What Goes Around Comes Around: *Water Reclamation*

By Anne V. Sonner

This "Classic" series article from the May/June 2004 edition of the Official provides background on the treatment of reclaimed water and serves as an ideal complement to our other offerings on the subject in this issue.

Sometimes simple questions don't have simple answers. When your three-year-old asks, "Where does it go when you flush the toilet?" you can answer, "to the sewage treatment plant." But if your youngster is truly inquisitive, you'll need to explain how wastewater undergoes a complicated process of mechanical, biological, and chemical transformation, and in the case of the Terminal Island plant, ultimately discharges clean water into Long Beach harbor and to other locations for salt water well injection, while the solids are baked and sent to "Green Acres." And that's the *short* answer.

United Plumbing and Pipefitters of Long Beach (UPPA) visited the Terminal Island Treatment Plant and witnessed the process first-hand. Kook Dean, a mechanical engineer who works for the city of Los Angeles, Wastewater Engineering Services Division, led the tour. Since UPPA is a fun group, jokes and humorous stories abounded, along with educational information on wastewater treatment and the related environmental and health issues, which affect everyone who uses water.

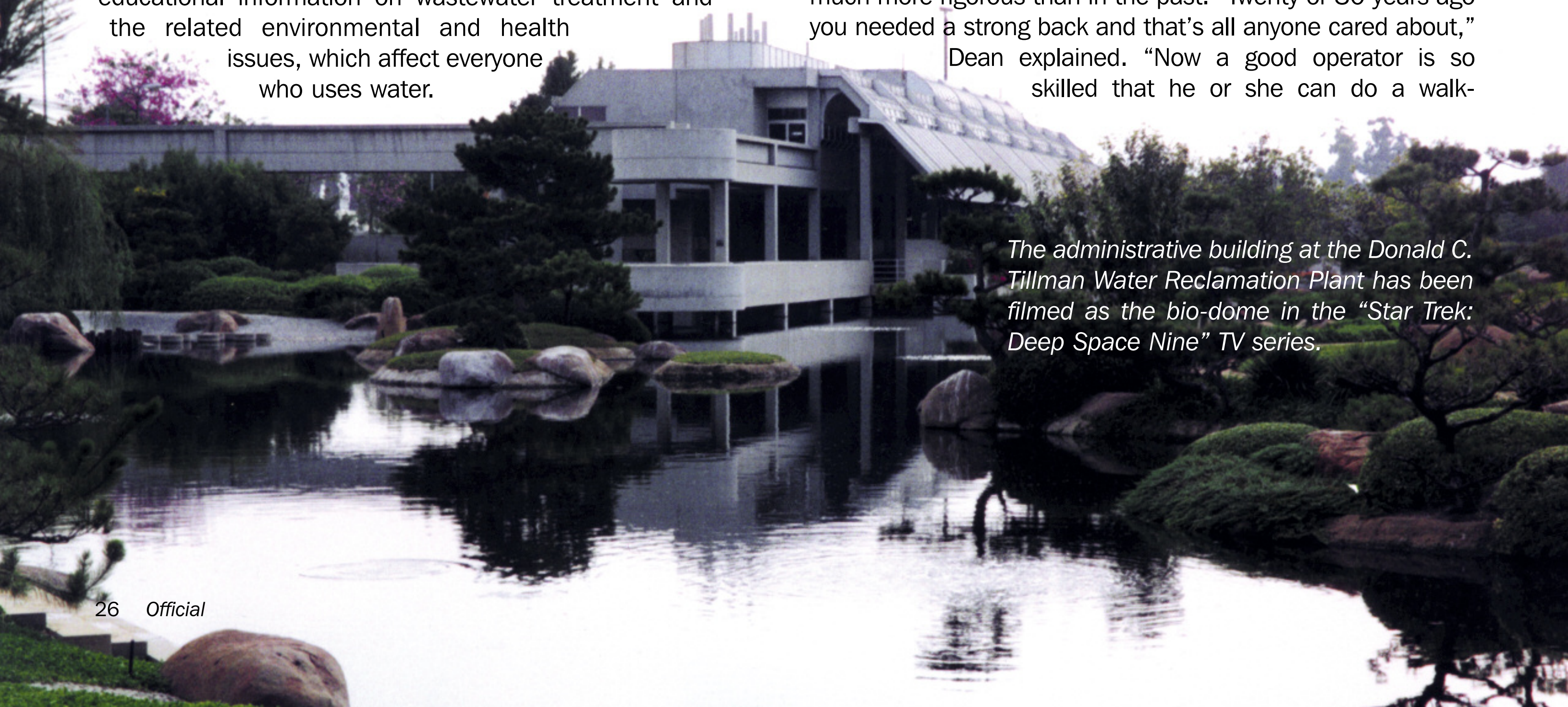
Terminal Island Treatment Plant – from the WC to the Harbor

