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OCEANSIDE WASTEWATER TREATMENT PLANT

A case study

An Interactive Qualifying Project Report

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by

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INTRODUCTION

A public works project is any project that is sponsored by and funded by the government, be it local state or federal, that helps to improve the community in some way. Some public works projects have very limited scopes such as building a city park or parking garage but can be as extensive as massive reconstruction of major integral parts of the city. In any form or size, the goal of the project is to improve the community. This project is the study of the design and construction of a major wastewater treatment plant in the city of San Francisco and seeing what factors made the project a success.

Many factors play a part in determining the success of a project. Cost-effectiveness, social impact, and public utility all are measures of success, but in a project of this type, one that immediately affects the people of San Francisco and their environment, the success of the project lies almost entirely in its design and operation. The purpose of a wastewater treatment plant is to clean all domestic wastewater, which consists of all water that is used in a house hold that goes down the drain, so that it can be reintroduced back into the environment from which it came. In order for a treatment plant in or around San Francisco, the discharge from the treatment plant must be able to remove enough pollutants from the wastewater so as not to harm the Pacific Ocean or the San Francisco bay, both of which are vital to the people of the Bay Area.

When studying a public works project it is important to look at what might influence the outcome. In this case the possible influences were the laws of the time, the public opinion of the project and its usefulness, the engineering and technology available and cost and funding. It is these factors that dictate the nature of the project and ultimately can cause a project to succeed or fail.

Methodology

Because this is a case study there are not many sources that can be used to research the topic. The majority of the information for this project will come from secondary sources such as interviews with engineers involved with the project and documents produced by the City of San Francisco and other agencies involved with the project. The engineers that were involved with the project from the beginning were the most valuable resource because they have the insight that can describe the process from start to finish and have an intimate knowledge of any problems that occurred. Legal sources, such as any applicable laws or cases, was investigated thoroughly in an attempt to understand the legal forces that had an influence on the project. Some traditional sources such as textbooks was utilized as background information to establish engineering practices and standards.

Purpose

The purpose of this project was not simply a study of how a modern wastewater treatment facility is built. As an environmental engineering, I will be capable of understanding how to build a wastewater treatment plant. I have been taught how to size

size the equipment and treat the water so that it may be reused or discharged safely to an ocean or river. The engineering is most definitely the easy part. The hard part is everything else, getting permission to use the land, keeping the project on time and on budget and keeping the people and the politicians, and the government happy. With this project I hope to find out the skills and knowledge required to accomplish the hard part because unfortunately no class I can take can teach me these skills. Interacting with people and communities is a vital skill for an engineer to have and I feel that this project is a good example of good interaction and hope to find out what made it so.

HISTORY & BACKGROUND

When undertaking the study of a major public works project such as the Oceanside Treatment Plant, there are many factors that control and influence the planning and construction. This project is studying why the treatment plant was a complete success, both in design and construction and to understand that, you must first look at all of the elements that were combined into this project.

The first element that was key to this project were the laws that governed water pollution control at the time. In 1972 the United States Congress amended the Federal Water Pollution Control Act of 1956. The amended legislation set standards for water quality and emission levels, set up a national discharge permit system as well as provided funding for the construction of wastewater treatment plants. Earlier pieces of legislation had attempted to control the water pollution occurring in the United States but this legislation was the first that really had an impact. The Legislation was amended again in 1977 and became known as the Clean Water Act[1]. The amended act of 1977 combined all the elements of the previous acts that preceded it and had the most aggressive stance against pollution. Although this was the most aggressive legislation, it was not the first. Water Pollution legislation. The first example of water pollution legislation dates back as far as 1899 when the River and Harbor Act was passed. This Act was actually intended to limit solid waste dumping into waters so as not to impede boat traffic and slow commerce. Although navigation was hardly the concern of the politicians for the legislation passed in the 70's, the 1899 Act was used in Supreme Court cases in an attempt to include liquid wastes as well as solid to help gain passage for the Clean Water Act. The River and Harbors was used in 1970 by the EPA administrator to establish water quality management using permits and penalties to regulate and punish Industrial polluters.

The Clean Water Act of 1977 had many goals. Its primary goal was to reduce the amount a water pollution that was being dumped into the Nations waters. The legislation had a number of ways to achieve this goal. The most important laws in the act that apply to this paper are the requirements for municipalities to use at least secondary treatment of their wastewater[2], have a discharge permit and use the best available technology[3] economically feasible. The responsibility to attain these goals fell into the hands of the

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[1] PL 95-217, Dec. 28, 1977

[2] Secondary treatment is used to further clarify the water and often includes a chemical disinfecting of some sort

cities to which they applied and to the EPA to enforce these new strict standards. The reason the Clean Water Act was popular was because of the government subsidies that it promised. The legislation stated that any new municipal treatment plants would be funded up to eighty percent by the federal government. This meant it was possible for the cities to use the best available technologies without having to use local taxes to afford them and as a result would be able to construct high quality treatment plants at a minimum cost.

History and Background of San Francisco

The City of San Francisco presents some significant problems in terms of water pollution control. The City is built on a peninsula surrounded by the Pacific Ocean to the west and the San Francisco Bay to the north and east. The city is built on a series of hills that divide the city into a number of smaller communities and roughly split the city in half, lengthwise. The city occupies a total of only seven square miles and has a fairly constant population of about 727,000. The city is almost entirely paved so when it rains, the run-off collects very quickly in the storm drains. Although the climate is very mild, it experiences a definite wet season lasting from October to April receiving an average of 21 inches of rainfall for the year[4]

The history of the City's waste treatment extends quite a ways back. The first treatment plant that the city constructed was the Sunset-Richmond treatment plant in Golden Gate Park on the western edge of the city on the Pacific Ocean side of the City. The Plant was constructed in 1939 and was a primary treatment facility. It did not have

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[3] Best available technology requires the most advanced technology be used
[4] The population and rainfall are based on 1990 census

any secondary treatment and had a capacity of only 20 Million Gallons per Day (MGD). The treatment plant was built with no expectations for future development, at the time wastewater treatment was a very new practice and secondary treatment didn't even exist in the way it does today.

The City of San Francisco has a combined sewer system. A combined sewer is one in which the storm drains and municipal wastewater collect in the same sewers for treatment. Combined sewer systems are common in largely populated and developed areas with high annual rainfall. The reason for this is that when it rains, the oil and other pollutants that collect on the street are discharged directly to the body of water that is used by the city. It can be very dangerous and have very negative impacts on the health of the water that is the point of the discharge. The advantage to having combined sewers is that the rainwater that collects all of the pollutants is treated along with the domestic wastewater. Many cities around San Francisco without combined sewers have very significant troubles with pollution in the local streams or ponds that collect the rainwater as well as the human pollution such as oil and detergents that collect in the storm drains and eventually are discharged to the streams. The feeling now is that it is much more environmentally friendly to have combined sewers for these reasons.

The most important and most involved part of this paper is the background of how the Oceanside Treatment plant was designed and built and the politics and decision making that revolved around its eventual construction. Many influences played a role, economics legal, engineering and social considerations each had a very significant role and helped to make this project so interesting and difficult for the people involved with it. Most major civil works projects are very complicated and have many problems that prevent quality work and take away from the finished project and although this project had the same influences guiding it, the projects eventual success started in the planning phase.

Early Planning

In 1974 the City of San Francisco adopted The Master Plan, which was a guideline for the renovation of the cities wastewater treatment system as a whole. The reason for the creation of the Master Plan was simple. The city had a combined sewer system and as discussed before this meant that the rain run-off and the domestic wastewater were transported in the same pipes. The problem was that when it rained the system would become full and above the capacity of the existing treatment plants and as a result, raw sewage would be dumped directly into the ocean. After the construction of the Southeast treatment plant, this was only a concern for the westside of the city. This was due to the small capacity at the existing Richmond- Sunset plant. Until the 1970's this pollution had not been a very serious issue because the environmental regulations for sewage discharges were much less strict. The city was aware that the public or the law would not tolerate discharging raw sewage in a few years. It was this realization by engineers and politicians as early as the mid-sixties that paved the way for the eventual need for the Oceanside facility.

The Master Plan called for a number of substantial public works projects. Before the projects were decided upon one possible solution had to be investigated. The problem of raw sewage discharge was created by the fact the San Francisco had combined sewers. The easiest solution was perhaps to have separate sewers there by guaranteeing that the flow of wastewater entering the treatment plants would not swell during wet weather and prevent the polluting discharges. Although this would solve the problem at hand, in order to redo the sewers, as a non- combined system would require the digging up of every major street in the city as well as modifying the plumbing in every household. In addition, the pollution from street run-off would have to be addressed. This solution was dismissed as too costly.

One other possibility that was looked into in the process of developing the Master Plan was to create a Cross-city transport. This would serve as a method of transporting the overflow wastewater from the West-side of the city to the Southeast Treatment Plant that was planned to have more than enough capacity so as to prevent the discharge of sewage prior to treatment. This idea of transporting the overflow would mean constructing a giant tunnel across the city, a distance of nearly three miles. This too was deemed too costly and too difficult a task to undertake.

The first solution to having to build a new treatment plant that the city explored was related the regulations stated in the Clean Water Act. The Clean Water Act established an exemption from secondary treatment for any treatment plant that discharged into any body of water that provided adequate dispersion of the pollutants so as to render them harmless. This was stated under section 301(k)(2) of the Clean Water Act and the city petitioned the EPA for an exemption. Before the city could even file for the exemption, a great deal of research was prepared to establish that the Pacific Ocean, to which the treatment plant discharged, did provide the necessary dilution. Once the Petition was filed by the city, it took the EPA nearly five years to provide a reply. The EPA did grant the City of San Francisco a secondary treatment exemption if they meet several requirements. The EPA mandated that the city had to establish monthly monitoring over a range of nearly 50 square miles surrounding the discharge point. The discharge the city was using was an outfall[5], which extended three miles into the Pacific Ocean. The exemption would have to be renewed after five years, provided that the monitoring was done and that no violations or accumulations of any pollutants were observed. The city decided that it would be to costly to perform the monitoring, especially since the exemption could be revoked in five years anyway. The city rejected the exemption, and to this day, no city has been granted an exemption from secondary treatment based on section 310(k)(2) of the Clean Water Act, although many cities have applied and did meet the requirements.

[5] An outfall is a pipe placed on the ocean bottom that transports the treated wastewater to the discharge point. The Oceanside outfall actually had more than one discharge point along its length to lessen the discharge volume at any one point.

At this point in time in the early seventies it was clear that San Francisco needed a treatment plant on the West- side of the city that could handle the increase in flows in the wet season. Two possible solutions were investigated, add on to the existing plant in Golden Gate Park or build an entirely new treatment plant.

