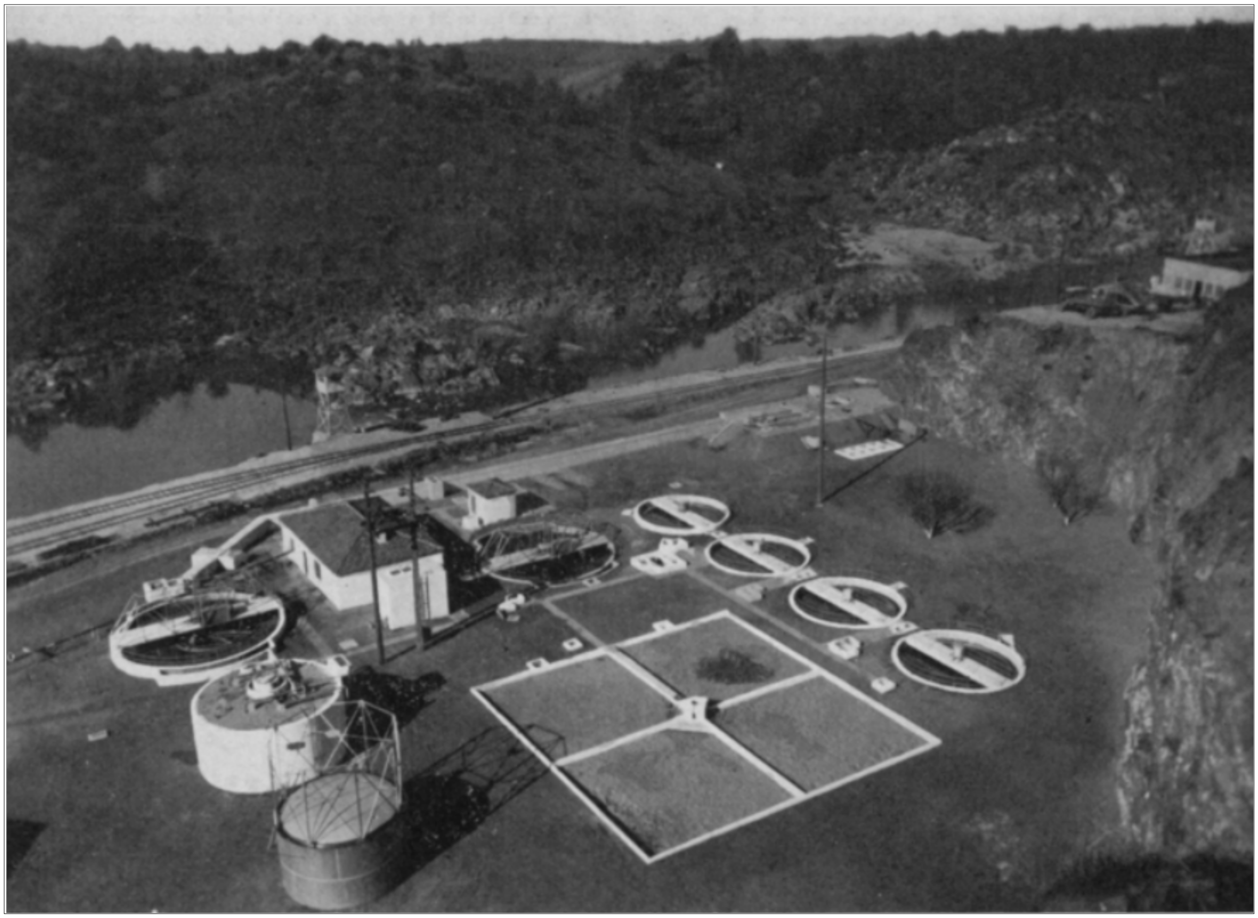
DRINKING WATER AND WASTEWATER TREATMENT FACILITIES IN CALIFORNIA

Historic Context and Research Design for National Register Evaluation



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1. INTRODUCTION

1.1. Study Objective and Scope

JRP Historical Consulting, LLC (JRP) and AECOM, in cooperation with Horizon Water and Environment and the California Department of General Services (DGS), prepared this statewide historic context and research design for drinking water and wastewater systems in California on behalf of the State Water Resources Control Board (State Water Board). The purpose of this study is to assist in the evaluation of drinking water and wastewater facilities to determine whether registration on the National Register of Historic Places (NRHP) and/or the California Register of Historical Resources (CRHR) is appropriate or necessary. This historic context and research design will assist applicants (and their consultants) who apply for funding from the State Water Board's Division of Financial Assistance (DFA) in complying with federal and state environmental requirements, including Section 106 of the National Historic Preservation Act and the California Environmental Quality Act (CEQA). This report may also be of assistance to other federal, state, and local agencies in the evaluation of these facility types.

The historic context provides statewide coverage of drinking and wastewater systems from the Spanish and Mexican eras to approximately 1980. The historic narrative focuses on the public health aspects of municipal water and sewage services, covering the scientific, political, and technological developments that gave rise to modern sanitary practices. An emphasis is placed on treatment systems, though collection and distribution systems are also covered as they relate to public health.

The report is organized into six chapters. This introduction is Chapter 1 and provides a statement of the project scope, summary of research conducted, and a glossary of key terms and acronyms. Chapter 2 presents a historic narrative of the development of drinking water and wastewater sanitation systems in California. The narrative is divided into three sections covering the nineteenth century, first half of the twentieth century, and the later twentieth century to around 1980. Chapter 3 identifies and describes the important property types associated with drinking and wastewater systems that are most likely to be encountered by architectural historians and archaeologists in California. Chapter 4 presents a research design to guide fieldwork and archival study of drinking water and wastewater systems. The chapter identifies pertinent research themes and reviews the published and archival resources available for use in developing resource-specific histories. Chapter 5 addresses the four significance criteria for evaluation to the NRHP or CRHR and provides guidance on their application to drinking water and wastewater systems, including assessing historic integrity. Finally, Chapter 6 offers conclusions and management suggestions on preservation goals and priorities, the resolution of adverse effects, and proposals for further study.

1.2. Research Conducted

In preparing this report, JRP and AECOM reviewed and collected a wide variety of materials related to the history of water development and sewage treatment in California. AECOM, with input from JRP, prepared and submitted a comprehensive thematic records search request to the California Historical Resources Information System (CHRIS). The request was made for all built-environment and archaeological resources related to historic-era wastewater and drinking water facilities in the state. Resources with a strictly irrigation association were excluded from the request. The search also included a review of the Office of Historic Preservation's Built Environment Resource Directory (BERD) for previously-recorded drinking water and wastewater properties. The State Water Board records were also selectively reviewed for relevant prior studies.

JRP took the lead in conducting archival and secondary source research for development of the historic context. JRP staff reviewed the archival records of the California Bureau of Sanitary Engineering at the California State Archives, Sacramento, and at the Water Resources Collections and Archives (WRCA) within Special Collections & University Archives at University of California (UC) Riverside, as well as the Charles Gilman Hyde Papers and Wilfred F. Langelier Papers at WRCA. JRP also made extensive use of the oral history interviews of three pioneering California sanitary engineers held by the Regional Oral History Collection at the Bancroft Library, UC Berkeley. At the California State Library, Sacramento, JRP reviewed the Biennial

Reports of the State Board of Health, 1870–1926, and the trade journals *Sewage Works Journal* and *California Sewage Works Journal.* Finally, JRP consulted published secondary studies, historic textbooks and manuals, newspaper records, and digital sources to contextualize the primary source materials. The research materials are further described below in **Section 4.3. Research Resources.**

Additionally, the State Water Board, with input and assistance from JRP and AECOM, selected five properties for evaluation that could serve as case studies for applying the historic context and evaluation procedures presented in this report. JRP arranged to visit and evaluate the City of Redlands Henry Tate Water Treatment Plant; the City of Yountville Wastewater Reclamation Facility; and two City of Pleasanton drinking water wells and an associated treatment facility. AECOM recorded and evaluated the Mokelumne Hill Sanitary District Wastewater Treatment Plant and the City of Redlands Mill Creek Water Treatment Facility. The facilities were recorded and evaluated on California Department of Parks and Recreation (DPR) 523 forms. The forms are appended to this report.

1.3. Users Guide

This report is intended principally for historical consultants and environmental planning professionals who will aid their water resource clients in complying with federal and state regulations regarding the identification, evaluation, and management of historically significant drinking water and wastewater facilities in California. The comprehensive historic context that follows will allow consultants to situate their projects within a rich understanding of the history of sanitary engineering and public health fields, and to reduce the need to conduct extensive secondary research themselves. The geographic, temporal, and thematic coverage is broad enough to aid in researching nearly any resource related to drinking water or wastewater treatment in the state from the Spanish and Mexican eras through to around 1980. Evaluators can use the context as a reference work, selectively reviewing sections as needed based on the specific property under consideration. Primary and secondary sources referenced in the footnotes, bibliography, and in Section 4.3, “Research Resources”, will aid in completing any general historic context required and provide a starting point for property-specific research.

For consultants without prior experience evaluating drinking water and wastewater systems, Chapter 3, “Property Types”, provides an overview of the historic and modern treatment processes, along with their associated resources. It may be helpful for evaluators new to this subject to start with that section to familiarize themselves with the common resources and treatment techniques encountered. Chapter 4, “Research Design”, provides a framework for recording and researching drinking water and wastewater resources that are in keeping with current best practices of the field. It presents historic themes that evaluators may use for structuring their reports to situate the properties within the most fitting larger context. The review of evaluation criteria presented in Chapter 5, “Evaluation Procedures”, pairs with the five case studies that are included in the report appendix. The case studies, recorded on standard State of California Department of Parks and Recreation (DPR) 523 forms present full recordations, histories, and NRHP/CRHR evaluations for a representative sample of drinking water and wastewater resources that were selected to include a variety of property types (archaeological and historic built environment, wastewater and drinking water) within a broad geographical and temporal range that reflects the state’s diversity. The case studies also demonstrate how a local and property-specific historic context may be developed to complement the larger national, state, and regional perspectives offered in this document. The case studies aim to aid consultants and planning professionals by providing practical models for recording, researching, and evaluating resources for historical significance. It is hoped that the report as a whole will enhance understanding of drinking water and wastewater systems, streamline the research, provide for consistency in evaluation procedures, and uphold the best practices in the field of historic resource management.

1.4. Definition of Key Terms

1.4.1. Abbreviations and Acronyms

Acronym	Definition
af	Acre-foot or acre-feet
AMA	American Medical Association
BAT	Best Available Technology
BERD	Built Environment Resource Directory
BNR	Biological Nutrient Removal
BPT	Best Practical Technology
CBI	Chicago Bridge & Iron
CCR	California Code of Regulations
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
cfs	Cubic feet per second
CHRIS	California Historical Resources Information System
CRHR	California Register of Historical Resources
DFA	Division of Financial Assistance
DPR	Department of Parks and Recreation
EBMUD	East Bay Municipal Utility District
EPA	Environmental Protection Agency
FWPCA	Federal Water Pollution Control Act
HABS	Historic American Building Survey
HAER	Historic American Engineering Record

Acronym	Definition
MCL	Maximum Contaminant Level
mgd	Million gallons a day
MIT	Massachusetts Institute of Technology
MOA	Memorandum of Agreement
MPN	Multiple Property Nomination
MPS	Multiple Property Submission
NHPA	National Historic Preservation Act
NIH	National Institute of Health
NRHP	National Register of Historic Places
PAO	Phosphorous-Accumulating Organisms
PWA	Public Works Administration
SHPO	State Historic Preservation Officer
SOI	Secretary of the Interior's Standards
SRF	State Revolving Funds
UC	University of California
UCLA	University of California, Los Angeles
USPHS	United States Public Health Service
UV	Ultraviolet
WRCA	Water Resources Collections and Archives

1.4.2. Glossary

The following glossary of terms is adapted from the California State Water Resources Control Board's "Water Words Dictionary." The complete compilation of terms may be accessed at California Water Boards: Water Words Dictionary.

Acre foot (af): The amount of water needed to cover one acre of land one foot deep (equal to 325,851 gallons). An acre foot can support the annual indoor and outdoor needs of one to two urban households.

Activated carbon: A highly adsorbent form of carbon used to remove odors and toxic substances from liquid or gaseous emissions. In waste treatment, it is used to remove dissolved organic matter from wastewater.

Activated sludge: Product that results when primary runoff is mixed with bacteria-laden sludge and then agitated and aerated to promote biological treatment, speeding the breakdown of organic matter in raw sewage undergoing secondary waste treatment.

Adsorption: Removal of a pollutant from air or water by collecting the pollutant on the surface of a solid material; e.g., an advanced method of treating waste in which activated carbon removes organic matter from wastewater.

Advanced wastewater treatment: Any treatment of sewage that goes beyond the secondary or biological water treatment stage and includes the removal of nutrients such as phosphorus and nitrogen and a high percentage of suspended solids.

Aeration: A process that promotes biological degradation of organic matter in water. The process may be passive (as when waste is exposed to air), or active (as when a mixing or bubbling device introduces the air).

Aerobic: Life or processes that require, or are not destroyed by, the presence of oxygen.

Anaerobic: A life or process that occurs in, or is not destroyed by, the absence of oxygen.

Backwashing: Reversing the flow of water back through the filter media to remove entrapped solids.

Biological treatment: A treatment technology that uses bacteria to consume organic waste.

Blackwater: Wastewater from toilets which likely contains pathogens that may spread by the fecal-oral route. Blackwater can contain feces, urine, water, and toilet paper from flush toilets.

Chlorination: The application of chlorine to drinking water, sewage, or industrial waste to disinfect or to oxidize undesirable compounds.

Cistern: Small tank or storage facility used to store water for a home or farm; often used to store rainwater.

Clarification: Clearing action that occurs during wastewater treatment when solids settle out. This is often aided by centrifugal action and chemically induced coagulation in wastewater.

Clarifier: A tank in which solids settle to the bottom and are subsequently removed as sludge. Also known as a sedimentation tank or settling basin.

Clean Water Act: Federal legislation enacted in 1972 to restore and maintain the chemical, physical and biological integrity of the surface waters of the United States. The stated goals of the Act are that all waters be fishable and swimmable.

Combined Sewer: A sewer system that carries both sewage and storm water runoff.

Cross Connection: Any actual or potential connection between a drinking water system and an unapproved water supply or other source of contamination.

Cubic feet per second (cfs): The rate of flow passing any point equal to the volume of one cubic foot of water every second. One cubic foot is equal to 7.48 gallons per second; 448.8 gallons per minute; 646,317 gallons per day.

Desalination: 1. Removing salts from ocean or brackish water by using various technologies, 2. removal of salts from soil by artificial means, usually leaching.

Dewater: Remove or separate a portion of the water in a sludge or slurry to dry the sludge so it can be handled and disposed.

Disinfectant: A chemical or physical process that kills pathogenic organisms in water. Chlorine is often used to disinfect sewage treatment effluent, water supplies, wells, and swimming pools.

Effluent: Wastewater—treated or untreated — that flows out of a treatment plant, storm sewer, or industrial outfall, or any other point sources. Generally refers to wastes discharged into surface waters.

Electrodialysis: A process that uses electrical current applied to permeable membranes to remove minerals from water. Often used to desalinize salty or brackish water.

Eutrophication: The slow aging process during which a lake, estuary, or bay evolves into a bog or marsh and eventually disappears. During the later stages, the water body is choked by plant life because of high levels of nutritive compounds such as nitrogen and phosphorus.

Filtration: A treatment process for removing solid (particulate) matter from water by means of porous media such as sand or a synthetic filter; often used to remove particles that contain pathogens.

Floc: A flocculent mass formed in a fluid through precipitation or aggregation of suspended particles (short for flocculus).

Flocculation: Process by which clumps of solids in water or sewage aggregate through biological or chemical action so they can be separated out.

Granular activated carbon treatment (GAC): A filtering system often used in small water systems and individual homes to remove organics. Also used by municipal water treatment plants, and can be highly effective in lowering elevated levels of radon in water.

Gray water: Domestic wastewater composed of wash water from kitchen, bathroom, and laundry sinks, tubs, and washers.

Groundwater: The supply of fresh water found underground, usually in aquifers, which supply wells and springs.

Hardwater: Water that has high mineral content, particularly in the amount of dissolved calcium and magnesium. Hardwater is formed when water percolates through deposits of limestone, chalk, or gypsum.

Influent: Water, wastewater, or other liquid flowing into a reservoir, basin, or treatment plant.

Jar test: A laboratory procedure that simulates a water treatment plant's coagulation/flocculation units with differing chemical doses, mix speeds, and settling times to estimate the minimum or ideal coagulant dose required to achieve certain water quality goals.

Maximum Contaminant Level (MCL): The maximum permissible level of a contaminant in water delivered to any user of a public water system. MCLs are drinking water standards that are primarily enforced by the Department of Health Services (DHS).

Million Gallons Per Day (mgd): A measure of water flow.

Nitrate: A compound containing nitrogen that can exist in water as a dissolved gas. It can have harmful effects on humans and animals. Nitrates in water can cause severe illness in infants and domestic animals. A plant nutrient and inorganic fertilizer, nitrate is found in septic systems, animal feed lots, agricultural fertilizers, manure, industrial wastewaters, sanitary landfills, and garbage dumps.

Non-potable: Water that is unsafe to drink because it contains pollutants, contaminants, minerals, or infective agents.

Outfall: The place where effluent from a point source is discharged into receiving waters.

Oxidation: A chemical reaction that takes place when a substance comes into contact with oxygen or another oxidizing substance. Rust is an example.

Pathogen: A disease-producing agent; generally, any viruses, bacteria, or fungi that cause disease in humans, animals, and plants.

Percolation: 1. The movement of water downward and radially through subsurface soil layers, usually continuing downward to ground water. Can also involve upward movement of water. 2. Slow seepage of water through a filter.

Permeability: The capacity of a rock, soil, or synthetic matter to transmit a fluid, usually water.

pH: A measure of the intensity of the basic or acidic condition of a liquid. It may range from 0 to 14, where 0 is the most acidic and 7 is neutral. Natural waters usually have a pH between 6.5 and 8.5.

Porter Cologne Water Quality Control Act (Porter Cologne Act): Anti-pollution legislation enacted by the California Legislature in 1969. It provides a framework for the regulation of waste discharges to both surface and groundwaters of the state. It further provides for the adoption of water quality control plans; and the implementation of these plans by adopting waste discharge requirements for individual dischargers or classes of dischargers.

Potable water: Water that is safe for drinking and cooking.

Preliminary treatment: The first phase of wastewater treatment, generally precursory to primary treatment though historically used as standalone treatment. It consists of the physical removal of large debris by use of screens or trash racks, and the settling out of large particles such as sand, gravel, coffee grounds, and eggshells in grit chambers.

Primary treatment: The phase of wastewater treatment following preliminary treatment that removes material that will either float or readily settle out by gravity. It primarily consists of clarifiers that provide detention time for gravity settling to take place.

Public water system: A system that provides piped water for human consumption to at least 15 service connections or regularly serves 25 or more individuals for at least 60 days out of the year.

Pumping station: Mechanical device installed in sewer or water systems or other liquid carrying pipelines to move the liquids to a higher level.

Raw sewage: An untreated municipal discharge and its contents.

Recarbonization: Process in which carbon dioxide is bubbled into water being treated to lower the pH.

Reclaimed wastewater: Treated wastewater that can be reused for beneficial purposes such as irrigation, recreation, or industrial application.

Recycled water: Water that is used more than one time before it passes back into the natural hydrologic system and is suitable for a beneficial use.

Reservoir: Any natural or artificial holding area used to store, regulate, or control water.

Reverse osmosis: A treatment process used in water systems by adding pressure to force water through a semi-permeable membrane. Reverse osmosis removes most drinking water contaminants. Also used in wastewater treatment.

Sand Filters: Devices that remove some suspended solids from effluent. Air and bacteria decompose additional wastes filtering through the sand or synthetic media so that cleaner water drains from the bed. Also called rapid sand filters.

Sanitary sewer: Underground pipes that carry off only domestic or industrial waste, not storm water.

Separate storm sewer system: A system of pipes (separated from sanitary sewers) that carries water runoff from buildings and land surfaces.

Sewage: The waste and wastewater produced by residential and commercial sources and discharged into sewers.

Sewer: A channel or conduit that carries wastewater and storm-water runoff from the source to a treatment plant or receiving stream. “Sanitary” sewers carry household, industrial, and commercial waste. “Storm” sewers carry runoff from rain or snow. “Combined” sewers handle both.

Sewerage: Term used historically to refer to a system of sewage pipes that collected, conveyed, and discharged sewage but did not provide treatment. The term may be used today to refer to the entire system of sewage collection, treatment, and disposal.

Sludge: A solid or semi-solid residue from the treatment of water, wastewater, and other liquids. It does not include liquid effluent discharged from such treatment processes. Sludge can be a hazardous waste.

Sludge Digestor: In wastewater treatment, a closed tank in which complex organic substances like sewage sludge are biologically dredged. Energy is released and much of the sewage is converted to methane, carbon dioxide, and water.

Soft water: Any water that does not contain a significant amount of dissolved minerals such as salts of calcium or magnesium.

Synthetic Organic Chemicals (SOCs): Human-made organic chemicals. Some SOCs are volatile; others tend to stay dissolved in water instead of evaporating.

Tertiary treatment: Advanced cleaning of wastewater that goes beyond the secondary or biological stage, removing nutrients such as phosphorus, nitrogen, and most suspended solids.

Trickling filter: A treatment system in which wastewater is trickled over a bed of stones or other material covered with bacteria that break down the organic waste and produce clean water.

Turbidity: A cloudy condition in water due to suspended silt or organic matter.

Wastewater: The spent or used water from a home, community, farm, or industry that contains dissolved or suspended matter. The modern term for sewage.

Water softening: The process of removing dissolved calcium and magnesium salts that cause hardness in water.

2. HISTORIC CONTEXT STATEMENT

The following historic context presents a narrative of the development of wastewater and drinking water sanitation systems in California from the nineteenth century until approximately 1980. The narrative is divided into three sections, covering the nineteenth century, first half of the twentieth century, and the later twentieth century to around 1980. Each section examines the scientific, political, and technological forces, and their interactions, that shaped the eras' distinctive sanitary practices. The emergence of modern water sanitation was a complex and multifaceted process that resists tidy periodization. However, each of the three eras has its own characteristic set of challenges and opportunities that arose from large shifts in scientific knowledge, understandings of public health threats, the emergent power of government regulation, and the biochemical technologies employed for purifying water. The eras may be broadly characterized as the Pre-Treatment Era (nineteenth century), the Era of Sanitary Engineering (1900–1949), and the Era of Advanced Treatment (1950–ca. 1980).

The principal focus through the historic context is on the public health aspects of municipal water and sewage services, with an aim towards improving the NRHP and CRHR evaluation of historic-era archaeological and built-environment resources. The grand narrative of water development in California, covering the damming and diversion of remote rivers for agricultural and urban consumption, is beyond the scope of this project and is well-covered elsewhere.[1]

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[1] For historic context and evaluation procedures for water conveyance systems, see: JRP Historical Consulting Services and California Department of Transportation, "Water Conveyance Systems in California," December 2000. Overviews of California water development include Donald J. Pisani, *From the Family Farm to Agribusiness: The Irrigation Crusade in California and the West, 1850–1931* (Berkeley: University of California Press, 1984); Donald Wurster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (Oxford: Oxford University Press, 1985); and Norris

2.1. The Pre-Treatment Era: Sanitation in the Nineteenth Century

The mid-nineteenth century saw the emergence of the first social-reform "Sanitarians" in England and America who linked cleanliness and good health. The reformers lacked a specific causal mechanism to explain waterborne disease transmission, but they succeeded in creating state and local boards of health with limited powers to enforce hygienic measures. No practical method for treating drinking water or sewage yet existed, so municipal engineers simply sought to direct sewage away from populated areas as rapidly as possible and to secure safe drinking water drawn from deep wells or remote mountain streams. The ad hoc nature of water procurement and sewer construction meant these efforts frequently failed, and cholera and typhoid fever took a frightful toll on urban populations through the century.

2.1.1. Knowledge

Modern sanitary sewage and drinking water systems first emerged in mid-nineteenth-century England. Prior to that time, systems of water supply and waste disposal were local in nature with limited public oversight. Individuals were responsible for procuring their own water and disposing of their own waste. So long as population densities remained low, these traditional methods functioned satisfactorily. However, as urbanization and industrialization took hold in Victorian England, the streams of human and industrial waste began to overwhelm the limited physical and legal infrastructure that governed the flows of pure and soiled waters. London, Birmingham, and Manchester choked on their own filth and suffered through regular epidemics that the medical theories of the day could neither explain nor ameliorate.[2]

Hundley, Jr., *The Great Thirst: Californians and Water: A History*, Revised Edition (Berkeley: University of California Press, 2001).

[2] Martin V. Melosi, *The Sanitary City: Urban Infrastructure in America from Colonial Times to the Present* (Baltimore: John Hopkins University Press, 2000), 43–46; Daniel Schneider, *Hybrid Nature: Sewage Treatment and the Contradictions of the Industrial Economy* (Cambridge: MIT Press, 2011).

In the 1830s, English social reformers—the so-called Sanitarians—began to link dirt, disease, and moral disorder. A cholera epidemic of 1831–1832 killed great numbers of people and particularly devastated the poorest and dirtiest districts of London. A nascent reform movement that aimed to improve living conditions for the laboring class seized on the moment to promote the idea that cleanliness and health were inextricably linked. Theorists began to conceive of the city as an organic entity that depended upon a regular flow of clean water for nourishment and as an aid in the disposal of waste. They pressed for improved public health systems, with a focus on securing clean sources of drinking water and, to a lesser extent, providing public sewerage systems.[3]

The sanitarian position was associated with miasmic theory, the then-dominant medical model. Miasmic theory held that disease arose from the putrefaction of organic wastes and was transmitted through the inhalation of contaminated airs (miasmas) such as vapors arising from stagnant ponds or sewer gases leaking through a storm grate. Scientists debated the exact nature of miasmas, but were in general agreement that they arose from a combination of warm temperatures, damp environments, and an overabundance of organic matter. A physician's proper duties thus extended beyond individual care to encompass social reform of the unsanitary conditions that endangered public health. Because many of the illnesses that the Sanitarians first combatted were intestinal in nature—cholera, dysentery, typhoid fever—their environmental campaigns produced real improvements that vouched for the theory among scientists, politicians, and the public. However, the miasmic theory always remained vague about the precise vectors of contagion, and by the end of the nineteenth century it had been largely replaced by the germ theory that identified bacterial pathogens as the agents responsible for spreading disease.[4]

Edward Chadwick was the great popularizer of sanitary ideas. A lawyer by profession, Chadwick led several government investigations of epidemics that established firm

[3] Melosi, *The Sanitary City*, 2–3, 43–46.

[4] Melosi, *The Sanitary City*, 46–47; Linda Nash, *Inescapable Ecologies: A History of Environment, Disease, and Knowledge* (Berkeley: University of California Press, 2006), 66–67.

connections between poor sanitary conditions and disease outbreaks. His 1842 *Report on the Sanitary Conditions of the Labouring Population of Great Britain* was widely read, selling more copies than any prior government publication. Chadwick argued that improving sanitary conditions required a strong centralized authority with the power to construct comprehensive public works systems that integrated water deliveries and sewage removal. He was too impatient to accept the more limited political realities of his time, and none of his proposals ever achieved full implementation. However, his forceful advocacy of sanitarian ideas shifted the public debate. His work brought together for the first time an environmental context for public health, an argument for the role of government in improving conditions for the greater good, and the identification of infrastructure technologies that could realize those goals.[5]

Sanitarian ideas crossed the Atlantic in the mid-1840s. A small but influential group of American physicians had closely followed developments in Europe and were eager to apply the new environmental models of health to their own country, which was then in the midst of its first great wave of urban expansion. John H. Griscom, the New York City Inspector at the time, corresponded with Chadwick and in 1845 published *The Sanitary Conditions of the Laboring Population of New York* that was modeled on Chadwick's report. Among other proposed reforms, the study called for an expanded public drinking water system and the construction of underground sewers. Griscom joined with other physicians in organizing the New York Academy of Medicine that made sanitarian reform one of its chief objectives.[6]

The American Medical Association (AMA) established a committee on public hygiene in 1848. The committee took a broad view of public health that included infrastructure improvements alongside quarantine laws, smallpox vaccinations, temperance advocacy, vital statistics gathering, pure food and drink measures, and mental health programs. The group urged the creation of state and local boards of health and called

[5] Melosi, *The Sanitary City*, 44–48; Jamie Benidickson, *The Culture of Flushing: A Social and Legal History of Sewage* (Vancouver, British Columbia: UBC Press, 2007), 107–112.

