

## ASCE Los Angeles Section Wastewater Treatment, Collection and Recycling

### Introduction

Most cities are defined not only by its people, but also by how we solve some of our most simple, yet compelling issues. There is no debate that one of the most important aspects of solving problems is the application of engineering. As the old joke goes, engineering is solving a problem we didn't know we had in a way that we can't understand it. Well, here in the Los Angeles region, engineers were able to solve a problem in a way we could understand it.

### 1800s-1950s

In the late 1800s, wastewater from El Pueblo de Nuestra Senora la Reina de Los Angeles traveled through the city via natural waterways as it flowed untreated to the ocean. As public knowledge of bacteria and its effects increased, so did awareness of how proper disposal of waste can contribute to the health of society. One of the most effective methods, then and now, of disposing of waste is through a sewer system. The sanitary sewer system, as we know it, is an extension of society's answer to an increase in both population and waste. Fred Eaton, considered by some to be the father of wastewater in the City of Los Angeles, designed the first comprehensive sewer system for the City of Los Angeles in 1887.



To address the emerging concern of a large increase in population, and endless wastewater odor complaints, the City of Los Angeles purchased 200 acres of oceanfront property in 1894 as part of a larger planned sewer system for the Los Angeles region. From 1894 to 1950, the City of Los Angeles followed the national standard of discharging raw sewage into Santa Monica Bay. As a result, the City of Los Angeles received numerous raw sewage complaints from swimmers and visitors to Santa Monica. To remedy these complaints, the City of Los Angeles built and operated the first treatment facility at the Hyperion site in 1925. The new wastewater treatment facility treated wastewater through Preliminary & Primary treatment processes.

### 1950s – 1980s

During World War II, several miles of beachfront property surrounding the Hyperion site were quarantined because of near-shore discharge of what was still essentially raw sewage. After the war, plans for a full secondary treatment plant at the Hyperion site were developed, eventually funded, and built. When the new Hyperion Treatment Plant (HTP) opened in 1950, it included full secondary treatment processes and biosolids processing to produce a heat-dried fertilizer. It was among the first in the world to capitalize on the energy values of biogas by operating anaerobic digesters, which have yielded a fuel gas by-product for over 50 years. At the time, Hyperion was the first large secondary treatment plant on the West Coast, and one of the most modern facilities in the world. At that point in our history, the population of Los

Angeles exploded. To keep up with growth and the resultant higher flows, treatment levels were cut back to enable Hyperion's operators to process the rising volume of wastewater using the available facilities. By 1957, the new plant was discharging a blend of secondary and primary effluent through a five-mile ocean outfall.

Hyperion then stopped its biosolids-to-fertilizer program and began discharging digested sludge into the Bay through a separate seven-mile ocean outfall. Discharging 25 million pounds of wastewater solids per month began to take its toll on the marine life in Santa Monica Bay. Samples of the ocean floor in the sludge discharge areas demonstrated that the only living creatures capable of sustaining life after 30 years of discharge were worms, and a hardy species of clam. The City of Los Angeles launched the Sludge-out to Full Secondary program in 1980. The \$1.6 billion construction program replaced nearly every 1950-vintage wastewater processing system at Hyperion while the plant continuously treated 350 million gallons a day in wastewater, and met all National Pollutant Discharge Elimination System (NPDES) permit requirements. The full Secondary System was completed in 1998, and immediately affected the region through:

- A large reduction of wastewater spills at the Hyperion Treatment Plant
- 95% reduction of wastewater solids flowing into Santa Monica Bay
- Elimination of the Bay's ecological dead-zone near the mouth of the sludge outfall
- Vast improvements in biological integrity of the bottom-dwelling marine community
- Remarkable increases in the relative abundance of many indicator-species

### Today

There are two major regional wastewater treatment systems in Los Angeles County. Sanitation Districts of Los Angeles County manage a wastewater treatment system serving over 5 million people in 78 of the 88 cities in Los Angeles County, plus unincorporated county areas. The Sanitation Districts' system includes 11 wastewater treatment plants, two tunnels extending from Carson to White Point on the Palos Verdes Peninsula, and four outfall pipelines that run along the ocean floor and discharge treated wastewater offshore.