Location

When it came time to decide on whether to build a new treatment plant or increase the capacity of the Sunset- Richmond treatment plant, both options had very serious problems and hurdles to overcome. The first problem that faced each option was land. The Sunset- Richmond Plant was tucked away in a small corner of San Francisco's picturesque and famous Golden Gate Park. The expansion of that plant would require a great deal of land. The Plant at the time was only able to treat wastewater to the level of primary treatment. It was clear that this was not going to be clean enough in the future as the environmental regulations were stiffening and secondary treatment requirements were not far off. So not only did the plant need to increase its primary treatment capacity, but would also have to have land for secondary treatment equipment as well. The Department of Parks and Recreations who oversees the land use of Golden Gate Park had made no secrets that they saw the treatment plant as a burden upon the park and getting approval for more land was not a very likely possibility.

One other problem that plagued the possibility of expansion at the Golden Gate plant would be the increased output of undesirables that are common with a major treatment plant such as odors, unsightly buildings and increased industrial traffic. The surrounding community would not tolerate the eyesore that a large plant would create in the middle of one of the city's most attractive landscapes. It became clear that the option of addition to the Sunset- Richmond plant was unrealistic. This process of elimination of the various possibilities shaped the requirement's that would be used in the search for a site and the final design phase of the project.

The City of San Francisco realized that a site had to be found on the West- side of the city to build a modern large-scale secondary treatment plant. The single biggest problem as mentioned before was land. The city is extremely densely populated and the amount of land that was needed could not be provided by all but a very few sites that were available and after some preliminary investigations only one was able to meet the requirements that the previous investigations had set. These requirements included a large piece of land that was accessible to large trucks, was far enough away from residential area's so as not to create problems with noise and odor and located near the ocean to reduce the distance the wastewater would have to be pumped.

The piece of land that fit most of these criteria was a small piece of undeveloped land that had been allotted to the parks department with specific intent to be used by the San Francisco Zoo for future expansion. The land was triangular and bordered by the zoo on the north and by the Great Highway and Lake Merced Boulevard on the other remaining sides. The land was mostly sand dunes covered with a piece of it being used as vehicle depot by the National Guard. The Pacific Ocean was 100 yards across The Great Highway, which was convenient for the outfall, which would discharge the treated wastewater into the ocean.

The first major problem that the project at this phase faced was getting permission from the zoo to use the site. As can be imagined, the zoo was very skeptical about not only giving their land to the city but also becoming neighbors with a treatment plant. Not only could the plant create problems for the zoo in terms of odor but would restrict the zoo to use only the land it had now for the future. The zoo and the engineers had to come to some sort of compromise because this was the only possible solution to the problem of where to build the plant. What was agreed upon between the zoo and the engineers was the most creative solution to any problem faced in the process of designing and building the treatment plant. In talks between the engineers for the city and the planners and administrators for the zoo the possibility of building the treatment plant partially or totally underground was mentioned. This was in 1974 and at that time the waste treatment technology had never been considered to be used underground. It was determined that it was feasible to have a treatment plant below ground and the zoo made a deal that the city could have the land for a treatment plant if the plant was built at least 70% below ground.

The zoo had a few other requests that went along with the requirement for the underground treatment plant. The zoo was concerned with the problem of odor that could detract from the quality the zoo could provide to their visitors as well as their animals. The zoo was very insisting that the new plant be designed with best available technology to eliminate odors as much as possible and within reason economically. The zoo was clearly concerned with the affects that a industrial plant would have on their visitors, they also required the parts of the treatment plant that were above ground not be visible from any of the existing or future zoo grounds. The zoo's overall concerns and conditions for construction were mainly aesthetic and created some issues in design and cost that had never before been faced in a project of this type and added to the unique character this treatment plant was building.

POLITICS & LAWS

The city of San Francisco was and continues to be a highly political city. The city population was, at this time in the late seventies very influential and truly a political force. It would be under normal circumstances, impossible for a project of this size and projected cost to be approved without problem. City officials were always too concerned with appearances and public opinion that the important projects and issues were often overlooked or dismissed due to cost and other unpopular reasons.

The first time it was realized that the Oceanside Plant was needed and the subject was brought to the attention of the proper city political officials, the project was dismissed as too costly and unnecessary. The engineers had known that the hardest part of the project was going to be getting it approved by the city. The politicians were going to need some help being persuaded into buying the idea of a $200 million dollar project. The major persuasion came in the form of the Clean Water Act of 1977. The act required a minimum of secondary treatment for all effluents and provided a large amount of subsidizing for new treatment plants being constructed.

The Clean Water Act provided the perfect excuse for the city to build the treatment mostly because of the funding that was so crucial in the passing of the legislation. The city gave permission in 1979 to the city engineers and supervisors that were involved with the Master Plan to begin accepting plans and cost proposals, based on the construction of a treatment facility 70% underground and capable of treating the wet weather capacity flows to the secondary level. Usually the EPA would have stepped in and brought legal action against the city requiring secondary treatment and implemented fines if the city did not provide a design proposal at this point of the project. However, because the city engineers had reacted so proactively and had anticipated the need for a new treatment plant, the plans for a new treatment plant were already far enough along so as not to warrant any sort of formal legal action taken against the city. This is a good example of how the city avoided problems through planning and acting in a proactive manner.

One previous case set a legal precedent that was used by the city. The treatment plant outfall was designed so that it would extend 3.2 miles out into the Pacific Ocean. Three miles was decided upon because it provided the best dilution and was far enough out to sea so that there was no possibility of pollution reaching the beach. The problem arose from the California Environmental Pollution Agency. The city was given the choice at the beginning of the project as to whether the national EPA would regulate the treatment plant or the state EPA would oversee the operation of the treatment plant. The city felt it would be much easier to deal with the state EPA because they would be better educated about the specifics of politics and environmental issues unique to the area. The problem that arose was that the state waters extended only to three miles beyond the shoreline. This was established in a case in the ninth district court of appeals in 1985[6]. The City of Los Angeles had come across a similar problem and it was determined that the federal government has to oversee operations that crossed the three mile barrier. This was because at the three-mile limit it was determined that disputes could arise in situations near state or international borders. The EPA was trying to protect itself from not being able to track the source of any pollution. If a treatment plant was polluting near a border a dispute could arise between states or countries even and a state agency would not be able to handle the dispute. This was the reasoning in the case, however for the City of San Francisco, the federal EPA concluded that no such dispute would arise and any that did could be handle by the California EPA..

By differing the regulating to the California EPA, the federal EPA did a huge favor to the City of San Francisco. It was going to be much easier for the local authorities to deal with the new treatment plant for a number of reasons. First, the members of the committee that would be overseeing the project would have a much greater understanding of the particular characteristics of a facility of this nature. A treatment plant discharging into the ocean like Oceanside is substantially different from most other municipal wastewater treatment plants because of the vast size of the body of water being discharged to. Having EPA regulators that had a better understanding of these traits and experience with other similar types of treatment plants and discharges would be a huge advantage as opposed to a regulator from some other part of the country as might be the case if the federal EPA was in charge of the regulating.

Some legal problems that can and have occurred with other treatment plants are lack of compliance with the original design or the discharge permit. One example that is a good demonstration of this is the Orlando Florida wastewater treatment plant. The city of Orlando was growing and in need of a new treatment plant to meet with the Clean Water regulations like San Francisco. A design was proposed and approved and the plant was built . As is common with any project like this in a major city the time from original design to the construction completion is at least three years. Unfortunately for the City of Orlando and the design engineers, the city had an explosion in growth and as a result, the treatment plant was at capacity by the time it opened. This was a catastrophe because the plant was not expected to reach capacity for ten years, minimum. As a result of this problem, a lawsuit was brought against the design company by the city for not fulfilling the requirements of the contract. The lawsuit was dismissed because the engineers had no way of predicting the explosion in population.

The engineers working for the City of San Francisco did not encounter any problems such as the one encountered in Orlando, partly due to the relative steady population of San Francisco. They were able to avoid any legal action taken against them, which in a project of this magnitude is extremely rare and is testament to the thoroughness of the design and research done.

In many public works projects the politics and laws completely control and often ruin the project. This was not the case for the Oceanside treatment plant and this is a significant reason why the project is viewed as a success. The politicians in the city had no reason to oppose the project partly because it had been so well planned and had a negligible impact on the city and partly because it was viewed at the time as a very positive step for the environment. The legal aspect of the success of the project can be moslty attributed to the excellent planning and accounting for all possible legal snags that could of occurred. By planning for them the engineers were prepared for them if and when they did arise. Luckily for the city, very few arose and the ones that did were handled very quickly and without any adverse affects to the project.

DESIGN AND CONSTRUCTION

As was mentioned before the design was being done by CH2Mhill, a company based in Denver and was working in conjunction with Bectel Corporation. The consultants were also working very closely with city officials closely related to the project. The design of the treatment plant process was not the difficult aspect but the adaptation of existing technologies to function in a subterranean environment. The engineers understood that space would be the main concern because the smaller the footprint of the plant the lower the cost. The biggest job was using available technology that could be adapted that was the most space efficient.

The biggest concern to the politicians involved with the project was the cost. Although the government was subsidizing a large portion of the cost, some cost was still going to be incurred by the people of San Francisco and if the project was a failure, the politicians knew that they would be in trouble. Something that is very common in public works projects is under-budgeting. Most cities award contracts by accepting the lowest bid for the required work. The problem is that the bid is always less than the project will cost and the contractor just adds to the cost. This is common and in most cases accepted as policy, but in some cases, such as the Big Dig going on in Boston right now, the public can find out and become outraged. This is what the San Francisco politicians were afraid of and especially since the idea of building the plant mostly underground had never been tried, the room for error was minimal. This project had the potential to spiral out of control and end up costing the city substantially more than originally expected.

The design team was well prepared to maintain the cost at a minimum even though some things were new. They were able to keep things as simple as possible and take advantage of certain aspects of the requirements. For example, in a normal treatment plant, odor control is a major problem because most of the odor creating processes take place outdoors. As a result special containment devices must be used to prevent odors from leaving the equipment and this can be a major cost. In the case of the Oceanside treatment plant, this containment equipment was not necessary because the odor would be released from the equipment to a confined room underground, all that was needed was an exhaust system that could direct the odor to some scrubbing equipment such as activated carbon filters which are relatively cheap and easy to operate.

The construction phase of the project was uneventful. Things went as they were supposed to and no real problems surfaced during the construction that created any major delays or additions in the cost. The only real problems that the treatment plant faced and have faced to this day are laughable. The entry to the administrative building has a lower entrance and an open stairway that leads to the offices and labs upstairs. It was discovered as the finishing to the building was being completed that the lights in this entry staircase could not be reached. No ladder could reach high enough and the spaces were to tight to allow lifts in to solve the problem. The solution was to use light sockets that allowed the bulbs to be popped out. This cost the city an extra $179. The only other problem was the operation of the door. The mechanical door has been a problem since the first day, and has just been replaced last June. Again this problem did not hinder the operations of the treatment plant in anyway.

