Title
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ABSTRACT

The City of Los Angeles Sanitation & Environment (LASAN) operates the Hyperion Water Reclamation Plant (HWRP) in the city of Los Angeles (City) which has an average dry-weather capacity of 450 MGD (million gallons per day). The HWRP has been operating since 1892, and its core mission is to champion the protection of public health and the environment. Separately from the primary and secondary water treatments, HWRP is currently applying an advanced system with the goal to be 100% recycled water by 2035. Part of the upgrade is at the new intermediate pumping station (IPS) odor control biotrickling filter (BTF) system. At the IPS, a total of 10 Archimedes Screws (hollow cylinder and spiral) lifts an average flow of 260 MGD wastewater from primary to secondary treatment at HWRP. The original IPS foul air treatment system had two (2) chemical wet scrubbers and two (2) chemical storage tanks. This old system was replaced by a new system featuring four (4) BTFs and four (4) carbon adsorber towers (CAT). The project was designed to remove hydrogen sulfide (H_2S) from the IPS foul air stream

and on September 13, 2021, the first IPS BTF unit was put into service followed shortly thereafter by the other three BTF units. Results have been outstanding with an average of over 99% H_2S removal occurring in the BTF process with a design air flow rate of 40,000 standard cubic feet per minute (scfm). The total IPS BTF project cost is $7,849,000, and operations, maintenance, and performance data at HWRP will be discussed further. Performance data, air emissions measures, operations and maintenance challenges, and future BTF advancements will be presented for LASAN's new technology IPS BTF odor control systems.

Hyperion Water Reclamation Plant (HWRP)

The Hyperion Water Reclamation Plant (HWRP) has been operating since 1892. LA Sanitation & Environment's (LASAN) core mission within the City of Los Angeles (City) is to champion the protection of public health and the environment. Overtime our environmental charge has evolved garnering our organization a strong standing as a world-class environmental leader. LASAN is poised to remain a leader in the environmental arena for many years to come by implementing novel technology and sustainability while delivering quality service to our valued customers. To address the sanitary requirements of a growing population, City of Los Angeles purchased in 1892 200 acres of oceanfront property. This property would become the Hyperion Water Reclamation Plant. LASAN manages the entire City sewer system and has invested billions of dollars on new wastewater treatment technologies in a commitment to protect public health and the area's environmental resources. LASAN's system consists of four treatment/water reclamation plants that serve more than four million people within two service areas containing more than 600 square miles and wastewater collection system of over 6,700 miles. HWRP is one of the largest treatment plants in the United States with an average dry weather capacity of 450 MGD (Million Gallons per Day). HWRP treats municipal wastewater from the City of Los Angeles so that the environmental impact from City to Santa Monica Bay can be dramatically reduced. HWRP includes preliminary treatment, advanced primary treatment, secondary (biological) treatment before final discharge to outfall extending five miles into ocean. Figure 1 shows map of the four treatment/water reclamation plants which serve more than four million people within two service areas. Figures 2 to 4 shows HWRP treatment process system flow in LASAN City of Los Angeles.

Here are some milestone dates at HWRP: 1892 - City purchased 200 acres of ocean front property; 1894 - Raw wastewater is discharged into near-shore waters at Hyperion's future location; 1925 - A Screening Plant is built at Hyperion; 1950 - The plant begins full secondary treatment, including capturing Biosolids for fertilizer and biogas for energy production; 1957 - Capacity issues require reduction in treatment levels. Biosolids are discharged into Santa Monica Bay; 1987 - Program completed to eliminate Biosolids from Santa Monica Bay; 1998 - Full secondary treatment facilities completed; 2002 - The production of Class A Biosolids begins; 2017 - Utilization of Hyperion biogas Hyperion BioEnergy Facility (HBEF) to generate renewable energy power and steam for in-plant use. Other important facts about HWRP: HWRP is one of the largest sewage treatment plants in the world; HWRP is about the size of Disneyland: 144 Acres; HWRP Staff: 400 Full-time Employees; HWRP Annual Operation & Maintenance Budget: $100 Million; HWRP Capital Improvement Projects: >$5 Billion Planned in 15 years; Average Dry Weather Capacity 450 MGD (1,703,435 m^3/day); Design Capacity; 850 MGD (3,217,600 m^3/day) Peak; Wet Weather Flow; 260 MGD (984,207 m^3/day); Current Average Dry Weather Flow; 27% of flow (71 MGD, 268,764 m^3/day) is currently recycled with a goal of 100% recycle of its wastewater by 2035; Hyperion has the largest field of egg-shaped digesters in the world with a capacity of 50 million gallons; Hyperion generates 20 Megawatts of power which is enough electricity each day to power 30,000 homes; Biogas utilization to generate power results in 95,000 tons/year emission reductions of Green House Gas which equivalent to taking 20,000 cars of the road.

Figure 1. Map Shows the Four Treatment/Water Reclamation Plants Which Serve More than four million people within two service areas containing more than 600 square miles and wastewater collection system of over 6,700 miles (LA Sanitation & Environment - City of Los Angeles).

Intermediate Pumping Station (IPS) Odor Control Biotrickling Filters (BTFs)

The Intermediate Pump Station (IPS) at HWRP raises the hydraulic elevation of primary effluent before flowing to the secondary treatment system. A total of 10 Archimedes Screws (hollow cylinder and spiral) lifts an average flow of 260 MGD wastewater from primary to secondary treatment. The IPS utilizes screw pumps that create significant turbulence of the wastewater during operations and cause release of odorous gases. The IPS Biotrickling Filter (BTF) Odor Control system was designed to collect and treat the foul air generated at the inlet and outlet bays of the screw pumps. The IPS BTF Odor Control system was a $7,849,000 project that started operations on September 13, 2021. The LASAN Intermediate Pumping Station BTF Odor Control system and the BTF system replaced aging odor control equipment that used chemical to treat foul air. Our IPS BTFs use microorganisms to remove pollutants from the foul air stream and have final stage carbon polishers, which remove any remaining trace odors. This project is a good example of LASAN implementing community input from residents regarding implementation of environmentally sustainable projects to phase out the use of chemicals where feasible without sacrificing the plant's obligations to comply with applicable regulatory requirements. This upgrade replaced the existing two (2) chemical wet three stage scrubbers and two (2) chemical bulk storage tanks. In its place are four new (4) BTFs and new four (4) carbon scrubber tanks [Carbon Adsorber Towers (CAT)] which run in parallel at the IPS Odor Control facility. At first, a single BTF unit along with its corresponding carbon scrubber were put into operation with the other three BTF units and carbon scrubbers following shortly thereafter. Performance has been outstanding with an average of over 99% H2S removal occurring in the BTF process at a design air flow rate of 40,000 scfm. Figure 5 shows Intermediate Pump Station (IPS), Technical Support Facility (TSF), Environmental Learning Center (ELC) at HWRP.

Figure 2. Hyperion Water Reclamation Plant, LA Sanitation & Environment - City of Los Angeles.