The City of Los Angeles, Department of Public Works, Bureau of Sanitation manages the other major sewerage system and is committed to protecting public health and the area's environmental resources. To that end, the City has invested billions of dollars in new wastewater treatment technologies and has implemented the most stringent operating procedures in history including comprehensive monitoring protocols. The Bureau of Sanitation operates four treatment and water reclamation plants that serve over four million people within two service areas containing over 600 square miles. This includes the Hyperion Treatment Plant, Donald C. Tillman Water Reclamation Plant, Los Angeles-Glendale Water Reclamation

Plant, and Terminal Island Treatment Plant. The city's system also includes two ocean outfalls, one in Santa Monica Bay and the other in Los Angeles Harbor.

Hyperion Treatment Plant (HTP), one of the largest treatment plants in the United States, is a City of Los Angeles owned and operated facility in Playa Del Rey, CA. The Hyperion Treatment Plant maintains a staff of 370 employees to operate & maintain the plant on a 24 hour, 7 day basis. The annual budget for HTP in Fiscal Year 2012-2013 was \$80 Million. If you've never personally visited the Hyperion Treatment Plant, you may have seen our facility featured in various television and film projects over the last 40 years. This includes such films and television shows as *Soylent Green*, *Planet of the Apes*, *Logan's Run*, *In like Flint*, *Mission Impossible* (TV series), *Highway to Heaven*, *Hart to Hart*, *Greatest American Hero*, *Bones*, and various 30 second commercials.

Wastewater flows to HTP through a network of 6,700 miles of underground sewer lines. The sewer pipes range in size from 8 inches to 12 feet in diameter. The sewer system was designed to take advantage of the city's geography, where roughly 85% of LA's wastewater flows to the HTP by gravity. The City of Los Angeles maintains 48 pumping plants in low lying areas where wastewater cannot flow by gravity. The pumping plants are located mostly along the edge of Santa Monica Bay, in the Harbor area, and in scattered pockets in the rest of Los Angeles. The Hyperion Treatment Plant also serves the Cities of San Fernando, Burbank, Glendale, West Hollywood, Beverly Hills, Santa Monica, Culver City, and El Segundo. There are also 21 other special districts and agencies who send their wastewater to the Hyperion Treatment Plant.

On average, 300 million gallons of wastewater enters the Hyperion Treatment Plant on a dry weather day. Because the amount of wastewater entering HTP can double on rainy days, the plant was designed to accommodate both dry and wet weather days with a maximum of 450 million gallons a day. Despite Los Angeles having a separate sewer system and storm drain system, some rainfall (which normally flows through the storm drain system) flows into the sewer system through one of the 140,000 sewer maintenance manhole covers that make up the Los Angeles area collection system. In addition to rainfall, cracked sewer lines damaged by growing tree roots can sometimes become saturated with urban runoff. In Los Angeles, wastewater is sent to the Hyperion Treatment Plant, where upon entry, is processed and treated using some of the most innovative and time withstanding methods for a facility large enough to handle a large portion of the waste created in the Los Angeles region.

### **Preliminary Treatment**

Before wastewater is treated, Preliminary Treatment consists of a screening process, and sand/grit removal. The screening process involves the use of eight bar screens (large metal racks of steel bars spaced  $\frac{3}{4}$  inches apart) to remove large objects from the entering wastewater. A large mechanical rake removes unwanted materials from the bar screen, and deposits the various items into a water trough which are then dewatered and stored in large silos. Once dewatered, the materials (consisting mostly of rags, wood, and other non-recyclable/non-beneficial materials) are then loaded onto a hauling truck, and taken to a landfill for disposal. HTP has recovered a number of unusual objects over the course of the years such as golf balls, wooden 2X4s, a bowling ball, 17 foot long telephone pole, and a motorcycle.