In terms of the impact of the construction of the plant on the surrounding community, again not much can be said. The contact at the zoo said that the construction did not in any way create problems of noise, cleanliness or traffic for the visitors to the zoo. Some accommodations needed to made to some of the behind the scenes areas of the zoo, but the arrangements were always made with plenty of lead time so as not to create confusion or problems. This is a testament to the professional way in which the project construction was planned as well as executed. Often times it is the lack of planning for such things as equipment movement or positioning, which were some of the things the zoo had to deal with, that get overlooked and become problems.

The communities close to the project had so little to complain about that there is no record of a single complaint about the construction. The plant location is immediately next to any neighborhoods but is close enough so that if a problem existed some one would notice and complain about it. Some of the engineers contacted about this project felt that part of the reason for the lack of complaints was the proximity in time to the 1989 Loma Prieta earthquake. The construction was taking place in the early 1990's and the public was accepting of some construction to rebuild from the earthquake. Also many people were much more involved with a project to rebuild the freeway that runs along the tourist-laden waterfront. It was felt that it was more important to preserve the water front than to quibble over small problems at the new treatment plant.

ENGINEERING[7]

The company that won the bid and designed the treatment plant was CH2MHill, a Denver, CO based company that was working in association with the Bectel corporation. The design team had a tough task in front of them, not only did they have to design a treatment plant from scratch because no plant had ever been built with this much of it underground, but they had do stay within a tight budget. It was this eventual success of a great product at a price well within reason and budget that defined this projects success.

Treatment Process Description

The secondary treatment process recommended in the 1988 Southwest Water Pollution Control Plant Facility Plan Technical report written by the city engineers as a proposal for the treatment plant to replace the Sunset – Richmond Plant, is the high - purity activated sludge[8] process with anaerobic digestion, employing egg- shaped digesters. Specific unit processing include preliminary treatment, primary treatment, secondary treatment and disenfection. The specific description of the technology used in each step and the purpose each process carries will be discussed in each sub section more thoroughly.

Preliminary Treatment

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[7] All information about the treatment process was taken from a handout produced by the City of San Francisco. Some additional information was found in texts as well as the interviews with the engineers.

Preliminary treatment consists of influent flow measurement, fine screening, and grit removal. Wastewater enters the headworks through a 48- inch force main from the Westside pump station (WSPS). Since the pump station was built before the Oceanside plant the Department of Public Works (DPW) modified the pump station to meet the hydraulic requirements at the plant influent. The WSPS discharge to the OWPCP is equipped with a magnetic flow meter. This device provides the OWPCP with influent flow measurement.

Influent to the Pretreatment/Solids Building from the WSPS enters a riser box and discharges through three motorized gates to fine screening. Fine screening of the wastewater ahead of primary treatment is necessary to protect the delicate equipment such as pumps and heat exchangers from dangerous heavy solid objects. The DPW replaced the existing, unreliable ¾- inch opening bar screens in the WSPS with trash racks having 2 1/8-inch openings.

At the Oceanside Plant three "climber" Screens, each with 1/2- inch openings between bars, fine screen the influent flow at the Pretreatment/Solids Building. These units were selected over continuous self- cleaning bar/filter screens and catenary screens. The screening system includes conveyors to deliver the screenings to a screening storage hopper, sized to contain three days of accumulated screenings.

Screened plant influent discharges to three grit tanks. Normally only one unit will be online, with the second unit placed online during wet weather. The third unit is a

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[8] Sludge is term used to describe the solids that are removed from the watsewater

standby during wet weather flows. Vortex grit tanks were selected over longitudinal gravity and aerated tanks because of space requirements, anticipated superior performance, and environmental factors, especially odor control. The grit removal system includes grit pumping, cyclone separation and classifier washing. The washed grit is discharged to an enclosed storage hopper capable of containing three days of grit accumulation.

The technology for pretreatment is fairly standard and the plant has mostly industry standard equipment except where noted and the choices made by the design engineers reflect personal preference based on experience and cost and space affectiveness.

Primary Treatment

Primary treatment includes primary clarification, primary sludge in-tank thickening, primary sludge pumping and primary scum handling. The degritted and screened wastewater is divided into five streams in the Pretreatment/Solids Building; one stream to each of five rectangular primary clarifiers. The purpose of a clarifier is to separate by gravity the waste solids and the water. Each stream flows through a magnetic flow meter and then into the respective clarifier where most solids settle to the floor of the tank. The clarified wastewater is removed by submerged launder[9] pipes located at the opposite from where the wastewater enters the tanks. The decision to remove the clarified water from the bottom of the tank as opposed to the surface was due to noise and odor considerations as well as moisture accumulation in the operating space above the tanks. The use of five tanks instead of one or two larger tanks is to maintain excess capacity if needed in wet weather and to have redundant systems for repair or maintenance.

The settleable solids (primary sludge) is concentrated by in- tank thickening rather than by separate tank thickening, this is another example of space considerations design because all of the primary and secondary treatment is done underground making space a valuable commodity and a driving force in most design decisions. Longitudinal sludge collectors equipped with variable speed drives scrape the settled primary sludge from the primary clarifiers floor and deposit this sludge into the primary clarifier hopper area. A deep (6- foot) primary sludge hopper with a variable speed sludge cross collector is provided to assist the in-tank thickening process at each primary clarifier.

The thickened primary sludge is pumped from each primary clarifier by two progressing cavity sludge pumps per primary clarifier into two sludge headers/pipelines. Each pump can discharge into either header, which in turn discharges to the feed tank. Each operating pump is controlled by timers, which may be overridden by a low solids concentration signal from that pump's sludge density meter or a "low" sludge blanket level signal from the respective primary clarifier's ultrasonic blanket detector. The primary sludge pumping system is designed to accommodate the large range in sludge

[9] Type of non corrosive pipe used in waste water treatment

quality and volume. The variation occurs due to wet weather and the flushing of the Westside Transport System[10].

The wastewater entering the clarifiers also contains grease and scum which does not settle like the solids that make up the sludge. The grease and scum mostly rise to the surface where it is collected using a series of spray nozzles, scum skimmers and troughs. The collected primary scum is gravity fed to two primary scum pits which use two scum breaker type pumps that chop and mix the primary scum. An indicator controlling level activates pumps to discharge the contents to the scum concentrator. The scum concentrator is based on a DPW conceptual design and is located contiguous with (and will discharge to) the digester feed tank. The scum concentrator is a simple, gravity separation design and is capable of receiving secondary scum flows as well as primary scum flows. A manhole opening is provided for tanker truck pumping of the scum concentrator contents.

Secondary Treatment

The goal of secondary treatment is to further remove solids from the wastewater and improve the chemical makeup of the water so that it may be able to be discharged as effluent. The secondary treatment at the Oceanside treatment plant consists of a high-purity activated sludge process, secondary clarification and return activated sludge (RAS) pumping. Primary effluent flows entering the secondary treatment process are measured

[10] West-side transport system is used to collect and transport sludge from all parts of the west half of the city to the oceanside treatment facility

with a 54-inch magnetic flow meter. Flows less than or equal to 43 MGD are treated to secondary effluent quality, flows in excess of 43MGD are blended with the secondary clarifier effluent and disinfected at the chlorine contact channels.

The biological treatment oxygen dissolution system consists of three parallel trains, each composed of six stages in series. The first, second and third stage can, in the future be converted to operate in the anaerobic anoxic mode should further studies and research conclude this is needed for control of Nocardia[11] and or to produce a measurably better settling secondary sludge.[12]

Initially these first three stages and the second three stages were equipped to operate in the aerobic mode. The first three stages are 31'W x 31'L x 14'SWD (Sidewall Depth). The last three stages are 38'W x 38'L x 14'SWD. Each stage is provided with an aerator equipped with both a surface aerator impeller and a bottom mixing impeller. The size and power draw of the aerator impeller decreases from stage one through stage six to match the anticipated oxygen demand and gas-phase oxygen purity conditions. The purpose of the aeration of the sludge is to aid in the breakdown of the sludge into products that can be more easily disposed or recycled. The high-purity oxygen activated sludge process was selected to minimize space requirements, facilitate the containment and collection of odors and aerosols and optimize treatment of the variable strength wastewater expected at the Oceanside facility.

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[11] Bacteria commonly found in Wastewater
[12] At the time this research was done, this was not necessary

A 30-ton per day pressure swing adsorption (PSA) oxygen generation plant supplies the project oxygen requirements for the secondary treatment system. It was determined in studies that a plant on site would be more economical and efficient than bringing in oxygen. However a back up system with a 3-day supply of liquid oxygen is kept in a storage system in case of failure or for high oxygen demand conditions. The liquid oxygen system is tied into the PSA system to automatically make up oxygen deficits as indicated by falling pressure in the aeration basins or if the PSA shuts down.

The major components of the PSA system include feed air compressors, air-cooling and drying systems, absorbers and control instrumentation. Three compressors provide compressed air to the PSA system after being discharged through an aftercooler. The cool, dry air then passes into one of the PSA adsorbent vessels rendering a 90-percent pure product. The reason the compressed air must be scrubbed and purified is to provide maximum affectiveness in the treatment process. The reason for having three beds is so that one may be used while one is being purged for reuse and still have one on standby in case of any sort of failure.

Mixed liquor from the aeration basins discharges to the seven secondary clarifiers where the biological solids are separated by gravity from the treated wastewater. The clarifiers are 15.5 feet deep at the ends and 16.5 feet deep adjacent to the center sludge hoppers where the sludge is removed from the tanks. The added deepness in the center helps to collect the sludge making it easier to remove. The inlet channel to the secondary clarifiers is aerated to assist stripping of carbon dioxide and maintain the biological solids in suspension. Flows into each clarifier are controlled by a high headloss inlet port and adjustable sluice gates. V-notch weirs on surface launderers control the water surface elevation in each clarifier.

Secondary scum is collected from each clarifier with a chain and flight mechanism and discharged, using a helical scum collector, into a scum trough. The scum gravity feeds from the scum troughs to two scum pits. The recessed impeller centrifugal pumps at each scum pit move the scum to the concentration system, discussed earlier under Primary Treatment, or to the plant headworks for recycle with the influent flow.

The design and equipment used in the primary and secondary treatment phases of the process were at the time very unique. Because of the underground construction and the limit on space, many newer technologies were used and adapted to the needs of the plant. The use of some equipment and designs were not based on economics but rather on necessity. Often times in public works projects, the top of the line equipment is not used because of cost considerations but because of the nature of this project, the cost was overlooked in many aspects and that was most apparent in this part of the plant. What was interesting was that even with many fancier technologies the overall cost of the plant was still very reasonable.