[6] Melosi, *The Sanitary City*, 60–62.

for medical schools to include instruction in the sanitary sciences. In 1857, the AMA staged the first national sanitary convention in Philadelphia, with annual meetings following in Baltimore, New York, and then Boston in 1860. The outbreak of the Civil War interrupted the gathering momentum of the American sanitarian movement, but public health had established itself as a key element in progressive medical thought.[7]

2.1.2. Political Organization

For all the gains that sanitarian ideas made among physicians and social reformers, the movement realized far fewer practical achievements. Americans shrank from accepting the sort of centralized authority that Chadwick and Griscom believed was needed to implement sanitarian reforms. State and local governments largely assumed public health responsibilities only when compelled to by an epidemic and the resulting regulations were typically allowed to lapse once the crisis had passed. Local governments lacked clear authority to do more even if they had so desired. A lack of definite knowledge about the causes of illness contributed to this reluctance as most early efforts at halting the spread of epidemics proved futile and divisive.[8]

A few Northeastern cities broke from this general pattern of passivity to take an active role in passing sanitary ordinances and establishing public health bodies. The city leaders of Boston in 1634 prohibited the dumping of fish or garbage near the common docks in what was apparently the first formal sanitary law in the American colonies. The city authored quarantine regulations in 1647 and began to regulate the construction of privies five years later. In 1797, Boston established the first permanent local board of health in the nation, though the body had limited formal powers and was staffed by political appointees. The New York state legislature in 1866 passed the New York Metropolitan Health Law that established the Metropolitan Board of Health. This was the first effective board of health in a major city, and it provided a model for subsequent developments. Massachusetts created the first state-level board of health in 1869. Still,

[7] Melosi, *The Sanitary City*, 64–67.

[8] Melosi, *The Sanitary City*, 18–21.

few states immediately followed the lead of New York and Massachusetts, and as late as 1875 many major cities had no permanently empowered health departments.[9]

Rather than adopting formal ordinances to regulate sanitary matters, most cities and states chose to rely on broad but vaguely articulated nuisance laws. The State of California later defined a public nuisance as "anything which is injurious to health, or is indecent, or offensive to the senses, or an obstruction to the free use of property, so as to interfere with the comfortable enjoyment of life or property."[10] In most circumstances, noxious odors and unsightly trash dumps posed more of an annoyance than a serious public health threat. However, because these sorts of nuisances were commonly limited to individual properties, they could be more easily addressed than systemic problems. And critically, the courts, rather than politicians, took the lead in enforcing nuisance laws. Americans were willing to accept litigation in private property disputes more so than government-imposed regulations. Thus, public nuisance lawsuits and abatement orders played the chief role through the nineteenth century in protecting water purity.[11]

2.1.3. Nineteenth-Century California

Nineteenth-century California was progressive in establishing public health organizations, but lagged in constructing effective infrastructure. While California generally followed national trends in sanitation and looked towards the Northeastern states and Western Europe for its models, the peculiarities of the Gold Rush in the late 1840s and early 1850s shaped the state's early experiences with water and sewage systems. The mass movement of population and the sudden emergence of urban centers, especially in San Francisco and Sacramento, fueled pandemics that galvanized early public health campaigns. Physicians strenuously advocated for improved sanitary conditions, but the actual development of water and sewage systems occurred in a piecemeal fashion that befit an era of limited governments. Systems constructed for the

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[9] Melosi, *The Sanitary City*, 19–23, 67–68.

[10] State Board of Health, *Twelfth Biennial Report for the Fiscal Years from June 30, 1890, to June 30, 1892* (Sacramento: State Printer, 1892), 220.

[11] Melosi, *The Sanitary City*, 21–22.

"instant cities" of the 1850s remained in use a half century later despite obvious inadequacies. Only in the twentieth century did California emerge as a national leader in sanitation matters.[12]

Boards of Health

The public health systems of nineteenth-century California emerged in response to the severe disorder that accompanied the Gold Rush. The surge of hundreds of thousands of global migrants into a region almost entirely lacking in public health infrastructure produced a calamitous series of disease outbreaks, including most notably the cholera epidemic of 1850. Cholera struck horror wherever it appeared in the nineteenth century. The intestinal illness, transmitted by food and water contaminated with fecal matter, caused violent vomiting and diarrhea that left victims with an unquenchable thirst and dehydration so severe that the skin pulled taut around skeletal features. Nearly half of cases resulted in death, often within hours of the onset of symptoms.[13]

Cholera arrived in San Francisco aboard an unquarantined ship in early October 1850. Within a week and a half, the disease had spread to Sacramento, where it had its most devastating impact. No authority then existed to keep a reliable count of the dead, but an estimated 800 to 1000 people, roughly 15 percent of Sacramento's population, are thought to have perished during the month-long outbreak. Of the 40 physicians based in Sacramento, 17 died while tending to the ill, one of the highest mortality rates ever recorded among medical first responders. This encounter with cholera and subsequent waves of smallpox, diphtheria, typhoid fever, and other communicable illnesses deeply

[12] Gunther Barth, *Instant Cities: Urbanization and the Rise of San Francisco and Denver* (New York: Oxford University Press, 1975).

[13] Mitchel Roth, "Cholera, Community, and Public Health in Gold Rush Sacramento and San Francisco," *Pacific Historical Review*, Vol. 66, No. 4 (Nov 1997), 527–551; J. Roy Jones, *Memories, Men and Medicine: A History of Medicine in Sacramento, California* (Sacramento: Sacramento Society for Medical Improvement, 1950), 33–38.

impressed upon the state's physicians the need to organize in support of quarantine laws and public sanitation measures.[14]

Sacramento physician Thomas M. Logan took a leading role in establishing the institutions of public health. Born and educated in South Carolina, Logan spent a year of study in Britain and France during a cholera epidemic that allowed him to learn firsthand the latest in sanitary science. Back in the United States, he served as a university lecturer, authored a compendium on surgery, and accepted a hospital appointment in New Orleans before the Gold Rush lured him to California in time for the 1850 cholera epidemic. Logan began compiling statistics on mortality in Sacramento and was ahead of his time in insisting that the control of disease depended largely upon the sanitation of the community. He took an active role in organizing the Sacramento Medical Society in 1855, the California Medical Society in 1856, and the Sacramento Society for Medical Improvement in 1868. Logan regularly served as corresponding secretary for these organizations, and he ranked among the most prolific writers of medical literature in the state.[15]

Logan and the medical societies campaigned for the organization of boards of health that would place matters of sanitation and quarantine under the direction of medical school-trained physicians rather than political patronage appointees. Both San Francisco and Sacramento established local boards in the mid-1860s, closely following the example set by New York Metropolitan Board of Health. Logan served as a charter member and secretary for the Sacramento board.[16]

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[14] Roth, "Cholera, Community, and Public Health," 542–543.

[15] Jones, *Memories, Men and Medicine*, 65.

[16] State Board of Health, *Second Biennial Report for the Years 1871, 1872, and 1873* (Sacramento: State Printer, 1873), 216–221; "An Act to establish a Quarantine for the Bay and Harbor of San Francisco, and sanitary regulations for the City and County of San Francisco," Apr 2, 1866, *Statues of California Passed at the Sixteenth Session of the Legislature, 1865–1866* (Sacramento: State Printer, 1866), 740–742; "An Act to authorize the establishment of a Board of Health in the City of Sacramento," Mar 27,

Local boards held responsibility for a complex array of health matters. The enacting legislation charged the boards with managing quarantine procedures at the ports; keeping records of birth, deaths, and interments; supervising the sanitary conditions of all public hospitals, jails, almshouses, and schools; providing guidance on the location and staffing of hospitals; and establishing “pest houses” for isolating contagious disease. While the boards held general authority to make and enforce any sanitary regulation deemed necessary, in practice their involvement with municipal water and sewage systems was limited to ordering the abatement of nuisances. The boards did not take a hand in planning such systems or in supervising their construction, which remained the purview of private developers and municipal engineers. The boards could order an individual source of pollution from a tenement house or butcher shop cleaned up at the owner’s expense, but the larger failures common in the ad hoc construction of sewage networks remained unaddressed.[17]

In 1870, Logan authored legislation to establish the California State Board of Health. Massachusetts had created the nation’s first state board of health only a year prior in 1869, and California was the second state to take the consequential step. Logan had been frustrated by the smallpox epidemic of 1868-69, when popular resistance to vaccinations cost hundreds of lives that might otherwise have been saved. He desired a strong state board that could coordinate the efforts of mandatory local health boards but accepted that politics required a less powerful organization. The law he crafted created a board of seven physicians, appointed by the governor and hailing from throughout the state. Logan was the first appointee to the board and served as secretary. In his opening address to the newly formed body, he stressed that the board would avoid sanitary measures that “might press too heavily on the individual and lessen too much the freedom of personal action.” “Our duties are not executive, but advisory,” he

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1868, *Statues of California Passed at the Seventeenth Session of the Legislature, 1867–1868* (Sacramento: State Printer, 1868), 403.

[17] State Board of Health, *Second Biennial Report*, 216–221.

declared, and in most all cases, “the observation of our sanitary rules will be voluntary and not compulsory.”[18]

As one of its first orders of business, the state board drafted the “Act for Sanitary Purposes,” by which it hoped to empower local boards of health to construct and manage sewage collection systems. As drafted, the act would have compelled every incorporated city and town to establish a local board of health staffed by medical professionals. These local boards were to have sole authority over the management of sewage and drainage pipes. All new buildings constructed within incorporated towns would be required to complete sewers that either drained to the sea or connected to a sewage collection system if one were within 100 feet of the building. Those outside of 100 feet from an existing system would need to install privies and covered cesspools with the construction overseen by local health officials “for the preservation of the purity of streams and springs, or other sources of fresh water.”[19]

The California Legislature declined to enact such an ambitious bill, and instead merely authorized (rather than required) city governments to appoint boards of health or health officers as they saw fit. County supervisors might likewise appoint boards of health, but only as a temporary measure during epidemics. Few cities immediately availed themselves of their appointment authority and only Stockton and Oakland created new boards to join those previously existing in San Francisco and Sacramento. In 1878, the legislature amended the law to make the formation of a local board of health mandatory for incorporated communities. Enforcement of the measure was limited, and many cities delayed appointing a board that might shift power away from city councilmembers. By the mid-1880s, a total of 19 local boards of health existed, representing less than one

[18] State Board of Health, *First Biennial Report for the Years 1870 and 1871* (Sacramento: State Printer, 1871), 18.

[19] State Board of Health, “This Draft of an Act,” in State Board of Health, *First Biennial Report*, Appendix, 102–113.

third of the 60 incorporated cities and towns in the state. In 15 counties, no incorporated towns existed and therefore there were no boards of health.[20]

The local boards of health had executive power to enforce nuisance abatement laws, but only a few cities had ordinances specific to sanitation. Serving on a health board was generally a thankless task that invited hostility from those who were served with abatement orders, so most boards acted only after receiving a formal complaint. The state board attempted to prompt the local boards into taking greater responsibility for their drinking water and sewage systems by sending out periodic questionnaires that asked for an assessment of current conditions and plans. However, the survey results tended to be more dispiriting than motiving. Of the 23 cities that responded to an 1879 survey, only one was judged to have a complete sewerage system, while seven others had partial systems that left out many neighborhoods. The remaining cities had no integrated systems but included disconnected sections of sewage pipe that were constructed by private interests to serve individual buildings or small developments. The state board concluded that the responses showed "an absence of a spirit of enterprise to overcome obstacles, and an apparent want of appreciation of the real importance of the subject."[21]

Professorships of Hygiene

In 1873, the regents of the University of California (UC) created a Professorship of Hygiene within the medical school at Berkeley, the fourth such position in the nation, and they appointed Thomas Logan, the founder and secretary of the State Board of Health, to the role. Logan had achieved national prominence in the years following the 1870 creation of the state board. He arranged for the 1871 annual convention of the AMA to be held in San Francisco, and he used his address to the body to tout the state's achievements and urge the nation's 37 medical schools to appoint chairs of

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[20] State Board of Health, *Fourth Biennial Report for the Years 1876 and 1877* (Sacramento: State Printer, 1877), 11.

[21] State Board of Health, *Fifth Biennial Report for the Years 1878 and 1879* (Sacramento: State Printer, 1879), 57–58.

hygiene. Logan was elected president of the AMA for the 1872 year. Although the UC regents appointed a leading man of medicine with a record of scientific and administrative innovation to head the new course of study, Logan died three years later without leaving a permanent, substantive plan of research and instruction.[22]

The University of California, Stanford University, and the University of Southern California all created professorships of hygiene or sanitary science in the nineteenth century, but the broad program of instruction gave limited attention to matters of drinking water supply or sewage management. Courses focused largely on what might be termed healthy living, covering such subjects as diet, exercise, sexual relations, and mental health. There was thus little university research conducted on public sanitation in nineteenth-century California that might have shaped the infrastructure being created.[23]

2.1.4. Nineteenth-Century Technology

Waterworks

Prior to the 1870s, only about half of American towns had any sort of public water system and these were concentrated in the larger cities of the Northeast. In all other areas, individuals procured their daily water supplies for drinking, cooking, and bathing in essentially the same manner as had European peasants for centuries. They dipped pails in surface streams, drew groundwater from springs or wells, and collected rainwater in cisterns. What public systems did exist, with a few exceptions, were nearly as crude. A town might dig an open ditch from a nearby river or enclose a hillside spring and run a log pipe to a community trough. More commonly, town leaders simply excavated a large central well. The Spanish and Mexican settlements of pre-1850 California made use of such public systems as the Zanja Madre (Mother Canal) in the Los Angeles pueblo and artesian wells and small dams at the missions to meet both agricultural and domestic needs.

[22] Jones, *Memories, Men and Medicine, 397–405; State Board of Health, Second Biennial Report*, 5.

[23] State Board of Health, *Second Biennial Report*, 212–214.

Some of these early Spanish and Mexican-period systems included rudimentary treatment facilities; such as the filtration building ("El Caballo") at San Buenaventura Mission, where aqueduct water flowed through layers of sand and charcoal to purify the drinking water. Few towns had any sort of distribution system, so households had to carry their water in buckets or purchase a daily supply from water carriers who hauled water by wagon or hand (**Figure 1**). Consequently, most individuals limited themselves to between three and five gallons of water per day, equivalent to a few flushes of a modern toilet.[24]

Figure 1: Chicago water peddler in 1835.[25]

These local systems functioned adequately so long as populations remained low, but any town looking to grow needed a supply of abundant, reasonably pure water for domestic and industrial consumption as well as firefighting purposes. The challenge of obtaining such a supply frequently served as the catalyst for organizing a municipal government, and for many towns the construction of a public water system was their first and largest financial undertaking. In states dominated by rural legislatures, towns were frequently constrained in their abilities to tax citizens or finance infrastructure projects through debt. Municipal government thus commonly turned to private companies that could borrow from capital markets. In nineteenth-century California, only Sacramento developed a water system that was predominantly publicly owned; all other cities and towns relied on private enterprise to meet their supply needs. Governments regulated the water companies through the granting of franchises. The companies were

[24] George W. Fuller, "Water-Works in the United States," *Transactions of the American Society of Civil Engineers*, Vol. 92 (1928), 1209; Melosi, The Sanitary City, 29–30; Blake Gumprecht, *The Los Angeles River: Its Life, Death, and Possible Rebirth* (Baltimore: John Hopkins University Press, 1999), 42–44. On Spanish and Mexican-era systems, see JRP, "Water Conveyance Systems in California," 8–11.

[25] Melosi, *The Sanitary City*, 30

offered access to water supplies, use of public rights-of-way, monopoly control over distribution networks, the right to exercise eminent domain in constructing their systems, and certain tax privileges. In exchange, the government could specify terms of service to include the distribution area and minimum water pressure requirements, as well as exercise a measure of control over pricing. Franchises also generally required that water be provided free for fire hydrants and public parks.[26]

Selecting a water source required weighing expense, convenience, safety, and palatability. The English River Pollution Commission ranked water supplies with respect to their comparative wholesomeness, palatability, and general fitness for drinking and cooking (**Figure 2**). Springs, deep wells, and mountain streams or lakes provided the most desirable supply, while lowland rivers and shallow wells were both hazardous to health and undesirable for consumption. Throughout California, wells were the most common source of water and most were relatively shallow at 35 feet of depth or less. Water from such wells was essentially surface water that had been lightly filtered by percolating through the soil. This removed the larger contaminants and the water was generally clear and cool, though shallow filtration did not capture the smaller microorganisms that caused disease. In trickling through stone, the water also acquired quantities of dissolved calcium and magnesium that rendered it hard and alkaline. This decreased the water's palatability and made it less effective in laundering and some industrial uses. In an era when water purity was assessed directly through the senses, the off-putting odor and flavor of hard water suggested contamination to many consumers. Where feasible, towns made use of deep wells, and deep artesian wells remained common in the nineteenth century through such locations as the Santa Clara Valley and the Los Angeles Basin. When located within a reasonable distance of

[26] Melosi, *The Sanitary City*, 35–36; Lionel Frost, "Water Technology and the Urban Environment: Water, Sewerage, and Disease in San Francisco and Melbourne before 1920," *Journal of Urban History* Vol. 46, No. 1 (2002), 15–32.

mountains, cities diverted pure water from upland sources and ran it through earthen ditches to reservoirs for distribution.[27]

Wholesome.	Spring water.	Very palatable.
	Deep well water.	
	Upland surface water.	Moderately palatable.
Suspicious.	Stored rain water.	
	Surface water from cultivated land.	Palatable.
Dangerous.	River water to which sewage gains access.	
	Shallow well water.	

Figure 2: Water supply classification by English River Pollution Commission.[28]

Infiltration galleries offered one practical method for improving the safety of non-mountainous surface water sources. Infiltration galleries consisted of perforated pipes, generally of concrete construction, that ran horizontally through the sand and gravel bedding that surrounded and lay beneath watercourses. The pipes collected the subsurface river flow and then discharged it by gravity at a lower point or carried it to a pumping station for lifting to the surface. Percolating through the sand and gravel naturally filtered the subsurface flows. This cleansed the water of most organic matter and improved its safety, though the addition of dissolved minerals increased the water hardness and diminished its palatability. Los Angeles constructed an early gallery system in 1886, consisting of two 3,656-foot-long pipes installed 10 to 15 feet beneath the Los Angeles River through the Glendale Narrows, north of downtown. The city expanded the existing system and completed additional galleries in 1904, 1905, and 1906. The largest of these burrowed through bedrock 115 feet beneath the riverbed (**Figure 3**). Nine vertical wells connected the bedrock tunnel to the river and collected the subsurface flow through their perforated linings. Collectively, these systems drained so much underground flow that the Los Angeles River routinely ran dry at the surface.

[27] State Board of Health*, Fifth Biennial Report*, 46–49; Benidickson, *The Culture of Flushing*, 102–103.

[28] State Board of Health, *Thirteenth Biennial Report for the Fiscal Years from June 30, 1892, to June 30, 1894* (Sacramento: State Printer, 1894), 214.

The improved water quality, however, allowed the city to abandon several chlorine treatment stations that had proven expensive and inefficient to operate.[29]

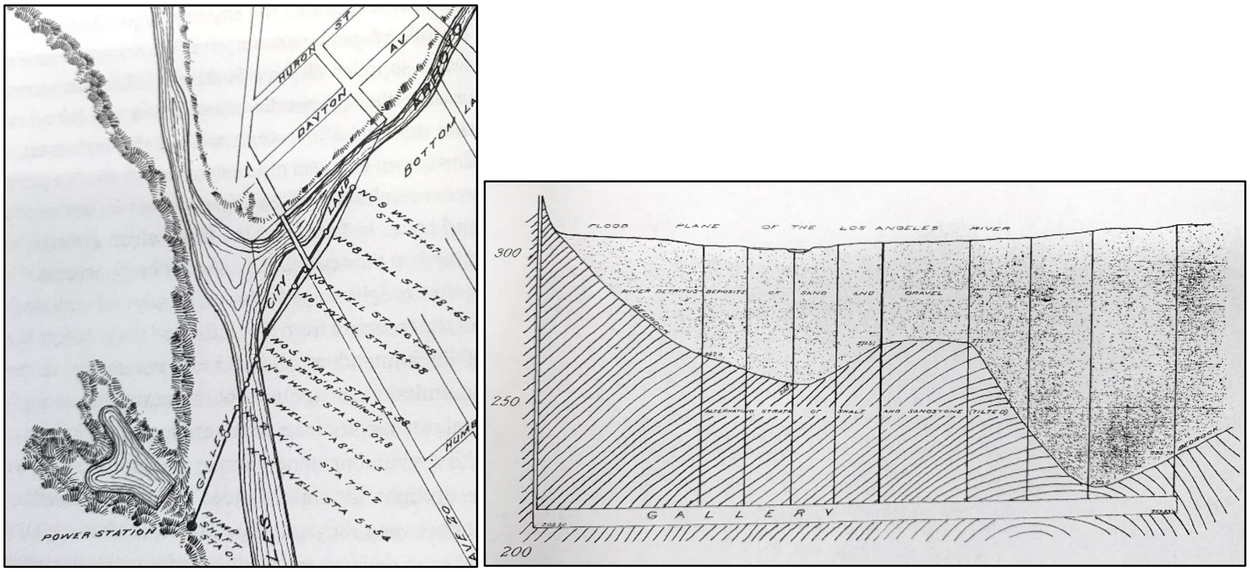

Figure 3: A map and cross section of the Narrows Gallery in Los Angeles, showing the gallery drilled through bedrock and nine connecting wells.**[30]**

Diverted water generally flowed first to a service reservoir or water tower before entering the distribution network. This provided a reserve of water for use in firefighting, allowed for pumps to shut down overnight to save on fuel and labor costs, and helped to balance pressure through the distribution system. A typical design for a small municipal system was to place reservoirs at opposite ends of the distribution system, with a main reservoir near the source supply and an elevated tank at the other end of town. Water was pumped overnight across town into the tower, and then during the day water was available at both ends of the distribution system. This prevented a loss of pressure for users at the far end of town. Some small, early water systems dispensed with reservoirs in favor of direct-pressure systems (discussed below), but these fell in popularity as populations increased and towns opted for the flexibility offered by storage. Reservoirs also helped to deal with variable surface-stream turbidity (water clarity) as towns could

[29] W. A. Hardenbergh, *Operation of Water-Treatment Plants* (Scranton: International Textbook Company, 1940) 7–8; Gumprecht, *The Los Angeles River*, 87, 98–101.
[30] Gumprecht, *The Los Angeles River*, 100–101.

fill their storage while a stream ran clear and then draw from that supply after a storm when river turbidity increased. Some larger suspended solids might also fall out of the water while in a reservoir, though the regular in and out flow prevented the water from calming enough to deposit the smaller bits of clay and organic matter that caused the most problems with turbidity and off-putting colors and odors.[31]

Reservoir design balanced cost versus storage capacity. Ideally, the system could store several days of water supply, but this required a large area and high construction costs. Earthen reservoirs were serviceable, but they benefitted from being lined on bottoms and slopes to make them watertight. Early linings were principally of puddle, a mixture of clay and sand, with dry stone paving reinforcing the slopes. As concrete quality improved over the nineteenth century, engineers increasingly used it for lining, though the large sheets were subject to cracking if exposed to temperature changes when a reservoir was drained for maintenance. Covering the concrete with asphalt improved its watertightness, and asphalt could also be applied over a brick lining as a sealant. Roofing the reservoir protected it from contamination and freezing during severe weather. Large city reservoirs sometimes featured elaborate groined arches to support roof structures, but simpler construction of brick, wood, or iron was more common. A standpipe was a contained tank, constructed of concrete or steel, that stood at ground level rather than being elevated. The distinction between a reservoir and standpipe was one of relative dimensions: a storage tank that was taller than it was wide was commonly classified as a standpipe while one wider than it was tall was identified as a reservoir.[32]

Water tanks replaced reservoirs in level terrain that lacked an elevation suitable for a storage basin, or where the needed supply was small enough that the expense of a tank was favorable compared to land acquisition and construction costs of an in-ground reservoir. Early tanks were wood barrels set on rooftops or girder platforms. The tanks

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[31] John Goodell, *Water-Works for Small Cities and Towns* (New York: The Engineering Record, 1899), 183–184, 218; Brian Hays*, Infrastructure: A Field Guide to the Industrial Landscape* (New York: W. W. Norton & Company, 2005), 88.

[32] Goodell, *Water-Works for Small Cities and Towns*, 219–223.

were constructed of vertical staves bound by steel hoops, with the hoops more tightly spaced towards the tank bottom where the pressure was greatest. Wood tanks were common features on rooftops in older urban areas through the mid-twentieth century and they continue to serve today in small water systems. Riveted or bolted steel replaced wood for larger municipal tanks beginning in the 1890s. These usually consisted of a steel cylindrical tank with a conical roof mounted on a steel girder platform. A riser pipe delivered water to and from the tank and a ladder provided maintenance access. Enclosing the base of the tower with wood or masonry material improved the tank appearance. Some communities transformed their water towers into monumental works of architecture with Gothic, Neoclassical, or other stylistic design elements. While this practice was more common in the East and Midwest than in California, some examples such as the 1894 tank in Fresno are found in the state (**Figure 4**).[33]

[33] Goodell, *Water-Works for Small Cities and Towns*, 235–245; Hays, *Infrastructure*, 85–86; Architectural Research Group (ARG), “Sacramento Railyards Water Tower,” DPR-523 form, June 22, 2016, 5.

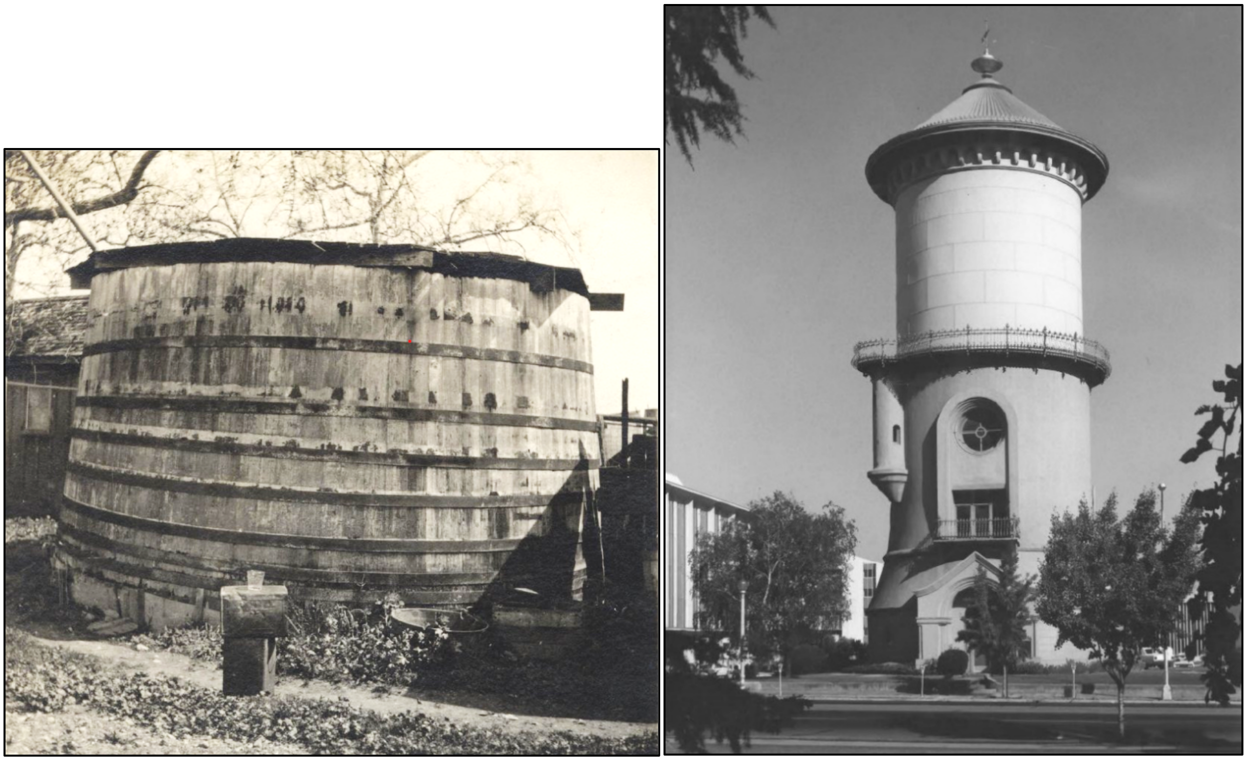

Figure 4: A mid-nineteenth century wood stave water tank in Mountain View (left) and Old Fresno Water Tower (right).[34]

The construction of a distribution network for delivering water by pipe to individual users was among the first improvements made to any water system. Main lines carried water through the public streets and connected to homes by service pipes. A variety of materials have been used over the decades for manufacturing pipes for municipal use in drinking water and wastewater systems. **Table 1** below includes the major materials used with an approximate date range for their period of peak popularity.

[34] “Water Tank at Richardson Home, Mountain View,” photograph, ca. 1905–1915, Blanchard Photograph Album, History San Jose; Fresno County Administrative Office, “Old Fresno Water Tower,” National Register of Historic Places Inventory—Nomination Form 10-300, July 10, 1970.