After the screening process, wastewater flows to aerated grit chambers for Sand/grit removal. Sand can enter sewer lines through the washing of dirt in sinks, showers, and washing machines. The sand, if left in wastewater as it is being treated, would act as an abrasive in eroding the various downstream pumps, valves, and pipes further in the treatment process. Air is pumped into wastewater to keep the light organic

material suspended, while the heavy sand settles to the bottom of the tank. The sand is removed by a pump, and the pump sends the sand to the materials handling Tower, where it is dewatered, washed, stored in a hopper, and loaded into trucks and disposed of in a landfill.(similar to the bar screen material). Over 885,000 lbs of solids and organic materials flow into the Hyperion Treatment Plant in a 24 hour period.



### Primary Treatment

The first step in treating wastewater is Primary Treatment. Wastewater enters the plant at an average speed of 2 to 5 feet per second; however, during Primary Treatment, wastewater is slowed to 2 to 3 feet per minute. Underground Large Primary tanks (roughly 300 feet long and 15 feet deep) hold wastewater for 1 ½ hours allowing heavy solids to settle to bottom, while oil and grease float to the top. Sometimes, Chemicals are added to allow more particles to bind together, and settle. These tanks can remove 80-85% of the solids in wastewater, and about 50-55% of the organic material. The heavy solids are then removed, and transported to the solids handling area of the plant for further processing.

After the wastewater effluent has been processed, it is then decanted (similar to bottled wine) and sent to Secondary Treatment for further processing. It is industry standard to measure the organic strength of wastewater by utilizing sampling, inoculation, and incubation methods to determine the amount of oxygen consumed by bacteria already present in the wastewater. This measurement of consumed oxygen is called Biochemical Oxygen Demand (BOD). With a proper BOD measurement, the organic strength of the current wastewater can be determined, allowing plant staff to make any necessary adjustments. Wastewater is then transported from Primary to Secondary treatment using an Intermediate Pump Station (IPS). The IPS consists of ten large 12-foot diameter Archimedes Screw Pumps. Each pump can lift 110 to 125 million gallons per day (MGD).

### Secondary Treatment

Secondary Treatment is the last step in the wastewater treatment process at HTP. After Primary treatment has removed the solids, Secondary Treatment will remove the remaining solids and organic material (BOD) suspended inside the wastewater. The solids and BOD left in the Primary effluent must be



removed by methods other than gravity, and they are now considered dissolved. The effluent is pumped into one of HTP's eight Secondary biological reactors where naturally occurring bacteria (aerobic bacteria) are cultivated in huge numbers (over 150 tons), and mixed with mechanical mixers to stir the bacteria, wastewater & oxygen to aid the bacteria in consuming organic waste. The bacteria eat the dissolved solids and BOD, and convert them into settle-able bacteria. The

bacteria then are removed by gravity (just like in Primary Treatment) and sent to another set of settling tanks (called circular clarifiers) where any remaining solids settle to the bottom before the effluent is discharged.

### **Cryogenics**

Oxygen used in the Secondary treatment process is created onsite at HTP's Oxygen Generation Facility. HTP uses cryogenics to separate oxygen from natural air to obtain pure oxygen that is piped into the Secondary reactors for wastewater treatment. In fact, HTP uses five (5) 4,500 horsepower four-stage air compressors (each producing 21,000 cubic feet per minute) to pump air into its cryogenic system where it is cooled using an Eagle Cryogenic Tank (ECT) and a Direct Contact Aftercooler (DCAC). The compressed air is filtered through a molecular sieve that filters water vapor, carbon dioxide,



hydrocarbons, and any other unwanted materials (which would otherwise clog up the cryogenic facility), only allowing oxygen and nitrogen to pass. The oxygen and nitrogen (which separate at different temperatures) then pass through a cryogenic cold box (approximately 125 feet tall) where they are cooled to around -280 degrees F to -360 degrees F. Resultant oxygen is used as part of secondary treatment, nitrogen is released back into the atmosphere,. HTP generates enough oxygen to operate the secondary treatment process for up to seven days in the event there is not enough power to run the cryogenic air compressors.