The Intermediate Pump Station Odor Control Upgrade Project includes the following major work as identified during the design and construction efforts: All applicable permits and including environmental regulatory compliance permits, permit(s) from the City of Los Angeles Department of Building and Safety; grading permit from the City of Los Angeles, Department of Building and Safety; demolition work; airflow routing for treatment; replacement of existing steel pipe racks; removal of the existing two (2) chemical scrubbers and existing two (2) bulk chemical storage tanks; the procurement, and installation of temporary carbon scrubbers; the replacing of spent carbon from the temporary carbon scrubbers; removal of temporary carbon scrubbers; construction of four (4) biotrickling filters units (BTFs units) each with three (3) layers of packing media and required sub-systems, four (4) double stage carbon adsorber vessels with activated carbon media, installation of ancillary mechanical components; installation of four (4) degreasers and four (4) demisters; furnishing and installing a supporting electrical system;

electrical, mechanical, and instrumentation functional testing; start-up; training City personnel in O&M of all installed systems & equipment; and commissioning.

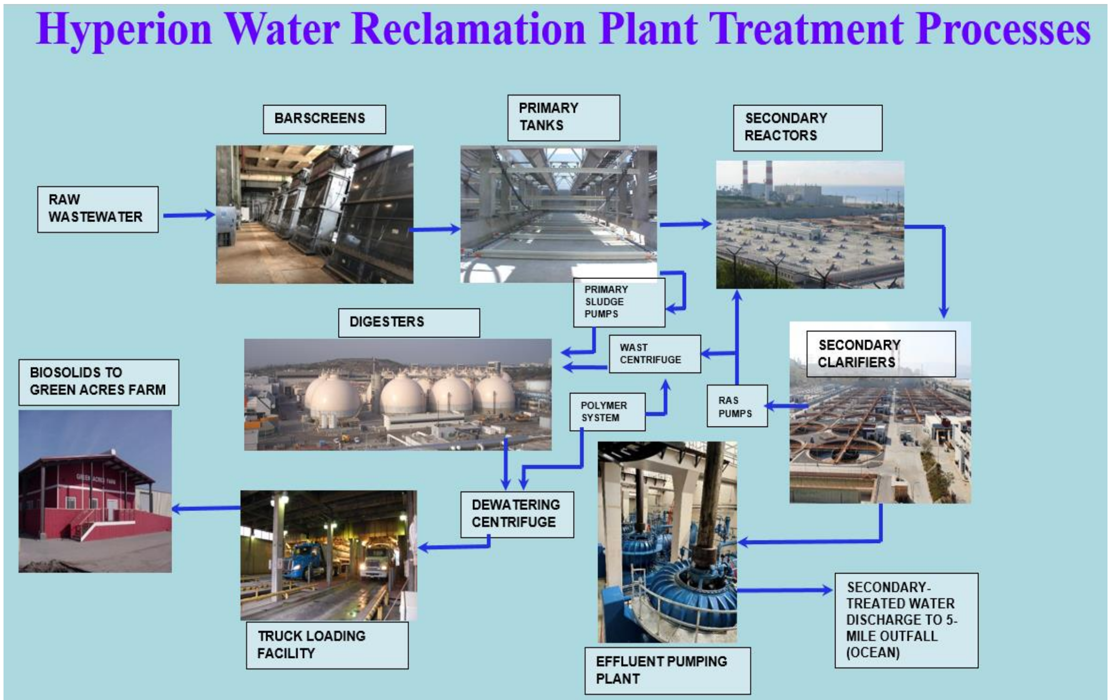

Figure 3. Hyperion Water Reclamation Plant Treatment Process in LASAN City of Los Angeles.

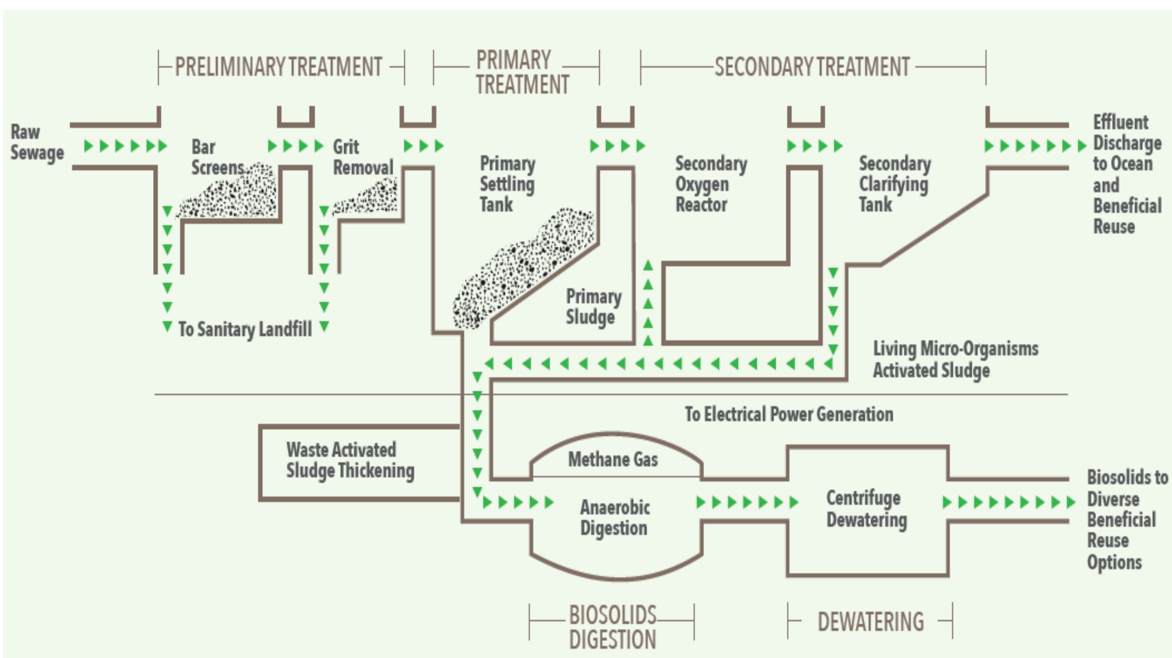

Figure 4. Hyperion Water Reclamation Plant Treatment System Flow in City of Los Angeles.