The jokes started even before the tour left. "Do we get any free samples?" someone asked. "Can we leave any samples?" kidded another. Located on Terminal Island, the plant keeps close company with military facilities, Mobil Oil, So Cal Edison, a prison, a coke refinery and the L.A. Yacht Club. It is in the middle of the Port of Los Angeles, one of the biggest and busiest ports in the country with shipyards and container terminals as far as the eye can see. Nearby are the downtown Long Beach high-rises and small islands sporting palm trees and oil wells.

One of four sewage treatment plants operated by the city of L.A., the Terminal Island plant was originally built as a primary treatment facility in the 1930s. Dean said, "It used to dump right in the harbor. The old-timers can tell you how bad it was." The plant was upgraded to secondary treatment in 1973. To provide advanced treatment, filtration equipment was added in 1996 and micro-filtration and reverse osmosis capability in 2001. Dean explained that this is a water reclamation plant where the incoming water is treated so thoroughly that it is clean enough to drink (though it is not actually used for potable water).

The influent comes mostly from the nearby towns of Willmington and San Pedro and is pumped through four force mains. The Terminal Island plant can process 30 million gallons per day. The average is 16 to 17 million gallons and the flow varies throughout the day. The highest flow is in the morning and the second highest in the evening, corresponding to home water usage patterns. It takes six to eight hours to process the liquid portion of the influent.

An around-the-clock staff operates the plant. Requirements for operators of sewage treatment plants are much more rigorous than in the past. "Twenty or 30 years ago you needed a strong back and that's all anyone cared about," Dean explained. "Now a good operator is so skilled that he or she can do a walk-



The administrative building at the Donald C. Tillman Water Reclamation Plant has been filmed as the bio-dome in the "Star Trek: Deep Space Nine" TV series.

through, look at the effluent and know if it meets specs or not, just by the visual inspection." For the highest operator level the minimum qualifications are four years' experience operating a sewage treatment plant plus four years of college study in chemistry, biology and hydraulics.

Computer Control

Steve Dapena, Operator 2, in the control room where computers monitor the processes in every area of the Terminal Island Treatment Plant.

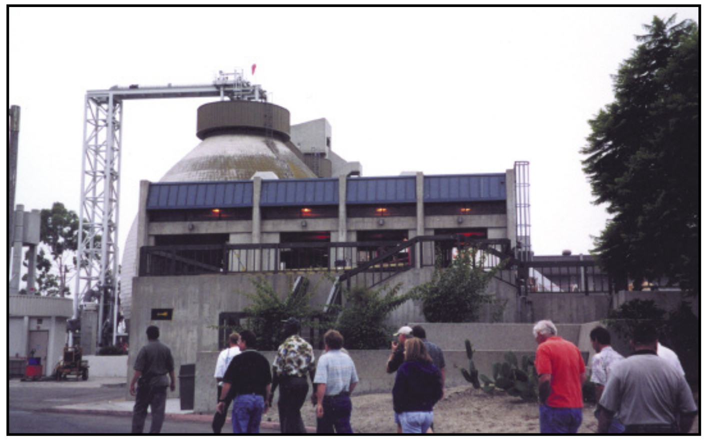
The tour started in the control room—"the brains of the plant." Three computers control the primary, secondary and advanced processes, plus two separate systems for the reverse osmosis facility. The computers monitor each process, and chemical and flow adjustments are made from the computers. The operators still do walk-throughs to verify that nothing unusual is happening and of course check an area when a computer screen flashes warnings. At regular intervals, samples are sent to the lab from every location for testing.

Steve Dapena was the operator in charge on the day of the tour. During the 25 years he has worked at the plant the biggest change he has seen is the computer control. "It's amazing what computers can do now," Dapena said. "The machines watch and control setpoints all over the plant. We used to do all this work manually." Because the plant is so automated now, fewer operators are needed to run the plant.

Preliminary Screening

Wastewater first enters the treatment plant via the underground sewer system and is pumped into the Headworks building of the plant. This area functions as a preliminary filter, capturing and removing large objects—"the chunky stuff," as Dean put it. Dapena said they typically remove paper, sticks, rags and plastic goods. Sometimes they get grease balls as large as six inches in diameter, sloughed off from the lining of sewer pipes.