Disinfection

The State Regional Water Quality Board's "Ocean Plan" requires disinfection as the final step in wastewater treatment before discharge into the ocean. Studies done at the Ocean Outfall discharge point show that bacteria in the Richmond- Sunset primary effluent experience die- off in the salt water. Therefore operation of the Oceanside disinfection system is not anticipated on a continuous basis. It will still be necessary to provide for full effluent disinfection during potential violation periods such as periods of high rainfall in the early spring.

Disinfection is accomplished using sodium hypochlorite, a compound similar to household bleach. Because chlorine can be harmful to the aquatic environment, the plant effluent is dechlorinated using sodium bisulfite. The choice of these chemicals was based on city, county and state regulations as well as cost and ease of handling and storage. The sodium hypochlorate is mixed with the secondary effluent in the influent channel of the chlorine contact channels. Because initial mixing and subsequent contact are critical for effective disinfection, several alternatives were considered for each subsystem. The selected alternative for mixing is injecting sodium hypochlorate solution immediately upstream of a static mixer. Three chlorine contact channels are provided. They are sized and configured to meet the design criteria and site constraints. Sodium Bisulfite is added just upstream of the effluent Parshall flume[13]. The flume provides a means of measuring flow as well as the necessary mixing required for good dechlorination.

Sludge Thickening

Waste activated sludge, which is removed from the wastewater at various points in the treatment process, primarily at the clarification steps must be thickened in order to be disposed of easily. Thickening includes waste activated sludge pumping, and gravity belt thickening, and thickened sludge transfer. In the design process options other than gravity belts, such as centrifuges and dissolved air floatation units, were looked at but the gravity belts proved to be the most reliable and were well suited for the sludge being handled at the plant. It was decided that Three 2- meter belt thickeners was the most cost- affective set-up. For each of the three belts there is a dedicated screw centrifugal pump with variable speed drives.

Sludge Digestion

From the Gravity thickening belts the Waste Activated Sludge is pumped by progressive cavity pumps to the digester feed tank. The sludge is then digested. The purpose of sludge digestion is to use microscopic organisms to remove certain pollutants that are harmful from the sludge and to break it down as much as possible and stabilize it. The primary and waste activated sludge is digested anaerobically. The anaerobic digestion process includes four single-stage egg- shaped digesters operating at the optimum temperature of approximately 95 degrees Fahrenheit. Egg-shaped digesters

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were chosen over conventional digesters because of their superior mixing and heating characteristics and their much-reduced cleaning requirements. The reduction in cleaning is very important because cleaning is a major source of odors and since the digesters are outside and near the zoo property the reduction of odor was crucial. The total digester volume is Million gallons which is equivalent to 24 days of retention time which is an average load with all units is operation. At the time of the design of this plant, egg-shaped digesters were a very new technology and were in use in only a few treatment plants world-wide but they have now become the standard equipment due to their excellent design and benefits such as improved odor control.

Primary sludge, concentrated scum and thickened waste activated sludge are blended in a digester feed tank and then pumped sequentially to each digester. The sludge entering the digester displaces digested sludge, which flows by gravity to a digested sludge day tank. The contents of the tank are pumped to the plant sludge dewatering facilities. The digester temperature is maintained at 95 degrees Fahrenheit by pumping the digester contents through spiral heat exchangers. Hot water for the heat exchangers is provided from the energy recovery system, which will be discussed later. The digester contents are mixed by an external pumped mixing system that provides a turnover of eight digester volumes per day.

Gas is produced as a result of the destruction of volatile solids within the digesters. The gas is collected from the top of each digesters and flows through two gas purifiers to remove hydrogen sulfide from the methane, which is the major product and the desired gas to be recycled in the energy recovery system. The gas is passed through the purifiers and kept in a low-pressure holder tank. The gas holder tank also serves to maintain the pressure in the digesters at 20 inches of water. If pressure builds in either the tank or the digester a safety valve releases gas in the holder tank to the Waste Gas Burners which burns off all of the digester gas.

Energy Recovery

The purpose of the Energy Recovery Facility is to use the gas produced by the anaerobic sludge digesters, supplemented by natural gas as required, to fuel engine generators and hot water boilers. The engine generators produce electrical power for the plant and provide emergency power during PG&E power failures. Both the engine generators and boilers produce hot water for plant process and heating, ventilating, and air conditioning (HVAC) heat requirements. In a power failure, with two engine generators online, this facility provides about 1/3 of the normal daily power requirements.

The engines are 550 kW generators. Thermal energy rejected from the engines heats water to maintain proper digester operating temperatures and to provide hot water to the treatment plant heating and dehumidification systems. In addition, two boilers are used to assist the engine generators to meet plant heating loads and to provide heating system redundancy if the engine generators are out of service. During normal plant operation there is sufficient digester gas to operate two boilers and one engine generator.

COST

The most important factor in measuring the success of the project can be to analyze the total cost of the project. Many public works projects that are constructed and serve their original purpose can be thought of as failures because the final cost of the project is significantly higher than was originally planned. The real problem with the cost of public works projects is that the final cost is rarely anything close to the estimated and bid cost. The reason for this is public works contracts are awarded to the lowest bidder, so what happens is that a company will underbid the project so they can get the contract. Once the company has the contract and the project is underway, and usually over budget, the contractor will issue a change order to increase the cost. Some projects may have millions of dollars in change orders and the project will cost much more than originally projected. This practice is extremely common an din many cases accepted and the result it has is to upset the people who are paying for the project and its change orders

One way of measuring the excellence of this project is the final cost. The design estimated $250 million and the project had a final cost of $256 million, a mere 2.4% over budget. This number is truly remarkable. In today's construction world, under-budgeting is common and accepted practice so for a major construction project to come in so close to budget borders on miraculous. This again is a tribute to the contractors, design and managing engineers for their ability to expect and be able to deal with the problems and not create cost increases. This lack of increases in cost kept the project out of the newspapers, which love to tell the taxpayers how their money is being wasted.

Because the relative inconspicuous nature of this project, mainly because of the cost management, nobody could criticize it.

One of the major arguments against the proposal to build the new plant underground was the cost increase that would come. At first people assumed that because the treatment plant was going to be underground it would increase the cost drastically. What people and even the design engineers at first didn't realize is that all that was being done was putting a roof over the treatment plant. A report was prepared with the final design proposal showing the cost of the treatment plant and the relative cost to build the same treatment plant above ground. The above ground plant would have cost $211 million dollars as opposed to the $250 million that the below ground design was expected to cost. When this was displayed people began to realize that this project was going to be better than they ever expected. What is somewhat humorous is that what was originally a requirement to build the plant underground became an advantage. For a minimum of cost the treatment plant for all intensive purposes, was disappearing, never to be seen by the public or the millions of tourist that drive right by the treatment plant on highway one every year. This feature of the treatment plant has been featured in many engineering magazines showing how a plant can be built that, for a limited cost can have minimal impacts on the surrounding community.

The money for the project came mostly from the federal subsidy created by the Clean Water Act. The CWA paid for eighty cents on the dollar. The remaining money came mostly from loans the city took out from the state called revolving loans. These are low interest loans that can be extended based on the cost of the project and the extension does not cost any more. Very little money was taken from city taxes to fund the project making it very popular with politicians and the people of San Francisco.

Overall the cost of the project was managed extremely well and the engineers were able to maintain the budget set out at the beginning of the project. The cost management is arguably the most important task if the project is to be considered a success. If the public doesn't hear anything about the cost overruns and change orders increasing the cost than the public wont even think about the project, not to mention criticize it. The cost management is also the most difficult to control because the contractors that do the actual construction often will knowingly underbid the project and force the cost increases after the project has begun. In this project the contractors did what the promised to do and the engineers did their jobs extremely well by properly managing the contractors as well as the entire project cost and keeping it close to budget.

PUBLIC RELATIONS

Because of the proximity of the treatment plant to residential neighborhoods, a public beach and the zoo, one way to determine the success of the project is determine the impact on the community. The public utilities commission, which operates the plant, has monthly public meetings, at which citizens are allowed to voice their complaints. Also the Zoo has a special coordinator by the name of Peggy Burkes who is in charge of overseeing all construction on or near the zoo grounds. Finally it is the treatment plants duty to monitor the waste water levels on nearby Ocean beach to make sure that no contamination is being deposited on the beach from the treatment plant as well as the level of odors in and around the treatment facility.

The Public Utilities Commission, which is headed by a WPI alumni, had asked to have a public coordinator for the Oceanside treatment plant to handle public complaints and issues. However, because the public made so few complaints, the position was terminated. The plant has maintained a very close relationship with the zoo ever since construction began, and according to the construction coordinator for the zoo, the treatment plant has been an excellent neighbor ever since construction began and to the present day[14]. The last neighbor of the facility, Ocean beach has not once had to close because of discharge from the treatment plant, nor have any toxic levels increased as a result of the new plant.

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[14] Based on conversation with zoo coordinator Peggy Burkes, 02/17/99

It is safe to say that the treatment plant has had a negligible impact on the surrounding community and in fact has improved the areas overall appearance. The City of San Francisco requires that any public works project must spend a certain percentage of the cost of the project on aesthetics. The treatment plant is covered by a retaining wall of dirt, which has been landscaped, and in a lot where military vehicles used to be parked is now a professionally landscaped hillside.

CONCLUSION

The goal of this project was to determine if the Oceanside Treatment plant was a success and in the process try to also determine what makes a public works project a success. What I found was that it can be hard to call any public works project a success due to the fact that most spend a great deal of money and cannot meet high expectations that are placed upon them.

As for the accomplishment of my goal, I found that Oceanside is a complete success but some aspects of the success of the project were easier than others. The easy part was the image the treatment plant has in the eye of the public and the image it had during the design and construction phases. Any wastewater treatment plant that was built as a result of the Clean Water Act in the 1980's and early 1990's was funded up to 90% by the federal and state governments. This made success in the eye of the public virtually guaranteed because of the limited cost impact on the people. It is always easy for people to get behind a project when it doesn't cost them anything and even if there are some problems, they may be overlooked and dismissed as unavoidable. The attitude of the public is never as lenient when the money comes more directly from people's pockets.

The difficulty and the true measure of success in this project and others like it is the superior design and functionality of the plant. The engineers on the design team and the city management had a very difficult balancing act that had to be accomplished in order for the project to be completed without any major problems. As an engineer and a public servant which all of the engineers working for the city are, many people have an interest in this sort of project and to keep all or as many as possible happy throughout the process is a major accomplishment. This is exactly what the engineers were able to accomplish. Not only did they keep people happy but also they were able to produce an excellent treatment plant that met all the design and land use criteria. This may sound trivial but it is not. Many things can change through the course of a design and considering the time frame that this plant had, close to fifteen years from conception to completion, it is incredible the lack of changes that had to be made.

The goal of this project was to discover what it took to organize a public works project in such a way so that it would be viewed as a success. This project has shown that in order for a project to be a success it must be planned impeccably and the engineers in charge of the planning and construction must be able to coordinate a variety of interests. This project could have caught a hundred different snags that could have caused it to fail but because of the excellent planning and response of the engineers involved these snags were either avoided or never encountered. It is this ability to avoid problems and deal with the ones that do occur quickly and quietly that make a public works project a success.