Table 1: Pipe materials and approximate date range of primary usage in United States.[35]

Material	Approximate Date Range of Peak Use
Wood	1600s–1800s
Clay	1800s–present
Lead	1800s–1920s
Cast Iron	Early 1800s–1960s
Wrought Iron	1850s–1930s
Copper	1850s–present
Concrete	1900s–present
Steel	Early 1900s–present
Asbestos Cement	1930s–1980s
Ductile Iron	1950s–present
Thermoplastics (PVC, HDPE)	1950s–present

Early watermains were made principally from bored and charred logs. Later pipes used milled timber of selected dimensions. Wire wrapped spirally along the pipe length added strength, and rings of iron fit around the pipe ends limited splitting. The pipes could be dipped in hot tar and sanded to add a protective coating. Wood pipes were reasonably durable in well-drained soil, but they were bulky, difficult to join, and generally came in only short lengths. Larger banded stave pipes (**Figure 5**) were introduced around 1850 and these later came into common use in the West for watermains and sewage outfalls, as well as on large irrigation and hydroelectric projects. Stave pipes constructed of

[35] Information compiled from various sources. See citations in discussion of individual materials. Note that the date ranges are approximate only.

redwood continued to be used occasionally for new construction in California into at least the 1930s.[36]

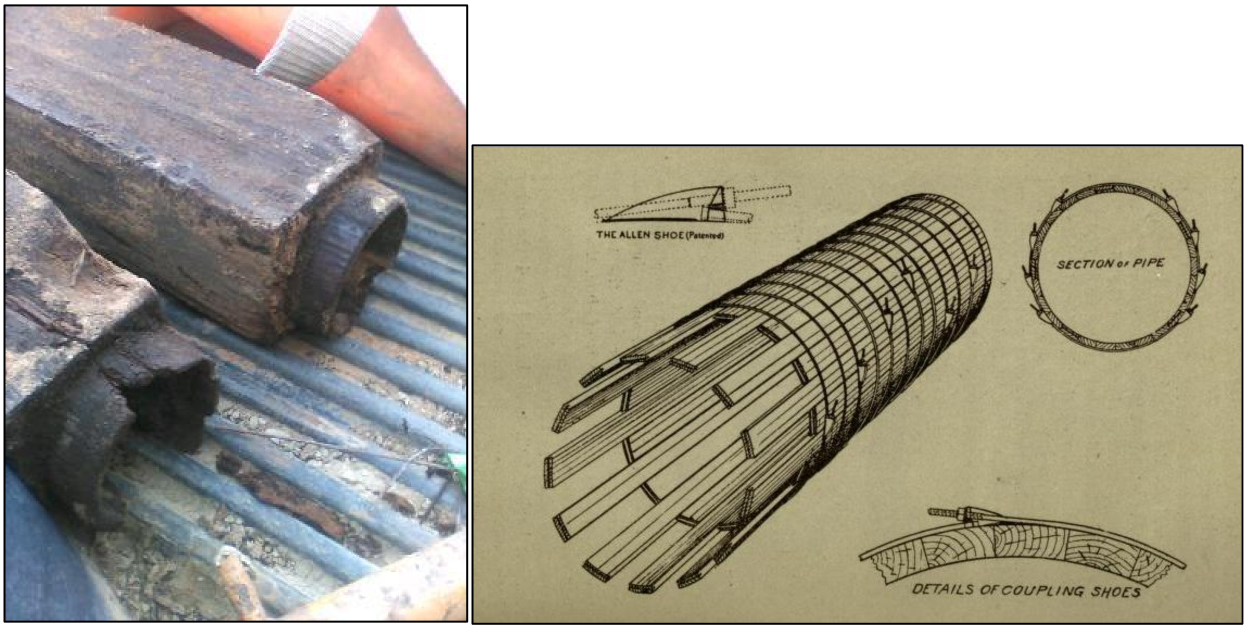

Figure 5: Milled wood pipe (left) used by the Fresno Water Works Company in 1876, and diagram of wood stave pipe (right).**[37]**

Cast iron pipes were introduced in England around 1800 and began to replace wood pipes for watermains. Philadelphia made the first use of cast iron watermains in the United States in 1807, but the city needed to import the pipe from Great Britain. Iron pipe casting involved considerable technical challenge and the early pipes manufactured domestically were prone to inconsistencies in thickness and strength.

Most pipe continued to be imported from Scotland prior to the Civil War, after which major foundries emerged in Pennsylvania, New Jersey, Ohio, and Kentucky. Pipe from these foundries remained relatively expensive until the financial Panic of 1873; the

[36] Fuller, "Water-Works," 1211; A. H. Howland, "Water Pipes," *Proceedings of the Engineers' Club of Philadelphia*, Vol. 6, No. 1 (December 1886), 55–69; Charles Roberti, "Sweasey Dam," in *Proceedings of the Mad River Symposium*, Humboldt State College, April 16–17, 1971, 69–75.

[37] Photograph by Natalie Lawson, PaleoWest, LLC, January 31, 2020; Redwood Manufactures Co., *Wooden Stave Pipe* (San Francisco: n.p., 1911), 4.

concomitant reduction in railroad construction caused a steep drop in iron prices and made distribution systems increasingly affordable. The durability, ease of manipulation, and comparatively low cost of cast iron pipe made it the standard product for water distribution by the end of the nineteenth century. As a protection against corrosion, manufacturers commonly dipped pipe in a hot bath of coal tar, asphalt, and linseed oil to create a smooth, hard, glossy coating. Techniques for galvanizing the iron or lining it with concrete or lead were introduced later in the nineteenth century. A confusing and often incompatible variety of pipe thicknesses, dimensions, and connection styles came into use during the following decades of growth before the American Water Works Association finally adopted standardized measurements in 1908. Improvements in the metallurgy of cast iron in the 1940s led to the introduction of ductile iron pipe in the 1950s. Under pressure, this more flexible material would deform slightly rather than cracking, making it more durable. Ductile iron pipe is distinguishable from older cast iron pipe by its smoother texture, gray versus black color, and the ringing sound it produces when struck by a hammer, versus the dull thud of cast iron.[38]

Initially, use of cast iron pipe was rare on the West Coast as no regional foundries existed and transportation costs were prohibitive. Hydraulic mining in California demanded a metal pipe capable of withstanding great pressure, so local manufacturers substituted wrought iron sheets riveted into tubes. When lined internally with concrete or asphalt, these pipes could be used for watermains. Wrought iron bands connected adjacent sections of pipe and a coating of cement mortar encased the whole exterior surface of the pipes. Hermann Schussler drew upon these mining experiences when he laid out the San Francisco Water-Works in the 1860s using concrete-lined wrought iron pipes. The pipes were serviceable but lacked durability as water pressure frequently eroded the poorly-mixed concrete and eventually rusted the metal shell.[39]

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[38] Fuller, “Water-Works,” 1211–1212; Howland, “Water Pipes,” 55–65; “Water-Works Service Pipes,” *Engineering News*, Vol. 76, No. 13 (September 28, 1916), 594–596; EPA “Wastewater Technology Fact Sheet: Pipe Construction and Materials,” EPA 832-F-00-068, September 2000.

[39] Fuller, “Water-Works,” 1212; Howland, “Water Pipes,” 64–66.

Techniques for welding, rather than riveting, wrought iron sheet into pipes developed gradually over the nineteenth century and started to enter common usage in the 1880s. These pipes were light, easily handled, resistant to damage, and came in lengths of up to 20 feet. Their smooth interiors presented low frictional resistance so that a welded pipe could carry more water than a cast iron or riveted pipe of the same diameter. The early joints were formed from iron sleeves welded into place, but these were later replaced by butt weld joints that directly connected two pipe sections. California manufacturers commonly coated the pipes with asphalt, but chemical processes also existed to oxidize the metal or plate it with copper to prevent further corrosion. Steel sheets were rolled and riveted to form pipes beginning in the 1850s, but the low tensile strength of the early steel limited its application. Manufacturers began successfully welding steel sheets into pipes in the 1880s. Gradual refinements to the process brought down costs and improved consistency, so that by the 1930s welded steel pipes largely replaced earlier riveted steel and welded iron for use in transmission and distribution mains.[40]

Clay pipes appeared frequently in sewerage systems but were less common in drinking water systems as they were susceptible to breaking under higher pressures. Manufacturers produced a variety of natural clay pipes that differed chiefly by the firing temperature in the kiln. When fired at comparatively low temperatures (below1,800 degrees Fahrenheit), the material produced was known as earthenware pipe. The material remained somewhat porous and would absorb water, making it useful for drainage systems but less so for sewage and drinking water systems. Higher firing temperature, up to around 2,300 degrees Fahrenheit, caused the clay to vitrify (turn to glass), making it a dense, durable, corrosion-resistant, non-porous material that was widely used in sewage, irrigation, and drainage systems. This material was generally known as stoneware or as vitrified clay pipe when a specialized mixture of clay and

[40] Howland, "Water Pipes," 66–67; Thomas J. Bray, "Welded Steel Tubes," *Proceedings of the Engineers' Society of Western Pennsylvania*, Vol. 4 (January 1888), 6–12; American Water Works Association, *Steel Pipe: A Guide for Design and Installation*, Fifth edition (Denver, CO: American Water Works Association, 2017), 1–2.

shale was used in manufacturing. To maintain water tightness, bands of wrought iron were wrapped around the joints between pipe segments, and as clay pipes were generally short, the joints needed to be spaced frequently. This increased the amount of friction in the pipes and therefore reduced their carrying capacity.[41]

Concrete pipe was used in sewage systems, storm drains, and agricultural irrigation, but was comparatively rare in drinking water distribution systems. While concrete pipes were inexpensive, easy to maintain, and could be constructed without skilled labor, the pipes could not well withstand the high water pressures of the distribution system and tended to leak. The pipes were also difficult to repair and generally required replacement if damaged. In the 1920s, manufacturers began mixing asbestos fibers into the cement slurry to form composite asbestos-cement pipes, also known as transite. This made for a stronger and more durable material that was resistant to chemical erosion. With the ability to withstand high pressures, asbestos-cement pipes were more widely used for drinking-water mains. A growing recognition of the health effects of asbestos exposure led to declining use in the 1960s and 1970s, until the material was largely phased out in the 1980s.[42]

Because of cost and their physical properties, lead pipes did not appear in main distribution systems, but were used extensively for service connections that linked individual homes and tenement buildings to street mains (**Figure 6**). These are now commonly referred to as lead service lines. Lead pipe was more expensive than the iron or steel alternatives, but it offered advantages in durability and flexibility. Lead provided superior protection against exterior soil corrosion and was second only to cement-lined iron pipe in guarding against interior corrosion. A line that rusted from the inside could clog, and as no practical means existed for flushing lines prior to 1910, stopped pipes needed to be excavated and manually cleaned or replaced. To avoid such costly and disruptive repairs, many municipalities opted for the higher upfront cost of building with

[41] Howland, “Water Pipes,” 68; Harold E. Babbitt and James J. Doland, *Water Supply Engineering*, Third Ed. (New York: McGraw-Hill Book Company, 1939), 327–330.

[42] Howland, “Water Pipes,” 68; Harold E. Babbitt and James J. Doland, *Water Supply Engineering*, Third Ed. (New York: McGraw-Hill Book Company, 1939), 327–330.

lead pipe. Lead's malleability also favored its use in dense urban areas where water pipes needed to be routed around existing gas and sewer lines and other obstructions. In the early twentieth century, manufacturers introduced lead lining for iron pipes that combined the greater corrosion resistance of lead with the lower cost of iron. Lead pipe was also widely used for household plumbing and in the solder used to connect iron pipes.[43]

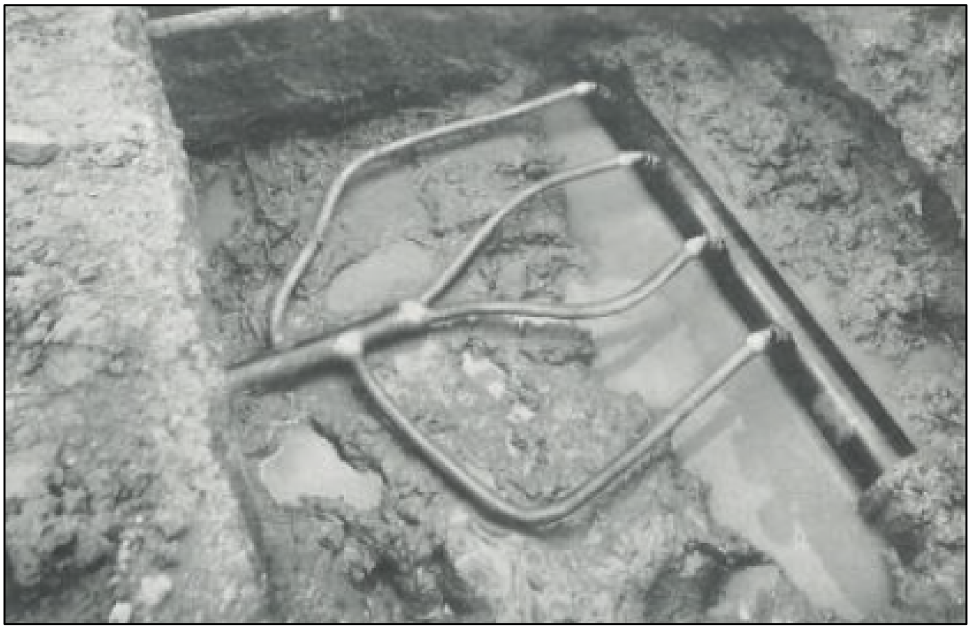

Figure 6: Lead service line (left) with multiple connections to a small street main, exhibiting the material's malleability.[44]

The material advantages of lead pipe led to its wide adoption, particularly in large cities. By the end of the nineteenth century, about half of all American municipalities and 70 percent of cities with populations greater than 30,000 used lead service connections either exclusively or in combination with some other pipe type. By contrast, two-thirds of

[43] "Water-Works Service Pipes," 594–595; National Lead Company, *Lead Products* (St. Louis, MO: National Lead Company, 1939), A1–A4; Werner Troesken and Patricia E. Beeson, "The Significance of Lead Water Mains in American Cities, Some Historical Evidence," in Dora L. Costa, ed., *Health and Labor Force Participation over the Life Cycle: Evidence from the Past* (Chicago: University of Chicago Press, 2003), 183–185.
[44] National Lead Company, *Lead Products*, A-1.

communities with fewer than 8,000 people made no use of lead service connections. Large cities had both the financial resources needed to make an upfront investment in more expensive lead piping and the complicated infrastructure that made the durability and flexibility of the material attractive. Small towns were less likely to have paved roads and could more readily access the buried pipes and handle the occasional failure of an iron service connection. Public water companies were also more likely to invest in lead pipes than were private utility companies, and such public utilities were also more common in large cities.[45]

The chief objection to the use of lead pipe, as was understood at the time, was its potential to contribute to lead poisoning. In low doses, lead exposure produced subtle symptoms that were difficult to diagnosis such as headaches, dizziness, and hypertension. At higher exposures, lead poisoning produced joint and muscle pain, gastro-intestinal distress, infertility, difficulties with memory and concentration, and mood disorders. Extreme levels could cause seizures and death. Children were particularly vulnerable to lead poisoning and could experience serve developmental delays, hearing loss, and a general failure to thrive. Despite this knowledge, most nineteenth-century physicians worried little about the potential for lead poising through the drinking water supply, but focused instead on occupational exposures and the use of lead tubing in distilleries. The sheer ubiquity of lead pipes in major cities and the difficulty in recognizing the signs of low-level lead exposure led many to assume that no major problem existed. Recent studies, however, suggest that the use of lead piping in nineteenth century cities increased stillbirth and infant mortality rates by as much as 400 percent. Effects varied between communities based on the acidity of the water supply and age of the pipes, as older lines developed a protective coating of corrosion that limited the leaching of lead. Upgrading water systems to add filtration and chlorination could increase water acidity, and when combined with new lead pipelines, the results could be disastrous. Lowell and Milton, Massachusetts, for example, overhauled their

[45] Troesken and Beeson, “The Significance of Lead Water Mains,” 186–191; Werner Troesken, “Lead Water Pipes and Infant Mortality at the Turn of the Twentieth Century,” *The Journal of Human Resources*, Vol. 43, No. 3 (Summer 2008), 553–575.

water systems around the turn of the twentieth century, leading to a sudden increase in lead levels that caused several deaths and multiple documented cases of nerve damage and cognitive disability. These widely publicized cases helped to discourage the use of lead pipe in new construction going into the twentieth century. Copper piping offered the chief alternative, with tin and brass following. Like lead pipe, copper pipe is more expensive and harder to work with that its alternatives, but its strength, corrosion resistance, and heat tolerance make it a common material for household plumbing and the smaller-diameter service lines that connect individual buildings to watermains.[46]

For all the improvements made by water companies, distribution networks remained highly inequitable through the nineteenth century. Frequently, central business districts and wealthy residential neighborhoods were the first to receive pipe service, while Black, immigrant, and working-class districts were more likely to continue to draw water from polluted wells. Even when distribution networks were run to more neighborhoods, individual expense was required to connect the public pipe end to private plumbing fixtures. Tenement owners rarely undertook such efforts, so renters continued to haul buckets of water up steep stairwells from the streetside taps.[47]

Water pressure through distribution networks was also inconsistent, owing to the leaky nature of early piping and plumbing. Many homeowners thus constructed water tanks in their attics or on rooftops to regulate the flow. The tanks would fill with water overnight and then the resident would release it for household use during the day when the distribution system pressure was at its lowest. These tanks, however, were troubling subjects for sanitarians as they often contained decaying organic matter and served as breeding grounds for mosquitos.[48]

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[46] Troesken and Beeson, "The Significance of Lead Water Mains," 185; Troesken, "Lead Water Pipes and Infant Mortality," 554–555; Babbitt and Doland, *Water Supply Engineering*, 330–332.

[47] Melosi, *The Sanitary City*, 39.

[48] Fuller, "Water-Works," 1211; A. B. Stout, "Water Tanks on the Tops of Houses," in State Board of Health, *Second Biennial Report*, 210–211.

Urban water systems began to proliferate in the 1870s owing largely to the promotional efforts of water-works equipment manufactures. Birdsill Holly of Lockport, New York, was the leading figure in this transition. The Holly Company manufactured steam-powered rotary and gang pumps that injected water at pressure directly into a town's watermains without need for a reservoir (**Figure 7**). This allowed pipes to maintain a desired pressure with relative consistency, facilitating firefighting and simplifying the overall waterworks systems, though the lack of flexibility in handling variable demands led to the obsolescence of direct-pressure systems by the end of the nineteenth century.

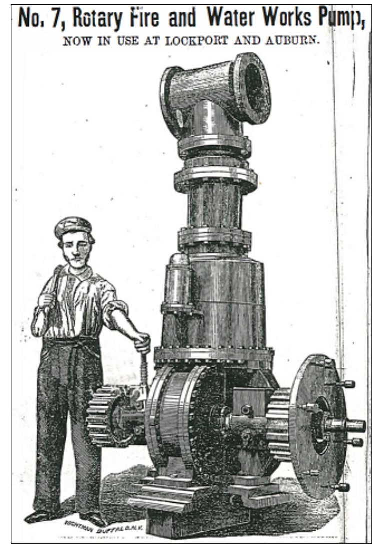

Figure 7: An 1867 prototype Holly pump.[49]

Holly canvased for towns lacking in water systems and offered to complete waterworks in exchange for an annual payment based on the number of fire hydrants provided. The practical and financial success of his system inspired other manufacturers to follow his example. Increased competition, in turn, spurred rapid innovations in waterworks technology, financing, and promotion, inducing many small towns to install their first public water systems.[50]

Throughout the nineteenth century, most cities had water supplies that were separate from sewage discharges, with the exception being communities that relied entirely upon shallow wells or which were located along major interior rivers downstream from other population centers. In the era before effective water filtration, the usual solution to pollution was simply to go further afield in tapping a supply. The largest cities could accomplish this, such as New York City, which in 1842 completed the Groton Aqueduct

[49] Holly Manufacturing Company, "Water Supply and Fire Protection for Cities and Villages," 1867, 8.

[50] Fuller, "Water-Works," 1209–1210.

which carried water by gravity for 41 miles. Most communities, however, lacked the political and financial power to create such systems.[51]

In California, pollution concerns were particularly acute in Sacramento. The upstream towns of Redding, Red Bluff, Chico, Colusa, Marysville, and Yuba City all sat along the Sacramento River or its tributaries north of the capitol city, and all discharged raw sewage into the waterways. The agricultural land immediately north of Sacramento also posed hazards as dead hogs were routinely disposed of in the river and washed up on sandbars to rot in the heat of summer. The State Board of Health held Folsom Prison responsible for "probably the most flagrant pollution of potable waters in California," as it discharged the raw sewage of several thousand convicts into the American River at a point only 22 miles above Sacramento to the east.[52] Logan, as board secretary, had recommended constructing a well into the gravels of the Sacramento River so that the water might be at least filtered before being collected by a Holly pump for distribution to the city. However, to his great frustration, the residents of the city expressed a clear preference for softer, if more hazardous, river water over hard well water. The city thus continued to consume surface water from the Sacramento and American rivers, while the State Board of Health redirected its attention to limiting pollution from Folsom Prison and other upriver sources.[53]

Wastewater

Municipal officials paid little attention to waste disposal prior to the mid-nineteenth century. Even as towns began to develop drinking water systems, they saw no need to construct parallel systems for disposing of the wastewater. The ancient civilizations of Babylon, Mesopotamia, and Rome had constructed sophisticated systems of drainage, but these practices had all but vanished in Medieval Europe. Primitive, folk methods of

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[51] Fuller, "Water-Works," 1211–1214.

[52] State Board of Health, *Fourteenth Biennial Report for the Fiscal Years from June 30, 1894, to June 30, 1896* (Sacramento: State Printer, 1896), 228.

[53] State Board of Health, *First Biennial Report*, 34–37; State Board of Health, *Fourteenth Biennial Report*, 24-28.

waste management, with an emphasis on individual responsibility, prevailed through the seventeenth and eighteenth centuries, and these habits were reproduced in the American colonies. These practices centered around the so-called “cesspool–privy vault system” (discussed below). The rapid growth of cities in the nineteenth century and particularly the introduction of water closets eventually overwhelmed the system by flooding the cesspools and privies beyond capacity.[54]

While the terms cesspool and privy vault were sometimes used interchangeably, the two structures were intended for different waste types and were designed accordingly. Privy vaults handled human fecal and urine waste (what is today termed blackwater), while cesspools received graywater from kitchens, laundries, and animal stalls. Cesspools were large pits constructed in the yard or cellar of a building. They were commonly lined with brick or stone, but mortar generally was not used so that the water might leach into the surrounding soil, leaving kitchen scraps behind to decompose. In areas too underdeveloped for cesspools, liquid household waste might be piped to a nearby drainage or merely be cast upon the ground.[55]

Privy vaults were little more than shallow holes dug in the ground, usually without lining. In rural areas, the privy would be covered with soil when filled and a new hole could be dug. In denser settlements, it was necessary to periodically empty privies to keep them in use. Individuals either did this work for themselves or contracted with private scavengers. Later, specialized collection companies employed odorless excavators to rapidly suction privies. Many cities required that privies be emptied only at night, giving rise to “night soil” as a euphemism for human waste. The collected material might be sold to outlying farmers for fertilizer or be dumped in a convenient waterway or refuse

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[54] Melosi, *The Sanitary City*, 39–40. The “cesspool-privy vault system” term is from Joel A. Tarr; see *The Search for the Ultimate Sink: Urban Pollution in Historical Perspective* (Akron, OH: University of Akron Press, 1996), 113–114, and Tarr, James McCurley III, Francis C. McMichael, and Terry Yosie, “Water and Wastes: A Retrospective Assessment of Wastewater Technology in the United States, 1800–1932,” *Technology and Culture*, Vol. 25, No. 2 (April 1984), 226–263.

[55] Melosi, *The Sanitary City*, 40.

pile. In built-up neighborhoods, privies posed a danger to nearby wells as waste leached through the soil. The problems were compounded when heavy rains caused privies to overflow through a neighborhood, mixing their raw waste with the general flooding.[56]

Sewers were uncommon before the mid-nineteenth century, and where they existed, they were used primarily for carrying storm runoff. Early sewers were largely of private construction without any systematic planning. Open ditches or brick-lined street gutters carried away rainwater and allowed for the drainage of cellars. Later the ditches were covered with brick, creating the first partially enclosed sewers. Municipalities began to specify construction techniques and the division of costs among neighbors in the 1820s, and commonly prohibited the dumping of solid waste, and particularly fecal matter, into the systems. However, these regulations were frequently ignored, and the surface sewers frequently carried kitchen waste, offal, manure, and the industrial byproducts of dye works or tanneries.[57]

The introduction of piped water seriously disrupted the cesspool–privy vault system. The availability of freely running water at the household tap led to a surge in per capita use, increasing from the prior three to five-gallon range to between 50 and 100 gallons per day. This increase alone threatened to overwhelm cesspools, but the problem was compounded by the introduction of water closets. Flush toilet technology had been around for some time, but it required the wide availability of piped water to make the system practical. Water closets were introduced in England around 1810 and the first models were patented in the United States in 1833. Affluent homeowners quickly adopted the modern technology which promised greater convenience and sanitation than outhouses and privies. By 1880, approximately one-third of urban households had installed water closets.[58]

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[56] Melosi, *The Sanitary City*, 40.

[57] Melosi, *The Sanitary City*, 39–42.

[58] Melosi, *The Sanitary City*, 40; Tarr, *The Search for the Ultimate Sink*, 113–115.

The increased flow into cesspools and privy vaults overwhelmed the ability of the soil to absorb the leach water. In city after city through the late nineteenth century, the old regime of waste management collapsed before a new system could be put in place. Cites attempted to order homeowners to empty their cesspools and privies more frequently, but compliance was poor. Many households constructed surreptitious connections to the city sewer system, illegally draining their water closets into pipes that were not designed for the task of carrying off human waste. Fecal matter began to spread over large areas, posing particular problems for low-lying neighborhoods that were generally populated by the poor and immigrants. Ironically, the piped water and water closet technologies that had been sold with the promise of improved sanitary health had the opposite effect. Incidents of waterborne disease surged as overflowing privies became a ubiquitous feature of urban life.[59]

Sanitarians proposed as a remedy a system of "water carriage," in which waste would be transported by hydraulic flow through a network of self-cleaning sewer lines. This meant abandoning privies and cesspools and repurposing the storm sewers to carry wastewater in addition to rain runoff. New interceptor lines needed to be constructed to tie together the patchwork of existing sewer lines. Brooklyn completed the first American combined sewage–stormwater system in 1857, followed by Chicago in 1859. These sewerage systems dumped the untreated waste into nearby riverways, where it was presumed that dilution would render the stream water safe. It was then widely believed among sanitarians and others that running water was self-purifying, though experiences in London with the highly polluted Thames River had already called that convenient assumption into doubt. The issue was largely a moot one anyway as no practical form of sewage treatment was yet available. (As a term, "sewerage" referred to the drainage and disposal of waste without treatment; when treatment was later introduced, the term "sewage system" was commonly used for the combined process of collection, treatment, and disposal).[60]

[59] Tarr, *The Search for the Ultimate Sink*, 113–115.

[60] Tarr, *The Search for the Ultimate Sink*, 117–122.

As an alternative to the combined sewer system, some engineers proposed constructing separate lines for stormwater and sewage. In England, a great debate over the relative merits of the combined and separate systems had raged since the 1840s, but the separate system got a toehold in America only in 1880, when Memphis, Tennessee, constructed the first such system of large scale in the country. The presumed advantage of the separate system was that it could more quickly evacuate waste from a city, so that the sewage left the populated area in fresh condition before putrefaction of organic material reached a critical point of giving off miasmic gases. The system attracted considerable attention but was not widely duplicated as the National Board of Health held that both combined and separate systems were of equal sanitary value and that the selection of one system over the other depended upon local circumstances. As most cities already had storm sewers, it was less expensive to construct a combined system. Only when sewage treatment became more widely adopted in the late nineteenth century did separate sewage systems begin to be constructed, as it was far easier to treat sewage that was separated from stormwater.[61]

Unlike drinking water systems that were largely constructed by private industry, municipal governments were almost solely responsible for building and operating sewers. Private utility companies naturally gravitated towards services that generated revenue such as providing drinking water, electricity, telegraph or telephone lines, and streetcars or railroads. Non-revenue generating activities such as refuse disposal, street construction, firefighting, and code enforcement remained principally the domain of government. Private industry participated in building sewerage systems as construction contractors and the manufacturers of pipe. Later, industry played important roles as engineering consultants and as patent holders on various mechanical devices and biochemical processes.[62]

[61] Tarr, *The Search for the Ultimate Sink*, 117–122.

[62] Sarah S. Elkind, *Bay Cities and Water Politics: The Battle for Resources in Boston and Oakland* (Lawrence, KS: University Press of Kansas, 1998), 27–28.

California Sewerage

Early sewerage construction in California occurred piece by piece, completed primarily by private interests in an unplanned, unsystematic fashion. At least 59 Californian cities constructed sewerage systems in the nineteenth century (**Table 2**), and while many made efforts to bring order to their network of public and private pipes, few achieved anything more than patchwork solutions. Sanitarians and municipal engineers might have envisioned comprehensive systems that collected and disposed of sewage in an orderly manner, but the reality was far messier. F. Walton Todd, a state board member from Stockton, wryly summarized the usual course of development:

> A drain is made from somebody's hotel, and another from a livery stable is allowed to connect with it, and so on until an interest is established that has weight in a Common Council, and thus, from step to step, a system grows up altogether vicious, which sooner or later, and always after large sums of money have been spent, has to give way to another, the work of a competent engineer, but not until some serious damage has been inflicted, which the engineer, Board of Health, and Common Council combined cannot repair.[63]

Table 2: Year of construction for nineteenth-century California sewerage works.[64]

Year	City	Year	City
1850	San Francisco	1895	Belmont
1850 (circa)	Sacramento	1895	Emeryville
1863 (circa)	Los Angeles	1895	Fort Bragg

[63] State Board of Health, *Fifth Biennial Report*, 91–92.