Bar screens with 3/4 inch openings catch the debris. A rake comes down and dumps the debris in a trench. The trash is put in a garbage can and ends up in a landfill. The



The UPPA tour group walks to the Headworks building where mechanical screening removes the big solids from the incoming wastewater. Typical solids are paper, rags and sticks, but occasionally unusual items such as bowling balls and shopping carts come in.

influent then flows slowly through a grid chamber where most of the sand and grit drops out. Dean said lots of sand comes in from the sewer pipes. It rips up pumps and equipment if not removed.

Over the years at the Los Angeles Hyperion treatment plant some unusual items have come in from the sewer: 2x4s, bowling balls, shopping carts and even a motorcycle. In the 1970s someone found a gold necklace and a one-carat diamond (one wonders how these small items were found amidst millions of gallons of sewage). In case you're wondering how a motorcycle could fit in a sewer pipe, the diameter of the sewer pipe closest to Hyperion is 96-inch. How it got there is a story we'll never know.

Primary Treatment

Separation of organic solids from liquids begins in these primary settling tanks.

From Headworks, the effluent is piped to the primary settling tanks. Here, more solids are removed. By this time most of the big solids—the things you aren't supposed to put in the toilet, like rags and bowling balls—have been removed and the "organics" remain. Organics refers to the solid material that is intended to be deposited in the toilet. Some of it floats and some sinks; the dragging and scraping process in these tanks is designed to catch both.

The flow in the primary tanks is ultra-slow—less than one foot per second. A system of chains and scrapers moving in a circular motion captures the solids by dragging, scraping and dumping them into a trench. Dapena said this process captures 75 to 80 percent of the "settlable solids" and 20 to 30 percent of the suspended solids. It takes four hours to do a complete pass-through of the scraping equipment in the 250-foot long, 15-foot deep tanks.

The primary tanks are covered for safety and odor control. The covers aren't strong enough to support your weight, so don't walk on them, Dean advised. If you do and fall in, "you'll find out who your friends really are because they'll have to pull you out."

Dean had more good advice—don't turn any valves. Dean once gave a tour and a "touchy feely engineer" opened a valve. Concentrated blackwater shot out all over the engineer and splashed onto Dean. For obvious reason, Dean asked his supervisor for permission to go home and clean up. Unfortunately, on that day he had forgotten his house key and after one whiff, his wife closed the door and refused to let him in. As for the engineer, the blackwater soaked into his skin and the odor remained for a long time. He complained that he couldn't get a date for three months. On a more serious note, Dean explained that water containing raw sewage is "nasty stuff," but isn't a big problem unless you ingest it. The exception is hospital waste, which is more hazardous.

Secondary Treatment

In this aeration tank at the Tillman plant, the remaining organic solids are biologically broken down by aerobic bacteria. Note the life preserver. Kook Dean said nobody has fallen in, but when the tanks are cleaned, they find pagers, wallets and cell phones at the bottom.

When the UPPA tour group reached the aeration tanks they saw the sewage bubbling and moving. A joker quipped, "nice Jacuzzis!" In these tanks the effluent piped in from the primary tanks is mixed with oxygen under turbulent conditions and the organics are broken down by aerobic bac-

The Water Cycle and Why We Need Treatment Plants

Water travels constantly, circulating through the atmosphere and onto and into the ground, changing between liquid, gas and solid. As UPPA member Bob Bailey puts it, "All water is reclaimed. When you open your faucet, you're drinking the same water from the time of Christ."

On its constant journey, water can clean itself of pollution by biological breakdown of impurities and by filtration through the soil down to the groundwater. We need treatment plants, UCLA Civil and Environmental Engineering Professor Keith Stolzenbach said, because nature can only process pollutants if it has enough space and time. With a dense population in a relatively small urban area, the task is beyond the capabilities of nature.