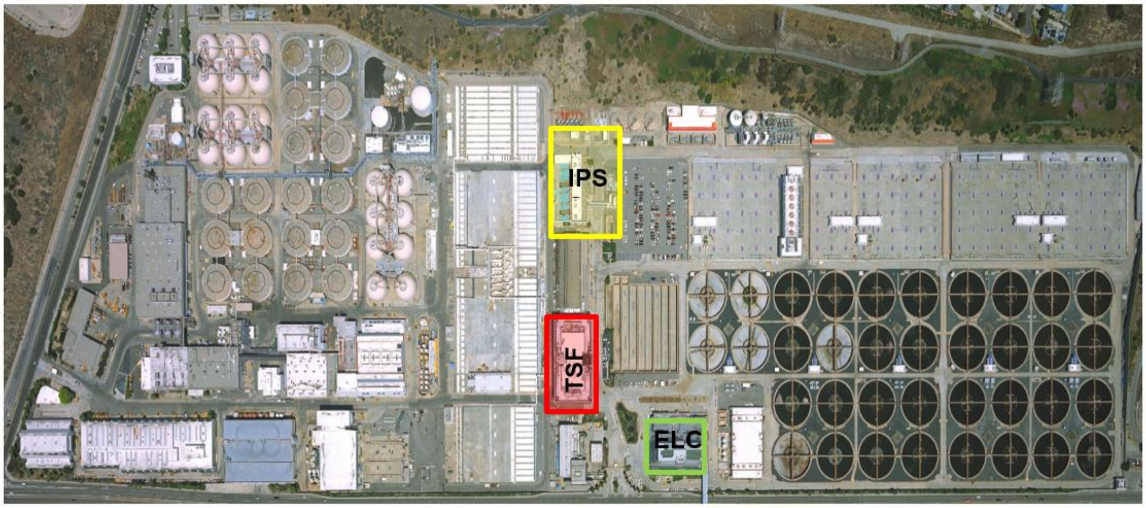

Figure 5. Hyperion Water Reclamation Plant (HWRP) with Intermediate Pumping Station (IPS), Technical Support Facility (TSF), Environmental Learning Center (ELC) in City of Los Angeles.

Intermediate Pumping Station Odor Control BTFs Operations & Maintenance (O&M)

The Intermediate Pumping Station Odor Control Biotrickling Filter Operations & Maintenance (O&M) tasks at HWRP will be discussed in detail. Figures 6 to 9 show the IPS odor control facility.

The odor control system collects foul air from three intake points at the inlet bay and from one collection point at the outlet bay. Two 42" fiber-reinforced plastic (FRP) ducts convey the collected air to the two existing 42" foul air duct which served the old three stage chemical wet scrubbers. From there those lines join into a new 54" inlet header that that will send foul air to the IPS Biotrickling Odor Control system. The system consists of four trains; each train consisting of an FRP biotrickling filter system, foul air fan, and an FRP activated carbon scrubber. Each BTF are of 14' diameter, the foul air fans have been equipped with Variable Frequency Drives (VFD) with a spare fan to be kept on site. The activated carbon scrubbers are 12.5' diameter dual bed carbon scrubbers. Preliminary sizing for BTFs and polishing carbon scrubbers are listed in Tables 1 & 2.

During normal operation, four process trains collect and treat 40,000 cfm (cubic feet per minute) of foul air, with each train treating 10,000 cfm of foul air. However, during maintenance related issues, if a train should need to be serviced, each train can reach a maximum flow of 13,350 cfm such that 40,000 cfm of flow could be treated through three trains. BTF maintenance is only expected during media replacement which is typically anticipated once every 10-15 years, when changing out spent carbon, or when re-establishing healthy bacteria on any of the BTF treatment trains, in a process we call reseeding. The foul air collected at this facility will pass through degreasers which are installed on each individual train prior to entering the BTFs themselves. In the BTF system, the autotrophic bacteria in the biofilm oxidizes the hydrogen sulfide from the incoming foul air stream and while doing so create an environment where they thrive. Autotrophic bacteria require an ambient pH of 1.5-2.0 for optimum growth and since sulfuric acid is a natural by-product of the oxidation process, the process itself could cause the system to be overly acidic. To combat this, a pH monitoring system consisting of probes and corresponding controllers have been installed. With both the pH probes and controllers, plant staff can use make-up water to raise the pH if needed and keep the ideal pH levels to support positive growth. If needed, HWRP wastewater flow concentration (waste activated sludge) will also provide necessary nutrients for biological growth.

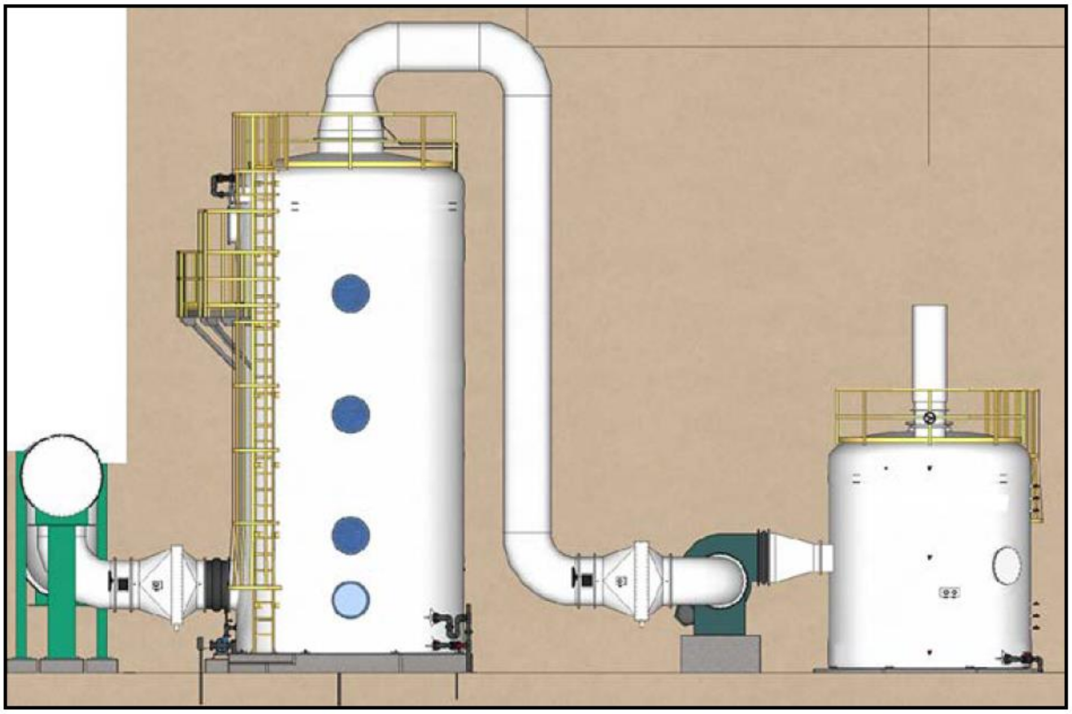

Figure 6. Elevation View of Intermediate Pumping Station Odor Control Facility in City of LA.

Table 1. Intermediate Pumping Station Biotrickling Filter Sizing.

Biotrickling Filter Sizing					
Flow (CFM)	Diameter	# of Vessels	Media Height (ft)	EBRT (sec)	Face Velocity ft/min
40,000	14	4	15	14	65
Biotrickling Filter with 1 offline					
Flow (CFM)	Diameter	# of Vessels	Media Height (ft)	EBRT (sec)	Face Velocity ft/min
40,000	14	3	15	10	87

In the IPS BTF Odor Control system, no chemicals are required to be added and the scrubbing solution is run through a recirculation system is used to irrigate the biotrickling media. A two level sprinkler system is used in the recirculation system with an option to use the top layer for Volatile Organic Compound (VOC) removal. In this two level system, the sprinklers are installed above the top layer and the second layer. The top layer is piped to either use in plant water or Industrial water. The second layer will be pipe to irrigate with in plant water. If level in the sump runs too high, process drains are routed and tied into the existing plant sewer system. The fans which serve the system are installed with VFDs for load control, vibration sensors, and amperage meters for monitoring. Other key process instruments include: flow meters for foul air flow, make-up water flow, and recirculation flow, scrubber sump level indicators, pressure indicating transmitters, pressure differential indicating transmitters, and pH monitors. All critical process and safety monitoring signals/alarms are routed to the central HWRP control room where they can be monitored.