[64] Bureau of Sanitary Engineering, "First Sewage Works Statistics for California," November 1932, reproduced in Charles Gilman Hyde, "Pencil Manuscript, A Chronology of Sewerage and Sewage Treatment and Disposal in the United States and Abroad," Box 17, Charles Gilman Hyde papers, WRCA 046, WRCA UC Riverside.

Year	City	Year	City
1869 (circa)	Oakland	1895	Ontario
1876	San Buenaventura	1896 (circa)	Martinez
1877	San Jose	1896	Piedmont
1878	Alameda	1896	San Mateo
1879	Napa	1896	Ukiah
1880 (circa)	San Rafael	1897	Hollister
1880	Santa Barbara	1897	Modesto
1880 (circa)	Suisun	1897	Salinas
1880	Vallejo	1897	Santa Rosa
1885	Coronado	1898	Red Bluff
1887	San Diego	1899	Belvedere
1888	Berkeley	1899	Ferndale
1888	Santa Cruz	1899	Palo Alto
1890	Fresno	1899	Paso Robles
1890	Redding	1899	Ross
1890	Redlands	1899	San Anselmo
1890	Redwood City	1899	Watsonville
1890	San Bernardino	1900	Beverly Hills
1890	Santa Ana	1900 (circa)	Daly City
1890	Woodland	1900 (circa)	Monterey
1892	San Luis Obispo	1900	Nevada City
1893	Auburn	1900	Pomona

Year	City	Year	City
1893	Los Gatos	1900 (circa)	Porterville
1893	Stockton	1900 (circa)	Sonora
1894	Mount Shasta	1900	Visalia
1894	Richmond	1900 (circa)	Wheatland
1894	Riverside	n/a	n/a

At the end of the century, the eminent civil engineer C. E. Grunsky surveyed sewage systems throughout the state and found that most remained a tangled web of pipes of various ages, materials, and designs. He concluded that nearly all the works operated by "a haphazard method that is really beyond all comprehension."[65]

Most of the early California sewer systems were of the combined sewage–stormwater variety. It made little sense, at an early date, to construct separate conduits for stormwater runoff as these would receive little use through the long dry season. Combined systems also allowed for subsoil drainage in low-lying areas like the Mission Flats district of San Francisco and downtown Sacramento. This drainage improved public health by limiting the formation of stagnant pools and made cellar storage feasible. The combined sewage pipes were necessarily large to handle winter runoff. The main pipes in Oakland, for example, were five feet wide by five and one-half feet high, while the San Francisco pipes were occasionally wide enough to drive a wagon through. The larger size also allowed sewage workers to physically enter pipes and

[65] C. E. Grunsky, "The Collection and Disposal of Sewage," in *State Board of Health, Sixteenth Biennial Report for the Fiscal Years from June 30, 1898, to June 30, 1900* (Sacramento: State Printer, 1901), 59.

move through them in a stooped position or by crawling so as to remove the sediment that invariably entered the combined pipes (**Figure 8**).[66]

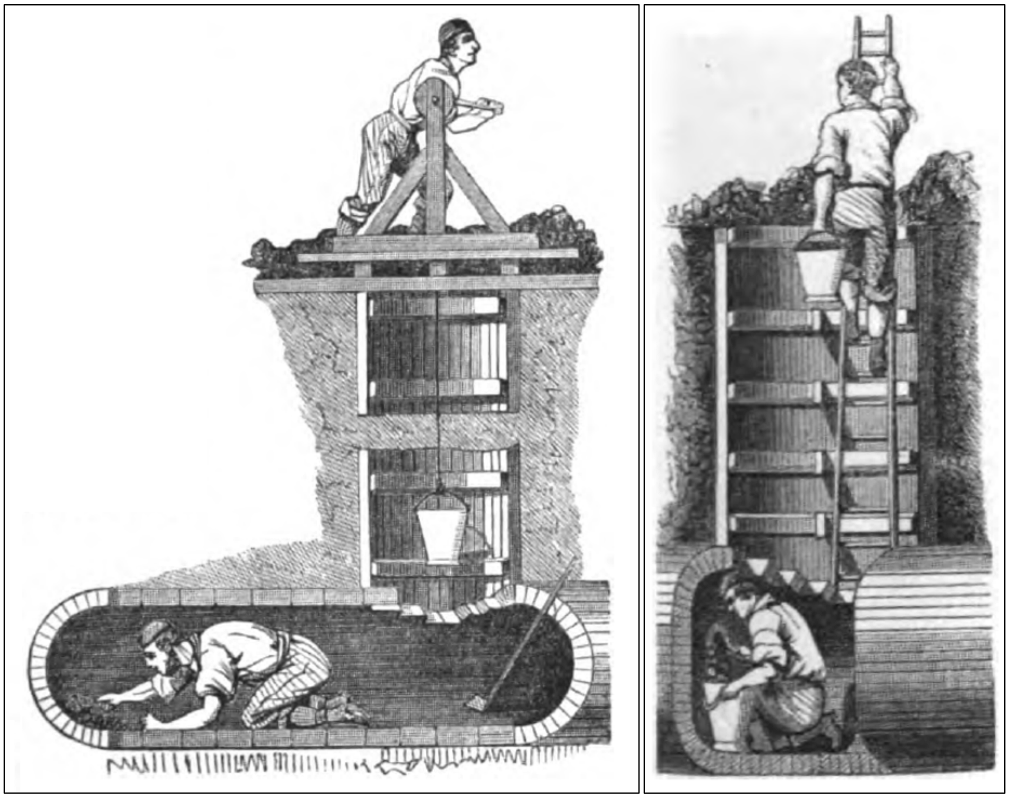

Figure 8: Manual removal of sediment from combined brick sewer lines.**[67]**

Cities began to construct separate sewage systems in the final decades of the nineteenth century. These systems were more common in Southern California where urban development occurred later and rainfall totals averaged lower than in the northern part of the state. San Diego, Los Angeles, Santa Barbara, and San Luis Obispo all had separate sewage systems by the 1890s, as did the campus of Stanford University on

[66] State Board of Health, *Fifth Biennial Report*, 68–69; Grunsky, “The Collection and Disposal of Sewage,” 60; Grunsky, *Report upon a System of Sewerage*, 13, 38; Stallard, *The Problems of the Sewerage of San Francisco*, 13.
[67] Latham, *Sanitary Engineering*, 75.

the San Francisco Peninsula. These systems utilized smaller pipes, with the main line in San Diego, for instance, being 24 inches in diameter.[68]

Main combined sewer lines were customarily constructed of brick because of their large size. Early construction used whatever bricks and mortar were readily available, but too often these eroded away as sand and silt washed through the pipes. Later work called for hard, thoroughly burnt bricks with smooth surfaces to reduce frictional drag. Where cost was an overriding consideration, common brick might be used on the sides and upper arch of the sewer as these were less subject to wear and tear. Blocks of terra-cotta or stoneware were frequently used at the bottom of the sewer for their enhanced durability and smoothness. Termed “invert blocks,” these came in both solid and hollow forms. The hollow blocks helped drain subsoil moisture during construction, but were weaker than solid forms and builders sometime filled them with cement at the conclusion of work. An egg shape was most frequently used in the main sewer lines as the profile placed low volume flows in the constricted bottom width to maintain velocity while widening above to increase capacity in large flow events (**Figure 9**).[69]

[68] Stallard, *The Problems of the Sewerage of San Francisco*, 23.

[69] Lathan, *Sanitary Engineering*, 214–227; Humphreys, “Plan for a System of Sewerage,” 600–601; State Board of Health, *Fifth Biennial Report*, 65.

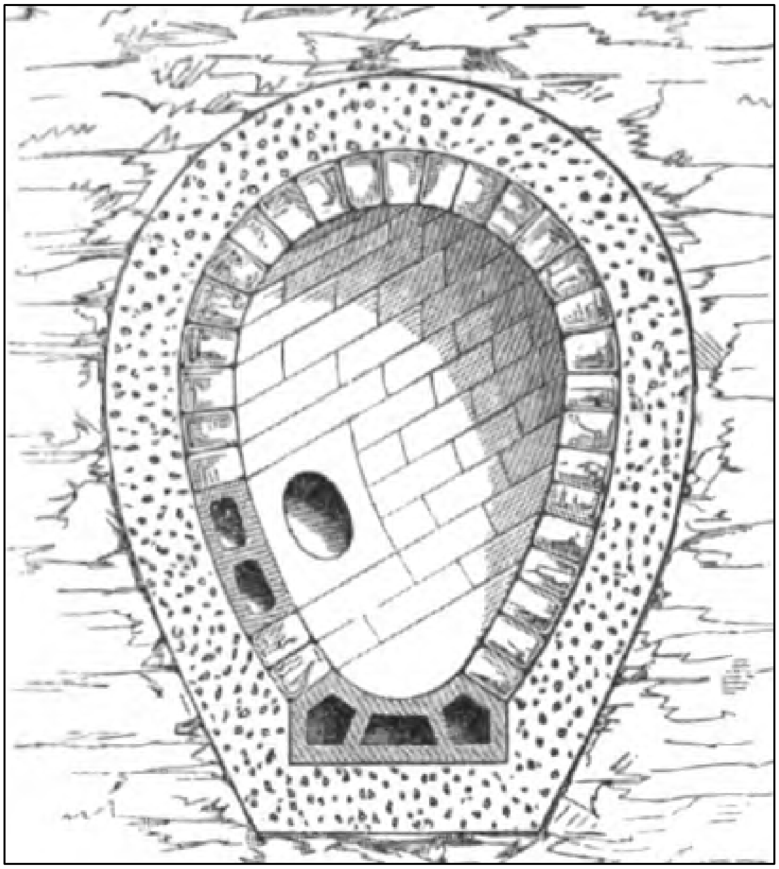

Figure 9: Cross section view of an egg-shaped brick sewer with hollow invert block and, at left, a branch line entrance made through a vitrified clay block.[70]

The smaller branch lines were generally constructed of vitrified clay or concrete, though specially curved bricks could be used for small diameter pipes. Concrete and vitrified clay were favored for their economy, durability, water tightness, and smooth internal surfaces (**Figure 10**). Concrete pipes could be manufactured locally and allowed for patch repairs in a way that vitrified clay pipes did not, but care had to been taken to ensure that contractors correctly mixed the concrete as a poorly constructed concrete line quickly eroded. Vitrified clay pipes had the smoothest surfaces and were the easiest to work with, but into the 1870s the best quality pipe still had to be imported from Scotland. Redwood pipes were less durable over the long term, but received wide-spread use owing to the ubiquity of the material and low cost. Wooden pipes were also

[70] Lathan, *Sanitary Engineering*, 284.

useful where sewer lines crossed marshy terrain as heavier brick sewer lines would require constructing piling foundations. Cast iron pipes were used nationally in sewerage systems in the mid-nineteenth century, but the extent of their employment in California is not well documented.[71]

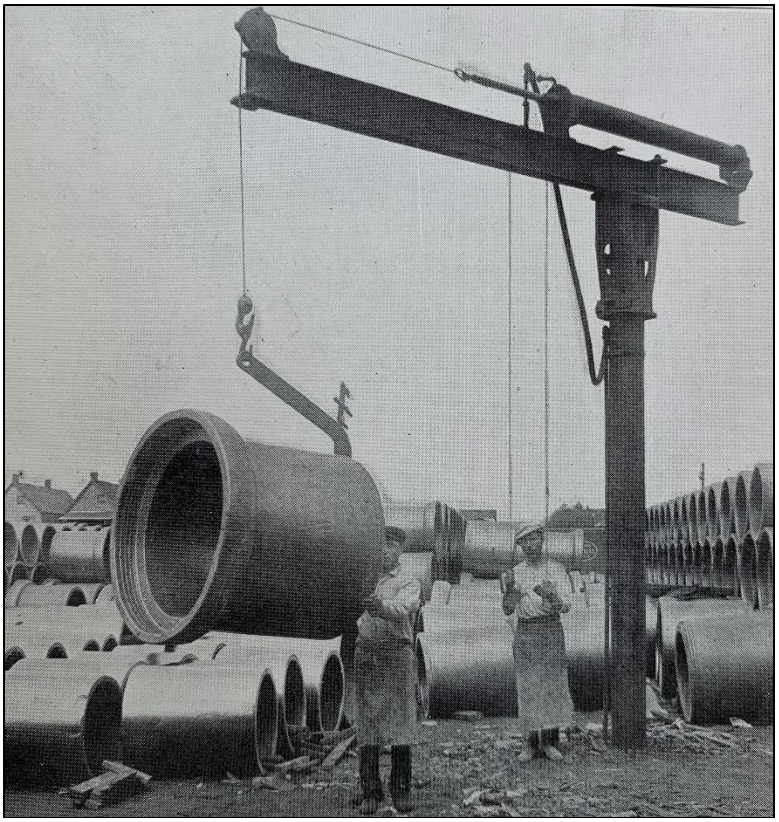

Figure 10: A crane lifts a large diameter section of vitrified clay sewer pipe in a manufacturer's storage yard.[72]

Manholes were placed at regular intervals along sewer lines to allow for maintenance and the clearing of obstructions. In most cases, this permitted repair work to be done without requiring the expensive and disruptive excavation of roadways. Manholes were generally constructed on a circular plan, being approximately three to five feet in

[71] State Board of Health, *Fifth Biennial Report*, 65; Humphreys, "Plan for a System of Sewerage," 600–601.

[72] Clay Products Association, *Vitrified Salt Glazed Clay Sewer Pipe: The Everlasting Material for Sewerage Construction* (Chicago: Clay Products Association, 1925), n.p.

diameter at bottom and tapering towards the surface, with brickwork lining the manhole well. Square manholes were used occasionally where larger entrances were needed, but these required additional brickwork and were thus more expensive to provide. Smaller lamp holes were added along lines to assist in locating and removing stoppages (**Figure 11**). A sewer worker would suspend a light in a lamp hole and then enter the adjacent manhole. He would know the obstruction had been cleared when he could see the lamp light shining down the pipe. Manholes also provided a means of ventilating the sewers through the holes left in the manhole covers, though these frequently clogged with dirt and manure on busy streets.[73]

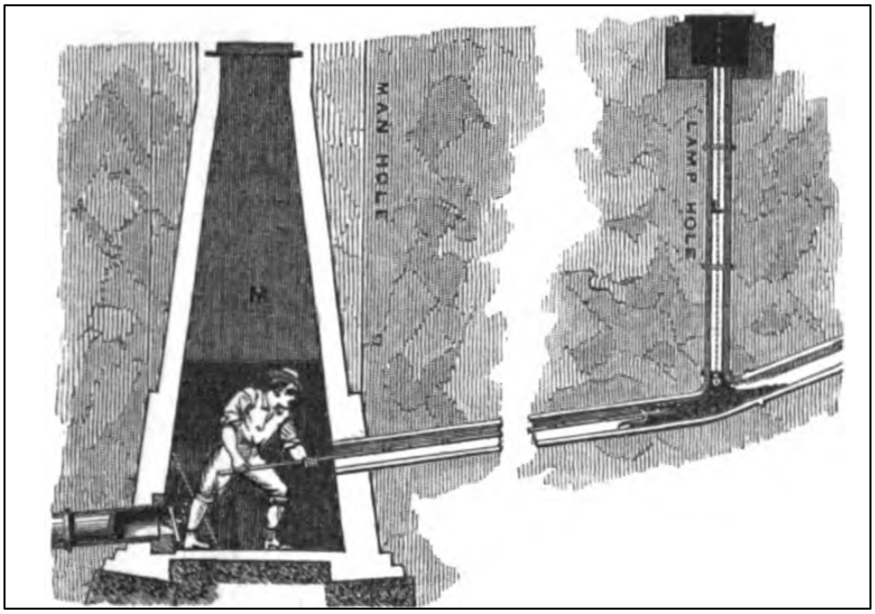

Figure 11: Manhole and lamp hole used for stoppage removal.[74]

Combined sewer lines required manual clearing or periodic flushing during periods of low rainfall. The low volume of fluid passing through a large pipe during the summer could not generate adequate velocity to clear accumulated silt and organic matter. The problem was compounded by the irregularities of nineteenth-century construction that caused velocities to vary through a sewer line owing to changes in grade, pipe diameter, surface friction, and other variables. The simplest system of flushing involved

[73] State Board of Health, *Fifth Biennial Report*, 67; Latham, Sanitary Engineering, 417–421.

[74] Latham, *Sanitary Engineering*, 165.

directing a hose from a fire hydrant into openings that were constructed along the sewer line. The water of several hydrants was combined to flush the main line. Sacramento, as a typical example, constructed flush holes at the head of every branch line and periodically along larger lines. Once or twice a month, maintenance workers began flushing at the bottom of the system and worked their way towards the heads.[75]

Automated flushing systems allowed for daily clearance of the lines and reduced the required labor but involved greater initial expense (**Figure 12**).

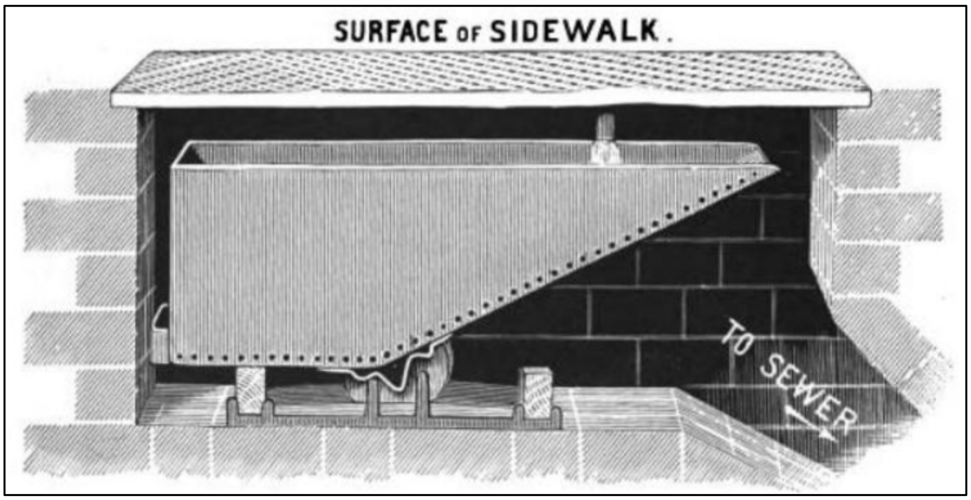

Figure 12: Automated flushing systems manufactured by the Gravity Flusher Co. of Alameda.[76]

These systems consisted of a network of tanks installed at the head of the sewer lines. Taps running from watermains slowly filled the tubs. The fill rate could be adjusted to provide for flushing intervals ranging from every two hours to twice per day. Once full, the tank tipped under its own weight, emptied its contents, and returned to the upright position to fill again. Alameda purchased 130 of these flushing tanks in the late 1880s to clear its 41 miles of sewage line. Each tank held 50 gallons of water and dumped every six hours. The tanks were installed just below sidewalk grade, in brick receptables covered by iron lids, to provide easy access for adjusting the flushing frequency.[77]

75 State Board of Health, *Fifth Biennial Report*, 67,

76 Stallard, *The Problems of the Sewerage of San Francisco*, Appendix A.

77 Stallard, *The Problems of the Sewerage of San Francisco*, 24–25, Appendix A.

More elaborate flushing systems were proposed in San Francisco and implemented in Oakland. San Francisco suffered from particularly bad problems of pooling sewage that ordinary fire hydrant flushing could not clear. In the early 1870s, State Board of Health member A. B. Stout proposed constructing a series of reservoirs along the ridges and hilltops above the city and filling these with salt water pumped from the bay. Great volumes of water could then be released to clear obstructions before flowing back to the sea. City officials never constructed the expensive proposal, but it remained under consideration through the end of the century. In Oakland, City Engineer T. W. Morgan designed an ingenious system that caused waters from Lake Merritt, then still connected to the bay tidelands, to flush the line twice daily. Floodgates in a dam at the bottom of the lake permitted water to enter on the flood tide, but prevented it flowing out with the ebb. Workers manually opened a gate at the head of the main sewer line to send a scouring burst of stored water through the sewer and back to the tidelands. Oakland thus treated Lake Merritt like the tank on a toilet bowl that was flushed and refilled by the regular motion of the earth beneath the moon.[78]

Engineers during this same period devoted considerable attention to finding means of venting sewer gases. Indeed, because of the influence of miasma theory, sanitarians regularly gave greater priority to the control of vapors than to the disposal of liquid waste. When homeowners caught a whiff of sewage coming up from a kitchen sink, they worried about the illnesses that their neighbors might be transmitting to them through the shared sewer lines. Despite intense study, however, sanitarians developed no practical method for dispersing sewer gas. Experiments were made with air vacuums, blowers, furnaces, and charcoal filters, but none were economical to deploy at scale. Oakland considered building towers through the city to vent gases above the rooflines, but never pursued the idea. Attention thus focused on simply keeping the gas out of homes and businesses through the use of drain traps. These basic U-shaped traps were installed beneath sinks and water closets to retain a small quantity of water

[78] State Board of Health, *First Biennial Report*, 10; Arthur B. Stout, “Sewerage,” in State Board of Health, *Second Biennial Report*, 206–207; State Board of Health, *Fifth Biennial Report*, 70; Humphreys, “Plan for a System of Sewerage,” 609–610.

in the pipe after draining. The trapped water formed a seal against rising gases and odors. While simple drain traps had been in use since the eighteenth century, the design continued to evolve through a great number of patented forms as the quantity and types of drains in households multiplied.[79]

Sewage Farms

The disposal of sewage on land offered the only practical alternative in the nineteenth century to the dumping of raw waste into bodies of water. The practice variously termed "sewage farming," "sewage irrigation," or "broad irrigation" both prevented river pollution and allowed for sewage effluent to be put to beneficial use as fertilizer. Sewage farming proved particularly well adapted to the arid American West, and Californians adopted the practice on a wider scale than did any other state. At least 50 California cities and 39 public and private institutions made use of sewage farms over a span of half a century between the late 1880s and World War II.[80]

Sanitarians were almost universally in favor of the use of sewage farms. The British reformer Edwin Chadwick advocated the practice beginning in the 1840s and argued

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[79] Baldwin Latham, *Sanitary Engineering: A Guide to the Construction of Works of Sewage and House Drainage*, Second edition (London: E. & F. N. Spon, 1878), 307–416; I. H. Stallard, *The Problems of the Sewerage of San Francisco: A Polyclinic Lecture* (San Francisco: H. S. Crocker, 1892), 18–19; State Board of Health, *Fifth Biennial Report for the Years 1878 and 1879* (Sacramento: State Printer, 1879), 69.

[80] Joel A. Tarr, "From City to Farm: Urban Wastes and the American Farmer," *Agricultural History*, vol. 49, no. 4 (Oct 1975), 598–612; George W. Rafter and M. N. Baker, *Sewage Disposal in the United States* (New York: D. Van Nostrand Co., 1894); George W. Rafter, *Sewage Irrigation, Water–Supply and Irrigation Papers of the US Geological Survey* (Washington D.C.: Government Printing Office, 1897); N. T. Veatch, Jr., "The Use of Sewage Effluents in Agriculture," in Langdon Pearse, ed., *Modern Sewage Disposal: Anniversary Book of the Federation of Sewage Works Associations* (New York: Federation of Sewage Works Associations, 1938), 180–190. Statistic on California cities and institutions: Veatch, "The Use of Sewage Effluents in Agriculture," 183.

that the entire cost of municipal sewer systems could be paid for through selling the output to farms. The Massachusetts Sanitary Commission echoed the recommendation in the 1850s, and by the 1870s American scientific journals and the popular press were regularly running articles on the practice. Sewage farming even showed up in the utopian writings of Victor Hugo and Edward Bellamy. The California State Board of Health joined the call for sewage farming beginning with its second annual report in 1873 and remained in support of the method into the 1930s.[81]

The use of human and animal waste on farms to boost productivity was, of course, an ancient practice. The Romans used human waste as fertilizer and the tradition remained common throughout Europe well into the nineteenth century. Particularly refined methods of gardening with night soil were in use in China, Japan, and Korea for centuries. These early methods utilized the waste of privies and cesspools. Scavengers with ladles and buckets or service companies with odorless excavators collected the waste and sold it either directly to farmers for depositing on the land or to processing plants for conversion into compost or fertilizer.[82]

The introduction of water carriage sewer systems (discussed above) in the nineteenth century required a change in practices. By one contemporary estimate, the sewage from a water carriage system consisted of 998 parts water, one part mineral matter, and one part organic matter. The intent of sewage farming was to neutralize that one-thousandth part organic matter while retaining its valuable nitrogen, phosphorous, and potash. The chief challenge was finding a way to dispose of the water, which could easily run to tens of thousands of gallons a day from even a mid-sized town. The land selected for a sewage farm should be well drained with a sandy or gravelly subsoil, accessible by gravity flow, and of low cost. The character of the surrounding habitations needed to be considered to avoid complaints about nuisance odors, although sewage farming advocates claimed the smells were no worse than those arising from pigsties and barnyards. The practice was particularly valued in the western states because low

[81] Tarr, “From City to Farm,” 607–611; State Board of Health, *Second Biennial Report*, 209.

[82] Tarr, “From City to Farm,” 598–601.

summer river flows made instream disposal an unbearable nuisance and there was always high demand for any irrigation source.[83]

The method of irrigating with sewage did not differ greatly from ordinary irrigation practices. A somewhat greater degree of care was needed to minimize direct contact between the sewage and growing plants and to control the ponding of sewage when effluent was placed on saturated soils during winter rains. Pipes were generally used to carry sewage to the farming grounds, but then the effluent could be run through ordinary, unlined, earth ditches. The land was leveled and prepared with furrows and ridges for row crops or divided into check basins for flood irrigation. As irrigation was not required during the winter months, it was necessary to set aside some land for uncropped infiltration. Most any crop could be grown by sewage farming, though in 1918 the State Board of Health issued regulations prohibiting the use of sewage on garden vegetables intended to be eaten raw. Fruit trees, melons, grains, and vegetables intended for cooking or canning all remained permissible.[84]

Public institutions were the first to use sewage farming in the United States, beginning in the 1870s. Asylums, prisons, alms houses, and reformatories could supply labor without expense and had a built-in market for the crops produced. Pullman, Illinois, was the first municipality to employ a sewage farm to dispose of its waste in 1881, though the practice did not long endure there owing to the heavy clay soils and natural abundance of rain. Pasadena in 1888 was the second American city to establish a sewer farm and it became a model for many of the other municipal programs that followed. By the early 1890s, municipal sewage farms were operating in Redding, Santa Rosa, Stockton, Fresno, and Los Angeles.[85]

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[83] Rafter and Baker, *Sewage Disposal in the United States*, 152–153; Rafter, *Sewage Irrigation*, 39–41; Veatch, “The Use of Sewage Effluents in Agriculture,” 181; Tarr, “From City to Farm,” 606.

[84] Rafter, *Sewage Irrigation*, 39–43; Tarr, “From City to Farm,” 610–611.

[85] Rafter and Baker, *Sewage Disposal in the United States*, 15, 539–559; Tarr, “From City to Farm,” 607–608.

The Redding sewage farm provides a typical example of a medium-scaled municipal operation. The city constructed a separate sewage system in 1889, designed by the city engineer. The system, serving a population of around 2,000, included 2.9 miles of line and seven 112-gallon automatic flushing tanks. The city had intended to dispose of its waste into the Sacramento River, but objections from the State Board of Health led to a search for alternatives. The city called for bids on a contract to dispose of the waste for a 40-year period at a beginning payment of $300 yearly, to be increased in proportion to the community's growth. L. F. Bassett, the former Sacramento city engineer, secured the contract and purchased 100 acres of land at the city fairgrounds, about a mile south of Redding, in the location of today's civic center (**Figure 13**). About 10 acres were initially prepared for irrigation by leveling the land and running furrows. Bassett laid a 12-inch-diameter pipe through the racetrack grounds and excavated open ditches to carry the sewage to the prepared land. The sewage irrigated a variety of crops including asparagus, turnips, beets, and potatoes, but was used primarily for raising fruit trees as nursery stock. The acreage had a soil of loamy sand underlain with a deep bed of gravel and did not require a separate system of drainage.[86]

[86] Rafter and Baker, *Sewage Disposal in the United States*, 548–551; "The Sewage Farm," (*Redding*) Free Press, October 1, 1892, 3.