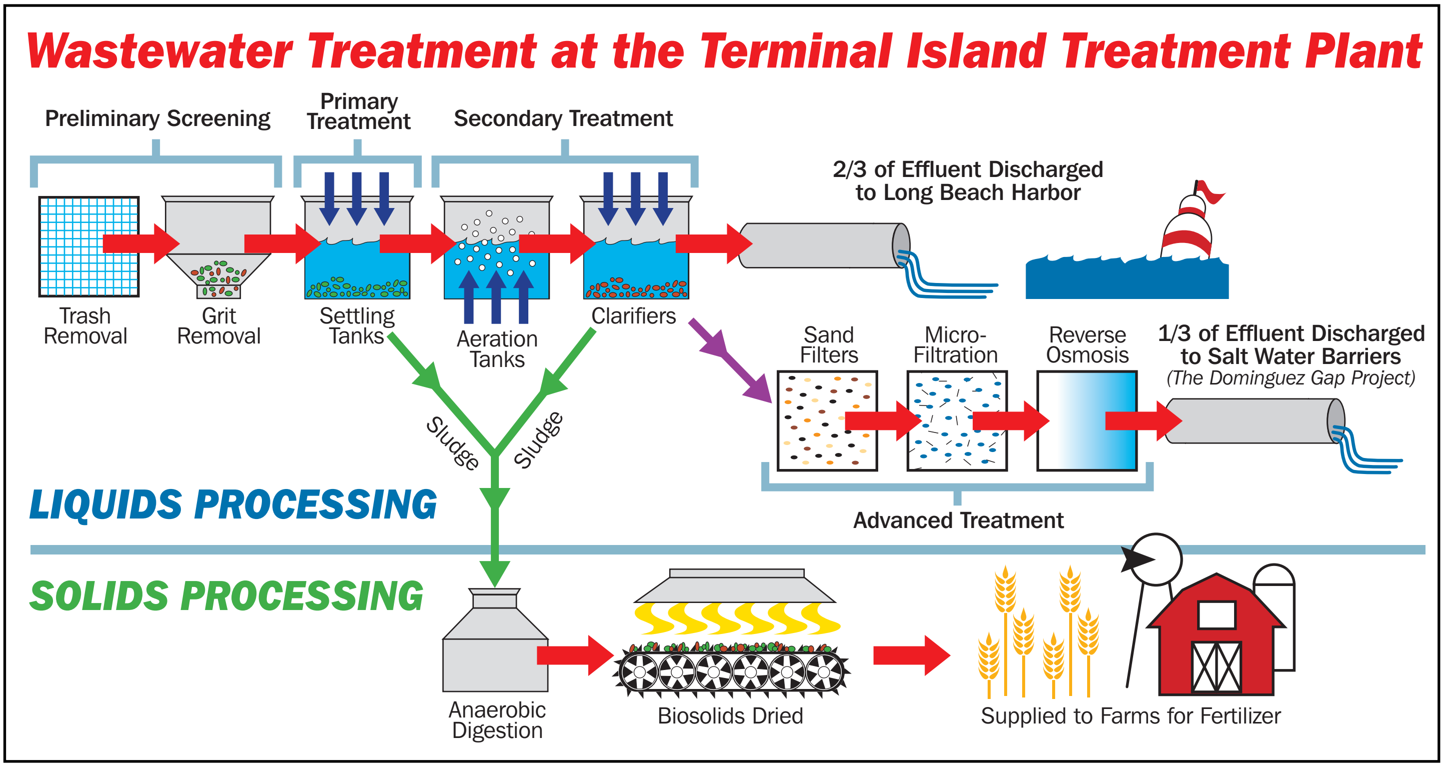
Wastewater treatment imitates and speeds up nature's cleaning process. Steve Dapena, an operator at the Terminal Island Treatment Plant, explained: "All the parts of this process occur in nature—we just accelerate it. For example, a river flows into a lake and some large solids are filtered out along the way. In the lake microbes eat up some organics. Then it settles—the muck on the bottom of the lake undergoes an anaerobic digestion process and the water clarifies at the top. It flows out the other end of the lake fairly clean."

Water pollution causes both human health and environmental problems. Though wastewater is over 99 percent water, dissolved and suspended solids can include industrial wastes such as chemicals, dyes, detergents and highly toxic materials, in addition to household sewage and agricultural run-off.

Human waste contains bacteria and viruses, some harmful to health. According to Stolzenbach, separating drinking water from waste disposal, and disinfecting drinking water are the primary ways to prevent disease spreading through water. Wastewater treatment contributes to a small extent, he said.

Water pollution affects the environment, not only by harming marine life with toxins and introducing poisons into the food chain, but by disturbing oxygen levels. Too much or too little oxygen disrupts the ecological balance, killing off some plant and animal species while encouraging the overgrowth of others. The result can be eutrophication with algae blooms, dead fish and foul-smelling water.

Sewage treatment removes impurities so the remaining wastewater can be safely returned to the water cycle. The process usually follows these steps: preliminary screening removes trash, primary treatment removes settled and floating solids, and secondary treatment breaks down the organic matter (the activated sludge process). The effluent may go on to advanced treatment, including filtration, microfiltration, disinfection, and/or reverse osmosis. Removed solids are treated separately.



teria. This level of treatment is called "secondary treatment" or "activated sludge treatment." When a plant initially opens, microorganisms must be "seeded" (added), but when operating continually, no more of these "bugs" need to be added as they reproduce at an amazing rate. "The bugs multiply like crazy and eat up everything," Dapena said.

"Bubblers," shown in this empty aeration tank, pipe in air to stimulate the growth of aerobic bacteria.