Table 2. Intermediate Pumping Station Activated Carbon System Sizing.

Dual Bed Carbon Adsorber					
Flow (CFM)	Diameter	# of Vessels	Media Height (ft)	EBRT (SEC)	Face Velocity ft/min
40,000	12.5	4	3	4.3	42
Dual Bed Carbon Adsorber with 1 offline					
Flow (CFM)	Diameter	# of Vessels	Media Height (ft)	EBRT (SEC)	Face Velocity ft/min
40,000	12.5	3	3	3.2	56

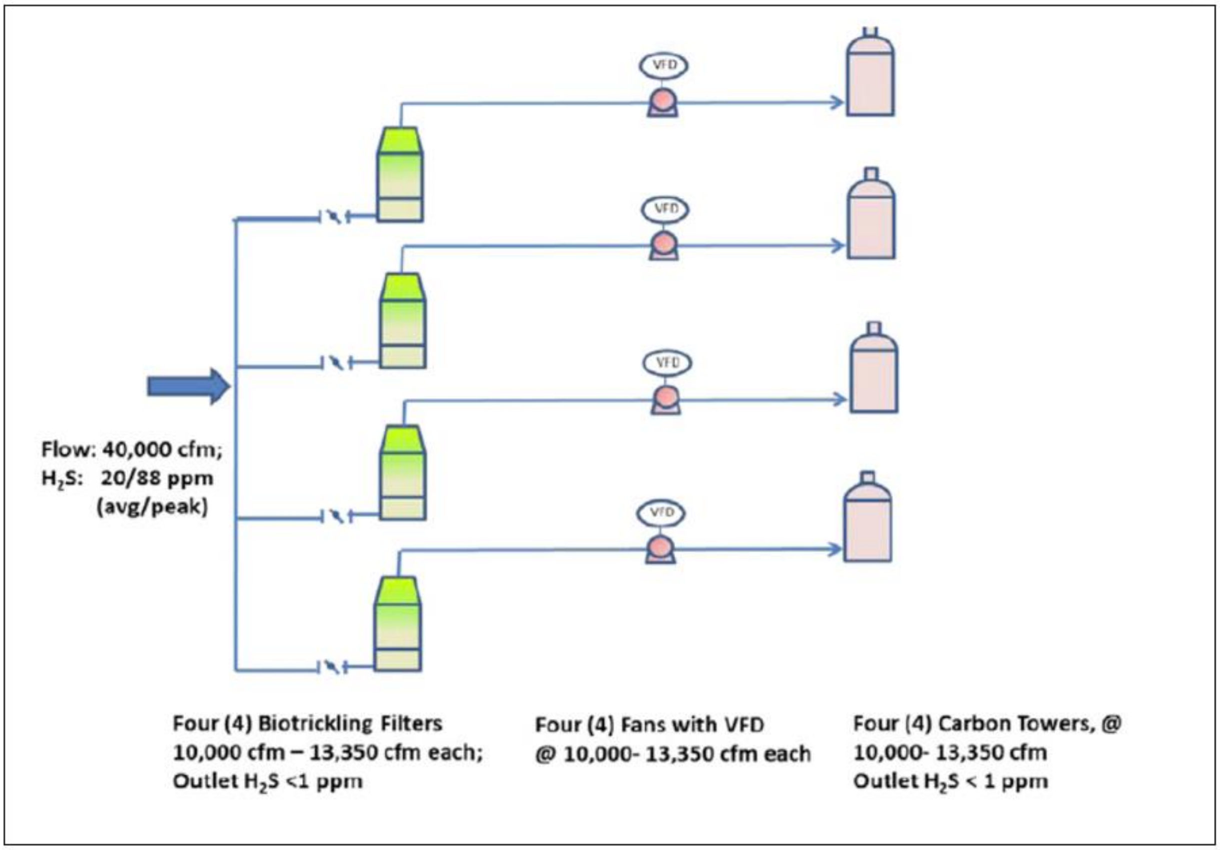

Figure 7. Hyperion Water Reclamation Plant (HWRP) Intermediate Pumping Station Odor Control BioTrickling Filter Perspective View in City of Los Angeles.

The biological startup introduces the biological culture (from our HWRP wastewater flow concentration: waste activated sludge) to the media inside the biotrickling reactors. Completion of this step may take up to six (6) weeks as the induced biomass grows to its natural limits and the system stabilizes. The amount of time required for the biomass to mature and the system to stabilize is a function of the condition of the biomass at the beginning of the startup procedure, and the chemical concentration and component characteristic of the foul air to be treated. Startup air flow rates been established during initial startup operations, detailed in the plant's startup procedures which can be found below.

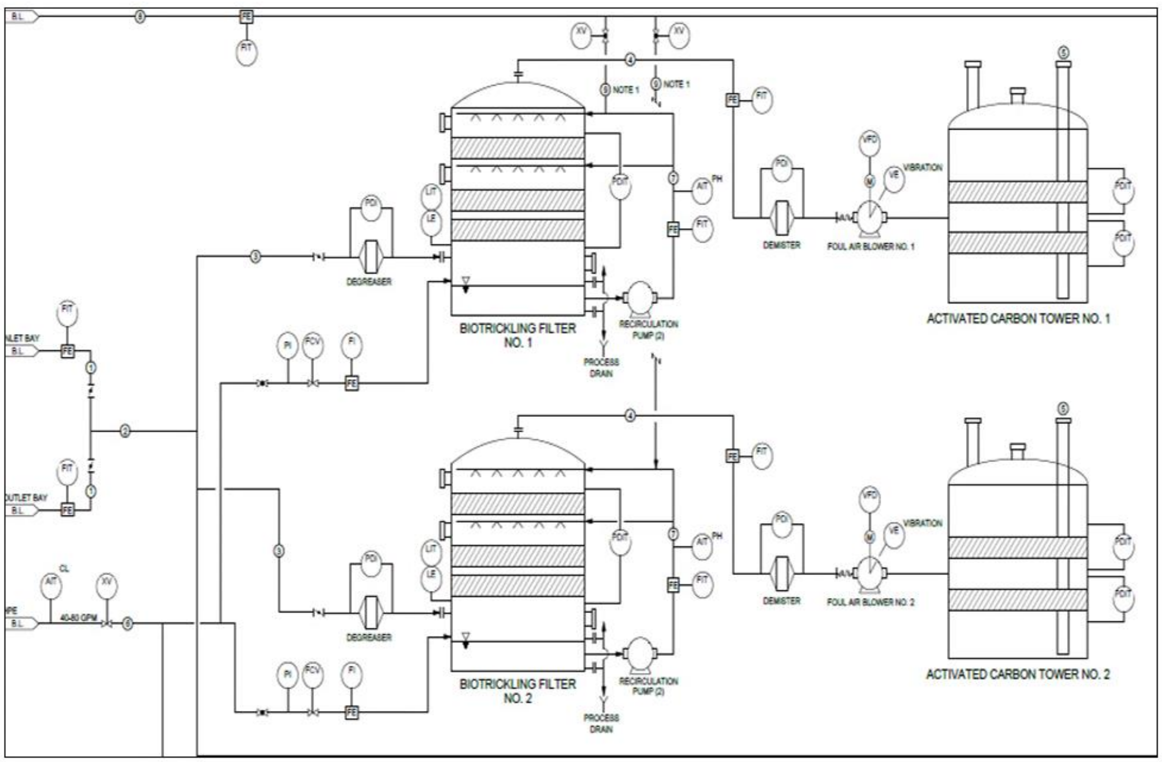

Figure 8. Hyperion Water Reclamation Plant (HWRP) Intermediate Pumping Station Odor Control BioTrickling Filter View in City of Los Angeles.