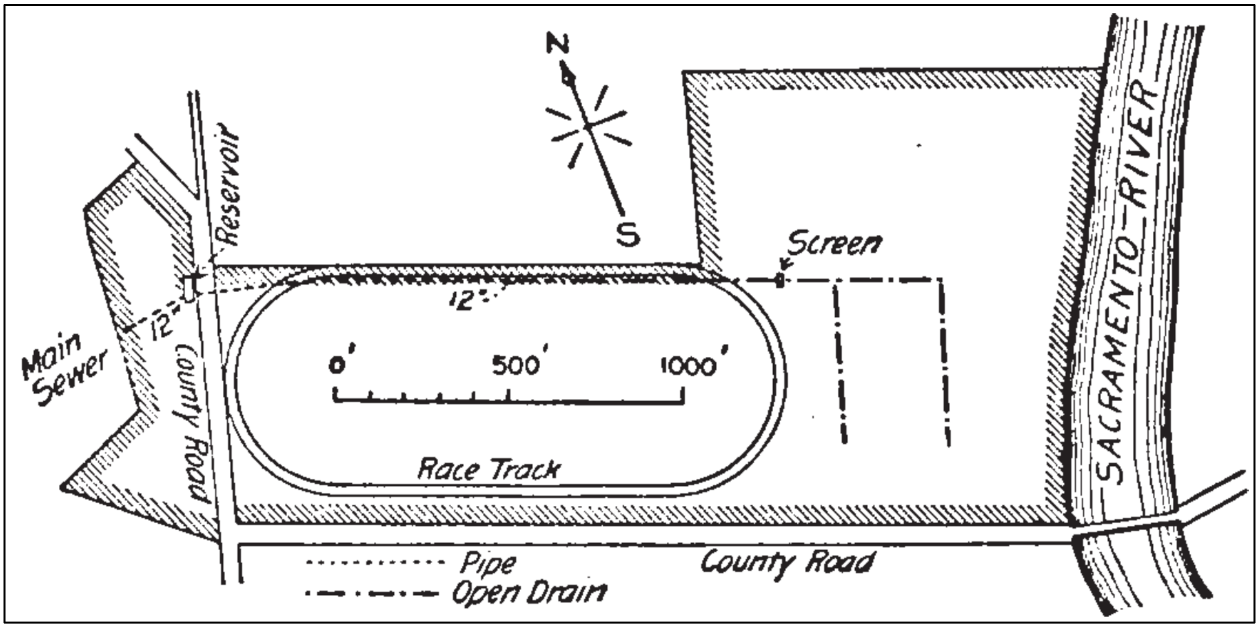

Figure 13: Plan of Redding sewage farm, designed in 1889.[87]

Rather than run the sewage continually, Bassett constructed a 75,000-gallon reservoir—equal to one day's average flow—to hold the material overnight. In the morning, the reservoir gate was opened and the sewage flowed onto the land for two to four hours before the gate was again closed. The reservoir was covered by a wood lid and included a 60-foot-tall timber chimney to disperse odors and prevent the site from becoming a nuisance to the adjacent county road. A screen above the irrigated lands removed any large objects that might obstruct the irrigation ditches. During the winter, when no crops were growing, it was necessary to run the sewage onto one piece of land for several days and then to plough it under when the ground had sufficiently dried. The greatest odor occurred at this time as the sewage ponded before being absorbed into the saturated soil.[88]

The construction and operation of the sewage farm was not without opposition. Neighboring landowners objected to the approval of the farm prior to its completion, and in 1892 they had Bassett arrested for maintaining a public nuisance. The courts,

[87] Rafter and Baker, *Sewage Disposal in the United States*, 550.

[88] Rafter and Baker, *Sewage Disposal in the United States*, 548–551; "The Sewage Farm," (*Redding*) Free Press, October 1, 1892, 3.

however, sided with the sewage farm, and the local press also offered support. The State Board of Health added its endorsement later in the year when a delegation visited the Redding sewage farm to ascertain its impact on the Sacramento River. Pleased with what they found, they declared the system satisfactory and "commendable to that progressive city."[89]

Nationally, sewage farming achieved its peak popularity in the 1890s and then declined. The adoption of new and generally superior technologies for sewage treatment around the turn of the century, including septic tanks, chemical precipitation, and sprinkling filters, was the chief cause of the decline. Advocates of sewage farming claimed that these new methods wasted the nutritional and economic value of sewage, but sanitary engineers countered that the fertilizing power of sewage had always been overrated. The large volume of water applied in sewage farming in many cases leached nutrients from the soil quicker than they could accumulate. Public health concerns about applying raw sewage to edible crops had been relatively muted when no better sewage treatment option was available, but the increase in alternatives brought greater attention to the problems. Rising land values on the margins of towns, where sewage farms were initially constructed, also favored abandoning the older plants. Sewage farming remained a viable option only in locations where irrigation water was in great demand, as in much of Southern California. The practice continued there in adjunct to other treatment methods, so that sewage was first processed by a septic tank or sprinkling filter before the treated effluent was discharged as irrigation water. In this way, the method prefigured the later practice of using reclaimed wastewater for irrigating roadsides and other public lands.[90]

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[89] State Board of Health, *Fourteenth Biennial Report*, 26; "Municipal Notes," (*Redding*) Free Press, January 11, 1890, 1; "The Sewage Farm," (*Redding*) Free Press, October 1, 1892, 3.

[90] Tarr, "From City to Farm," 609–610.

2.2. The Era of Sanitary Engineering, 1900–1949

The first half of the twentieth century witnessed rapid advances in sanitation science and technology, but slower progress in policy. The creation of two new academic and regulatory bodies epitomized the era. In 1905, the University of California established a department of sanitary engineering at Berkeley, headed by Charles Gilman Hyde, and a decade later, the State Board of Health created the Bureau of Sanitary Engineering, led by Hyde's former student, Chester Gillespie. The careers of both men extended into the late 1940s and coincided with the emergence of modern sanitary engineering practices.

The first decades of the twentieth century saw the creation of nearly all the major processes and pieces of infrastructure employed at drinking water and wastewater treatment plants today. These included the processes of chlorine disinfection and rapid sand filtration for drinking water, and the biological wastewater treatment methods used in trickle filters and activated sludge tanks. These advances largely halted the scourge of typhoid fever except in locations that lacked modern services because of their remoteness or economic marginality. Still, the laxness of state regulations meant that few municipalities constructed modern sewage treatment plants prior to World War II. The newest and most sophisticated systems tended to be constructed in Southern California, where communities were young and growth rapid, while Northern California employed more legacy systems from the nineteenth century.

2.2.1. Knowledge

Germ Theory

By 1900, the germ theory of disease, more formally known as bacteriology, had replaced the earlier miasma theory in sanitary planning. Among public health professionals it became accepted fact that it was not filth in general that caused disease, but the presence of particular microorganisms. Expectations faded for the sort of broad social reforms that had animated the sanitarian movement and were replaced with the more narrowly focused task of ridding public water supplies of disease-causing organisms. The application of this knowledge, particularly through the chlorination of drinking water, produced sharp drops in death rates from typhoid fever and other intestinal illnesses. Ironically, the decline in disease led to greater tolerance for sewage dumping as the public came to see pollution as a mere nuisance rather than a public health crisis. It was only when officials later began to worry about the economic impacts of pollution that they again made efforts to limit raw sewage discharges.[91]

At its core, germ theory held that discrete, microscopic organisms penetrated bodies and caused disease through their growth and reproduction. These pathogens, or "germs," could be bacterial, viral, or fungal. Ideas related to the germ theory had been in circulation for centuries, but they gained dominance among medical professionals only in the late nineteenth century. The investigations of Louis Pasteur and Robert Koch between the 1860s and 1880s were the first to identify specific organisms responsible for disease and to demonstrate conclusively the shortcomings of alternative theories. Still, the theory was slow to find full acceptance. Most physicians were flexible in their thinking and for decades continued to freely combine the germ theory with their long-standing beliefs about miasmas and the influences of climate and topography on health.[92]

The impact of germ theory on public health measures was thus initially subtle, but it ultimately proved transformative. Physicians shifted their focus from society to the individual and from preventing disease to curing it. Medical practitioners and engineers grew irritable with the efforts of sanitarian reforms, which while well-meant and often at least indirectly beneficial, seemed to miss the essential scientific point. "Smells are not dangerous," claimed San Francisco engineer Ernest McCullough. "They are rarely, if ever, a cause of illness. They are simply unpleasant to our modern sense of what is right and proper."[93] Local boards of health shifted their efforts from supervising sanitary systems to measures that more directly aligned with the new science such as vaccination campaigns and inspecting health conditions among the increasing immigrant population. By the First World War, municipal health departments had largely

[91] Elkind, *Bay Cities and Water Politics*, 63–67.

[92] Melosi, *The Sanitary City*, 110–111; Nash, *Inescapable Ecologies*, 49–50.

[93] Ernest McCullough, *Engineering Work in Towns and Small Cities* (Chicago: Technical Book Agency, 1906), 62.

turned over their former responsibility for water and sewage systems to engineers and public works departments.[94]

Sanitary Engineering

Sanitary engineering emerged as a distinct professional field at the start of the twentieth century. The field had its roots in the larger English sanitarian movement, and the term "sanitary engineer" was first used in the 1870s to describe anyone with a concern for using technology to clean the environment, including plumbers, building contractors, asylum superintendents, and municipal engineers. Over the remainder of the nineteenth century, the field gradually shed its association with the building trades and came to define itself as a science-based profession. The series of technological triumphs that emerged from the field in the early twentieth century, from the chlorination of water supplies to the activated sludge treatment of sewage, allowed sanitary engineers to displace physicians and sanitarian reformers as the chief figures in public health.[95]

In 1887, the Massachusetts State Board of Health founded the Lawrence Experiment Station that was transformative to the practice of sanitary engineering in the United States. The station brought together experts in engineering, chemistry, and biology to conduct basic research across disciplines related to water filtration and sewage treatment. The station biologist, William T. Sedgwick, also headed the Department of Biology at the Massachusetts Institute of Technology (MIT). He introduced a public health orientation to his department that drew heavily on the new field of bacteriology, but he knew that applying that knowledge required engineering skill. Engineers had always constructed sanitary systems, but they had taken their direction largely from their clients and built basic systems for water or sewage collection and transport. Sedgwick desired to train engineers in the sciences of biology and chemistry so that they might innovate solutions to the problems of treatment. In 1892, MIT started the first sanitary engineering program in the nation. The University of Illinois followed a year or

[94] Melosi, *The Sanitary City*, 111–113.

[95] Tarr, "Water and Wastes," 246–247.

two later, and in 1905 the University of California president, Benjamin Ide Wheeler, organized the nation's third department of sanitary engineering at Berkeley.[96]

Wheeler hired Charles Gilman Hyde to head the newly created program, and Hyde—the recognized "Dean of Sanitary Engineering of the West"—exercised a profound influence on the development of the field in California. Hyde graduated in the first class of sanitary engineers to emerge from the MIT program in 1896. He worked as an assistant engineer with the Massachusetts State Board of Health for four years and then in Pennsylvania on major water supply projects for the cities of Philadelphia and Harrisburg. When Hyde moved to Berkeley in 1905, he was the first well-trained and experienced sanitary engineer to locate on the Pacific Coast. He remained at UC Berkeley through 1944 except for two years spent with the US Army Sanitary Corps during the First World War. He closely mentored two generations worth of students, and "Hyde's boys" went on to fill major positions in government, industry, research, and education (**Figure 14**).

Hyde served as Engineering Consultant to the California State Board of Health and advocated for the establishment of a State Bureau of Sanitary Engineering that was then headed by his student Chester Gillespie. He also worked as an industry consultant and designed wastewater and drinking water treatment plants in Sacramento, San Francisco, the East Bay, Los Angeles, San Diego, and beyond.

[96] Tarr, "Water and Wastes," 247–248; Wilfred F. Langelier, "Teaching, Research, and Consultation in Water Purification and Sewage Treatment, University of California at Berkeley, 1916–1955," transcript of oral history interview conducted by Malca Chall, April and May, 1970. Regional Oral History Office, Bancroft Library, University of California, Berkeley, 1984, 21.

PROFESSOR HYDE'S "BOYS"
U.C. – 1905 to 1944

Presented to him as a token of remembrance
by "the boys" at his Retirement Party, Hotel Claremont, Berkeley, California
July Eighth, Nineteen Hundred and Forty-Four

Class of 1905
Thomas E. Ambrose
Ezra O. Burgess
Thomas V. Cannell
Clarence E. Day
Howard Marshall
Harold Petterson

Class of 1906
John W. H. Barnes
John C. Black
Wm. L. Borthwick
Walter E. Burns
Earl L. Cope
Henry D. Dewell
Austin W. Earl
Wm. W. Gilmore
Harry M. Goodman
John P. Hickey
Lawrence R. Kessing
T. D. Kilkenny
Clarence H. Kromer
Leon H. Nishkian
George A. Posey
Bernhard Silberberg
Harry E. Squire
E. B. Stillwell
Henry W. Taylor
Howard C. Whitman

Class of 1907
Charles W. Backe
Herbert B. Foster
Guy O. Fraser
Louis A. Frei
Chester G. Gillespie
Harold F. Gray
Joseph W. (Joe) Gross
Sinclair O. Harper
Louis T. F. Hickey
Henry B. (Bert) Kitchen
Morris H. Levy
Sol D. Levy
Kingsbury E. Parker
Frank S. Robinson
Emanuel Scheyer
Rueben J. Wood

Class of 1908
Henry H. Burton, Jr.
Albert W. Miller

Class of 1909
Sylvain S. Abrams
Ned D. Baker
Lee O. Murphy
Glenn V. Rhodes
Harold G. Weeks

Class of 1910
Paul Bailey
Leo Glick
Earl H. Markwart

Class of 1911
Clyde C. Kennedy

Class of 1912
Elbert M. Chandler
James R. (Ralph) Shields

Class of 1913
Tom A. Bither
Harry W. Bolin

Class of 1914
Joseph (Joe) Doman
Edgar C. Fitzgerald
Edmund D. (Ed) Margrave

Class of 1915
Albert W. Paine
Adolph C. A. Sandner

Class of 1916
John N. Adams
William H. Hooker

Class of 1917
Bert A. Bone
Harry N. Jenks
Andrew M. Jensen
Edward A. (Ed) Reinke
Victor R. Sandner

Class of 1918
Gottlieb T. (Ted) Luippold

Class of 1919
George E. (Earl) Troxell

Class of 1920
Archer R. (Archie) Norcross

Class of 1921
Benjamin (Ben) Benas
Antonino LoPrest

Class of 1922
Ray L. Derby

Class of 1923
George W. Reed

Class of 1924
Carl Benson
Joseph D. (Joe) DeCosta
Emerson Dolliver
Andrew (Andy) Gram
Frederick G. (Fred) Nelson

Class of 1925
Adam C. (Carl) Beyer
Chester C. (Chet) Fisk
John L. Mason
Wm. J. (Bill) O'Connell, Jr.
Lawrence G. Sovulewski
Dario Travaini

Class of 1926
Oscar C. Blumberg

Class of 1927
Frank E. DeMartini
Thomas F. (Tom) Galvin
Emil O. Hokanson

Class of 1928
Raymond R. (Ray) Ribal

Class of 1929
Harry Hayes
Oswald H. Milmore
Joseph M. (Joe) Sanchis
Lester M. (Les) Snyder

Class of 1930
Luis Girault
Judson A. (Jud) Harmon
Edward A. (Ed) Heiss
Parker Kwan
William (Bill) McCoy, Jr.
Robert J. T. (Bob) Smith
Franklin M. (Frank) Stead

Class of 1931
Douglas H. Burnett
Curtis H. Cleaver
Thomas O. (Tom) Crow
Herbert B. (Herb) Foster, Jr.
Paul A. Loeffler
Iwao M. Moriyama

Class of 1932
Edward J. Reese
Leonard (Len) Schiff
Otto J. Wittman

Class of 1933
Frank Giusto
George Hall
John C. (Carl) Jennings
Thomas F. (Tom) McGowan
Charles L. Reasoner
Primo A. Villarruz

Class of 1934
Edwin W. (Ed) Barbee
Casimir C. (Cas) Blonski
Blair I. Burnson
Earl W. Dakan
Byron E. Doll
Sidney F. (Sid) Dommes, Jr.
Claude M. Helm
Frank J. Juchter
Alfred M. (Al) Keuhmsted
Richard R. Kennedy
John W. Straser

Class of 1935
John R. Burnham
Ignacio P. Chavez
Joseph L. (Joe) Grahek
Homer W. Jorgensen
Jack H. Kimball
John C. Luthin
James A. (Jim) Millen
Alfredo C. Ocampo
Paul A. Oliver
Henry J. Ongerth
Roy E. Ramseier
W. M. (Mel) Riegelhuth
Thomas M. Saliba
Victor W. (Vic) Sauer
W. R. (Bill) Seeger
Sidney W. Smith
Tom W. Snedden
R. L. (Bill) Stanley
Marvin G. Sturgeon

Class of 1936
Samuel G. (Sam) Dolman, Jr.
Edward F. (Ed) Gabrielson
Theodore R. (Ted) Gregory
R. M. (Bob) Heidenreich
Anselmo J. (John) Macchi
Hiram C. (Chris) Medbery
Wyatt W. Monroe
Earl C. Myers, Jr.
Charles A. Perkins
Thomas (Tom) Smithson
Sam A. Weed
William K. (Bill) Weight

Class of 1937
Robert W. Baunach
D. J. (Jack) Faustman
J. B. (Jim) Hommon
Kaarlo W. Nasi
Arthur W. (Art) Reinhardt
Yale Rosenfeld
Bernard Schiller
D. W. (Don) Sloss

Class of 1938
Jack S. Barrish
Millard E. Buckman
David H. (Dave) Caldwell
Stanley H. Cowell
Randolph H. Dewante
Alfred J. Geandrot
Pierce B. McIntosh
John A. (Jack) Maga
Charles P. Martin
John T. H. (Jack) Morris
Charles D. Y. Ostrom, Jr.
Gleason L. Renoud
Edwin R. (Ralph) Stowell
W. W. (Bill) Tinniswood

Class of 1939
Julian L. Bardoff
Frank V. Chiarolla
Roy E. Dodson, Jr.
Walfred A. Flod
Michael H. (Mike) Keyak
Thomas A. (Tom) Long
Harvey F. Ludwig
Jack W. Pratt
Morgan E. Stewart

Class of 1940
Robert C. (Bob) Adolphe
Vinton W. Bacon
Peter W. Burk
R. R. (Bob) Campbell
Harvey M. Cole, Jr.
James E. (Jim) Dunlap
Howard R. Gesley
Milton S. Hilbert
Robert P. Lonergan
Clyde N. Moore
Byron L. Nishkian
Norman T. Riffe
Arthur F. Royce
Irving M. Terzich
R. G. (Bob) Williams

Class of 1941
John W. (Jack) Bell
Fred H. Dierker
Howard S. Hitchcock
Gordon H. Klippel
William C. (Bill) Langley
Robert P. (Bob) Lowe
Russell G. Ludwig
William R. (Bill) Tolton

Class of 1942
George Adrian
Ichiro Fukutome
Bert Jameyson
Albin W. Johnson
John N. (Jack) Kerr
Arthur E. (Art) Lappinen
Karl J. Maier
Edward H. (Ed) Morjig
Edward I. (Ed) Murphy
Henry T. Omachi
Weldon L. Richards
Paul J. Toien

Class of 1943
James B. (Jim) Dupuis
Raymond M. (Ray) Hertel
Charles S. (Charlie) Howe
John B. (Jack) Howe
Robert C. (Bob) Levy
Leonard (Len) Melberg
Danilo (Danny) Prodanovich
Robert W. (Bob) Purdie
Ralph Stone

Class of 1944
Robert M. Glick
Stanley Goldhaber
Thomas R. Ostrom
Louis R[illegible]

Figure 14: Students of Professor Hyde at UC Berkeley.[97]

[97] Reproduced in Langelier, "Teaching, Research, and Consultation," 71.

His colleagues remembered him as "an engineer's engineer – a designer, a builder, and an innovator."[98]

To teach the necessary chemistry courses, Hyde recruited Wilfred Langelier in 1916 from the Illinois Water Survey where Langelier had been involved in pioneering work in chlorine disinfection. The two men comprised almost the entirety of the UC Berkeley sanitary engineering program through World War II and earned a reputation as one of the most effective engineer-chemist teams in the evolving field. Water chemistry was then a neglected subject among municipal engineers, limited to little more than water testing, and Langelier was able to make fundamental advances in the field. In an attic laboratory, Langelier developed methods to "jar test" coagulation procedures that allowed for careful control of variables and became standard scientific practice. His study of the corrosive potential of water is still recognized today through use of the Langelier Saturation Index. And in his work with Hyde in the early 1920s on designing the Sacramento water filtration plant, he developed a process for inducing flocculation (removal of colloidal particles from a suspension to form a sediment) through agitation with mechanical paddles that soon became standard in plants worldwide. In addition to teaching chemistry courses within the specialty, Langelier lectured architectural students on plumbing practices (including future modernist architect William Wurster with whom he later designed the San Leandro Filtration Plant) and taught a basic sanitation class to women students within the gender-segregated Domestic Science program.[99]

[98] Percy H. McGauhey, "The Sanitary Engineering Research Laboratory: Administration, Research, and Consultation, 1950–1972," transcript of oral history interview conducted by Malca Chall, July 16, July 25, September 17, 1970, and September 11, 1971. Regional Oral History Office, Bancroft Library, University of California, Berkeley, 1974, 41–42; Xiuzhi Zhou, Finding aid to Charles Gilman Hyde Papers (WRCA 046), WRCA, UC Riverside.

[99] Langelier, "Teaching, Research, and Consultation," ii–iv, 15, 24–25, 32–37; Charles Gilman Hyde, "Diffusion Baffles for Sedimentation Basins," n.d., ff Hyde 9, Box 1, Charles Gilman Hyde papers, WRCA 046, WRCA UC Riverside.

Professional organizations emerged concurrently with the creation of the university programs. The American Society of Sanitary Engineers was founded in 1906, though it reflected an earlier understanding of the field in accepting plumbers and building contractors for membership. The American Public Health Association created a sanitary engineering section in 1911, and the US Public Health Service granted civil service classification status to the title "Sanitary Engineer." Finally, in 1922, the American Society of Civil Engineers (ASCE) organized a Sanitary Engineering Division with 526 initial members, offering full recognition of the standing of the field.[100]

Biological Treatment of Sewage

The introduction of biological sewage treatment methods in the 1890s revolutionized sanitary practices, and today's secondary treatment methods all trace their origins to that turn of the century moment. Biological treatment methods were discovered more or less independently on four occasions, giving rise to different technologies. In the early 1890s, the Lawrence Experiment Station in Massachusetts performed the initial studies that led eventually to the trickling filter, while William Joseph Dibdin, chief chemist for the London Metropolitan Board of Works, developed the contact filter. In 1896, Donald Cameron, City Surveyor for Exeter, England, invented the septic tank. And finally, in 1912, a group of scientists and engineers associated with the University of Manchester and the Manchester Disposal Works introduced the activated sludge process, the most advanced of the biological treatment techniques. This section deals with the new knowledge that informed and arose from the experiments; for specifics on the various treatment methods, see the discussions in the technology section below (Section 2.2.4).[101]

Biological treatment methods employed microorganisms to digest (decompose) organic matter within sewage in an orderly and controlled fashion. This largely eliminated the

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[100] Tarr, "Water and Wastes," 249.

[101] Christopher Hamlin, "William Didbin and the Idea of Biological Sewage Treatment," *Technology and Culture* Vol. 29, No. 2 (April 1988), 189–218; Schneider, *Hybrid Nature*, 1–44 and passim; Melosi, *The Sanitary City*, 168–171.

pathogens that cause disease and rendered the effluent safe for discharge. These methods differed fundamentally from prior sewerage techniques that had simply evacuated waste as rapidly as possible from populated areas so as to avoid decomposition and the production of miasmic gases. The greater knowledge of microbiology that developed towards the end of the nineteenth century allowed for a better understanding of both the causes of disease and the biochemical processes of decomposition. While the microorganisms necessary to digest organic wastes occurred naturally within sewage, researchers learned that their numbers and effectiveness could be greatly increased by providing them with a favorable environment. The biological treatment methods thus consisted principally of supplying the proper living conditions for the desired organisms (largely bacteria) by regulating the food supply, oxygen saturation, temperature, pH levels, and other variables.[102]

Digestion occurred both in the presence of oxygen (aerobic) and in its absence (anaerobic). Anaerobic digestion liquefied organic solids, greatly reducing the volume of waste while producing methane gas as a byproduct. Aerobic digestion allowed for more complete decomposition as it could reduce large organic polymers such as cellulose to carbon dioxide and water, whereas anaerobic processes left behind more complex, partially digested substances. Complete digestion required both aerobic and anaerobic conditions, and sewage treatment plants thus commonly divided the digestion process into two or more parts with each devoted to a particular class of microbes. Biological treatment altered the character of the organic matter in sewage, but it did not necessarily remove the material, and in some circumstances the discharged treated water might contain more suspended matter than the raw influent, though the material had been rendered safe for disposal. Treatment plants thus commonly used additional clarifiers at the end of the treatment process to settle out the remaining material and produce a final, clear effluent.[103]

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[102] Hamlin, "William Didbin and the Idea of Biological Sewage Treatment," 193–194.

[103] W. A. Hardenbergh, *Operation of Sewage Treatment Plants* (Scranton, PA: International Textbook Company, 1939), 158–160; Judith Bower Carberry,

A sewage farm provided a basic form of biological treatment, though it was not understood as such prior to the late nineteenth century. Sanitarians recognized that filtering sewage through soil cleansed it of some of its organic material. However, they could not agree as to whether this was simply a matter of the soil particles mechanically screening the sewage or if there was some "essence" of the soil that participated in the process. Work conducted at the Lawrence Experiment Station began to demonstrate that the process was essentially a biological one, driven by living microorganisms in the soil. If the soil within an experimental plot was sterilized, for example, it lost its capacity for cleansing organic matter from sewage, though there had been no alteration to its character as a mechanical filter.[104]

Near simultaneous work by William Didbin on the Thames River started to develop a practical understanding of the conditions required to nurture populations of beneficial microorganisms. According to historian Christopher Hamlin, Didbin began his experiments without any real understanding of the biology involved or with any conviction that bacteria could effectively deal with the immense stream of pollution flowing from London. Rather, he was under enormous political and legal pressure to show that the city was making efforts to address its problems, and his experiments bought him time without generating costs his employers would be unwilling to pay. Didbin placed various filter media (sand, gravel, baked clay, coke) within sewage basins and intermittently filled and drained them, measuring the change in quantities of organic matter and bacteria. He came to recognize that an inverse relationship existed between the two: greater quantities of bacteria meant lower levels of organic matter. And he learned that he could influence the size of the bacterial populations by regulating the rate at which they were fed waste and controlling how often the tanks were reoxygenated by draining the liquid sewage. This led to the realization that the successful use of the contact beds relied entirely upon nurturing and sustaining

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Environmental Systems and Engineering (Philadelphia: Saunders College Publishing, 1990), 154–159.

[104] Schneider, *Hybrid Nature*, 7–9.

beneficial bacteria. The bacteria did the real work and the sanitary engineer became a sort of zookeeper, tending to the wants and needs of his microorganisms.[105]

While the work by Didbin and the Lawrence Experiment Station focused primarily on aerobic processes, Donald Cameron discovered the capacity for anaerobic digestion to consume the sludge that accumulated at the bottom of sedimentation tanks. Anaerobic bacteria developed within the tank over a period of a couple weeks to several months, and then worked continuously on digesting the organic matter of the sludge into gases of methane, carbon dioxide, and nitrogen as well as finely divided organic compounds. This greatly reduced the volume of sludge and thus the expense and difficulty involved in disposing of it. Cameron named his invention the “septic tank” to emphasize its reliance on bacteria and to contrast it with the deliberately antiseptic systems that proceeded it. To showcase his discovery, Cameron constructed an observation chamber in the City of Exeter tank so that visiting engineers could descend into the belly of the device and watch the digestion in action through a porthole. Large modern treatment plants use separate sludge digestion tanks, rather than septic tanks, for anaerobic digestion, but the fundamental process remains the same.[106]

In contact or trickling filters, the biological treatment occurred in a narrow film that surrounded the filter particles. The bacteria and algae physically lived upon the bits of stone, plastic, or other media that filled the beds. The breakthrough of the activated sludge process was to realize that the microorganisms could live suspended within the sewage itself, feeding and reproducing rapidly in a highly oxygenated environment. Experiments with aerating sewage had been conducted since the 1870s but without great success. In 1912, Gilbert Fowler of the University of Manchester observed one such experiment at the Lawrence Experiment Station, and he persuaded Edward Ardern and W. T. Lockett, engineers with the Manchester Disposal Works, to add

[105] Hamlin, “William Didbin and the Idea of Biological Sewage Treatment,” passim; Schneider, *Hybrid Nature*, 26–30.