Dean explained that this biological process would take a day or two to occur in nature, but only takes two hours with the increased aeration. Air piped in through "bubblers" at the bottom of the tanks speeds up the process. Running the effluent through the aeration tanks "gets the bacteria hungry," Dean said. The effluent containing activated sludge (solids with microbes) goes in a serpentine flow from tank to tank to tank to tank, with gates controlling the entry and exit between the tanks. By this time the organics are chopped up to such a consistency that "you could suck it through a straw." "It's like a malt," another joker contributed.

Dapena told how adjustments are made to various factors during treatment when necessary. For example, he may need to increase the wasting rate of activated sludge in aeration tanks if the suspended solids are too high and the microbes are too concentrated. Also, "You have to keep the dissolved oxygen at a certain rate to keep the bugs happy—not too much and not too little," Dapena said.

When Dean started in the sanitation business many years ago, aeration tanks were not used. The common method of dealing with solids was to spread out the sludge, let it dry and truck it to farms for fertilizer. Sharing a gem of sewage trivia, Dean said because tomato seeds are not digested in the human intestinal tract, "you would see the most beautiful tomato plants growing in the sludge with big red tomatoes, but of course they weren't safe to eat." Dean is still not fond of tomatoes. That method of handling sludge is no longer used because of the odor.

After winding their way through several aeration tanks, the liquid and solids part company. The liquid goes on to the clarifiers for more cleaning and the solids are piped to the digesters for further microbiological processing.

At the clarifiers the water is 72°F, producing warm vapor. The water flows over dozens of concrete structures that resemble mini-waterfalls. "Just like Hawaii," someone remarked. The effluent is now lighter, clearer and there are less organics. The flow is slowed again and there is no more mixing. The effluent is quiet and settles well. Flowing over a system of weirs, the clear water is taken off and sent for final filtration. The activated sludge is pumped back to the aeration tanks, "returning the bugs to do their jobs again."

Advanced Treatment and Discharge

After the aeration tanks, the effluent goes to the clarifiers where remaining organic solids settle to the bottom through a system of weirs.

About two-thirds of the water emerging from secondary treatment is discharged into the harbor. The rest goes on to advanced treatment. The highly treated water is used to inject saltwater barrier wells along the coast to push saltwater, which has entered the pumped-out wells, back into the ocean. This is known as the Dominguez Gap Barrier Project. Dapena said a potential industrial use for the highly treated water is for washdown at the coke refinery across the street. By 2010, all of the Terminal Island Plant's influent will receive advanced treatment.

Filtration is next. This part of the process removes lighter materials that didn't settle out in previous processing. The effluent passes through layers of porous granular materials, in this case six feet of rock and sand. The filters trap and remove suspended particles.