Once the system has completed the startup process and is operating at full capacity, the system can then be transferred to normal operational conditions and settings. Full capacity is achieved when the air flow reaches 100% design air flow, or 10,000 scfm, and a pH in the BTF system in the range 1.5 to 2.0 in each bio-reactor. Normal operating procedures will follow pre-established orders which include: routine mechanical inspections and checks, instrumentation checks, other equipment checks, sample gas analysis for H_2S and other explosive gases concentrations, bioreactor and carbon adsorption unit efficiency calculations, and any process adjustments as required. The routine operation includes a periodic check on the operation of all equipment to make sure of proper operation, checking of process flow rates, the maintenance of sufficient nutrient solution in the nutrient tanks, recording of process parameters and facility housekeeping. Under normal operating conditions, all four carbon scrubber units are in continuous service. However, periodically it may be necessary to take a single unit offline for maintenance purposes as previously described. The handling, cutting and installation of the BTF media was quite an elaborate and labor-intensive operation. The conversion of square media sheets to a round bed was responsible for 50% or more of total media installation cost. Figure 9 shows the determination of the least wasteful use of the rectangular media sheets and a total of 6,720 cut pieces were produced, using plywood jigs for the 14 different shapes.

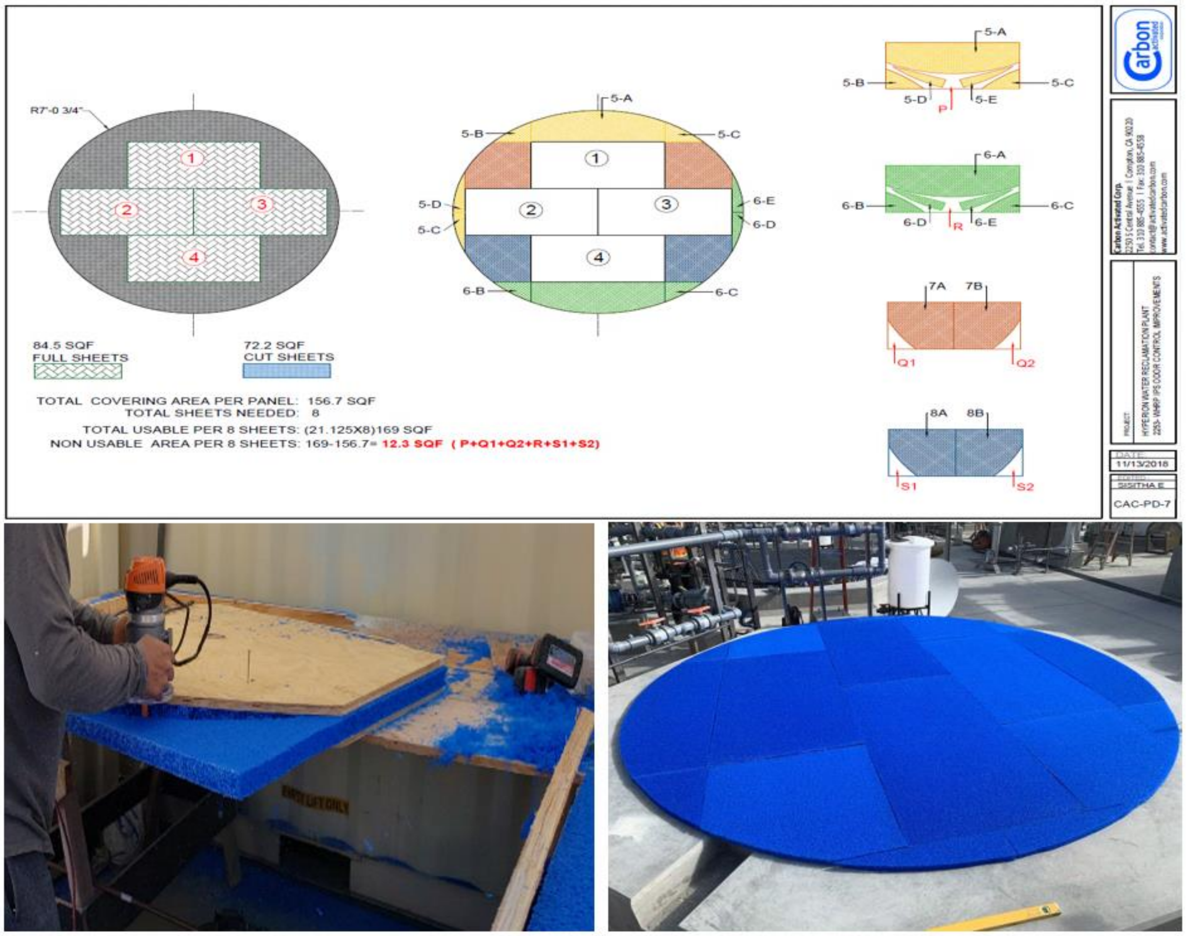

Figure 9. Hyperion Water Reclamation Plant (HWRP) Intermediate Pumping Station Odor Control BioTrickling Filter Media Installation in City of Los Angeles.

The IPS BTFs initial biological startup was accomplished with the following procedures:

- The IPS BTF start the desired setup for nutrient pump speed and stroke positions. Manually fill nutrient tank to 30 inches of depth with nutrient solution and the following:
  - ➢ When starting with fresh water in the BTF vessel sump, use a concentrated solution of three (3 each) of 25 pound bags of nutrient crystals (GROW MORE 15-16-17). This is accomplished by dissolving 3 25-pound bags of nutrient crystals per 150 gallons into each nutrient tank. If the BTF sump contains nutrients from the prior shutdown, then a nutrient mix of two (2 each) of the 25 pound bags per 150 gallons should be used.
  - ➢ In either case, after pre-mixing, add nutrient makeup solution to the Nutrient Tank and care should be taken to ensure that all the nutrient crystals are dissolved prior to pouring into nutrient tank at the IPS BTF system. After the biological culture is

established the concentration of the nutrient solution may be decreased depending upon the removal efficiency of the H_2S within the biological reactors. This is normally one 25-pound bag of nutrient crystals per 150 gallons.