[106] Schneider, *Hybrid Nature*, 13–14, 47–48.

oxygenation to research they were doing on using retained sludge to treat fresh influent.[107]

When sludge from a prior treatment was retained, decanted of its liquid, and returned to a tank of fresh sewage, it arrived preloaded ("activated") with a high concentration of aerobic bacteria that seeded the treatment tank. Blowers or paddles supplied the bacteria with copious oxygen to enhance its metabolism and thoroughly mix it through the sewage. The bacteria attached themselves to bits of suspended matter and served as a flocculant, causing the organic matter to clump together and fall out of suspension. After the sludge was separated in a sedimentation tank, the remaining effluent was clear, odorless, and safe for discharge. A portion of the separated sludge was then returned to the aeration tank, beginning the process anew. A landmark 1914 publication announced the discovery of the activated sludge process and attracted immediate attention. The outbreak of World War I shortly thereafter suspended additional research within Europe and allowed American engineers to take the lead in further developing the process.[108]

The refinement of the biological treatment process, from simple sewage farming to sophisticated activated sludge plants, allowed for ever smaller plants to treat ever greater volumes of sewage. The need to conserve real estate was an overriding concern that justified the higher energy inputs and greater technical skill required to operate the more complex processes. Sewage farming had the advantage of simplicity, but it required access to more land than any decent-sized community could reasonably provide. Turn-of-the-century Berlin, for instance, operated the most efficient sewage farms in all of Europe, but at 23,000 acres, the sewage farms were larger than the city itself. **Table 3** shows the approximate population that different biological treatment

[107] Schneider, *Hybrid Nature*, 30–34.

[108] Schneider, *Hybrid Nature*, 30–34; Hardenbergh, *Operation of Sewage Treatment Plants*, 125–127.

methods could support per acre by the 1930s, and highlights how much more intensive were the later practices.[109]

Table 3: Population supported by different treatment methods.[110]

Treatment	Population per Acre
Sewage Farming	50–100
Intermittent Sand Filter	1,000
Contact Bed	5,000
Trickling Filter	10,000–40,000
Activated Sludge	80,000–160,000

The adoption of biological treatment methods marked a shift towards a more scientific approach to wastewater management as it required a greater degree of process control and an ever-evolving understanding of microbiology. It spurred the introduction of new technologies in the form of pumps, aeration equipment, and tools for laboratory testing. On the downside, biological treatment methods were vulnerable to greater disruption. Bacteria are living organisms that behave in sometimes unpredictable manners. A cold snap or the inadvertent introduction of a toxic chemical could cause a collapse of bacterial populations. Recovery from such a disaster was slow as the colony needed to rebuild itself organically. Particularly in the early years, when biological knowledge remained limited, many communities were reluctant to embark upon such a potentially perilous course and loose regulations did not require them to make the risky investment.

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[109] Schneider, *Hybrid Nature*, 15; Langdon Pearse, “Functional Outline of Processes of Sewage Treatment,” in Langdon Pearse, ed., *Modern Sewage Disposal: Anniversary Book of the Federation of Sewage Works Associations* (New York: Federation of Sewage Works Association, 1938), 16–27.

[110] Pearse, “Functional Outline of Processes of Sewage Treatment,” 21.

The practical adoption of biological treatment methods thus lagged behind the rapid pace of scientific advancement.[111]

2.2.2. Political Organization

Federal Drinking Water Oversight

The federal government established the first national water quality standards in 1914 when the US Public Health Service (USPHS) set requirements for the water used on common carriers in interstate travel, including ships and trains crossing state lines. The standards initially applied only to bacteriological agents associated with contagious diseases, but they were later revised and expanded in 1925, 1946, and 1962 to cover broader criteria. Every state eventually adopted the standards with minor modifications. By the 1930s, USPHS was certifying nearly a hundred California water supply systems per year to allow for their use in interstate transportation. Even local inspections adhered to the federal standards, so that for decades all water analyses performed in California included a statement about the sample's conformity with USPHS standards for drinking water.[112]

State Oversight

The State of California also increased its oversight of sanitary matters during the first decades of the twentieth century and granted the State Board of Public Health its first formal permitting powers over water and sewage systems. The board had passed through a period of reduced activity at the end of the nineteenth century as it turned largely to managing the state hospital system. The 1906 San Francisco earthquake revived state interest in sanitary issues as a wave of epidemics afflicted the displaced

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[111] Schneider, *Hybrid Nature*, 38–44.

[112] Frank M. Stead and Edward A. Reinke, "Water Quality Control in California," Journal (*American Water Works Association*) Vol. 41, No. 2 (February 1949), 131–138; EPA, "The History of Drinking Water Treatment," factsheet, 2; Langelier, "Teaching, Research, and Consultation," 53; C. G. Gillespie, "Twenty Years of Sanitary Engineering," *Weekly Bulletin* (*California State Department of Public Health*), Vol. 15, No. 1 (February 1, 1936), 1–3.

population. The Public Health Act of 1907 required communities to receive a permit from the State Board of Health for new sewage system construction. The Sanitary Water Systems Act of 1913 extended the permit system to water systems having 200 or more connections or supplying a hotel or labor camp. However, the permitting was done on a case-by-case basis rather than establishing general standards that all dischargers had to meet, and it depended on whatever review the underfunded and understaffed board could provide. Permits also applied only to new construction so that systems that predated the 1907 law were not subject to state review.[113]

The state elections of 1910 and 1911 launched California to the forefront of progressive reform. Hiram Johnson was elected governor in 1910 on a promise to end corporate and municipal corruption, and in 1911 the voters approved a sweeping array of progressive voting reforms including women's suffrage, ballot initiatives, referendum, and recall. Collectively these measures displayed an eagerness to have the state tackle issues that previously had been accepted as intractable. Additional funding and staffing allowed the State Board of Health to expand its reach, and it created six new bureaus or divisions between 1911 and 1920, including the Bureau of Sanitary Engineering. A reorganization of the state government in 1927 to reflect its expanded scope promoted the board to become the Department of Public Health.

The staff of the state board began performing regular sanitary inspections of towns and private establishments in 1913. The inspections aimed at nuisance abatement without making pretext to proposing systematic improvements to water or sewage systems. A typical inspection from 1914 examined conditions at the Gregory Hotel outside of Fresno:

> Said premises consist of a large frame building used as a hotel. The toilet facilities were complained of. They consist of one modern water flushed toilet, located in the building for the women, which discharges into a dilapidated cesspool in the barn yard about three hundred feet from the

[113] "Historical Notes on Public Health," *Weekly Bulletin (California State Department of Public Health)*, Vol. 16, No. 30 (August 21, 1937) ,117–118.

> hotel, also a dilapidated privy in the yard about twenty feet from the building, close to the county road, which is open to flies, etc. and it is in filthy condition, and one urinal inside of the building which discharges into the vault of the privy. The refuse water from the sinks, bathtubs, etc. is being disposed of by means of open wooden drains, which discharge in the yard.[114]

The state inspectors had authority to examine public accommodations and to make recommendations (in the case of the Gregory Hotel to demolish the privy, construct a sealed cesspool, and add a flush toilet for men) but lacked any enforcement powers. Only local authorities could compel the proprietor to comply with the recommendations.

The Progressive Era also saw the state centralize control over utility regulations. The Public Utilities Act of 1911 extended the authority of the California Railroad Commission to cover all private utility and transportation companies. In 1946, the agency was renamed the California Public Utilities Commission to better reflect its expanded scope of authority. Commission approval was required for rate increases, service area expansions, mergers, and changes to service. This effectively replaced the municipal franchise system and reduced the chances for local corruption or favoritism to interfere with the rational development of services. Private water companies generally favored the transition as they expected better, more scientific management from state officials. They also hoped that increased regulation would temper demands for public ownership of water systems. Because state regulation did not extend to municipal systems, the new order conversely provided an incentive for local governments to reassert their authority by taking ownership of utilities.[115]

[114] California State Board of Health, *Sanitary Report* No. 24, February 24, 1914, ff. Public Health—St. Brd of Health*, Sanitary Inspection Reports*, No. 1–29, 1914, Box 1, Dept. of Public Health, Record of the State Board of Public Health, 1904–1923, California State Archives (CSA).

[115] Elkind, *Bay Cities and Water Politics*, 122–123.

Municipal Reforms

The multiple impulses of reform that pulsed through Progressive Era California transformed the character of municipal government and its relationship to the delivery of sanitary services. No single, overall plan guided the reform movements and different causes regularly acted at cross purposes to one another. Efforts to strengthen municipal governments, for example, clashed with competing impulses to centralize power in state bureaus. And every water dispute in California came deeply enmeshed in local rivalries with their own idiosyncratic histories that defy easy generalization. More than 700 municipal water and sewage systems operated in California by 1936, along with approximately one hundred smaller institutional systems. Each system had its own distinct set of local circumstances and trajectory of development. Nonetheless, several broad patterns of change can be identified through the early twentieth century that led to greater public ownership of water supplies, the increased professionalization of municipal utility services, and the creation of special districts to serve multiple communities.[116]

Nineteenth-century Californians largely welcomed private water companies, viewing them as an efficient means of developing resources without high taxation. However, that support gave way to distrust and dissatisfaction in the early twentieth century. The politics of Progressive Era California were largely shaped by opposition to the monopoly powers of the Southern Pacific Railroad and the heavy-handed ways in which it intervened in state and local politics. Anti-monopoly politics then broadened to include resistance to a wide array of corporate interests that were seen as conspiring against the public good. Private water companies found themselves on the defensive as they sought to prevent their systems being forced into competition with public utilities. For decades, the companies were largely successful in that fight as they held monopoly control of local water rights, but they faced rising discontent among consumers as their

[116] Gillespie, "Twenty Years of Sanitary Engineering," 2; Elkind, *Bay Cities and Water Politics*, passim.

aging systems struggled to provide water in adequate quantity and quality at a reasonable price.[117]

In the early twentieth century, the largest cities in California all outgrew the local creeks and wells that had fed their water systems. This required them to reach further afield for water sources and opened the possibility for creating new, publicly owned water systems. Los Angeles seized control of the Owens River and later tapped the Colorado River; San Francisco developed the Tuolumne River behind the Hetch Hetchy Dam; and the East Bay communities of Oakland, Berkeley, and Richmond turned to the Mokelumne River in the Sierra Nevada foothills. Each of these far-reaching systems originated through public ownership, financed with municipal bonds. The private water companies that served these cities recognized that a transition had occurred and they generally sold their remaining systems to the public. Many smaller cities followed the example in acquiring private water systems, though not every campaign for public ownership was successful as many voters continued to view local government as more inclined to corruption and ineptitude than was private enterprise.[118]

Ironically, providing better service—making abundant pure water conveniently and cheaply available—led to a surge in demand that frequently exceeded planning expectations for the new municipal water systems. This inevitably produced disappointment among citizens and fueled accusations of political incompetency. To protect vital services from the corrupting influences of patronage politics, many communities transferred control of their systems from politicians to engineers. Progressive reforms had introduced the city manager form of government to California and increasingly a nonpartisan, technocratic class of sanitary workers had responsibility for managing municipal systems and advocating for their improvement.[119]

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[117] Elkind, *Bay Cities and Water Politics*, 7, 67, 75–78; Brechin, *Imperial San Francisco*, 75–76.

[118] Elkind, *Bay Cities and Water Politics*, 75–78, 119–120, 128–145; Brechin, *Imperial San Francisco*, 104–117.

[119] Elkind, *Bay Cities and Water Politics*, 42–44.

The expanded reach of water and sewer systems beyond traditional city boundaries led to the creation of regional utility districts. The East Bay Municipal Utility District (EBMUD), organized by Oakland, Berkeley, and Richmond in 1923, and the Metropolitan Water District of Southern California, established in 1928, typified the new organizational model. This trend reflected a national movement towards the creation of special districts in the decades between 1880 and 1930 to provide a wide variety of services from fire protection and flood control to port management and mosquito abatement. Districts enjoyed substantial administrative and financial independence from county or municipal governments in pursuit of a narrowly defined set of functions, and seemed to offer the best hope for professional, science-based management. Because state law limited cities to bonded debt equal to 15 percent of a community's assessed valuation, independently funded districts appealed to small, fast-growing towns that had many competing needs to meet. Regional districts could also better match services to the natural boundaries that governed the distribution of water and disposal of sewage, rather than requiring a wasteful duplication of services within artificial political boundaries.[120]

Bureau of Sanitary Engineering

The State Board of Health established the Bureau of Sanitary Engineering in 1915 following the advocacy of Charles Hyde. Chester Gillespie, one of "Hyde's Boys" from the class of 1907, headed the bureau and he remained as chief until 1947. The early bureau had a two-year budget of $30,000 and consisted of Gillespie, two sanitary engineers, and a couple of stenographers. The group operated out of the UC Berkeley civil engineering building in an office adjacent to Hyde's and they shared the attic laboratory space with Langelier. The bureau remained on the UC Berkeley campus until 1942 when it moved two blocks west to Shattuck Square. Bureau staff were responsible for reviewing the water and sewage plants plans submitted by cities, conducting field inspections, and making recommendations on permits to the State Board of Health.

[120] Elkind, *Bay Cities and Water Politics*, 1–4; Gillespie, "The Sewage Situation in California," 468.

They also had responsibilities for inspecting shellfish production, mosquito control, and other assorted issues.[121]

The bureau contributed to professionalizing municipal utility operations. Gillespie recognized early on that operating personnel were not advancing in their knowledge as rapidly as was the complexity of sewage science and technology. The turnover rate among sanitary engineers was a problem as those drawn to the field soon mastered the issues and left to find few more meaningful challenges and job prospects. In 1928, Gillespie took the lead in organizing the California Sewage Works Association to encourage the sharing of information among municipal sewage workers and managers. The association began publishing the *California Sewage Works Journal.* Nationally, the Federation of Sewage Works Association formed in the same year and published *Sewage Works Journal*.[122]

Typhoid Fever

The Bureau of Sanitary Engineering's strong focus through its first five years was combatting typhoid fever. Chlorinating the public water supply was the chief tool for reducing typhoid fever and was highly effective. Secondarily, bureau staff inspected sewage systems to locate and correct potential sources of cross contamination between sewage and water services. This was the case, for example, during a 1924 outbreak in

[121] "History of the Sanitary Engineering Branch," ff. Carton 1:1, Administrative Files, History, Various Dates, Box 1, California Bureau of Sanitary Engineering papers II, WRCA 148, WRCA, UC Riverside; "An Outline of the Laws of California with Regard to Public Health Procedures," *Weekly Bulletin (California State Department of Public Health)*, Vol. 13, No. 15 (May 12, 1934), 58; "Bureau of Sanitary Engineering Moves," *Weekly Bulletin (California State Department of Public Health)*, Vol. 21, No. 19 (May 30, 1942), 75.

[122] Gillespie, "The Sewage Situation in California," 466–467; C. G. Gillespie and E. A. Reinke, "Early History of the California Sewage Works Association," *California Sewage Works Journal*, Vol 13, No. 1 (1941), 8–88; California Water Environment Association (CWEA), "Celebrating CWEA's 90 Years and Counting!" 2018, accessed July 2022 at [CWEA: Celebrating 90 Years].

Santa Ana that was among the worst of the twentieth century in California. An undersized sewer line habitually overflowed on Mondays, the local washday, and the runoff made its way into an open drinking water reservoir, carrying raw sewage with it. Expanding and relocating the line solved the problem. Other practices for reducing outbreaks included pasteurizing milk, improving general sanitation habits, and identifying carriers of typhoid fever through medical examination.[123]

Typhoid fever death rates dropped dramatically with the effort. In 1906, the death rate was calculated at 34.9 per 100,000 population, a number that was somewhat elevated by the aftermath of the San Francisco earthquake. The following year the rate was a more typical 27.9. By 1920, the rate had fallen to 4.9 and it continued a downward trajectory to 1.7 in 1930 and finally below 0.9 in 1937. Within years of starting the campaign, the efforts were saving in excess of a thousand Californian lives annually and municipal water systems had been rendered almost entirely safe.[124]

Still, smaller outbreaks of typhoid fever continued to occur nearly every year in a few specific locations, particularly among the farm labor camps of the Sacramento-San Joaquin Delta and Imperial County. The camps, both temporary and semi-permanent, tended to be located along levees, and irrigation ditches served as both sewers and drinking water sources. The droughts of the 1930s compounded the problem as the Sacramento River fell so low that sewage did not wash out to sea but sloshed back and forth with the tides through an 8–12 mile stretch below the city of Sacramento. The Bureau of Sanitary Engineering installed emergency chlorination units at sites with

[123] "Gillespie, "Origin and Early Years of the Bureau of Sanitary Engineering," 5–7, 28–29.

[124] "Diphtheria, Typhoid Fever and Smallpox in California," *Weekly Bulletin (California State Department of Public Health)*, Vol. 10, No. 15 (May 16, 1931), 58; Chester Gillespie, "The Conquest of Typhoid Fever," *Weekly Bulletin (California State Department of Public Health)*, Vol. 11, No. 2 (February 13, 1932), 5; "Typhoid Death Rate Drops," *Weekly Bulletin (California State Department of Public Health)*, Vol. 17, No. 26 (July 23, 1938) ,102.

identified problems, but too many labor camps were remotely located and all but unknown to authorities.[125]

The bureau was inclined to blame the sanitary habits of the farm laborers for these outbreaks, writing in 1938 that “it is not always easy to obtain the cooperation of the some of the foreign-born races in the observance of preventative measures.”[126] However, as legal scholar Camille Pannu has demonstrated, many rural communities made deliberate decisions to exclude labor camps from municipal water and sewer systems in order to keep laborers dependent upon farm owners for essential services and to discourage permanent settlement by Dust Bowl migrants or ethnic minority groups. As late as 1971, the Tulare County General Plan continued to argue for underinvestment as a strategy of population removal:

> Public commitments to communities with little or no authentic future should be carefully examined before final action is initiated. These non-viable communities would, as a consequence of withholding major public facilities such as sewer and water systems, enter a process of long term, natural decline as residents depart for improved opportunities in nearby communities.[127]

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[125] Typhoid Fever Still a Problem,” *Weekly Bulletin (California State Department of Public Health)*, Vol. 12, No. 4 (February 25, 1933), 15; “Typhoid Fever at Isleton,” *Weekly Bulletin (California State Department of Public Health)*, Vol. 10, No. 24 (July 18, 1931), 93; “Sacramento River Survey” and “Typhoid Fever Reported,” *Weekly Bulletin (California State Department of Public Health)*, Vol. 10, No. 38 (October 24, 1931), 150; “Typhoid Fever, 1934–1935,” *Weekly Bulletin (California State Department of Public Health)*, Vol. 16, No. 4 (February 20, 1937), 15.

[126] “Typhoid Death Rate Drops,” *Weekly Bulletin (California State Department of Public Health)*, Vol. 17, No. 26 (July 23, 1938), 102.

[127] Camille Pannu, “Drinking Water and Exclusion: A Case Study from California’s Central Valley,” *California Law Review*, Vol. 100, No. 1 (February 2012), 223–268; quote from 234.

In 1938, the bureau noted with pride that 94 percent of the population within incorporated cities or service district boundaries had sewage systems. That figure, however, excluded precisely the sort of unincorporated communities on the margins of agricultural towns that were intentionally left beyond the reach of municipal services. Because of de jure and de facto segregation, those communities were largely populated by ethnic minorities. The Central Valley today still has more than 450 unincorporated communities, many of which are a legacy of pre-World War II settlement patterns, and these areas remain among the least well provided with essential sanitary services.[128]

Environmental Pollution

In contrast to the successful campaign against typhoid fever, California's Bureau of Sanitary Engineering had decidedly more limited success in combatting the environmental pollution of streams, rivers, lakes, and bays (**Figure 15**). This effort took the bureau beyond the immediate issue of public health and was met with resistance from the cities that were being urged to clean up their sewage discharges. Tax funds spent on sewage treatment provided little immediate return to the community making the investment, but instead benefitted downstream areas. Most municipalities thought that the solution to river pollution was for every town to treat their drinking water while cleaning up only the most noxious sources of nuisance dumping. This attitude changed only when economically valuable tourism or industry were directly impacted.[129]

[128] "Improved Sewage Disposal Methods," *Weekly Bulletin (California State Department of Public Health)*, Vol. 17, No. 30 (August 20, 1938), 119.

[129] Gillespie, "Origin and Early Years of the Bureau of Sanitary Engineering," iii; Gillespie, "Twenty Years of Sanitary Engineering," 2–3.

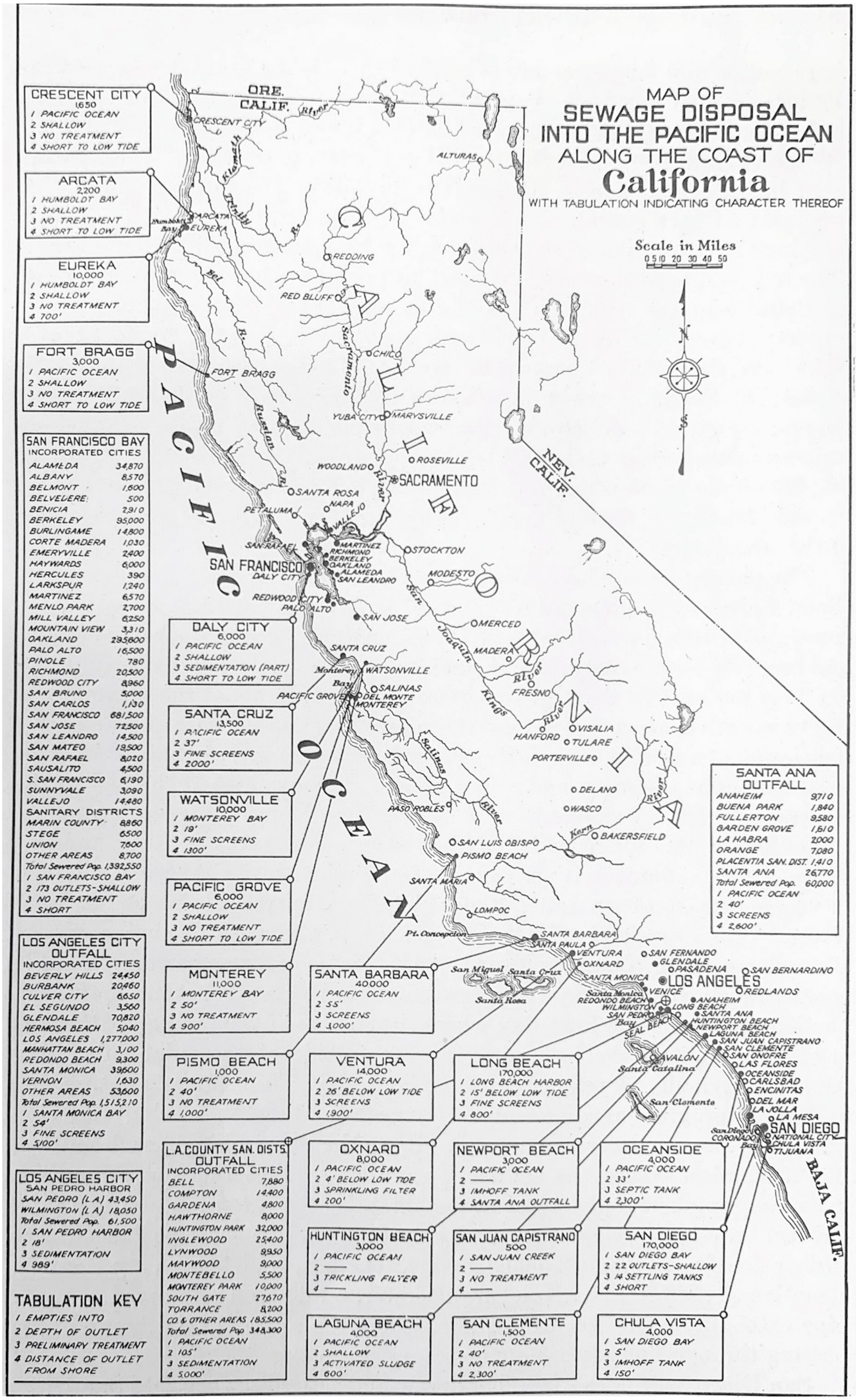

Figure 15: Sewage disposal to the Pacific Ocean, 1937.[130]

130 Warren and Rawn, "Disposal of Sewage into the Pacific Ocean," 203.

When Gillespie assumed his position as bureau chief in 1915, he found conditions along many of the state's rivers to be deplorable. The Merced River, he wrote, was "receiving sewage in the heart of Yosemite"; Tuolumne River "was a source of endless complaint"; Truckee River "was useless even for fishing"; the upper Sacramento River "was notorious for the piles of sewage along its edge"; Sonoma Creek "was a source of stench through a famous vacation belt"; and Napa River reeked of "offensive odors [that] prevented picnicking on its banks."[131]

Many of the state's famous beaches needed to be closed regularly for quarantines. In Northern California, communities dumped untreated sewage into the shallow water of bays and harbors. Conditions in Southern California were somewhat better as outflows were commonly into deep ocean water where currents could disperse the waste. Most southland cities also provided at least preliminary sewage treatment with sedimentation or screening. San Diego, Long Beach, and the San Pedro Harbor were exceptions, as they continued to use short outfalls into the late 1930s. And even where deep water outfalls existed, regular breaks in the lines meant that sewage periodically washed up onto beaches.[132]

The sanitary bureau had its greatest success in halting environmental pollution where it originated in relatively small institutions, most of which were state or federally operated. Folsom Prison, Sonoma State Home, Patton State Hospital, Yosemite National Park, Weimer Sanitarium, and UC Davis all installed trickling filters or activated sludge plants in the 1910s or 1920s that provided a high level of sewage treatment. Success was also possible in areas valued for their recreational potential. The bureau cooperated closely with the National Forest Service to clean up formerly squalid campgrounds and received support from Lake Tahoe resorts to end the practice of running sewers directly into the lake. Elsewhere, the bureau had to accept partial improvements. Towns such as Gilroy,

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[131] Gillespie, "Twenty Years of Sanitary Engineering," 2–3.

[132] A. K. Warren and A. M. Rawn, "Disposal of Sewage into the Pacific Ocean," in Pearse, ed., *Modern Sewage Disposal*, 202–08; "Sewage disposal method in Los Angeles County," ca. 1934–1937, *Los Angeles County Department of Health Services Collection, 1930–1932*, The Huntington Library, San Marino, California.

Watsonville, and Yuba City replaced river dumping with sewage farms, but still provided limited treatment. Ukiah, St. Helena, Winters, and Paso Robles used land disposal during the summer months of low river flow, but continued to dump minimally processed effluent into rivers during the winter. And large areas through the Mother Lode and the California Delta dumped raw sewage into rivers year-round along with large quantities of unprocessed industrial waste from wineries, dairies, and fruit canneries.[133]

2.2.3. Regional Variation

Distinct regional variation in the sophistication of water and sewage systems emerged in the early twentieth century. These systems developed through path-dependent processes so that decisions made in the mid-nineteenth century had an outsized influence on subsequent events well into the middle of the twentieth century. A divide thus opened between the older population centers of Northern California and the newer cities of Southern California that grew out of the oil, citrus, and real estate booms of the early twentieth century. Neither region was monolithic and in both halves of the state the fastest growing communities were most likely to embrace new technologies while outlying areas continued to accept older solutions as adequate. Nonetheless, real differences existed between the cutting-edge practices common in Los Angeles and the creeping progress that was made around the San Francisco Bay.[134]

The location of sewage disposal—whether into freshwater, saltwater, or on land—was important in influencing how rapidly a community advanced its level of sewage treatment and drinking water chlorination. Few new systems for disposing of raw sewage into freshwater streams were constructed after 1920, and many existing

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[133] "Stream Pollution Stopped," *Weekly Bulletin (California State Department of Public Health)*, Vol. 16, No. 16 (May 15, 1937), 61–62; Gillespie, "The Sewage Situation in California," 465–466.

[134] C. G. Gillespie, "Standards Set by Southern California Sewage Treatment Plants," *Weekly Bulletin*, Vol. 15, No. 19 (June 6, 1936), 73–75; C. G. Gillespie, "Sewage Disposal in San Francisco Bay," *Weekly Bulletin (California State Department of Public Health)*, Vol. 19, No. 36 (September 28, 1940) ,141–143.

freshwater systems began treating their sewage. Land disposal at sewage farms remained common through the 1920s, though increasing regulation meant that most added partial or advanced treatment methods. The chlorination of drinking water supplies advanced most rapidly in communities that drew their water from wells within groundwater basins that included sewage farms. Treatment advances were slowest in areas that discharged their waste to seawater. Two-thirds of the new disposal projects involving raw sewage through 1930 discharged into bays or sloughs, mostly in Northern California. No advanced treatment of sewage was applied at any seawater location, though partial treatment became the norm along Southern California's recreational beaches.[135]

Physical and economic realities underlay the different trajectories of the regions, but Gillespie and others also saw issues of human psychology playing a major role. In older areas, people had grown accustomed to disposing of raw sewage and it was difficult to persuade them to abandon familiar practices. Older communities through the Mother Lode and the San Joaquin Valley, Gillespie wrote, proved "to be the most refractory cases with which the sanitarian has to deal." Conversely, new cities took it for granted that they would need to treat their sewage before disposing of it, and "once a community puts in sewage treatment, no matter how meager, it has been a psychological truth that the people there are ready for further sewage treatment when plausible reasons appear."[136] Naturally, the areas most open to change attracted the engineers and managers who were prepared to deliver it.

Southern California

The national idealization of California shifted around the turn of the century so that images of Los Angeles's pristine beaches and suburban orange groves replaced the earlier gold fields and timber empires of the north state. Fitting its reputation as a land of health, Southern California assumed a position of national leadership in innovating practices of drinking water treatment and sewage disposal.

[135] Gillespie, "The Sewage Situation in California," 464–465.

[136] Gillespie, "The Sewage Situation in California," 464.