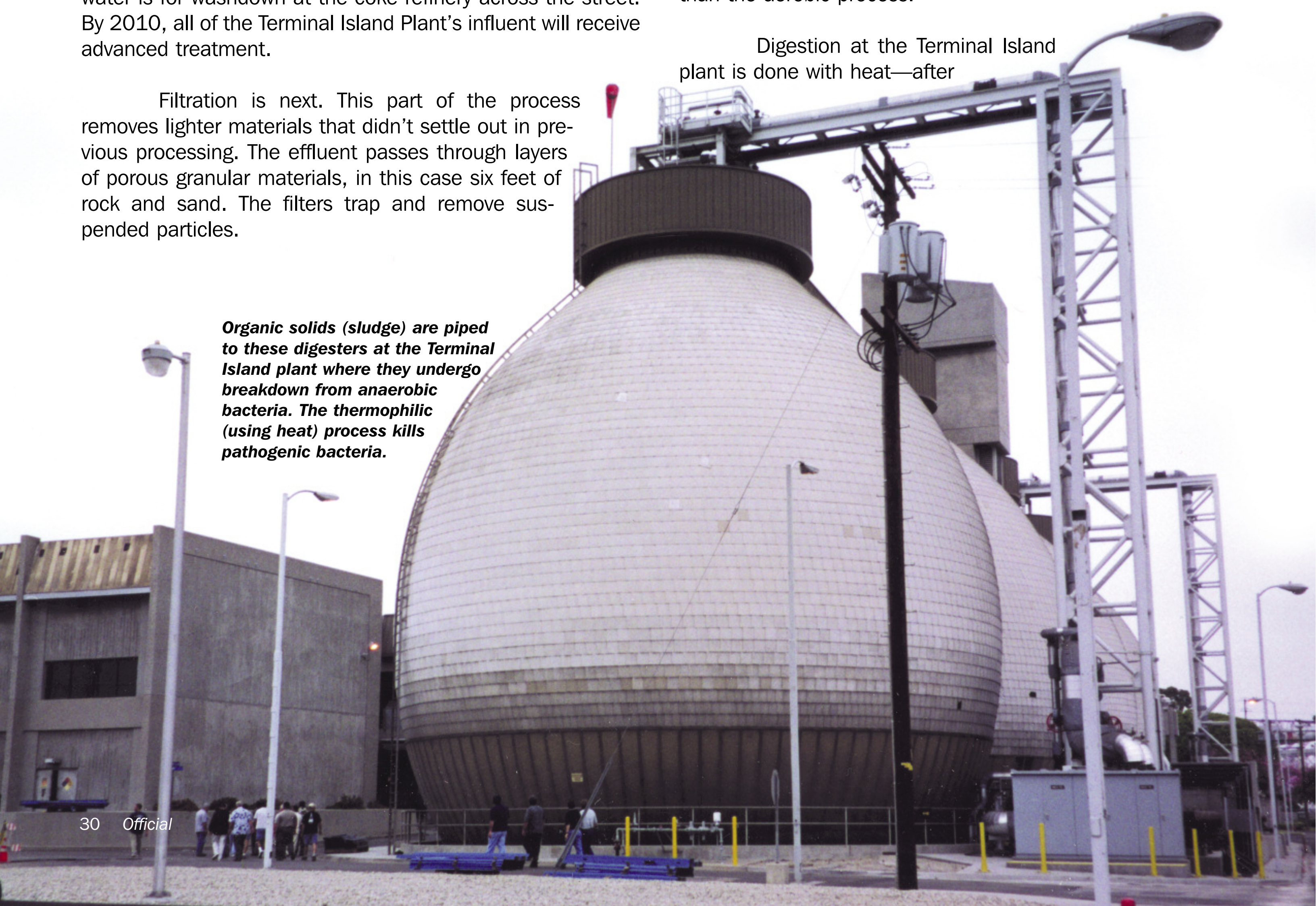
The final steps of micro-filtration and reverse osmosis produce a very high quality product, Dean said. Suspended particles, including salts, minerals, metal ions, organic compounds and microorganisms are removed. Dapena said the micro-filtration "gets a lot out, on even a cellular level." Dean described the micro-filtration apparatus: "It looks like a cable—a bundle of plastic spaghetti wrapped up. The pressurized exterior of the bundle filters out bacteria, viruses and chlorides."

Reverse osmosis gives the water its "final polish," Dean said. It gets everything out, even tiny viruses. Some minerals have to be reinjected. The plant has had this technology for only a few years. "It's had its ups and downs," Dapena reported. "It's needed a lot of fine-tuning, but is doing well now."

Solids Treatment

The sludge from the aeration tanks and settling tanks is piped to the digesters—huge beehive-shaped structures where anaerobic bacteria now act on the organics without much oxygen. Like digestion in your stomach, "more stuff is broken down," Kook said. During this part of the process a lot of the nitrates are removed. It is less putrescible (yet another new vocabulary word, it means "likely to become putrid") than the aerobic process.

Digestion at the Terminal Island plant is done with heat—after



Organic solids (sludge) are piped to these digesters at the Terminal Island plant where they undergo breakdown from anaerobic bacteria. The thermophilic (using heat) process kills pathogenic bacteria.

About one third of the clarified liquid goes on for advanced treatment by micro-filtration, starting in this building at the Terminal Island plant.

three or four days of anaerobic biological action, the solids are "baked" for 48 hours at 130 to 134° F. The plant has been using this thermophilic process for a year and a half. "Thermophilic is the big thing now," Dapena said. "It kills a huge amount of pathogenic bacteria. The kill-off is tremendously more than with the cooler process commonly used."

The digested organics are centrifuged in a large vat, removing 75 percent of the water and forming a wet cake product called "biosolids." ("Is this when the @#$! hits the fan?" someone asked. "Yes!" Dean replied.) The biosolids then go on a conveyor belt to a big hopper. They are loaded on trucks, covered with tarps, and trucked to Kern County. There they are rehydrated and used for fertilizer on a farm, affectionately called "Green Acres," that grows animal feed. "Do they sell it or give it to the farm?" someone asked. "We *bought* the farm," Dean answered.

Digestion produces lots of methane gas. The methane is piped to two tanks—one low-pressure and one compressed to 15 psi. It is used to power boilers at the plant. Flares also burn off some excess methane.

The digestion process produces methane gas, which is piped to these tanks. Some of the methane is used to heat the digesters and some is burned off.