- Inoculate reactor sump water with seed bio-media to create a bio-solution, a suspension of micro-organisms and nutrients in potable water, to be used as recirculation water. Position the recirculation pump control panel LOR selector switch to “Local” and energize the pump. Verify the nozzle spray pattern to ensure complete wetting of the top of the media. Adjust the spray pattern and all valves on the recirculating waster system are ball type. The recirculation system is operated in a closed loop arrangement with the nutrient solution being continuously circulated back through the biotrickling filters.
- Position the nutrient pump control panel On/Remote selector switch to “Remote”. It will energize the nutrient pump. Check the flow and pressure of the recirculation system. The flow should be in the approximate range 65-75 gpm and the pump discharge pressure should be about 30-35 psi.
- Allow the recirculation pump and nutrient pump systems to run for 24 hours prior to introducing foul air into the system. This step is required for initial biological startup only. If the system is being re-started, the foul air should be introduced into the reactor vessels as soon as practical to maintain the existing biological culture.
- Then position the recirculation pump control panel LOR selector switch to the “Remote” position and energize the recirculation pump at the PLC HMI interface in the electrical room. At this time introduce foul air into the system as per the Standard Operating Procedures.
- Measure the amount of H_2S in the foul air inlet to the bioreactor, and measure the amount of H_2S in the foul air outlet from the bioreactor. This measurement is used in determining the efficiency of H_2S removal from the reactor vessel and also to determine when loading foul air flow rates to the reactor vessels can be increased.

Intermediate Pumping Station Odor Control BTFs Control Panels

The Local Control Panel (LCP) is the primary source of control in each IPS BTF train. The Allen-Bradley (PanelView Plus) is installed as the LCP hardware of choice in the IPS BTF Odor Control system project. In addition to the controls for the BTF, the LCP also monitors flow rate, flow totalizer, and pressure regulator on plant makeup water for the four Degreasers, four Foul Air Fans, four Carbon Adsorber Towers, BTF air flow rate, industrial water makeup, and HWRP plant water makeup. Each of the LCPs provide complete BTF system monitoring, alarm, and control functionality for that train. Each of the four BTF Systems act as individual BTF units and allows for all four BTF Systems to operate independently. Operational details of the degreasers, foul air fans and carbon scrubber units along with static images of the various equipment accompany the narratives on the LCP. Screen images presented in Figure 10, were created using static versions of the displays in Development Mode. These screen samples are NOT intended to represent actual system operating conditions, but, rather to show functions.

Lessons Learned for Intermediate Pumping Station Odor Control BTFs

These are some lessons learned for the Intermediate Pumping Station Odor Control BTFs project. LASAN and their building contractor, Carbon Activated Corporation, were required to work together for the tuning, automation, and optimization the system. Plant staff on the maintenance, operations, and engineering sections during startup needed to have steady involvement throughout the startup phase to ensure a smooth handover. Specialized nutrient mixing equipment was needed as hand mixing nutrient was not sufficient. Hand mixing nutrient led to clumps and clogging of both drain lines and nutrient injection lines. After the installation, LASAN did a specialized nutrient mixer which has helped with system stability and reduced future O&M costs. In the future, we more than likely will need to rethink on our packing media as many man hours were needed to cut and layout the current mesh media. Installed redundancy, which has been a lesson learned from prior facilities, on critical equipment (pumps, breakers, air vents, etc.) has been key to maintaining high reliability and has allowed us the ability and flexibility to repair and replace equipment while ensuring that HWRP operations is not interrupted.

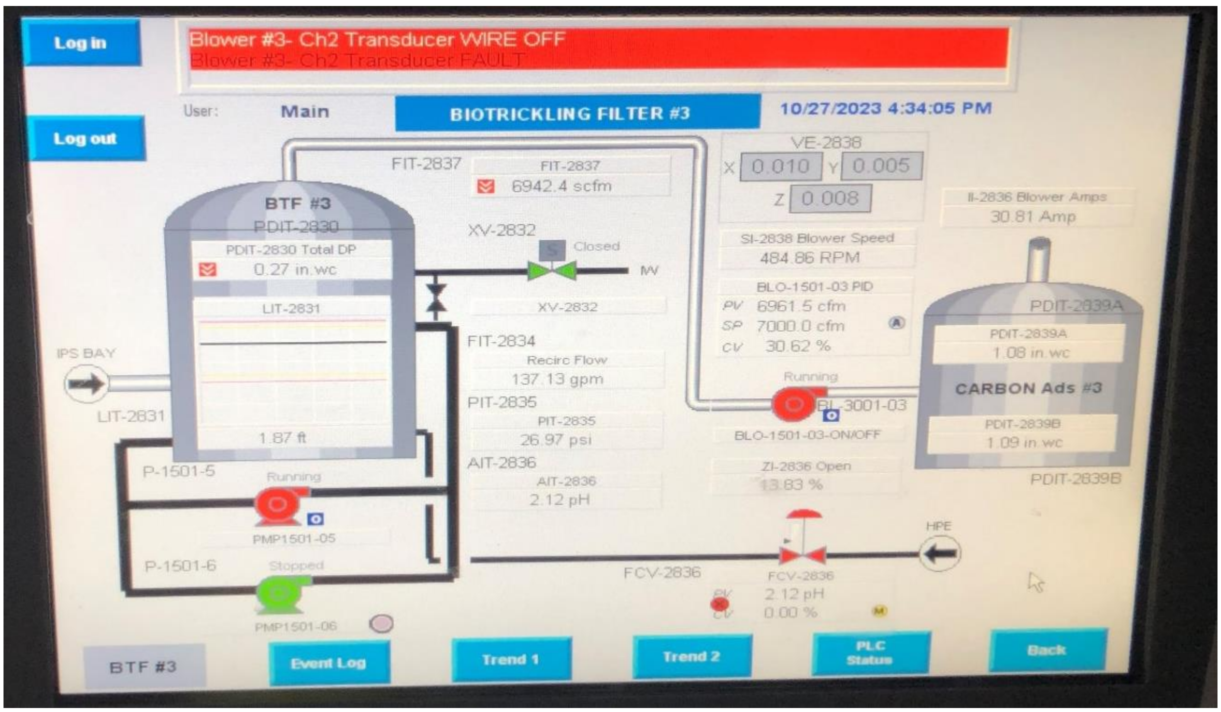

Figure 10. Hyperion Water Reclamation Plant (HWRP) Intermediate Pumping Station Odor Control BioTrickling Filter Control Panel for BTF#3 in City of Los Angeles.

Intermediate Pumping Station Odor Control BTFs Performance Data

Since September 2021 when the first BTF unit was put in operation to when the other three BTF units were put online, the results have been spectacular. The Intermediate Pumping Station BTF Odor Control performed excellently with an average of over 99% H_2S removal occurring in the BTF process and final carbon polishing from the foul air stream. The performance data (Figures 11-13) are all well below the South Coast Air Quality Management District (SCAQMD) air emission requirements of 1.0 ppm from the final carbon polish to the atmosphere. Figure 14 shows IPS Odor control pictures of inside/outside the Carbon Adsorbers Towers.