What this project has done is show that government agencies are not filled with incompetent politicians filling in roles that they are not capable of filling. What I was expecting to find is that the treatment plant should have been built years before and when it was built was tremendously over budget and finished behind schedule. My image of politicians putting this necessary improvement for the community off for as long as possible to avoid any sort of controversy was wrong. What was most fascinating about this project is that it exceeded the expectations that were first placed on it. The project began as an ordinary design and construction but because of the very nature of San Francisco and its lack of land and the ingenuity of the engineers and the other circumstances that made this project exceed its expectations[15] and become a model for many cities to follow.

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[15] Oceanside has been awarded many design and operations awards and many densely populated cities have looked into the option of a below ground treatment plant due to the success of Oceanside.

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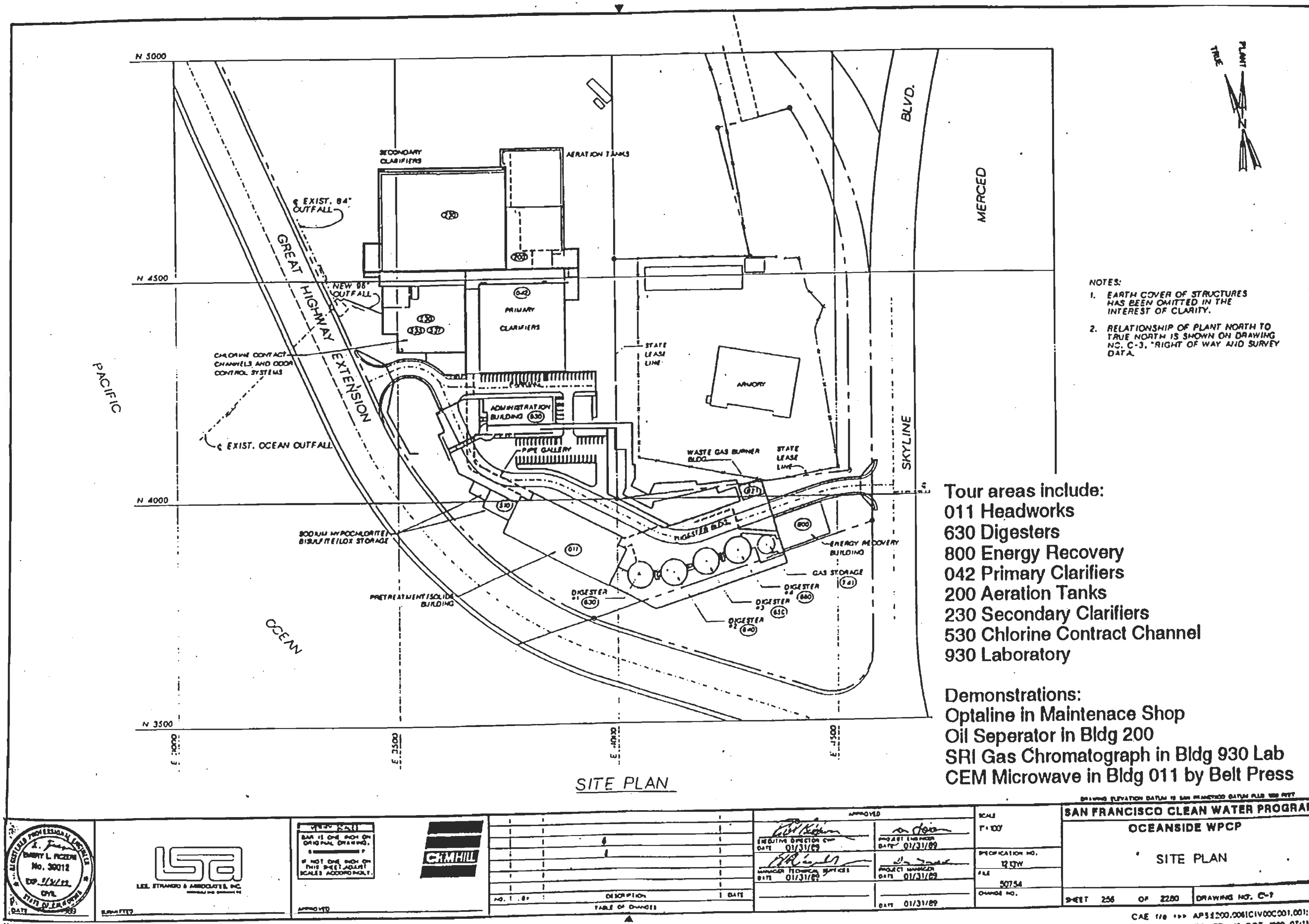
Wong, Jackson, telephone interview (11/06/98)

APPENDIX I

Engineering drawings of Oceanside treatment plant



Tour areas include:
011 Headworks
630 Digesters
800 Energy Recovery
042 Primary Clarifiers
200 Aeration Tanks
230 Secondary Clarifiers
530 Chlorine Contract Channel
930 Laboratory

Demonstrations:
Optaline in Maintenace Shop
Oil Seperator in Bldg 200
SRI Gas Chromatograph in Bldg 930 Lab
CEM Microwave in Bldg 011 by Belt Press

SMOKING IN DESIGNATED AREAS ONLY.