Another of those simple questions came up at the end of the tour: "Where are we in the food chain?" Humans are at the top, right? Yes, but the answer gets a little more

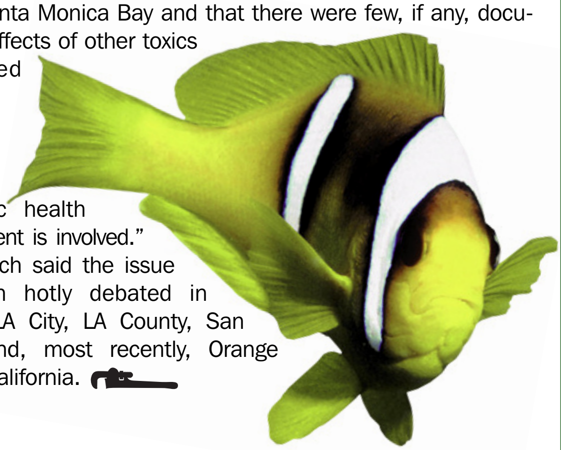
Water Regulation—*How Clean is Clean Enough?*

The U.S. Environmental Protection Agency (EPA) sets federal standards for clean water. State water quality agencies also set standards. Different standards are for different uses of water. The EPA regulates wastewater as well as drinking water, and includes surface water but not groundwater. A 1972 law, later known as the Clean Water Act (CWA), gave the EPA authority to set wastewater standards, required secondary treatment for most effluent, and helped fund the construction of sewage treatment facilities. The goal is for the wastewater to be treated to the level that it is harmless to the receiving river, ocean or lake. To maintain a permit to discharge into the natural water system, treatment facilities must follow regulated programs of testing and reporting to prove their discharge will consistently meet regulatory standards. Factories must use their industry's best available treatment (BAT) to treat their wastewater before discharging it.

Municipalities have an ongoing challenge to comply with changing regulations. For example, the 2001 CWA amendments now require upgrading old facilities, filtering out higher levels of certain impurities and reducing chlorine by-products in drinking water.

How clean is clean enough, and at what cost? Not everyone agrees. In 1976 an engineer from the L.A. Bureau of Sanitation spoke to IAPMO's Southern California Chapter. The chapter minutes reported on the speech and strong opinion of the speaker: "Due to new federal laws, the present treatment system is not adequate. This in spite of the fact that the city has been sampling the ocean and beaches at about 50 various points since Hyperion was remodeled in 1955 and there has never been any problem…. This change to the Hyperion plant will cost $300,000 and about $15,000,000 per year to operate for absolutely no benefit at all simply because the federal government passed a law."

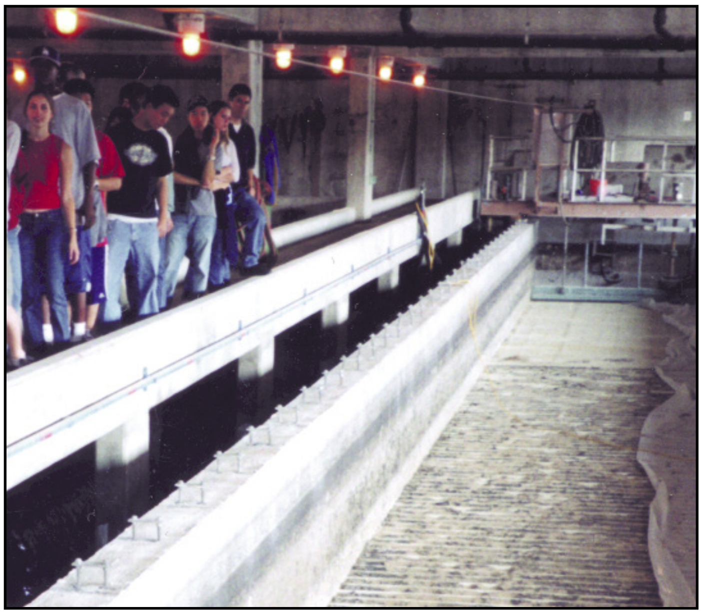
Keith Stolzenbach, professor of Civil and Environmental Engineering at UCLA, comments on the public health versus cost issue: "The upgrades to Hyperion, which were carried out and which cost the $1 billion forecast, were to install full secondary treatment, a process mainly designed to remove oxygen demand from the waste, but which also reduces the total solids discharge to the ocean. Many people think these improvements were not worth the money, given that low oxygen levels were not a problem in Santa Monica Bay and that there were few, if any, documented effects of other toxics associated with the additional solids removed. No public health improvement is involved." Stolzenbach said the issue has been hotly debated in Boston, LA City, LA County, San Diego, and, most recently, Orange County, California.



complicated when you think that the hamburger you just ate might have come from a cow fed on barley grown at Green Acres, which was fertilized with biosolids from Terminal Island, which came through the sewage system from your toilet.