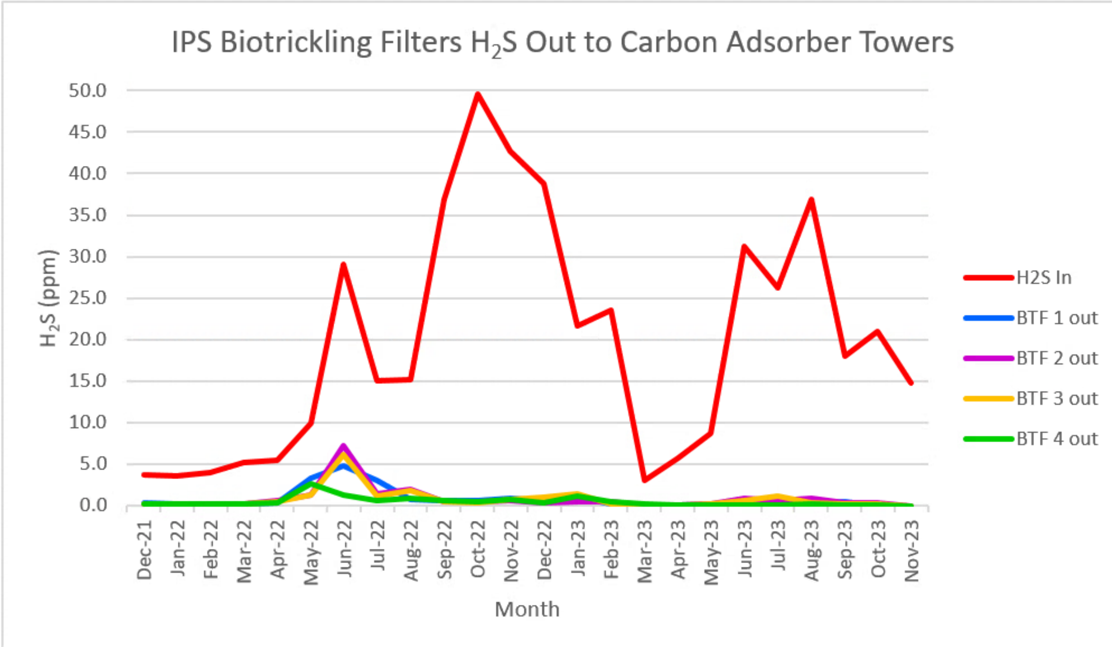

Figure 11. HWRP Intermediate Pumping Station (IPS) Odor Control BioTrickling Filter H_2S In and Out from the BTF in City of Los Angeles. Start Time for BTF 1 to 4 Shown on the Graph.

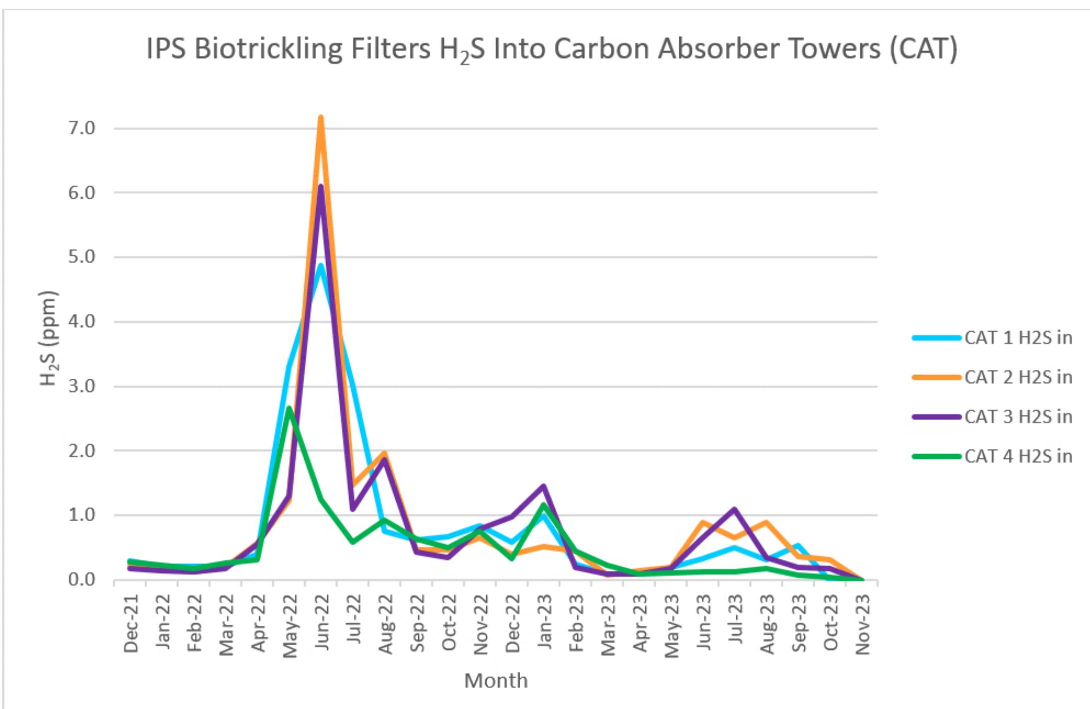

Figure 12. HWRP Intermediate Pumping Station (IPS) Odor Control BioTrickling Filter H_2S In the Carbon Adsorber Towers (CAT). Start Time for BTF 1 to 4 Shown on the Graph.