Los Angeles led the state in providing chlorination treatment for drinking water supplies. The region's success was built upon a robust network of public health laboratories that continually monitored water supplies and fine-tuned chlorination levels. The Los Angeles County Health Department alone maintained 11 full-time public health laboratories from the San Fernando Valley to Pomona. There were additionally three city health departments with their own laboratories in Los Angeles, Pasadena, and Long Beach. This contrasted with a single laboratory serving the City and County of San Francisco and four laboratories in the East Bay.[137]

The state's southern region also innovated methods for improving the palatability of drinking water. In part, this was driven by necessity as Southern California could not draw upon pure mountain river water with the same ease as the north state. Large parts of the Los Angeles Basin relied upon well water as their primary supply, and as groundwater levels sank the remaining waters carried high concentrations of minerals that imparted undesirable tastes and appearances. Colorado River water imported into the basin after 1939 also required extensive treatment for its hardness and turbidity. Private water companies experimented with sand and carbon filters to improve the palatability of the supply, and in 1941 the Metropolitan Water District constructed the world's largest water softening plant in La Verne, with an ultimate capacity of 400 million gallons a day.[138]

In sewage treatment, the southland was particularly active in creating joint sewerage projects that channeled the waste of multiple communities to a central treatment facility. By 1936, nine treatment plants handled the sewage of 43 separate communities. So, while Southern California had built only about one-third of all the high-grade treatment plants in the state, those served one-half of all the communities in the state receiving the top level of sewage processing. Exemplary of this trend was the City of Los

[137] "Laboratories Approved by the State Board of Public Health," *Weekly Bulletin (California State Department of Public Health)*, Vol. 16, No. 9 (March 27, 1937), 33; Gillespie, "Standards Set by Southern California Sewage Treatment Plants," 73.
[138] Gillespie, "Standards Set by Southern California Sewage Treatment Plants," 73; Langelier, "Teaching, Research, and Consultation," 9.

Angeles's Hyperion plant near Santa Monica that treated the combined waste from seven cities and several unincorporated communities (**Figure 16**). The Los Angeles County Sanitation Districts, organized 1923-1925, handled waste from 32 other incorporated cities located through the county, treating most of the sewage at an activated sludge plant near the Palos Verdes Peninsula.[139]

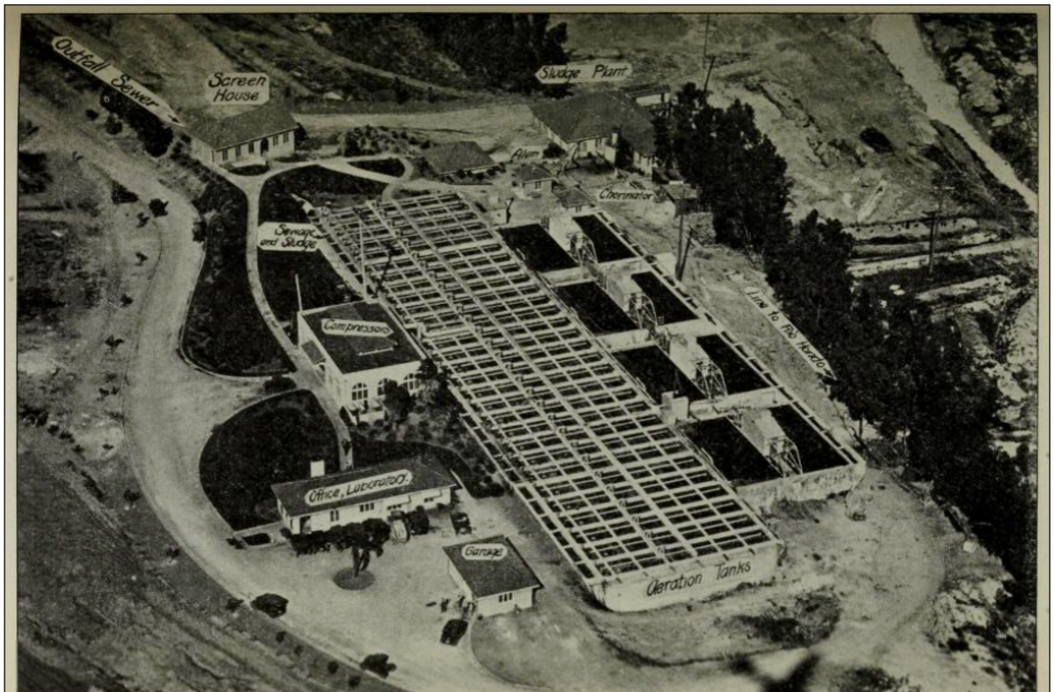
Figure 16: City of Los Angeles Hyperion screening plant and incinerator.[140]

These joint plants had the financial resources to experiment with innovative technologies. The Tri-City plant serving Pasadena, South Pasadena, and Alhambra enjoyed a national reputation as a proving ground for new sewage treatment practices, and the facility constructed an activated sludge pilot plant in 1917, the first in the state

[139] Gillespie, "The Sewage Situation in California," 462; Gillespie, "Standards Set by Southern California Sewage Treatment Plants," 74; A. M. Rawn, *Narrative—C.S.D.*, Vol. 1: 1924–1958 (Los Angeles: County Sanitation Districts of Los Angeles County, 1965), 3–12.

[140] Sewage disposal method in Los Angeles County, No. 1: Los Angeles City Sewar Plant at Hyperion, photCL 396 Vol. 3, ca. 1934–1937, Los Angeles County Department of Health Services Collection, 1930–1932, The Huntington Library, San Marino, California.

(**Figure 17**). The Los Angeles City Hyperion plant was the first in the state to employ fine sewage screens and its 12-foot-diameter drums were then the largest in the nation (**Figure 18**).[141]



ACTIVATED-SLUDGE SEWAGE TREATMENT PLANT AT PASADENA, CALIFORNIA

Figure 17: The Tri-City Plant in aerial view, circa 1928.**[142]**

[141] Gillespie, "Standards Set by Southern California Sewage Treatment Plants," 73; Franklin Thomas, "The Seage Situation of the City of Los Angeles," *Sewage Works Journal*, Vol. 12, No. 5 (September 1940), 879–94; Nicholas Pinhey, "Forgotten Facilities: The City of Pasadena Tri-City Sewage Treatment Plant," *Wastewater Professional*, Vol. 51, No. 2 (April 2015), 18–25.

[142]A. W. Wyman, "Trials and Tribulations of a Sewage Works Operator," *California Sewage Works Journal*, Vol. 1, No. 1 (1928), 103.

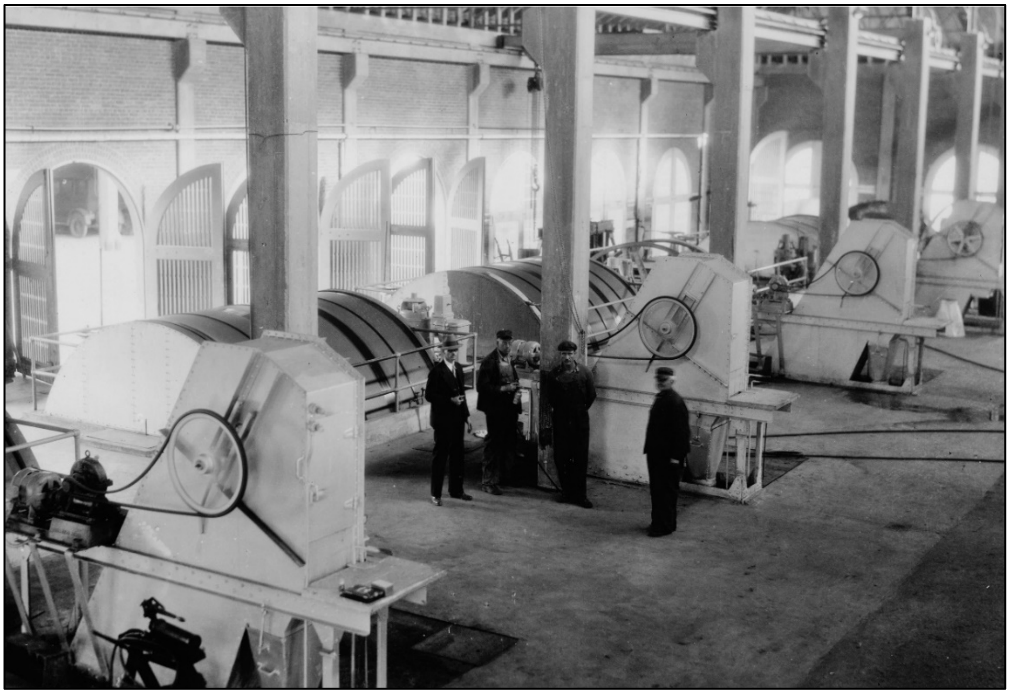


Figure 18: Interior of Hyperion plant showing screen drums and motor drives, circa 1929.[143]

The cities of Southern California also paid unusual attention to the beautification of their water and sewage treatment plants. The Pasadena Tri-City plant was among the first sewage treatment facilities in the nation to landscape its grounds with lawns and ornamental trees. The City of Beverly Hills water filtration and softening plant, constructed in the mid-1920s, was a particularly ornate example (**Figure 19**). Nicknamed the "Public Water Cathedral," the building resembled a Spanish-Romanesque church and had a soaring Moorish-style bell tower that disguised a chimney used for burning off sulfur above roof level of the surrounding neighborhood. Landscape architect Seymour Thomas designed the grounds in a hacienda layout to serve as a public park for visitors. No longer in use for water treatment, the building now

[143] "Interior of the City of Los Angeles Hyperion Treatment Plant, North Screen Plant," ca. 1929, California Historical Society Collection, 1860–1960, University of Southern California, Libraries.

houses a library and film archives for the Academy of Motion Picture Arts and Sciences.[144]

Figure 19: City of Beverly Hills Water Treatment Plant No. 1, 1931.[145]

The rapid progress made in drinking water and sewage treatment through Southern California resulted not from a genial consensus about the need for high standards, but from intense conflict between neighboring communities. Pasadena in the nineteenth century operated what was widely regarded as a model sewage farm, but the

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144 Gillespie, "Standards Set by Southern California Sewage Treatment Plants," 73; "Beverly Hills Constructing Plant," *Los Angeles Times*, April 22, 1928, V-2; Martin Turnbull, "City of Beverly Hills Water Treatment Plant No. 1, 333 South La Cienega Boulevard, Los Angeles, 1928," June 18, 2019, accessed June 2022 at Treatment Plant No. 1.

145 Bishop G. Haven, Buildings Miscellaneous—La Cienega Plant, Beverly Hills Pumping Plant, 02-17542, June 26, 1931, Southern California Edison Photographs and Negatives, The Huntington Library, San Marino, California.

conversion of surrounding citrus groves into suburban tracts led to increasing odor complaints. The city added a septic tank in 1910 to treat the sewage prior to irrigation, and an Imhoff tank (a two-story septic tank with separate chamber, discussed further below) was completed in 1913. Among sanitary engineers, these improvements were believed to satisfactorily address the problem, but the neighbors were not appeased. In 1916, the areas surrounding the sewage farm incorporated as the City of Monterey Park and promptly passed an ordinance prohibiting sewage treatment facilities within city limits. It was this action that forced the Tri-City partners into developing the activated sludge treatment plant. Later, a plan to dump the dried sludge in Alhambra led 6,000 residents to sign a protest to the Los Angeles County Board of Supervisors and necessitated the addition of a kiln drier that converted the sludge to marketable fertilizer.[146]

Similar conflicts occurred through the southland in the first decades of the twentieth century. When Anaheim began searching for territory for a sewage farm in 1911, the Speaker of the California State Assembly and local resident, Philip Stanton, led an effort to block the project by incorporating 16 square miles of rural land as the community of Stanton. Succeeding in their efforts, the community later disincorporated in 1924 in order to receive state funding for road improvements. West Covina, with a population of less than 1,000, incorporated in 1923 to block Covina from building a sewage project. West Covina later annexed additional territory to frustrate a second proposed plant. The organization of the Los Angeles County Sanitation Districts was in part a response to opposition against local sewage disposal in Compton, Watts, and Huntington Park. Similar experiences in Glendale, Burbank, and among the beach communities from Santa Monica to Hermosa drove the planning of the Los Angeles City Hyperion plant.[147]

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[146] Pinhey, "Forgotten Facilities: The City of Pasadena Tri-City Sewage Treatment Plant," 19–26; Gillespie, "Standards Set by Southern California Sewage Treatment Plants," 74.

[147] Gillespie, "Standards Set by Southern California Sewage Treatment Plants," 74; *Rawn, Narrative—C.S.D.*, 12.

As Gillespie wrote in 1936, "Just why this Los Angeles area should be so universally sewered and at the same time be so violently opposed to sewage disposal forms an interesting subject on which to muse."[148] He credited the suburban boom that attracted great numbers of Midwestern migrants who came seeking a better and more modern way of life than what they had left behind. Escalating land values made every corner of the coastal plains a potential subdivision gold mine if the proper utility and transportation connections could be managed. And each subdivision required a sewer system, and yet no developer could tolerate a disposal plant next door. The result was a pattern of growth that consolidated sewage treatment into fewer and fewer plants, while demanding a continually higher level of odor control and facility beautification.

The great sensitivity to sewage and the escalating levels of treatment was a phenomenon largely confined to the major metropolitan areas. In more outlying areas, people adjusted themselves to the realities of sewage disposal and lived at peace with conditions that elicited bitter conflict among suburbanites. There, Gillespie concluded, "the pattern of sewage disposal will probably continue along its present course with sewer farming the rule, accompanied by high grade plants in critical neighborhoods, and cheaper plants elsewhere."[149]

San Francisco Bay Area

The progress made in Southern California was not matched by the communities around the San Francisco Bay. Cities there largely remained tied to antiquated combined sewage systems without treatment plants. On the eve of World War II, some one million people continued to dump raw sewage through short outfalls into the Bay's harbors, sloughs, and mudflats (see **Figure 15** above). That accounted for 80 percent of all the raw sewage disposed of by California's urban population. An estimated 205 municipal sewer outlets discharged into the Bay, while oil refineries, industrial manufacturers, and innumerable fruit canneries used it indiscriminately as a dumping ground. Surveys of the Bay shores found them littered with vegetable scraps, chemical slicks, and floating

[148] Gillespie, "Standards Set by Southern California Sewage Treatment Plants," 74.

[149] Gillespie, "Standards Set by Southern California Sewage Treatment Plants," 75.

fecal matter. A putrescent sludge covered the mudflats, and on warm days the smell of sewage carried several miles inland.[150]

Still, there were few immediate health problems associated with the sewage and local concerns focused predominately on the economic impacts. The Bay Area drinking water supply was entirely separated from the saltwater sewage disposal, with much of the water being piped in from the Sierra Nevada mountains, and the cold waters of the San Francisco Bay did not attract bathers as did the beaches of Southern California. The pollution was instead seen as an impediment to industrial development. Hydrogen sulfide that arose from the anerobic digestion of waste caused corrosive damage to ships, buildings, and harbor structures. The oxygen-deprived waters starved nearshore habitats of life, and sewage threatened to contaminate shellfish, making them a potential source of cholera, hepatitis, and other infectious diseases. Trade organizations and local boosters also worried that the foulness of the Bay made the region appear backwards in comparison with their rivals in Southern California.[151]

San Francisco was the largest offender in sewage production, but the city also did the most to address the problem. The first, relatively small, advanced treatment plant was constructed in Golden Gate Park in 1932 using New Deal relief funding (**Figure 20**). Raw sewage had previously been used in the early twentieth century to irrigate the western portion of the park. After odor complaints, a septic tank was installed in 1912 and the treated effluent filled the ornamental lakes of the park. A lawsuit forced the abandonment of that practice in 1931, leading to the construction of the activated sludge plant the following year. The plant operated only during the irrigation season, running from mid-February to November, and produced around 500,000 gallons of treated effluent daily as well as dried sludge for fertilizer. Fitting its location in Golden Gate Park, the facility was beautified with flowerpots and landscaping. The plant

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[150] Gillespie, "Sewage Disposal in San Francisco Bay," 141–142; Elkind, *Bay Cities and Water Politics*, 145–146.

[151] Gillespie, "Sewage Disposal in San Francisco Bay," 141–142; Charles Gilman Hyde, "Shore Pollution Reduction at San Francisco," *Sewage Works Journal*, Vol. 15, No. 1 (January 1943), 3–13; Elkind, *Bay Cities and Water Politics*, 147–149.

(decommissioned in 1982) has been recognized as the first recycled water facility in California.[152]

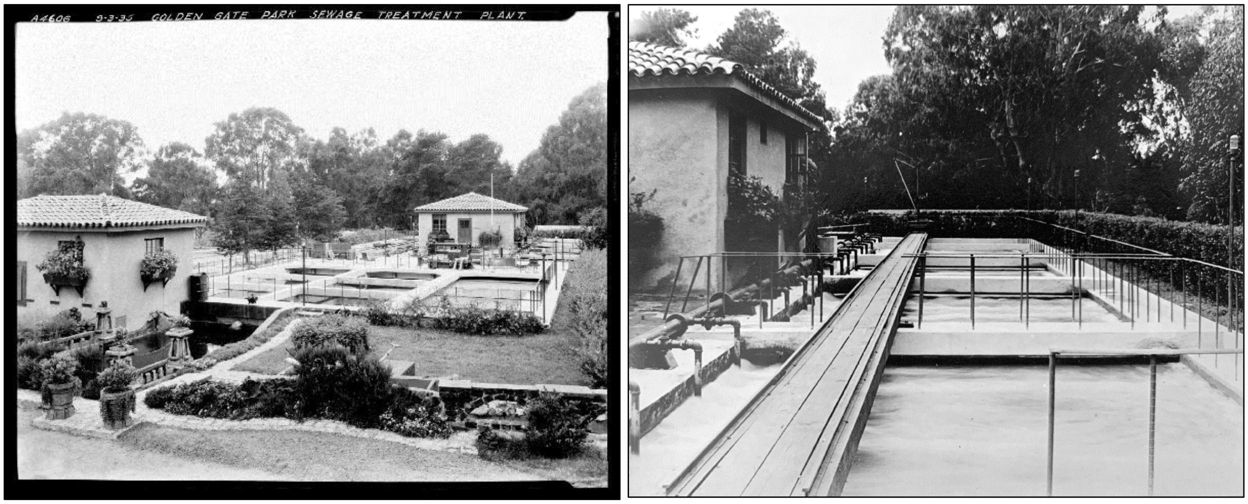

Figure 20: Golden Gate Sewage Treatment Plant: grounds view, 1935, (left) and activated sludge basin (right), 1936.[153]

In 1933, the citizens of San Francisco voted approval for issuing $2.6 million in Public Works Administration (PWA) bonds to improve the sewer network and construct limited sewage treatment plants. When C. E. Grunsky undertook a study of sewage conditions in 1899, he found 125 separate sewer outlets and his plan called for consolidating those into six main outlets. In the intervening years, the expenditure of $17.5 million allowed for the total number of outlets to be reduced to 31, with 19 discharging to the Bay, 11 to

[152] Charles Gilman Hyde, "The Beautification and Irrigation of Golden Gate Park with Activated Sludge Effluent," *Sewage Works Journal*, Vol. 9, No. 6 (November 1937), 929–941; Nicholas Pinhey, "Forgotten Facilities: Golden Gate Park's 1932 Recycled Water Plant," CWEA, Accessed July 2022 at CWEA: Forgotten Facilities.

[153] Left: City photographer, "Golden Gate Sewage Treatment Plant," September 3, 1935, San Francisco History Center, San Francisco Public Library. Right: Louis Mayer (photographer) in Charles Gilman Hyde, "The Beautification and Irrigation of Golden Gate Park in San Francisco, California with an Activated Sludge Treatment Plant Effluent," September 1937, ff Hyde 2, Box 1, Charles Gilman Hyde papers, WRCA 046, WRCA, UC Riverside.

the Golden Gate Strait, and one to the Pacific Ocean. With the WPA funds, the city hired a board of consulting engineers that included Charles Hyde of UC Berkeley to prepare a plan for improvement. The board recommended construction of three treatment plants, but had funding adequate to complete only the Richmond-Sunset facility. The 15 million-gallons-a day (mgd) plant was completed in 1939 and provided only basic treatment with an Imhoff tank and sludge digester. Chlorination of raw sewage was used ahead of the tank for odor control year-round, and the final effluent was chlorinated for bacterial disinfection when the beaches were in use. The bulk of the city's sewage, however, remained untreated.[154]

The East Bay communities appreciated the need for sewage improvements, but could not find a way to coordinate their efforts prior to World War II. EBMUD was the obvious agency to manage a joint venture, but the district directors believed they lacked the authority to create special subdivisions for sewage disposal. Only after the state legislature amended its authorizing act in 1941 did the district feel enabled to engage in sewage planning, but then the outbreak of war delayed any further efforts. Nine individual East Bay cities made attempts to apply for WPA funding, but the inability of the applicants to reach agreement on essential issues prevented any of them from receiving funding.[155]

Along the San Mateo Peninsula, Burlingame, Redwood City, and Palo Alto installed limited treatment plants, largely funded with WPA grants, to remove suspended solids from the sewage before discharging effluent onto mud flats or sloughs. Marin County did the same north of the Golden Gate. These plants, combined with those in San Francisco, provided basic treatment for the sewage of some 230,000 people, less than 20 percent of the region's population. This fell far short of what the Bureau of Sanitary Engineers regarded as minimal conditions, which should include sedimentation, with or without chemicals, and sufficiently long outfalls to reach ocean currents. Grease

[154] Hyde, "Shore Pollution Reduction at San Francisco," 3–7; Gillespie, "Sewage Disposal in San Francisco Bay," 141; B. Benas, "The Richmond-Sunset Sewage Treatment Plant," *Sewage Works Journal*, Vol. 12, No. 1 (January 1940), 81–94.

[155] Elkind, *Bay Cities and Water Politics*, 149–155.

removal would be required to prevents slicks, and to minimize land use, sludge should be disposed of by digestion and compact mechanical filters.[156]

In reviewing the minimal progress made in the San Francisco Bay Area, Gillespie was sympathetic to challenges faced by the communities. The legacy sewer lines were expensive to operate and maintain. Merely mapping the lines was a challenge and attempting to link them required extensive construction in heavily built-up areas. Treatment plants necessarily needed to be located along the shores, as that was where gravity carried the waste. This meant acquiring expensive real estate and competing with industry for the land. The historic reliance on combined sewer lines also made it impractical to fully treat the flow during winter months and required that some overflow be tolerated. Gillespie was willing to accept lower standards of treatment for Bay pollution over freshwater streams, both because of the lower health hazard posed and because the heavy ship traffic made a certain level of pollution inevitable.[157]

Still, Gillespie saw a dark cloud on the horizon in 1940 in the lack of preparation for dealing with industrial expansion. Already, studies in the East Bay indicated that the organic waste from industry, primarily canneries, was twice as great as that from human sewage. The refineries and heavy manufactures introduced chemical waste that was little understood in terms of effects or potential treatments. And of course, World War II would vastly increase the scale of industry in the San Francisco Bay Area and throughout the state.[158]

2.2.4. Technology

Sewage and water treatment technologies advanced rapidly at the start of the twentieth century, giving rise to most of the processes that are still in use today. Chlorination was introduced for drinking water treatment in 1908 and rapid sand filtration entered common use in the 1920s. The era saw the beginning of the biological treatment of

[156] Gillespie, “Sewage Disposal in San Francisco Bay,” 141–143.

[157] Gillespie, “Sewage Disposal in San Francisco Bay,” 143.

[158] Gillespie, “The Sewage Situation in California,” 463; Gillespie, “Sewage Disposal in San Francisco Bay,” 143.

sewage with the introduction of trickling filters around the turn of the century and the activated sludge process in 1914. The biological treatment of sewage marked a shift to a more scientific process as they required a greater degree of control and an understanding of microbiology. It required new technologies in the form of pumps, aeration equipment, and tools for laboratory testing. Still, the technology was adopted only gradually, hindered by the slower rate of regulatory change, and as late as 1929 fewer than 20 percent of all sewage treatment plants used the activated sludge process.

Water Works

Most of the fundamental processes of modern drinking water treatment emerged during a brief period at the beginning of the twentieth century. The years between 1909 and 1916 saw the adoption of three major advances: the application of chlorine for disinfection; the use of rapid sand filters for treating turbidity; and the employment of the zeolite or ion exchange process for reducing water hardness. These techniques allowed municipalities to effectively treat drinking water for the first time, rather than just seeking out ever-more-remote sources of uncontaminated supply. By 1936, nearly 150 Californian communities provided at least some form of water treatment, predominately chlorine disinfection, and 36 cities had constructed full-scale filtration plants that treated surface waters for public use.[159]

The common methods of water treatment consisted of disinfection, coagulation, sedimentation, filtration, aeration, and softening. The type and level of water treatment provided depended ultimately upon the source of supply. Coagulation, sedimentation, and filtration worked together to reduce turbidity and were used in treating surface waters at large filtration plants. Groundwater extracted by wells, the most common municipal water source, required comparatively little treatment beyond disinfection and thus needed little infrastructure. A chlorinator could fit into a small room at a pumphouse or be located at a centralized collection and distribution facility. If the water had a high mineral content, it might benefit from additional softening and aeration to improve

[159] Langelier, "Teaching, Research, and Consultation," 3–4; Gillespie, "Twenty Years of Sanitary Engineering," 2.

palatability and remove minerals that could interfere with industrial processes. Surface water treatment required a larger investment in infrastructure than did groundwater because of the issues with turbidity, but it generally benefited from greater gravity flow and thus had lower on-going energy demand and pumping costs.[160]

Water distribution systems, in contrast to water treatment, changed only modestly from the nineteenth into the twentieth century. The physical infrastructure benefited from incremental improvements in materials and energy sources. Pipes of galvanized steel, reinforced concrete, asbestos cement (transite), and ductile iron gradually replaced cast iron pipes, leading to greater durability and lower costs. Thermoplastic pipes, including those of Polyvinyl Chloride (PVC) and later High-Density Polyethylene (HDPE), began being manufactured in the 1930s and entered water system usage from the 1950s onward (see **Table 1** above). The plastic pipes were light weight, corrosion resistant, versatile, and inexpensive and soon found many applications in drinking water and wastewater systems. Electricity replaced steam and oil in operating most pumps, allowing for smaller engines and plant footprints. Of greater direct consequence, engineers improved distribution networks to remove potential sources of contamination. Many of these occurred in factories or institutions that made primary use of a public municipal water supply but maintained a private auxiliary supply of untreated water for backup purposes. If a connection between the two systems lacked an air gap it was possible for untreated, contaminated water to find its way into the public supply. The Bureau of Sanitary Engineering identified and removed more than 1,000 such cross-connections through the first half of the twentieth century. This painstaking and labor-intensive service received little public recognition, though it was essential to ensuring safe municipal water supplies and guaranteeing public health.[161]

[160] Hardenbergh, *Operation of Water-Treatment Plants*, 50–51.

[161] Hardenbergh, *Operation of Water-Treatment Plants*, 14, 46–47; Gillespie, “Twenty Years of Sanitary Engineering,” 2.

Chlorination

The permanent, continual chlorination of American drinking water supplies beginning in 1908 was one of the great public health achievements of the twentieth century. Chlorine is a strong oxidizing agent that, when applied in the correct dosage, can quickly kill the microorganisms that cause cholera, dysentery, typhoid fever, and other illnesses, without causing adverse effects in humans. The introduction of chlorination promptly saved tens of thousands of lives that waterborne illnesses would otherwise have claimed. Chlorination also improved the efficiency and palatability of water systems by reducing the mold, algae, and slime that grew in water intakes and distribution systems.[162]

The first experiments in using chlorine compounds to disinfect water occurred in the late nineteenth century. British and German sanitarians in the 1890s used bleaching powder to sterilize watermains and other equipment following outbreaks of typhoid fever and cholera. These short-term efforts succeeded in preventing reoccurrences of the epidemics, but they did not attempt to provide continual disinfection of the water supply. In 1905, officials again used chlorine to halt a typhoid epidemic in Lincoln, England, but then as a precautionary measure they continued a slow feed of chloride solution for a period of years until a new water source became available. This marked the first continual disinfection of a public water system and prompted further experimentation in Europe and America.[163]

The earliest American efforts at continual disinfection occurred in 1908. Wilfred Langelier of the Illinois Water Survey and later professor of chemistry at UC Berkeley participated in the first experiment at the Union Stock Yards of Chicago. The engineers selected the site as only animals would be affected, and the heavily contaminated water

[162] Michael J. McGuire, "Eight Revolutions in the History of US Drinking Water Disinfection," *Journal (American Water Works Association)* Vol. 98, No. 3 (March 2006), 123–149; Langelier, "Teaching, Research, and Consultation," 4–6; Hardenbergh, *Operation of Water-Treatment Plants*, 205–207.