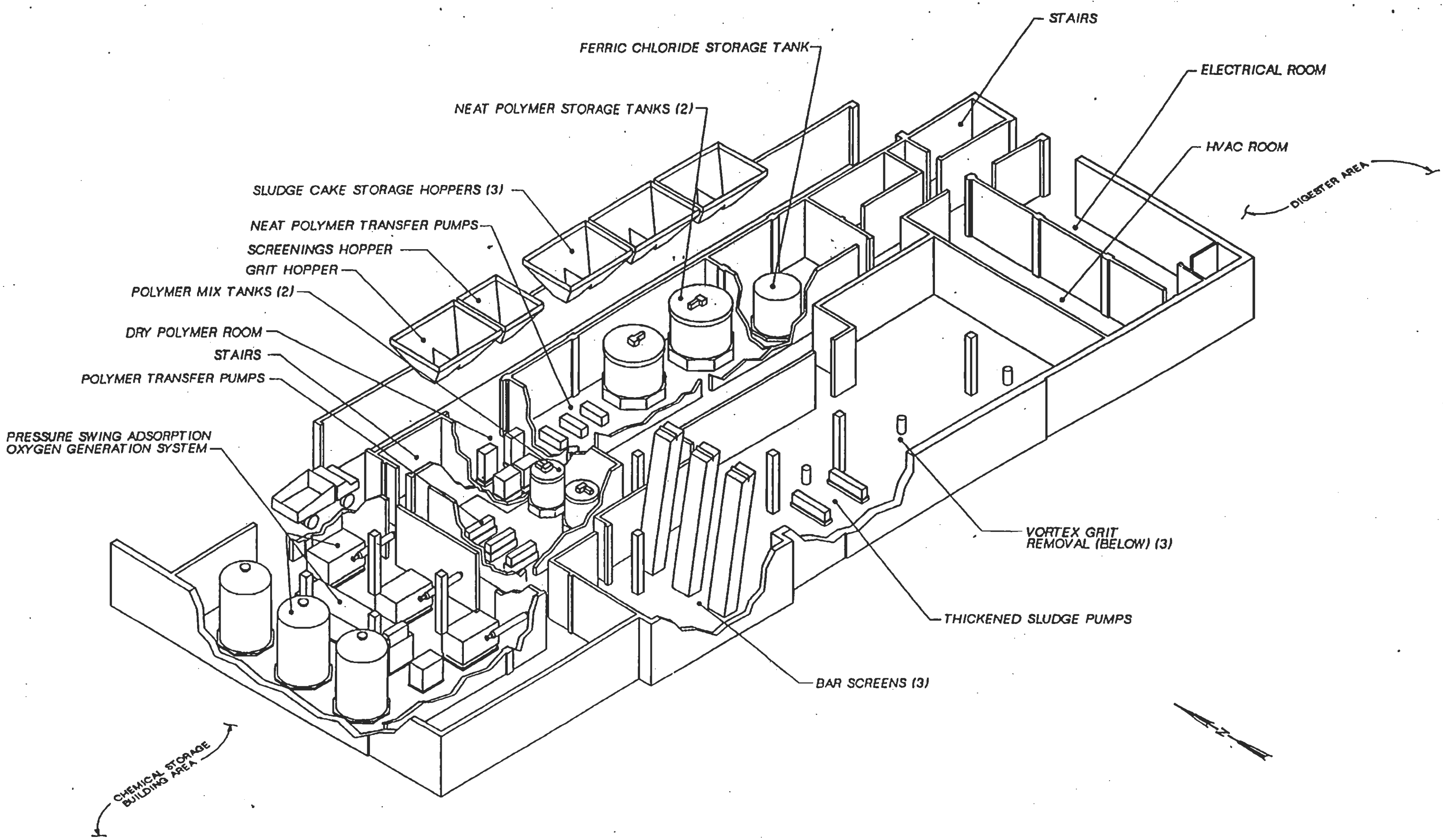


FIGURE 1
OWPCP PRETREATMENT/SOLIDS BUILDING (011) - FIRST FLOOR

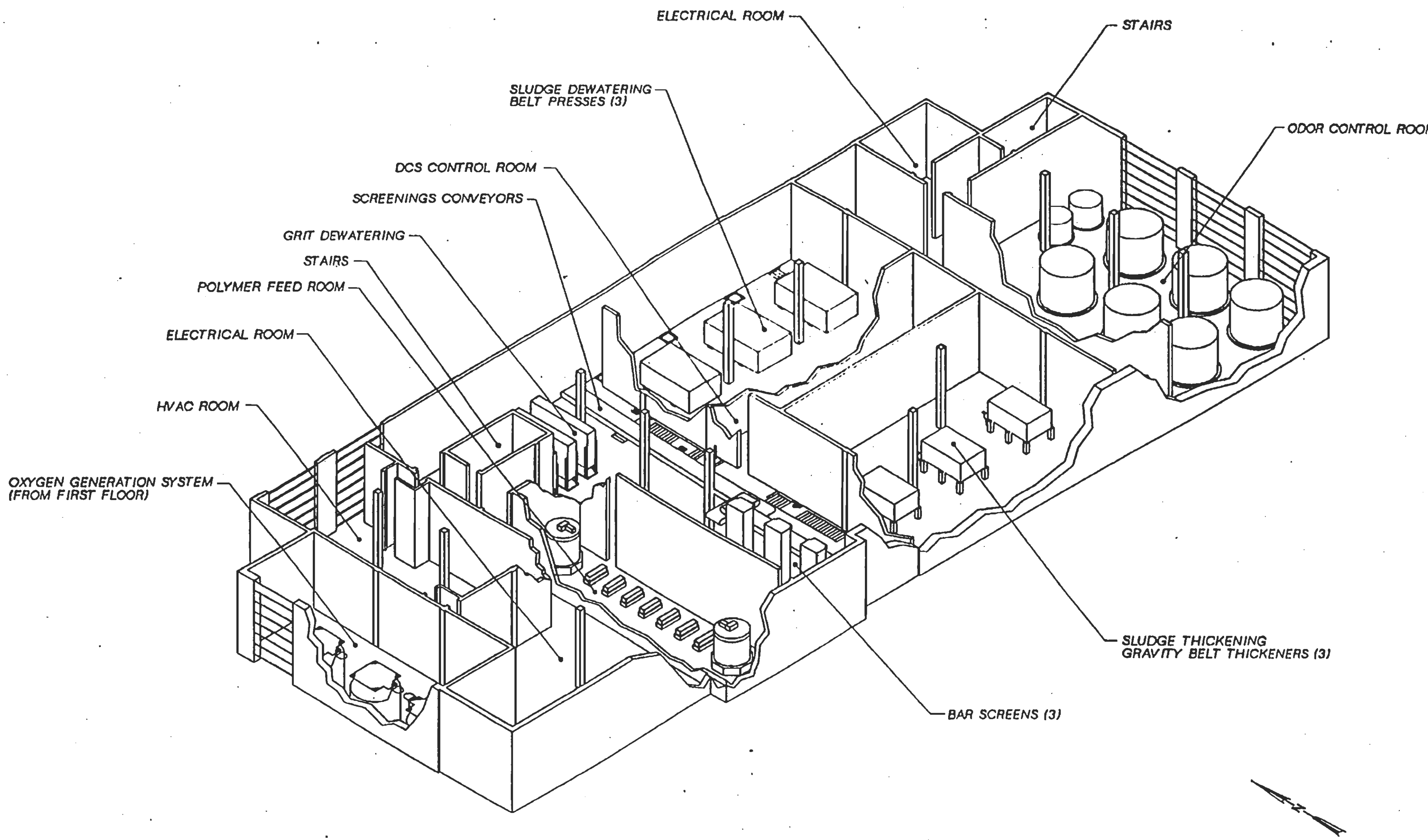


FIGURE 2
OWPCP PRETREATMENT/SOLIDS BUILDING (011) - SECOND FLOOR

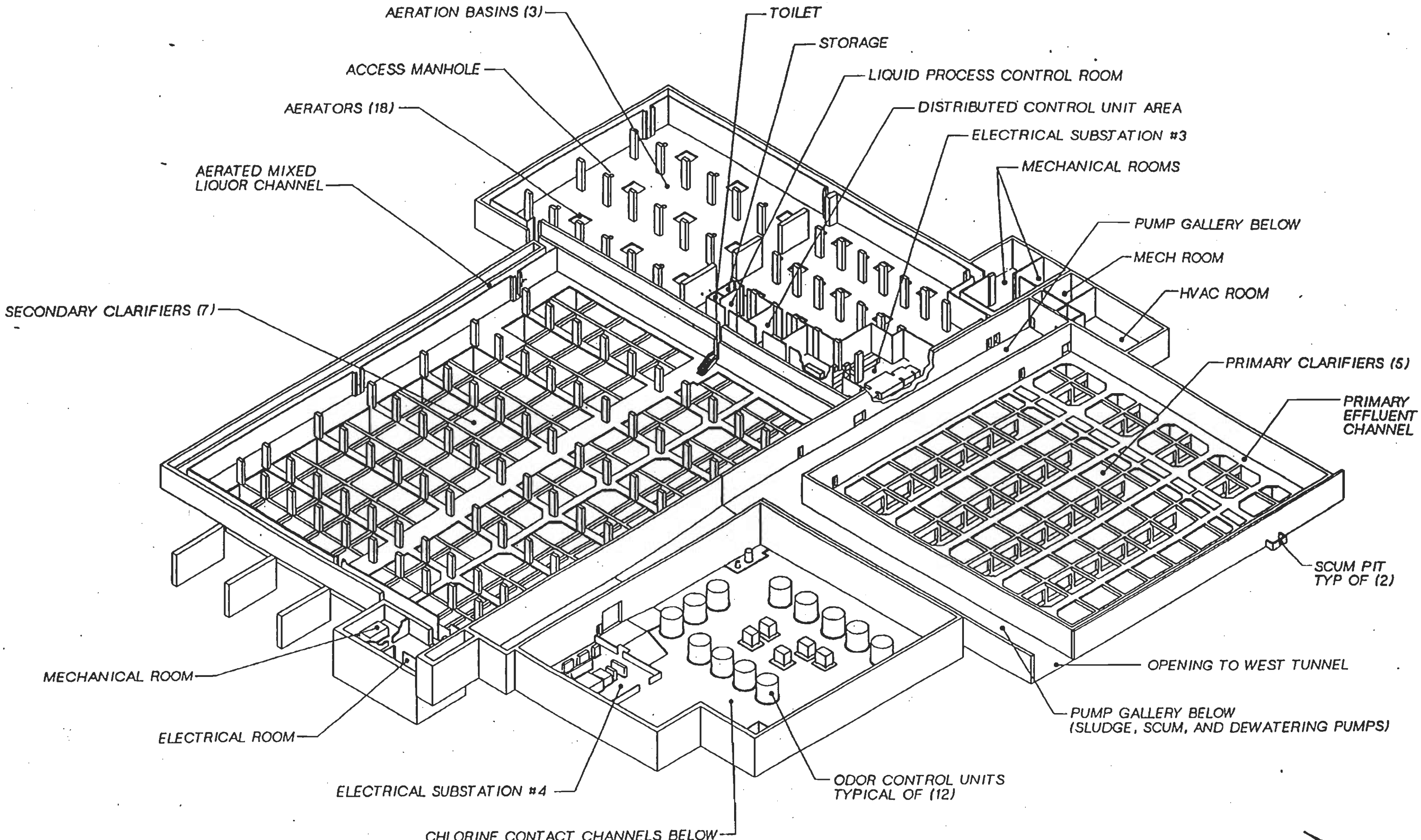


FIGURE 3
OWPCP LIQUID PROCESS AREA - OPERATIONS LEVEL
PRIMARY CLARIFIERS (042), AERATION BASINS (200),
SECONDARY CLARIFIERS (230), CHLORINE CONTACT CHANNELS (530)

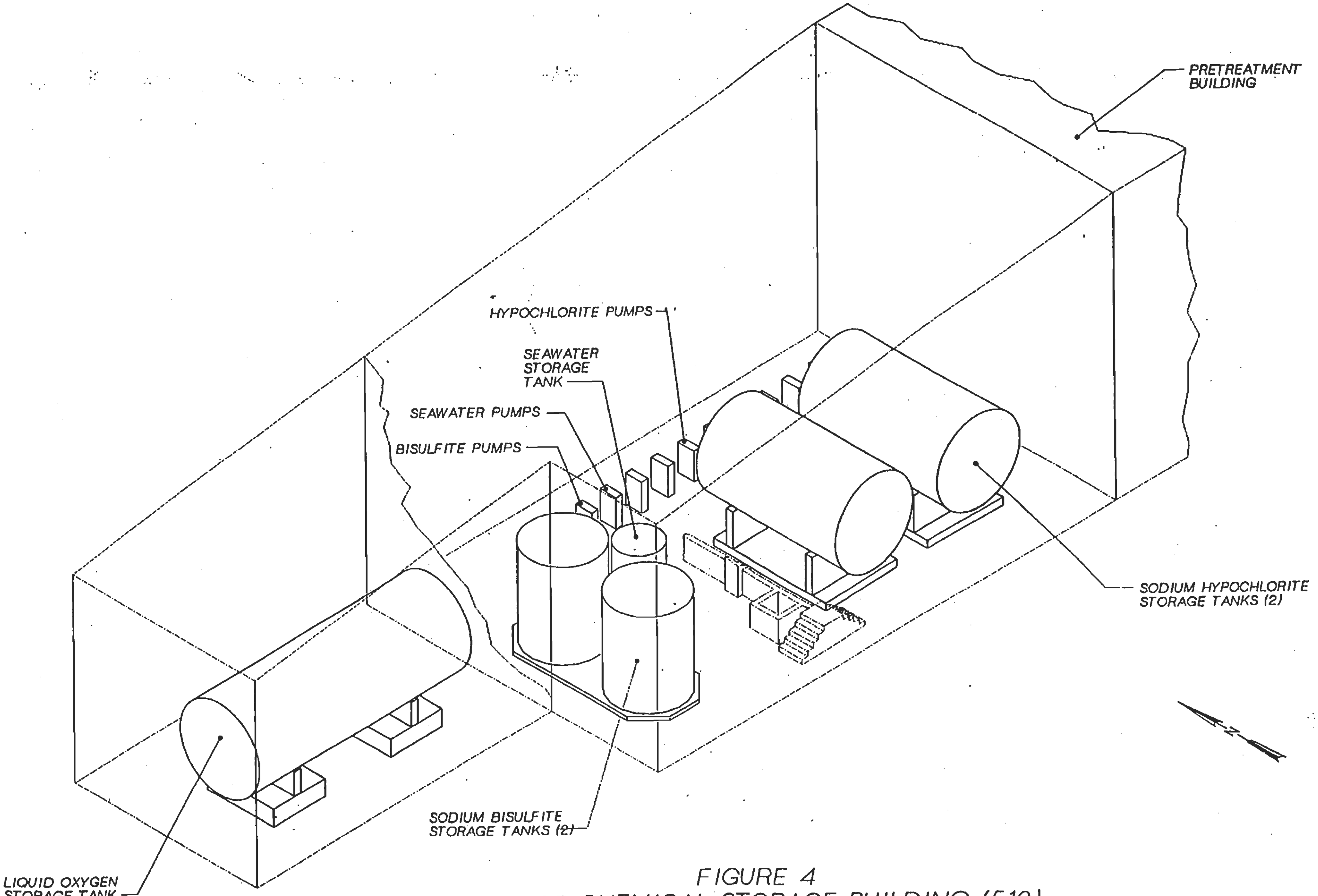


FIGURE 4
OWPCP CHEMICAL STORAGE BUILDING (510)
(CANYON IN BACKGROUND)