Tillman Treatment Plant – Clean Water, Japanese Gardens and Hollywood Stardom

Dean led another tour of a water reclamation plant a few weeks later. This time UCLA environmental science students visited the Donald C. Tillman Plant in Van Nuys. Unfortunately, the students didn't display the same humor as the UPPA group.



UCLA environmental science students get a rare view of an uncovered sand filter at the Tillman plant.

Utility corridor underneath the Tillman plant. The brown pipe transports sludge bound for the Hyperion plant. The overhead air ducts send air to the bubblers in the aeration tanks. Some of Tillman's underground corridors have been used in movies and TV shows for chase scenes.

This plant differs from the Terminal Island plant in several ways. The primary difference is the processing. At Tillman only liquids are processed. Solids are sent on to the Hyperion plant. Reverse osmosis is not done at Tillman because it is very expensive for a large volume of water. Also, the effluent at Tillman is chlorinated to kill pathogens and is then de-chlorinated.

Piping at wastewater treatment plants (process piping) is regulated by ASME. The lower pipe discharges into a recreational lake near the Tillman plant. Note the heavy-duty pipe supports and color coding.

Second, the Tillman plant features Japanese Gardens on its grounds, complete with lotus flowers and cherry trees, a teahouse for weddings and festivals, and a waterfall and lake flowing with reclaimed water fresh from the Tillman plant. Fish swim in the lake and birds fly in to feed on the fish. The Japanese Gardens were built for public enjoyment and to prove to the public that reclaimed water is clean.

The Tillman Plant supplies water to the adjacent Japanese Gardens, which were built for public enjoyment and to prove to the public that reclaimed water is clean.

This waterfall is another example of the many beautiful features at the Japanese Gardens.

Last, and probably unique for a wastewater treatment plant, Tillman has Hollywood connections. The administration building has been filmed as the bio-dome in the "Star Trek: Deep Space Nine" TV series and also appeared in the movie "Rising Sun." The underground corridors have been used to film chase scenes in various TV shows and movies.

Built in 1985, the Tillman plant was named after Donald C. Tillman, the city engineer who had the vision for the water reclamation facility. At that time there was one tunnel to transport wastewater to the Hyperion treatment plant located near the Los Angeles airport. Anticipating that the vacant farmland of the San Fernando Valley would soon become cities, it was clear that more capacity to transport sewage would be needed in the future. The choices were to build a second tunnel to Hyperion or to build a water reclamation facility that would remove and process a large portion of the water. The smaller load of solids could then be sent Hyperion.

This plant processes 80 million gallons of influent per day. (In comparison, the huge Hyperion processes 450 million gallons daily.) The reclaimed water is discharged to the Japanese Gardens, Wildlife Lake, Lake Balboa and the L.A. River. In fact, 80 percent of the L.A. River water is from the Tillman and Glendale plants, Dean said. The whole process takes about eight hours and costs $700 per one million gallons of water treated.

Dean claims that Tillman water is of higher quality than drinking water. He said that if DWP water were piped into the gardens, it would not pass the exit standards. He also claims the Tillman plant "smells better than the Anheuser Busch factory on a sunny day."

Water has always been big business. Now it is also high tech. The public depends on treatment plants to clean wastewater before returning it to the environment. There is little room for error. "If you screw up," Dean said, "it's spectacular." When asked if heads would roll, he said it would be more serious than that: "You'd make the front page of the *L.A. Times.*"

Reuse of Reclaimed Water and Biosolids

The earth has a finite amount of water, but a growing population with a constant cycle of water use. Therefore, water must be used efficiently. Reclaimed water that has received advanced treatment has many uses. It can be used for industrial processes such as cooling at nuclear power plants and for landscape irrigation, for example at golf courses. Other uses include replenishing groundwater, filling ornamental fountains and washing vehicles. Wastewater reuse is increasing with increasing population growth and is cost efficient.

Reclaimed water for potable use is controversial. It has not won public acceptance due to the public's perception that it is unsafe and lack of data on the long-term consequences of consuming intensively chemically treated water.

Dumping of biosolids—treated solid waste—into waterways is no longer legal. Biosolids can be disposed of in landfills and by incineration. They can also be reused as fertilizer and for projects such as land reclamation in strip-mined areas. Like reclaimed water, reuse of biosolids is cost efficient. They can be sold, offsetting part of the treatment costs.

If you or your group are interested in taking a tour of the Hyperion Treatment Plant, call (310) 648-5363. For tours of the other Los Angeles waste water treatment facilities, contact Kook Dean at (323) 342-6221.