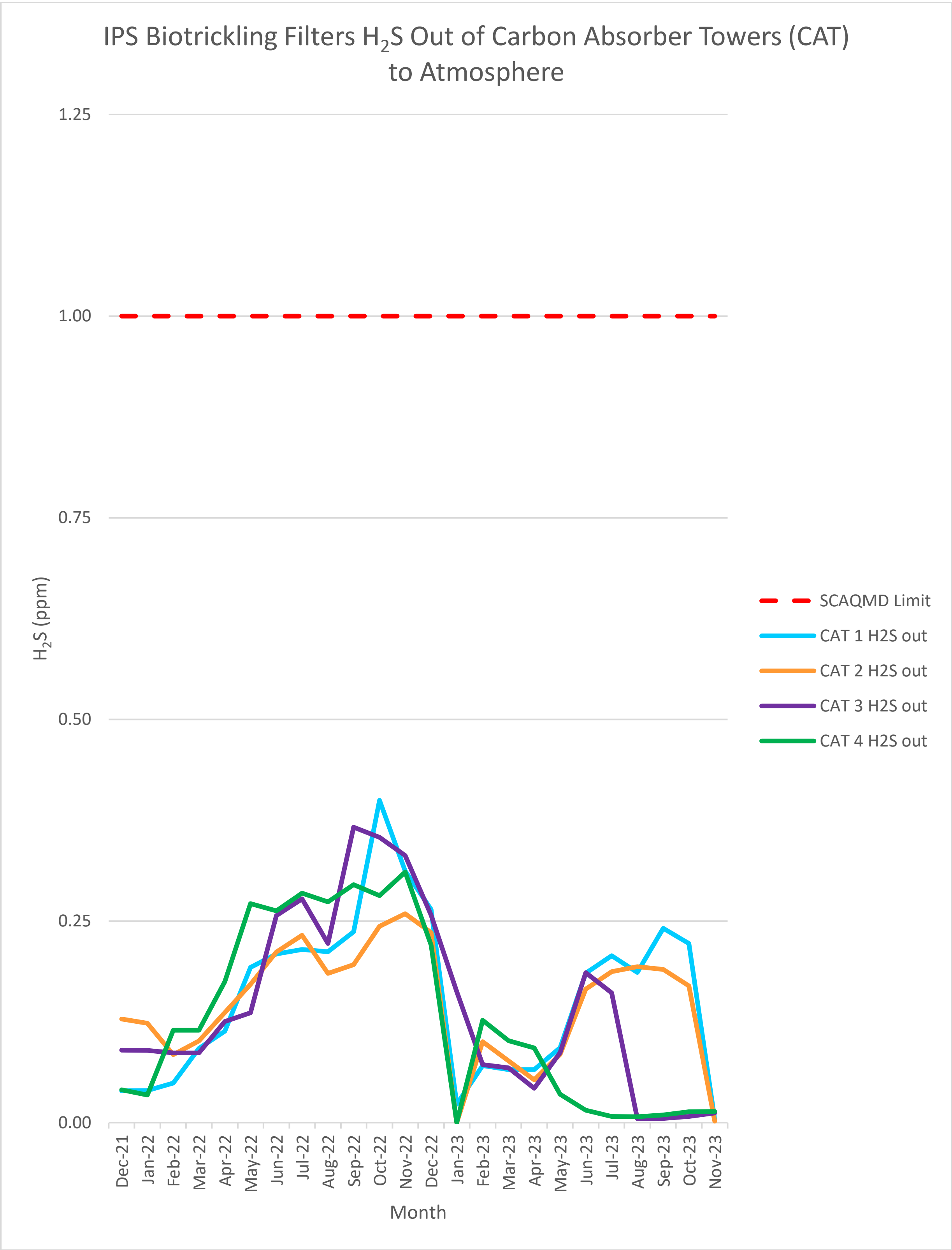

Figure 13. HWRP Intermediate Pumping Station (IPS) Odor Control H_2S In and Out from the Final Carbon Adsorbers Towers (CAT) after the BTF 1 to 4 in City of Los Angeles.

Figure 14. HWRP IPS Odor Control Pictures of Inside and Outside the Carbon Adsorbers Towers.

Figure 15. Hyperion Water Reclamation Plant (HWRP) Intermediate Pumping Station Odor Control BioTrickling Filter with Four BTFs & Four Carbon Scrubber Tanks in City of LA.

CONCLUSIONS

The Intermediate Pumping Station Odor Control BTFs system project succeeded in creating a self-sustaining odor control system where O&M costs were reduced and safety for plant staff was improved. By replacing the existing chemical wet scrubbers and chemical storage tanks, the elimination of chemical pumps, several pressure gauges, flow meters, probes, controllers, and other equipment has raised system reliability. By reducing the possible points of failure the system has performed as expected. Also, by removing the wet scrubber system, the HWRP has reduced the amount of chemicals they are dependent on, which produces large savings and increase plant staff safety. Now installed four (4) BTFs and four (4) carbon scrubber tanks have been designed to remove hydrogen sulfide (H_2S) from the IPS foul air stream organically. Results thus far have been outstanding with an average of over 99% H_2S removal occurring in the BTF process. The total project cost was $7,849,000 and with this performance data and future BTF advancements, LASAN will continue to consider BTFs as a strong option for future odor control systems. Figures 15 and 16 shows IPS BTF foul air flow system.

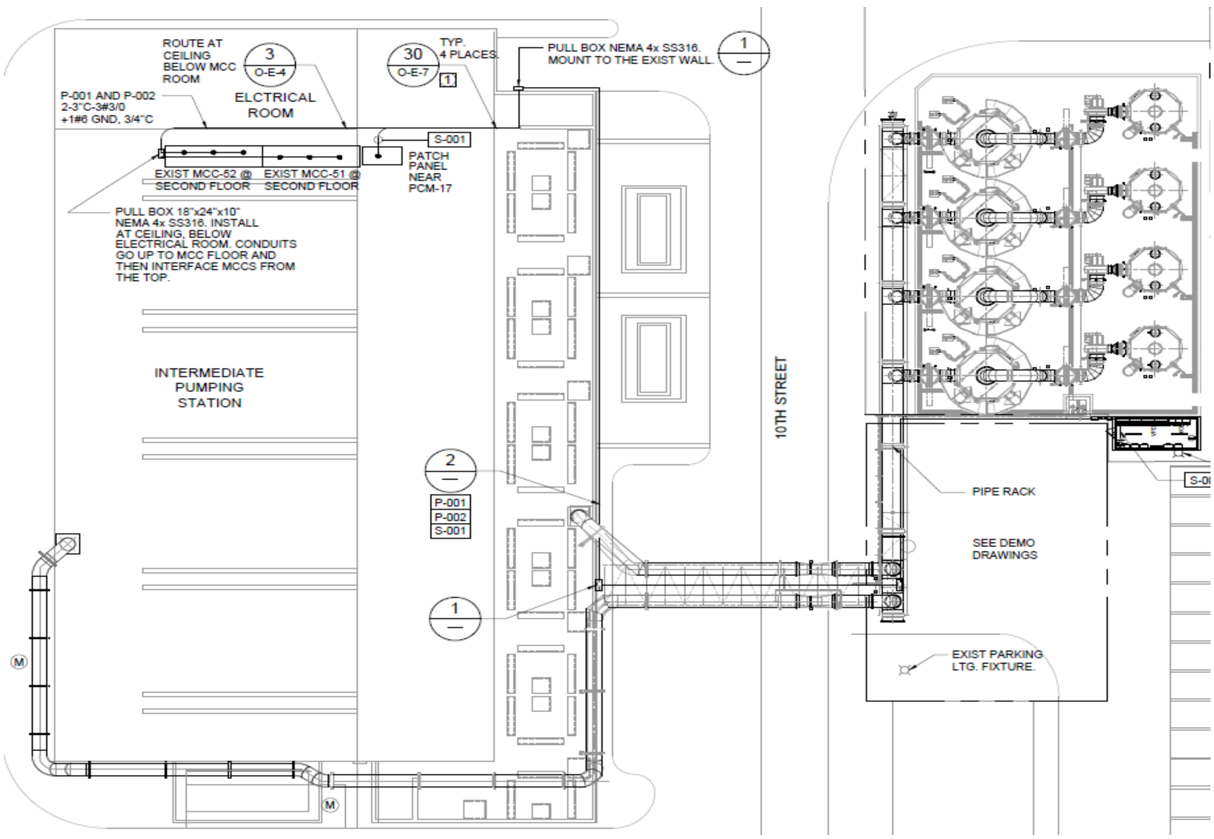

Figure 16. Hyperion Water Reclamation Plant (HWRP) Intermediate Pumping Station Odor Control Air Flow Systems Plan View in City of Los Angeles.

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