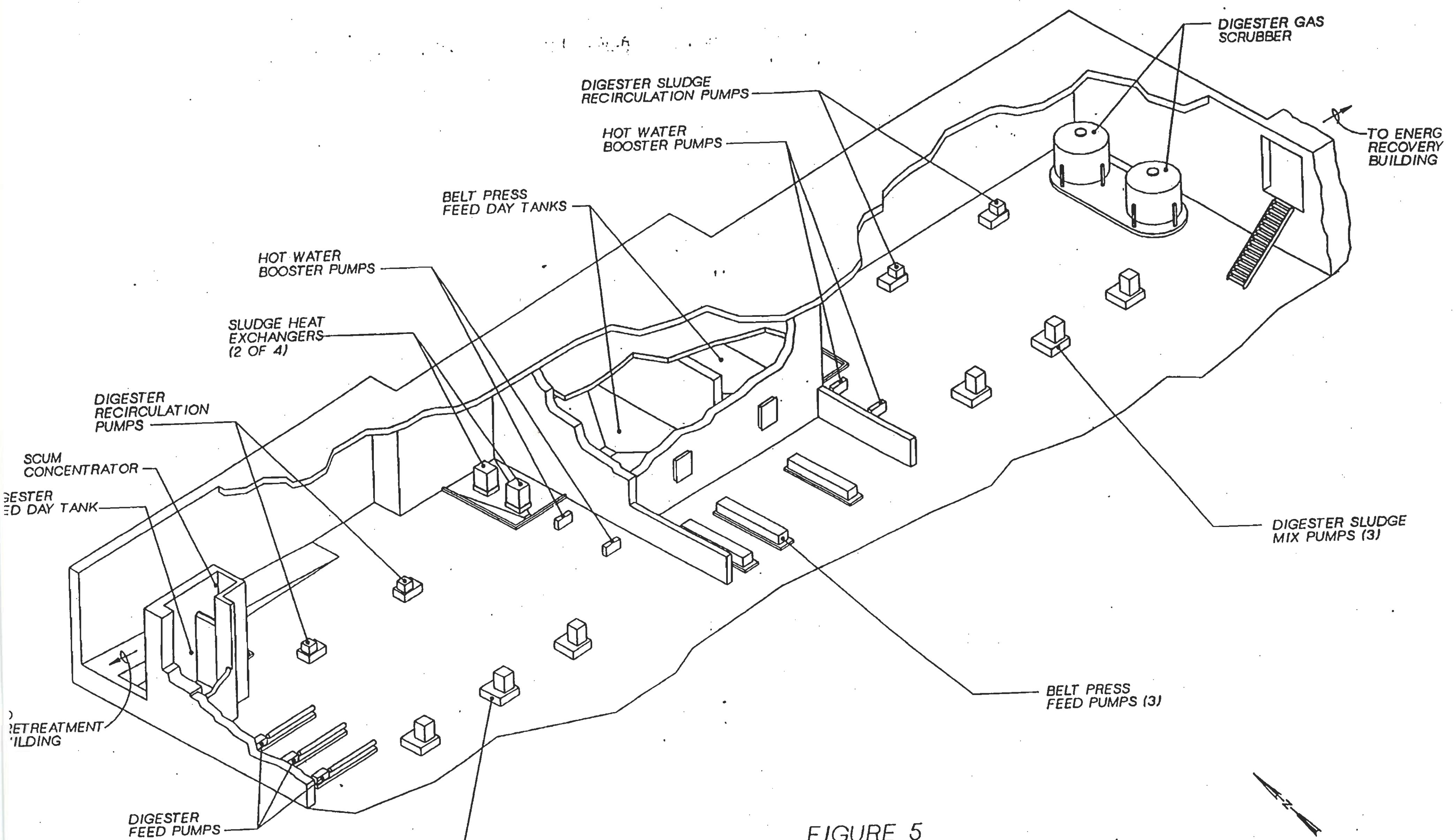


FIGURE 5
OWPCP DIGESTER GALLERY AREA (620)
(DIGESTER SLUDGE TRANSFER PUMPS AND DIGESTERS NOT SHOWN IN FOREGROUND)

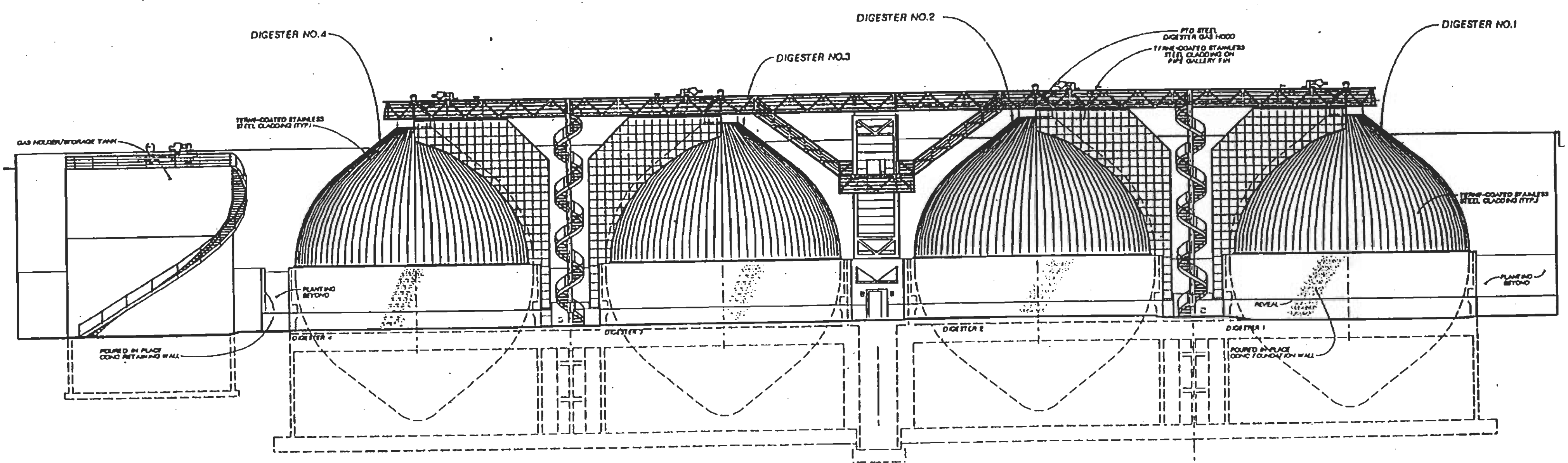


FIGURE 6
OWPCP DIGESTERS NO.1 (630), NO.2 (640), NO.3 (650), NO.4 (660)
OWPCP GAS HOLDER (741)

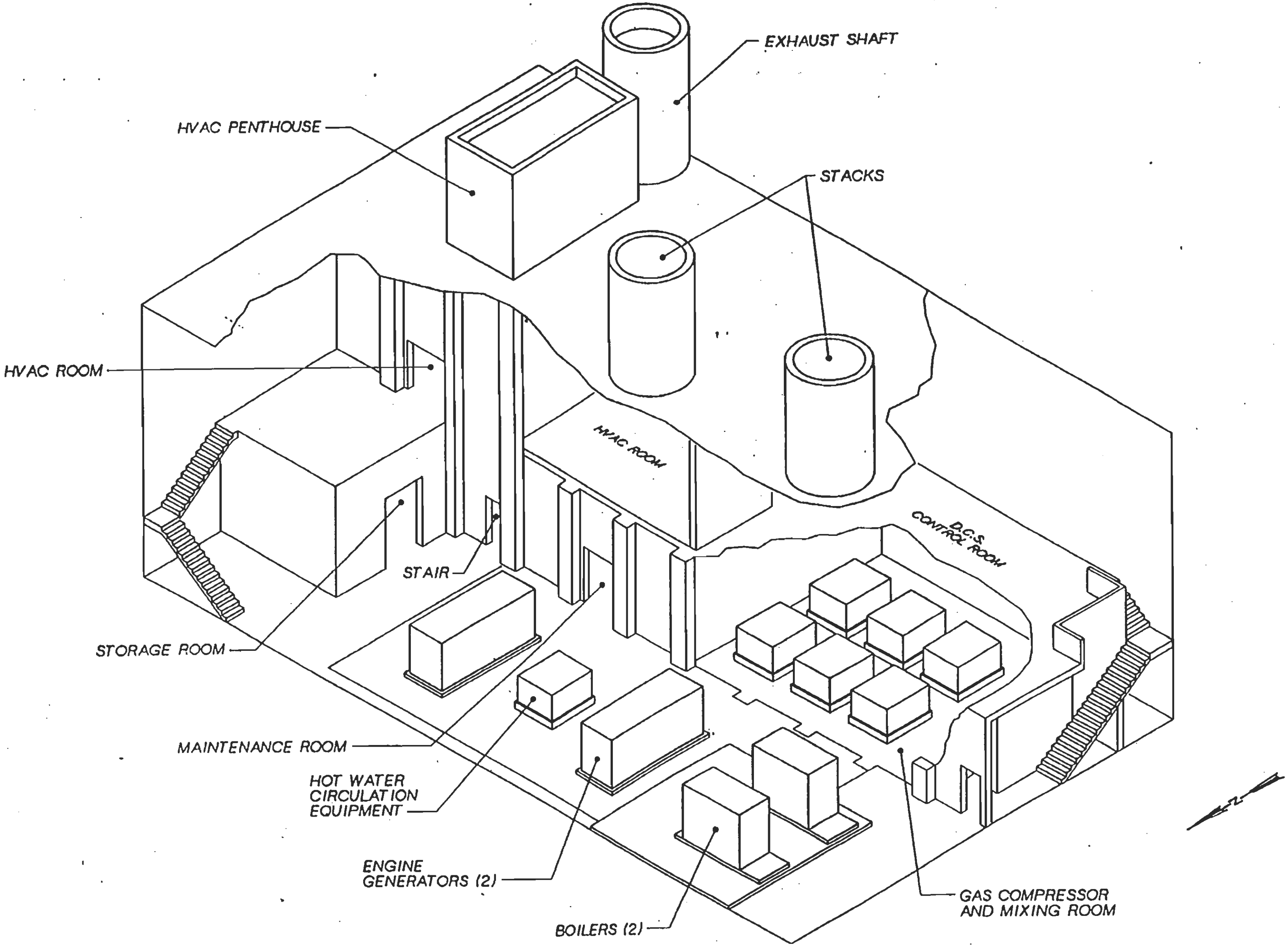


FIGURE 7
OWPCP ENERGY RECOVERY BUILDING (800)

