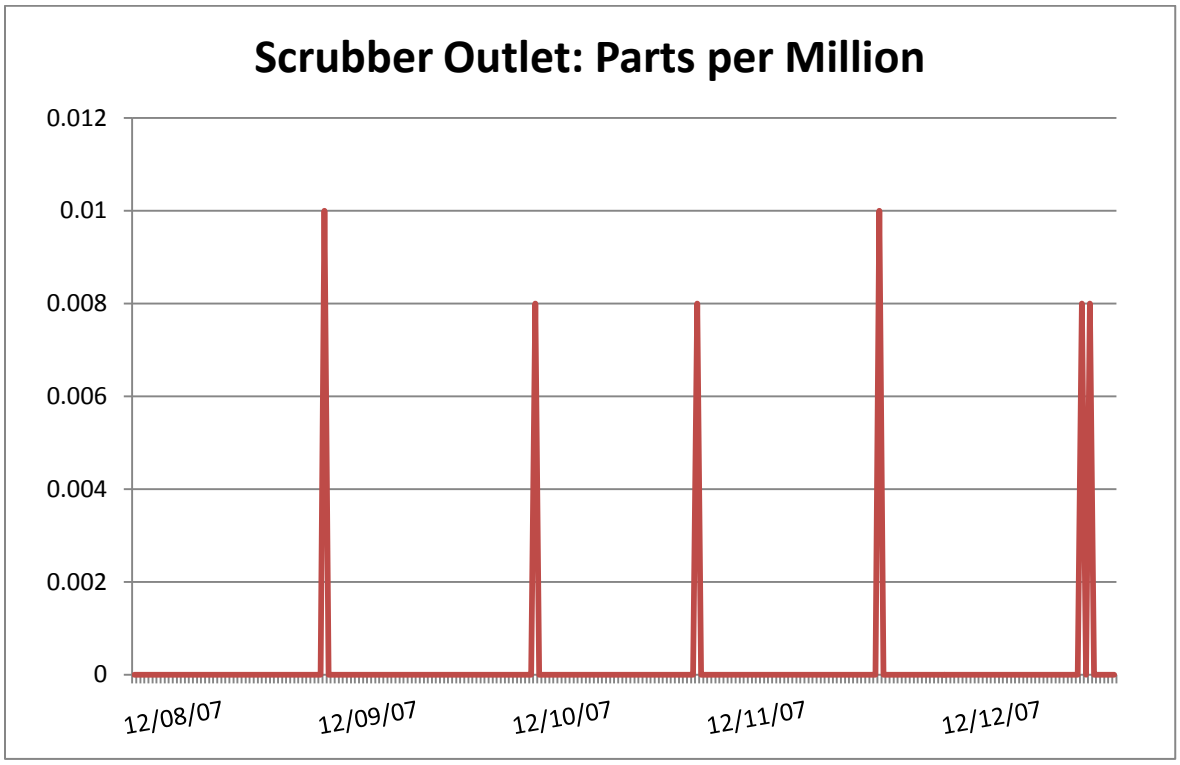

Figure #9: Independent Testing: Scrubber Exhaust, Post Installation

TOTAL COST OF OWNERSHIP

There are three key financial benefits of implementing an Aerisa Solution over traditional scrubber solutions:

- Lower capital costs
- Lower maintenance costs
- Lower energy cost: reduction of nearly 80% over chemical scrubber solution

This results in a lower total cost of ownership of an estimated $927,863 over five years.

The following chart is a comparison of the Aerisa solution and the chemical scrubbers proposed by a competing engineering firm.

Aerisa Cost versus Competing Chemical Solution

	Aerisa	Chemical Scrubber
Capital Cost for Upgrade	$364,000.00	$610,000.00
Installation	$84,000.00	$150,000.00
Engineering	$22,400.00	$38,000.00
General Conditions and Other Indirect Costs	$44,800.00	$76,000.00
General Maintenance Labor/Materials	$1,000.00	$6,000.00
Cold Plasma Ion Tube Replacement	$45,770.00	
Chemical Usage		$76,569.60
Estimated Annual Energy Usage	$12,249.98	$90,263.04
Total Equipment and M&O Costs	**$574,219.98**	**$1,046,832.64**
Total Equipment and M&O Savings	**$472,612.66**	
Estimated Five Year Costs	**$810,299.90**	$1,738,163.20
Estimated Five Year Savings	**$927,863.30**	

Figure 10: Table of Comparative Costs

FINAL COMMENTS

In summary, Aerisa's WaveFour™ technology proved to be the most cost effective and technically feasible solution to resolve the odor issues that were being experienced at PVWRF since it was significantly less expensive than traditional chemical scrubber technology and could be installed in a much shorter time frame. In addition, Aerisa's technology has the added benefits of lower operating costs, elimination of on-site chemical storage, effective treatment of air in place, easy to install and maintain duct work, low visual profile, and low noise generation.