### **Odor Control Methods**

HTP has 58 odor control scrubbers. The odor control scrubbers remove the foul air from the process; neutralize it with chemicals, and filters it through a bed of charcoal or Activated Carbon to remove odors before the air is released into the atmosphere. In addition, wastewater flowing through HTP contains some odorous smelling chemical compounds such as Hydrogen Sulfide (H<sub>2</sub>S) or commonly referred to as the rotten egg smell. The presence of H<sub>2</sub>S occurs after bacteria have eaten up all of the oxygen in the wastewater. Air fans pull the foul air out of the air space above the process tanks in HTP, and the air is treated in a liquid scrubber by blowing the air into the bottom of air tower, and spraying a cleaning solution containing Sodium Hydroxide (Caustic) and Sodium Hypochlorite (Bleach) into the top of the tower. The treated air is further polished by passing it through a bed of Activated Carbon or charcoal that absorbs and H<sub>2</sub>S not removed in the scrubber. The South Coast Air Quality Management District (SCAQMD) has jurisdiction over the scrubbers, and HTP spends approximately \$1 million annually on odor control methods.

### **What happens to the treated wastewater?**

90% of secondary effluent is sent to HTP's Effluent Pumping Plant (EPP) where five 2,500 horsepower pumps discharge effluent through a 12-foot diameter outfall pipeline that stretches 5 miles long offshore, and is 170 feet below sea level. Due to the large number of bacteria still present after Primary & Secondary treatment, the 5 mile outfall length was selected in the 1957 to allow the bay to naturally disinfect the plant effluent by discharging fresh water bacteria (normally accustomed to warm body temperatures) into a cold (32 degree F) salt water environment. An additional one mile outfall pipeline is used for emergencies and/or repair of the 5 mile outfall pipeline. Roughly 5% of the remaining secondary effluent is pumped to the West Basin Municipal Water District (WBMWD) plant (located approximately three miles from HTP) where the effluent is further treated using a method called Tertiary Treatment. Tertiary treated effluent is used for industrial cooling and boiler applications (such as in oil refineries) and to irrigate parks, golf courses, and highway median strips. Any remaining secondary effluent is used onsite by Hyperion staff.

### **What happens to the biosolids?**

The primary solids (consisting of proteins, fats, and carbohydrates) and excess secondary bacteria (excess bacteria generated in the course of the Secondary treatment) are pumped into one of the world's largest collection of egg-shaped digesters, where the solids and bacteria stay for 25 days, are heated to 95 degrees F, and are processed using Anaerobic Digestion. The bacteria anaerobically break down the solids by digestion using no oxygen, and the end product is biogas. Anaerobic Digestion is similar to the process used by beer and wine makers to produce beer or wine. The biogas has two-thirds the heating value of Natural Gas, and enough biogas is produced to cover about 85% of HTP's power needs (which run to 21.5MW) at only 1.3 cents per kilowatt hour. The digested solids are screened to remove any fibrous material that might plug up the dewatering process.

Excess Secondary bacteria needs to have excess water removed from them before they are sent to the anaerobic digesters. Large pieces of equipment called centrifuges work just like the spin cycle of your washing machine. Centrifugal forces separate the solids from the water inside the machine. A chemical is added to enhance the solids/liquid separation. The water is then removed, and recycled back to the plant for reprocessing. The solids (now called wetcake) are collected, placed on conveyor belts, and are sent to storage silos and hoppers. The Digested solids entering the dewatering process are about 2 percent solids, 98 percent water. After going through the dewatering process, the material is about 27 percent water, and only 73% water. The dewatered material is drier than toothpaste, is sent to land application and composting sites, and is used on marginal farmland that has no organic soil content. Los Angeles is the largest municipal agency in the U.S. converting sludge to Class A (Exceptional Quality) Biosolids.