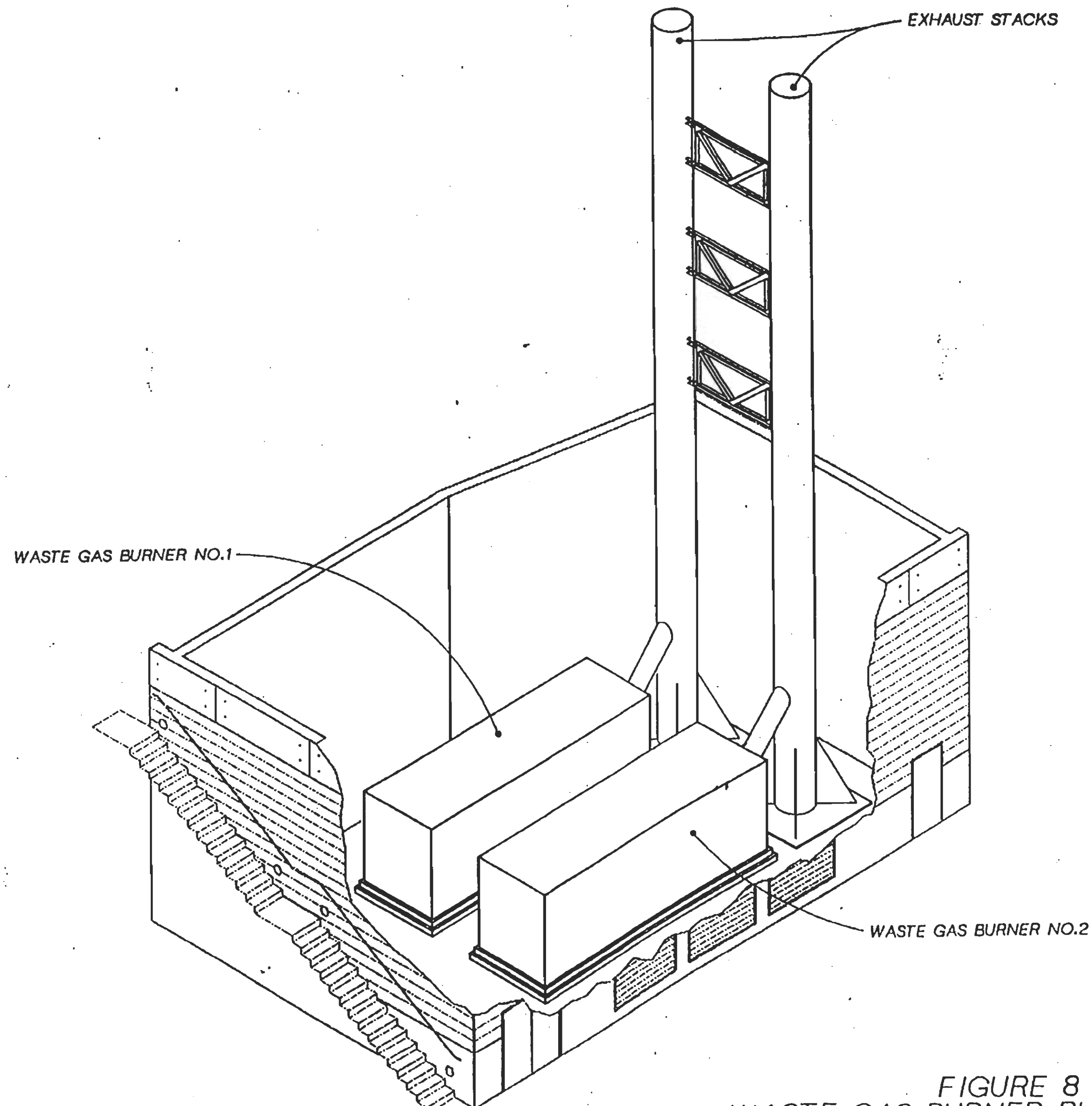


FIGURE 8
WASTE GAS BURNER BUILDING (821)

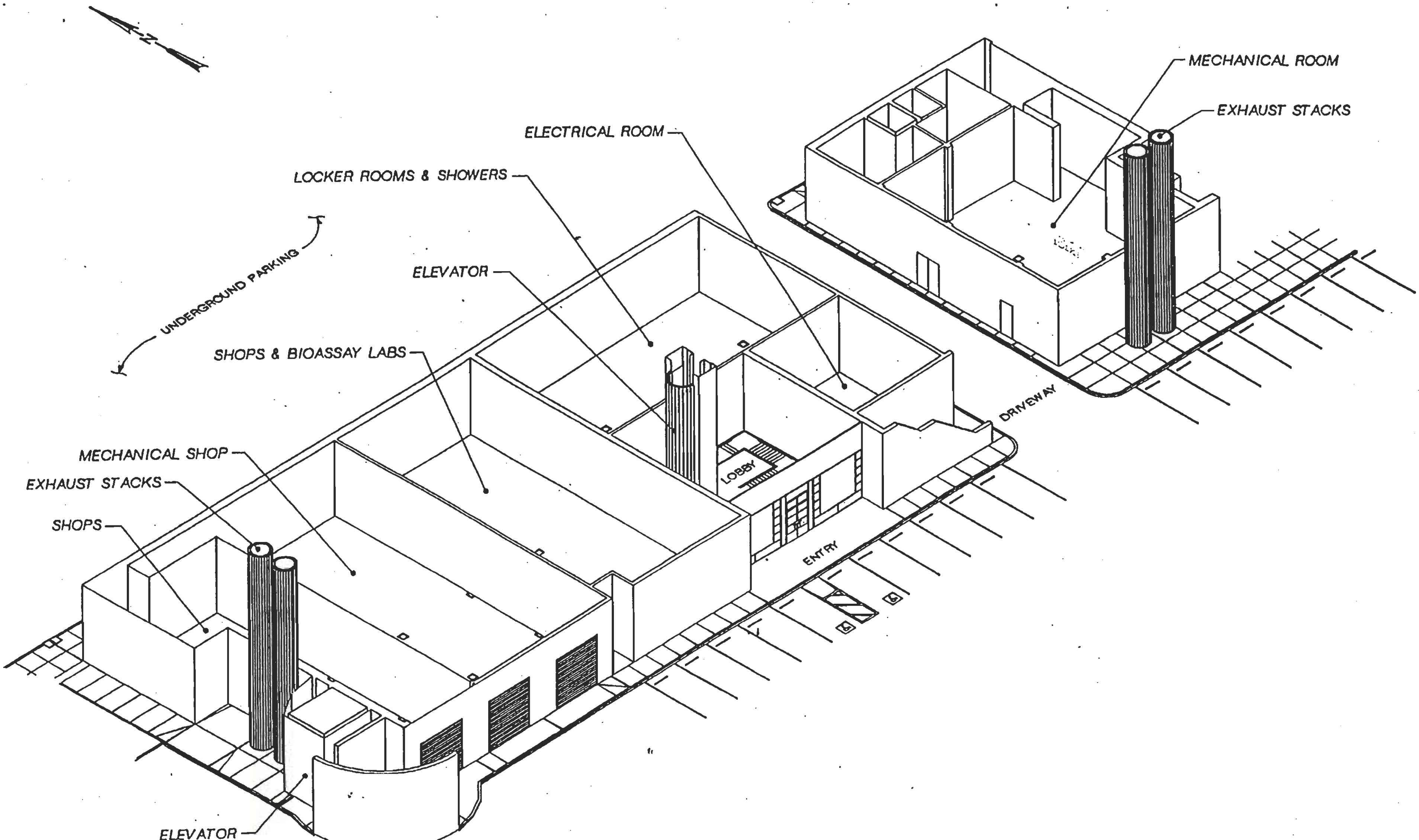


FIGURE 9
OWPCP ADMINISTRATION BUILDING (930) - FIRST FLOOR

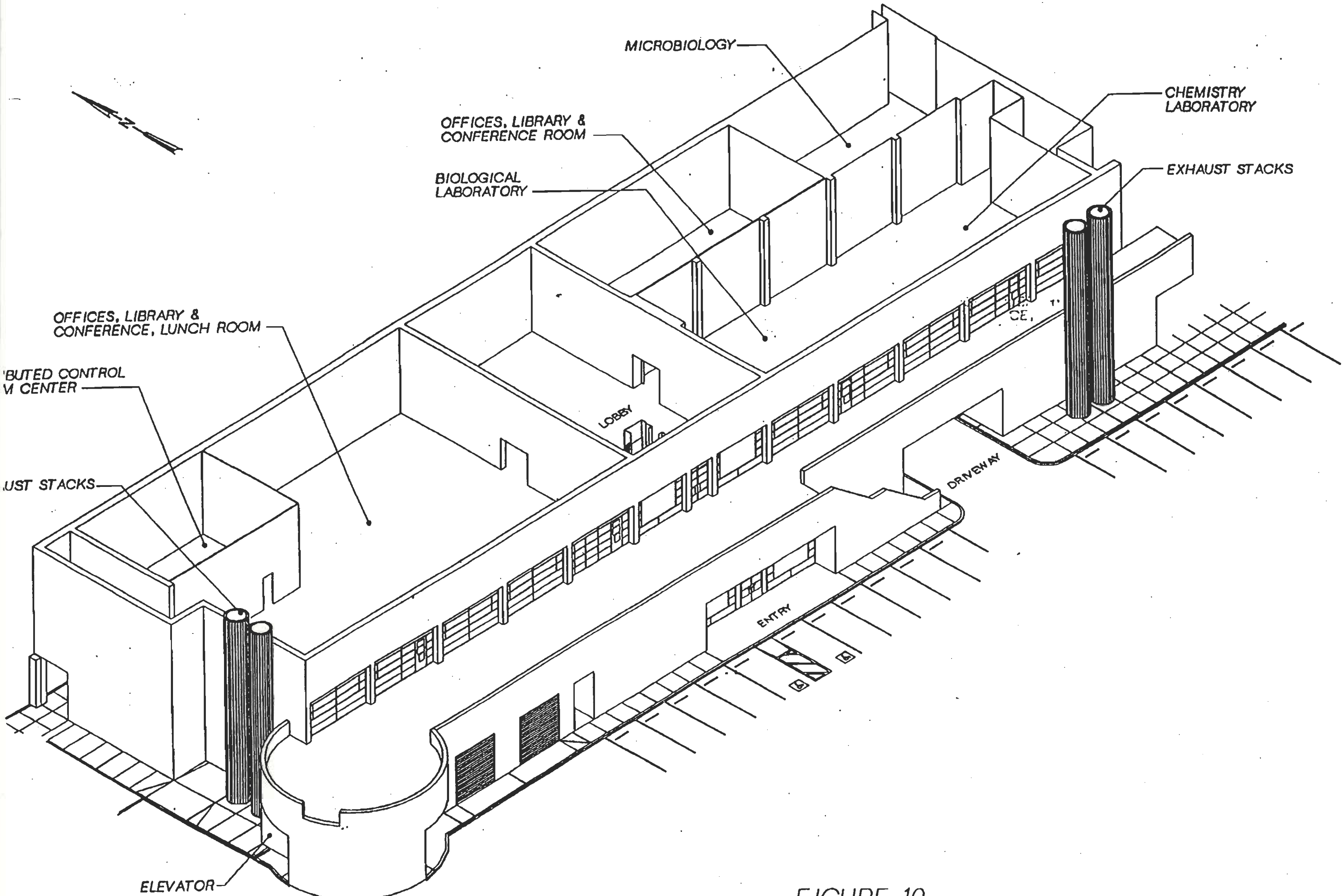


FIGURE 10
OWPCP ADMINISTRATION BUILDING (930) - SECOND FLOOR