### **Environmental Monitoring**

The Bureau of Sanitation has an independent program to evaluate the quality and the impact of our operations to ensure maximum protection of the environment. Environmental Monitoring staff perform extensive testing and assessments in the fields of microbiology, marine biology toxicity testing, wastewater and marine chemistry, solid waste and air quality monitoring, process control, and industrial waste pretreatment analysis. Daily testing of wastewater from all treatment processes is routinely provided at HTP to ensure compliance with operating permits. They also monitor the health of the Santa Monica Bay, and the beaches along Santa Monica Bay. The beaches are inspected daily, and samples are taken for bacterial analysis. The City owns marine survey vessels that collect samples at over 60 predetermined site for analysis on a weekly, monthly, quarterly, semi-annual, and annual basis. Plant engineers and operators immediately use test results to fine-tune the treatment process. This valuable information is used to provide the best waste management services to the public while protecting the air, land, and water from anthropogenic input.

### **Environmental Learning**

The Los Angeles Environmental Learning Center (ELC) was developed by the City of Los Angeles, Department of Public Works, Bureau of Sanitation to:

- Address the need for increased public education about how urban activities affect the environment,
- Educate children (and adults) about sustainable water and solid resources management as a catalyst to change behavior, and
- Share information about the Bureau of Sanitation's infrastructure, programs and people, and how they are improving the environment.



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Building the ELC involved the renovation of an existing two-story building at the Hyperion Treatment Plant to accommodate two floors of educational exhibit galleries, an indoor patio, an 87-seat auditorium, a learning laboratory, a conference room, a green roof, wetland and other sustainable features on 2 acres of land. The ELC was also redesigned to meet the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) standards for certification, and to demonstrate sustainable water management through its design and operation, and teach sustainable water and solid resources management through its interactive learning exhibits. The entire HTP wastewater treatment process is on display at the ELC for visitors. For more information, please visit the ELC's website at [www.lacitysan.org/elc](http://www.lacitysan.org/elc) or call 310-648-5363.

### **Groundwater Replenishment System (GWRS)**



Two other major coastal wastewater treatment facilities in the ASCE Los Angeles Section lie to the south of LA County and are located within Orange County. These are the Fountain Valley Plant No. 1 and the Huntington Beach Plant No. 2 operated by the Orange County Sanitation District (OCSD) that provide most of the wastewater treatment in the region. The northern portion of Orange County serves a population of more than 2.5 million people covering approximately 350 square miles.

The Huntington Beach facility is bordered by Pacific Coast Highway, the Santa Ana River and Brookhurst Street. The plant is directly across from the Huntington State Beach which gives us a clear picture of what we strive to protect on a daily basis. Plant No. 2 currently treats just over 100 million gallons of wastewater daily to full secondary treatment standards.

The Fountain Valley facility encompasses 100 acres of land where OCSD treats almost 100 million gallons of wastewater a day. A major treatment component of this facility is the Groundwater Replenishment System (GWRS) project, a joint project between the Orange County Water District and the OCSD. Under the partnership of OCSD and OCWD, OCSD supplies OCWD with 96 million gallons per day of secondary treated wastewater, without cost, to OCWD. The facility construction costs amount to \$481 million (U.S. Dollars) but was subsidized with federal, state and other local funding sources. The GWRS creates a new source of recharge water that increases the reliability and sustainability of local groundwater supplies. The GWRS augments existing groundwater supplies by producing up to 72,000 AFY of purified water to recharge the basin and provide a reliable supply of water for the Talbert Seawater Barrier. The GWRS consists of three major components: (1) Advanced Water Treatment facilities and pumping stations, (2) a pipeline connection from the treatment facilities to existing recharge basins, and (3) expansion of the Talbert Barrier.

Secondary-treated effluent from the OCSD Wastewater Reclamation Plant No. 1 in Fountain Valley is pumped to the advanced water treatment facilities instead of to the ocean for disposal. The Advanced water purification plant purifies the water with microfiltration; reverse osmosis; and advanced oxidation processes, which consist of ultraviolet and hydrogen peroxide.

The first step in the tertiary treatment process is microfiltration (MF) membrane treatment. MF is a low-pressure membrane process that removes small suspended particles, protozoa, bacteria and some viruses from the water. Sodium hypochlorite, a bleach solution, is added to the MF feed water to minimize MF membrane fouling. Next, the MF Filtrate is fed to the reverse osmosis (RO) treatment system. Dissolved contaminants and minerals, including dissolved organics, total dissolved solids, silica, and virus, are removed in the RO treatment process.



The water then undergoes ultra violet (UV) and hydrogen peroxide treatments. UV light penetrates the cell walls of microorganisms, preventing replication and inducing cell death. This provides an additional barrier of protection against bacteria and viruses, more importantly; UV with hydrogen peroxide oxidizes organic compounds. At this point, the product water is so pure that it cannot be moved in conventional pipes so small amounts of minerals are added back into the water so that it is stable in the concrete pipes.

The GWRS is capable of producing 72,000 AFY of high quality water and work is underway to expand the capacity of the facility to 90,000 AFY in anticipation of increased flows from OCSD in the future.

The benefits of this indirect potable reuse joint project are as follows:

- Provides a reliable supply of high-purity, near distilled quality water even during drought
- Offers a more cost-effective and energy-efficient strategy than importing water from distant sources (uses half the energy required to import water and one-third the energy required to desalinate seawater)
- Provides a measure of protection from variations in the availability of imported water supplies
- Creates a hydraulic barrier that prevents seawater intrusion into drinking water wells
- Recharges groundwater supplies and minimizes overdraft
- Improves water quality in the basin
- Reduces the volume of wastewater discharged into the ocean and puts it to beneficial use
- Reduces the region's need for imported water
- Produces water at a unit cost of \$478/AF with subsidies and \$850/AF without subsidies—each less than the cost of imported water



Another major component of the GWRS project is the improvements that deliver the highly treated water to 23 multi-casing injection wells along the Talbert Gap. The injection of a portion of the GWRS water into these wells forms a hydraulic barrier protecting the groundwater from seawater intrusion. This mound of fresh water near the coast allows for seasonal fluctuations in the aquifers landward of the barrier without the risk of seawater intrusion and its associated salt water contamination.



**Future**

Further improvements at Hyperion and many other wastewater treatment facilities are being planned and built to keep remain on the leading edge environmental protection. Air emission controls continue to represent the leading edge of technology. Odor management facilities are integrated in all improvements. Resource recovery programs capitalize upon every possible opportunity to recycle renewable resources of wastewater and sludge treatment by-products.

It recognized that within the ASCE Los Angeles Section, there are countless other wastewater treatment facilities and recycling facilities that provide high quality treated effluent for reuse throughout the region. The recycled water now plays a major role in supplying indirect and non-potable water needs particularly for irrigation and recharge. With the semi-arid environment that dominates much of the ASCE Los Angeles Section area, recycled water now represents one of the dominant and reliable water supply sources and is anticipated to grow as development and population of the region grows.

Together, the civil engineering involved in the design, construction and operation of wastewater treatment and water recycling infrastructure needed to keep pace with a growing populace is extremely important and valuable to our quality of life. It is these accomplishments that have produced high levels of efficiency and cost savings to the region and has led to one of the great environmental achievements of the 20th Century.

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