[163] McGuire, "Eight Revolutions," 125–126.

supply made an ideal test case. The introduction of a minute quantity of chlorine continually fed into the supply line almost completely sterilized the stockyard water, leaving it in better condition than Chicago's municipal supply. Shortly after, the same engineers applied the technique to the drinking water of Jersey City, with chlorination beginning on September 26, 1908. The city received many complaints about the odor and taste of chlorine, which could not yet be administered with precise control, but the results were so promising that the objections were overruled. In the years immediately following the experiments, sanitary officials constructed many emergency chlorination plants in areas affected by flooding or disease outbreaks.[164]

The introduction of improved chlorine gas feeders around 1913 allowed the process to spread into wide municipal use. Compressing chlorine gas under pressure converted it into a liquid that could be stored and transported in tightly sealed metal containers. A British officer in the Indian Medical Service was the first to use liquified chlorine gas on a small scale in 1903. The US Army experimented with the technology in the Philippines in the early 1910s, and a Niagara Falls plant began using liquid chlorine for temporary treatment in 1912. Philadelphia installed the first permanent liquid chlorine plant in 1913. The Wallace & Tiernan Company of New Jersey designed nearly all the early chlorinators that allowed for the controlled application of dosages, and according to Langelier, many of the first graduates of the UC Berkeley sanitary engineering program found employment with the firm.[165]

All large treatment plants used liquefied chlorine gas as it was the most economical option. However, as the gas is highly toxic, it could be difficult to safely store and an accidental release would endanger employees and nearby communities. Smaller plants therefore sometimes used chlorine in a powdered bleach form. In either case, the chemical was administered through chlorinators of various and evolving designs that connected to the water main with non-corrosive tubing. The chlorine and water mixed within a baffled chlorine contact basin for a specified period of time to produce effective

[164] Langelier, "Teaching, Research, and Consultation," 4–6.

[165] McGuire, "Eight Revolutions," 128–129; Hardenbergh, *Operation of Water-Treatment Plants*, 207; Langelier, "Teaching, Research, and Consultation," 6.

disinfection. Duplicate equipment allowed chlorination to continue in the event of a failure of the primary apparatuses. The chlorine and dosing equipment occupied a dedicated room so that any leaks could be isolated. This room commonly had a separate entrance from the building exterior and no direct connection between it and any other room in the treatment plant or pumping house. Good ventilation facilitated repairs in case of a minor leak. Because liquified chlorine was commonly delivered in large steel cylinders weighing up to a ton, chlorination rooms generally included loading docks built to truck bed height for easy on and off loading.[166]

Sedimentation

Sedimentation is an ancient technology used to clarify muddy waters. Most surface waters carry quantities of clay, silt, and sand that are too fine to catch on a screen. Allowing the water to stand in or pass slowly through a settlement basin causes much of the suspended matter to settle to the bottom of the reservoir. This process of plain sedimentation could greatly improve water clarity, and in some cases was sufficient in and of itself to prepare the water for public consumption. However, the finest particles of clay and silt did not settle readily and could remain in suspension even after months of storage. It was therefore more common to use sedimentation as a preliminary treatment step preparatory to more thorough filtration. The addition of coagulating chemicals aided sedimentation, especially in highly turbid waters.[167]

Sedimentation at its most basic required a bare minimum of infrastructure. Any natural or artificial basin with enough capacity to retain water for several hours could remove some portion of the suspended matter. These simple reservoirs could be left as exposed earth or be lined with stone, brick, asphalt, or concrete. The primitive basins lacked means for removing deposited settlement and thus required periodic draining

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[166] Hardenbergh, *Operation of Water-Treatment Plants*, 207; Langelier, “Teaching, Research, and Consultation,” 55–56.

[167] Hardenbergh, *Operation of Water-Treatment Plants*, 139; Goodell, *Water Works for Small Cities and Towns*, 182–183.

and clearing. Gillespie recalled that, prior to 1915, such “small weed grown settling basins” provided the only form of water treatment through most of California.[168]

More sophisticated sedimentation basins (also known as sedimentation tanks or clarifiers) allowed for greater process control. Early, purpose-built sedimentation basins followed the fill-and-draw method in which tanks were filled, held for a specified retention period, and then drained and cleaned. This method was labor intensive, and managers soon abandoned it in favor of the continual flow method with inlets and outlets always open. The concrete basins came in rectangular, square, and circular forms. Rectangular basins used baffles of concrete, wood, or metal to prevent water flowing directly from the inlet to outlet. A circuitous route ensured an adequate retention time and limited the formation of eddies that would inhibit sedimentation. In circular basins (**Figure 21**), untreated water entered the center of the tank from below and passed through a perforated baffle. Flow velocities declined rapidly away from the middle of the tank, so most materials fell out into a sump near the tank center. The cleaned water flowed out over an overflow weir that circled the tank and connected to an outlet pipe. As with most items in treatment plants, sedimentation basins generally came in pairs so that one basin could continue to operate while the other was taken offline for cleaning, repair, or maintenance.[169] The use of sedimentation basins increased with the introduction of mechanical equipment for automatically removing sedimentation around 1919. In rectangular basins, chain loops dragged scrapers in a straight line down the tank towards a collection sump and then returned the scrapers raised above the tank bottom (**Figure 22**). In circular tanks, a series of arms with bottom scrapers revolved around a central axis. In both cases, the scrapers moved at barely perceptible speed to avoid disturbing the calmed water. Numerous patented variations on mechanical cleaning equipment existed to meet different specific needs.[170]

[168] Gillespie, “Twenty Years of Sanitary Engineering,” 3; Hardenbergh, *Operation of Water-Treatment Plants*, 139–140.

[169] Hardenbergh, *Operation of Water-Treatment Plants*, 163–174.

[170] Hardenbergh, *Operation of Water-Treatment Plants*, 166–169.

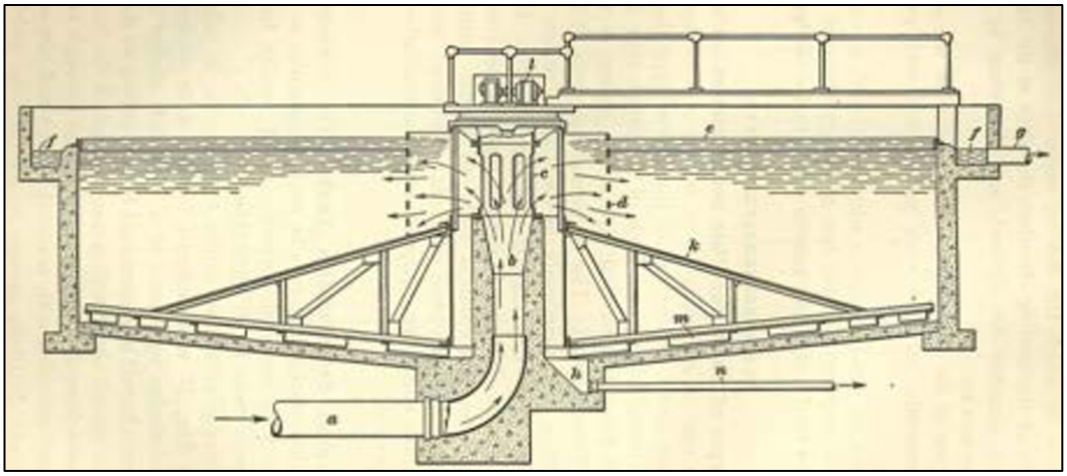

Figure 21: Sedimentation basin with circular plan.[171]

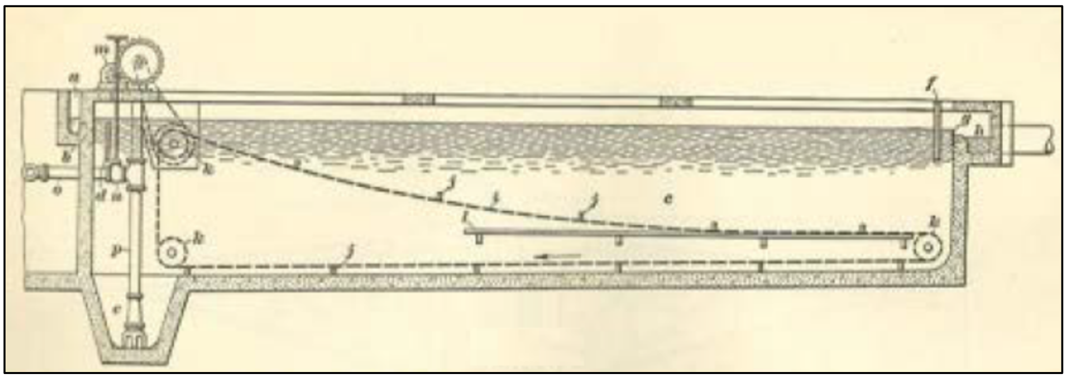

Figure 22: Rectangular sedimentation basin with straight-line scraper.[172]

The addition of coagulating chemicals facilitated sedimentation by causing suspended matter to clump together, forming a jelly-like precipitate known as floc. The clumped floc readily settled to the tank bottoms. Sanitary engineers experimented with many chemicals, using the jar test developed by Langelier, to ascertain their coagulating properties under different conditions. The most widely used substance through the twentieth century was aluminum sulfate, also known as alum. Ferrous sulfate, ferric chloride, ferric sulfate, and chlorinated copperas were common substitutes. The

[171] Hardenbergh, *Operation of Water-Treatment Plants*, 168.

[172] Hardenbergh, *Operation of Water-Treatment Plants*, 167.

chemicals functioned most efficiently within narrow pH limits, and the addition of soda ash, lime, or similar helped to fine tune acidity.[173]

Small mixing basins, located ahead of the sedimentation tanks, served to thoroughly mix the coagulates and raw water. The basins employed a range of methods for mixing the chemicals including baffles located within the flow stream, mechanical stirring paddles, and air blowers (**Figure 23**). The simple baffles generally worked adequately, but equipment manufacturers patented and marketed more complex apparatuses that promised some particular advantage.[174]

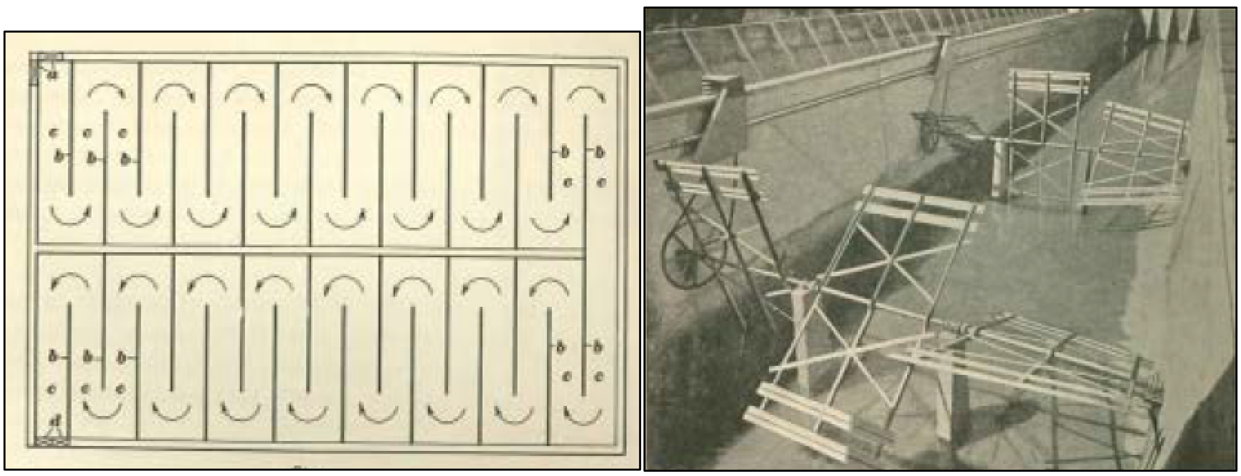

Figure 23: Mixing basin strategies included baffles (above) and mechanical paddles (right).[175]

Sand Filters

British sanitarians began experimenting with sand filters in the early nineteenth century. In 1829, a private water company constructed a sand filter to serve their customers in the London area, creating the world's first treated municipal water supply. These British sand filters, also known as slow sand filters, differed in design and operation from the

[173] Hardenbergh, *Operation of Water-Treatment Plants*, 140–163; Goodell, *Water Works for Small Cities and Towns*, 184–185.

[174] Hardenbergh, *Operation of Water-Treatment Plants*, 158–163.

[175] Hardenbergh, *Operation of Water-Treatment Plants*, 159, 161.

later rapid sand filters that became dominant in America in the early twentieth century, but they provided a model for subsequent developments.[176]

A slow sand filter consisted of a large watertight basin, generally of concrete, that contained a layer of sand of uniform small size over a bed of gravel with drainage tiles below. The sand layer had a minimum depth of 12 inches up to a maximum of around 40 inches. The slow percolation of water through the sand caused suspended materials to settle out, depositing a thin layer of sediment on the surface of the sand bed. As the sediment layer increased in thickness, it produced increasing resistance to infiltration and operators thus needed to increase the depth of the water above to maintain an even filtration rate. When the sediment layer became too thick, the operators drained the tank, scraped off the top layer of sand, and began the process again with a fresh bed. The layer of sediment, known as *shmutzedecke* (German for “dirty skin”), functioned as a biofilm that digested organic matter in the water, serving to purify as well as clarify it, though the nature of this biological treatment was not understood in the nineteenth century. Because of their creeping rate of infiltration, slow sand filters required large basins of at least a quarter acre in size, with a half-acre or full acre more common.[177]

Americans constructed their first slow sand filter in 1872 in Poughkeepsie, New York, and completed a number of similar plants through New England over the following decades. However, the design proved ill adapted for American conditions where rivers were far more turbid than the sedate English streams. The filters rapidly filled and choked on sediment, making them inefficient and uneconomical. In the 1890s, the eminent sanitary engineer George Fuller experimented with rapid sand filtration techniques in Louisville, Kentucky, to treat Ohio River water. By introducing a coagulant immediately prior to the sand filter, Fuller was able to process a large quantity of water

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[176] Gary S. Logsdon, Michael B. Horsley, Scott D.N. Freeman, Jeff J. Neemann, and George C. Budd, “Filtration Process—A Distinguish History and a Promising Future,” Journal (American Water Works Association), Vol 98, no. 3 (March 2006), 150–164.

[177] Hardenbergh, Operation of Water-Treatment Plants, 174–175; Goodell, Water Works for Small Cities and Towns, 185–192.

in a relatively small tank. However, the great quantity of floc that settled on the sand bed required more frequent cleaning than did British slow sand filters, up to several times a day versus a monthly cleaning. To address this problem, Fuller adopted a system of backwashing that forced water under pressure up through the sand layer to cleanse it. This combination of features—small basin size, use of a coagulant, and backwashing—distinguished the American rapid sand filter from the predecessor models.[178]

Several decades of incremental improvement gradually refined Fuller's process until it operated with enough consistency and efficiency to be widely adopted. Much of the effort focused on improving the backwashing process to avoid forming mudballs that could clog the filter. In the 1920s, John Baylis developed a system of auxiliary scour that used horizontal water spray from a grid of pipes to enhance the cleaning action during backwashing. A decade later, the introduction of rotary sweeps improved the cleansing of the sand bed surface. Both scour types allowed for using aerated water, with air injected under pressure to enhance the scrubbing action. Researchers also adjusted the ordering of the filtration process, adding sedimentation basins ahead of the filtering, and thus reduced the required frequency of cleaning. By the late 1920s, the treatment chain of chemical coagulation, mixing, flocculation, sedimentation, and then filtration became known as "conventional treatment" and was used wherever muddy surface rivers were a principal water source.[179]

The layout of municipal rapid sand filtration plants followed some general conventions, even as the particulars responded to the individual demands of the site, water source, available funding, and the decisions of the designer. Most large plants grouped small, rectangular, concrete tanks into two rows and placed a pipe gallery between the rows and beneath the floor of the tanks (**Figure 24**). During normal operations, the water level in the beds stood above the top of the lateral half pipe troughs. After trickling through the sand, gravel, and underdrains, the water filled a reservoir or clear-water well below the beds. During backwashing, water from an elevated tank was forced up through the filter beds and drained through the troughs. The plant operators generally

[178] Logsdon et al., "Filtration Process," 150–152.

[179] Logsdon et al., "Filtration Process," 151–152.

piped the removed sludge to a drying basin, where the water content was drawn down prior to disposal. Small plants were more likely to use circular units of concrete or steel, and equipment manufacturers sold many such patented apparatuses ready for rapid assembly and use.[180]

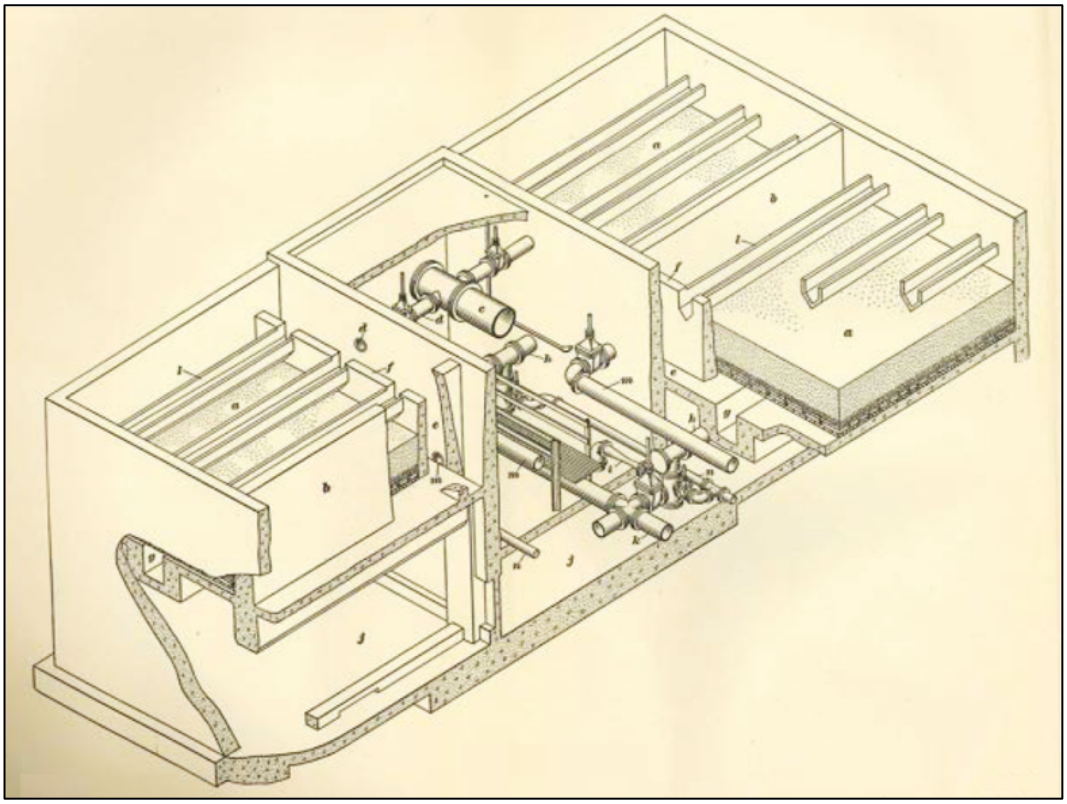

Figure 24: Schematic of a representative small rapid sand filtration plant.[181]

A pressure filter was a variation of rapid sand filter that contained the process within an air-tight cylindrical shell and functioned by virtue of water pressure rather than gravity flow (**Figure 25**). The small cylinders could operate vertically or horizontally and required little space. With their limited capacity, pressure filters were suited for industrial use or on small private or public water systems with low turbidity sources. Engineers commonly designed such water systems with a single set of pumps that removed water at its source, forced it through a pressure filter, and conveyed it to the point of

[180] Hardenbergh, *Operation of Water-Treatment Plants*, 179–182.

[181] Hardenbergh, *Operation of Water-Treatment Plants*, 179.

consumption. When used in combination with chlorine disinfection, pressure filters allowed for small-scale water systems to operate safely and economically. Light weight pressure filters replaced the sand media with engineered fabric or paper filters. These systems lacked durability, but were suited for temporary installation at labor and military camps or the like.[182]

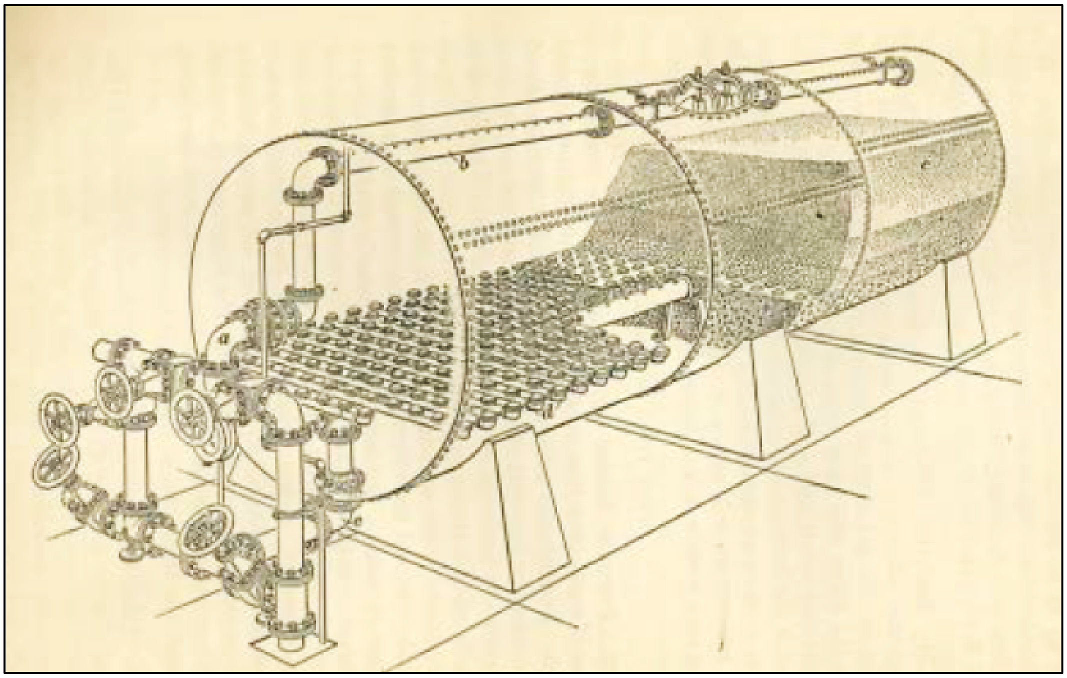

Figure 25: A pressure filter enclosed in a steel cylinder.**[183]**

Aeration and Water Softening

Groundwater drawn from certain geological formations by wells could contain high quantities of dissolved minerals including iron, calcium, and magnesium. These dissolved solids make water hard, which detracts from its palatability and interferes with industrial uses by forming scales in boilers and other equipment and requiring greater quantities of soap in laundry applications. Water softening is the process of removing these hardening minerals. The iron from an anaerobic well occurred in an invisible, soluble form, but as it oxidized following exposure to the atmosphere, it produced rust

[182] Hardenbergh, *Operation of Water-Treatment Plants*, 195–199.

[183] Hardenbergh, *Operation of Water-Treatment Plants*, 196.

that gave the water an unappealing color, clogged distribution lines, and made it unfit for some industrial purposes.[184]

Aeration provided the simplest means of oxidizing and removing dissolved iron. Aerators came in a variety of forms as there were many methods of exposing water to air. Spray nozzles could throw water into the air ahead of a storage basin, or a series of baffles, steps, or protruding stones could be placed within a shallow channel leading to the basin. A tray-type aerator (**Figure 26**) distributed water to the top of a series of shallow trays with perforated bottoms, allowing the water to aerate as it dripped between levels. The trays commonly contained coke or rock on which a coating formed that sped the process of oxidation. A number of patented devices employing nozzles, paddles, and propellers were also available.[185]

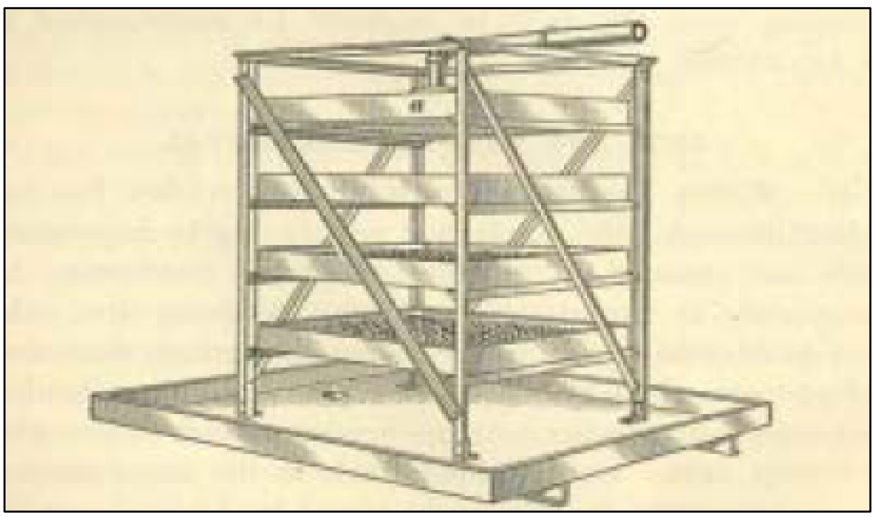

Figure 26: A tray-type aerator.[186]

Two different techniques existed for softening water: the lime-and-soda-ash process and the zeolite ion-exchange process. Lime and soda ash acted through a series of chemical reactions to convert soluble compounds of calcium and magnesium into

[184] Mark J. Hammer, *Water and Wastewater Technology*, 2nd ed. (New York: John Wiley and Sons, 1986), 273–282.

[185] Hardenbergh, *Operation of Water-Treatment Plants*, 238–240; Hammer, *Water and Wastewater Technology*, 274.

[186] Hardenbergh, *Operation of Water-Treatment Plants*, 238.

insoluble forms that either precipitated out through sedimentation or were removed by filtration. The process was similar to that used in rapid sand filtration. Operators added lime and soda ash to raw water either separately or in combination, and thoroughly stirred the materials together in a mixing basin to produce flocculation. The heaviest material settled out in a sedimentation tank. The partially treated water was then recarbonized by injecting carbon dioxide gas into the water as it flowed from the sedimentation tank towards the filter. The carbon dioxide interacted with any excess lime to form soluble bicarbonates which helped to minimize the buildup of calcium carbonates deposits in the filter and distribution system. A final pass through a filter removed most of the remaining coagulant and prepared the water for consumption.[187]

The zeolite process used ion exchange to replace the soluble calcium and magnesium in water with sodium. Ions are molecules that have acquired a net electrical charge as the result of gaining or losing electrons. As opposite charges attract, positively charged ions, known as cations, will adhere to their negatively charged anion partners. In ion exchange, molecules within solution are swapped with like-charged particles that are adhering to an oppositely charged solid that is immersed in the solution. Ion exchange is a common, natural process that is fundamental to soil fertility as the negative charges of clay soil and organic matter attract and hold plant nutrient cations such as potassium, calcium, and magnesium. British soil scientists in the mid-1840s were the first to study the ion exchange process and to recognize that any single cation in the soil could be replaced with any other cation by saturating the soil with water rich in the replacement nutrient.

European chemists began experimenting with ion exchange using zeolites in the 1850s, but without immediately recognizing the material's potential for water softening. The term zeolite refers to a group of natural materials (and today, synthetic products) that combined iron, aluminum, and sodium in a silicate form. Greensand, a marine sandstone, was the most common natural zeolite. When hardwater ran through a bed of zeolite, it exchanged its calcium and magnesium cations for the sodium cations adhering to the zeolite until the sodium was exhausted. Flooding the zeolite with a brine

[187] Hardenbergh, *Operation of Water-Treatment Plants*, 223–232.

solution then reversed the process, releasing the calcium and magnesium for disposal and replenishing the sodium for another softening cycle. Coating the zeolite with manganese dioxide allowed it to also strip the water of iron. The potential to use zeolites for water softening was recognized by the early twentieth century, and the German scientist Robert Gans patented the process in 1906.[188]

Over the next two decades, small zeolite softeners found their way into many industrial processes as they demineralized water for use in steam boilers, laundry plants, pulp mills, and the like. A zeolite softening unit was essentially a rapid sand filter but with a bed of zeolite replacing the sand quartz and with a special lining to protect against corrosion caused by the brines used in regeneration. Depending on the size of the operation, the units could be either of the gravity-fed basin type or pressurized steel tanks. The plant then blended the fully treated water with raw or partially treated water to produce a finished product with a desired level of hardness. The Ohio Valley Water Company constructed the first municipal softening plant below Pittsburgh in 1926 (**Figure 27**).

[188] Hardenbergh, *Operation of Water-Treatment Plants*, 232–240; J. T. Campbell and D. E. Davis, "Softening Municipal Water Supplies by Zeolite," *Journal (American Water Works Association)*, Vol. 21, No. 8 (August 1929), 1035–1053.

Figure 27: Zeolite water softening tanks at the Ohio Valley Water Company Plant.[189]

The company added a second plant in 1929, and the area served as a working laboratory for experimenting with the zeolite process on a large scale. The plants entered wide use in the 1930s, appearing in every part of the country. In 1941, the Metropolitan Water District of Southern California constructed its large water softening plant in La Verne using a combination of lime treatment and zeolite filter beds. After a later expansion, the La Verne facility had the distinction of being the largest zeolite softening plant in the world.[190]

[189] Campbell and Davis, "Softening Municipal Water Supplies by Zeolite," 1049.

[190] D. E. Davis, "Observations on Zeolites in Water Softening and Demanganization," *Journal (American Water Works Association)*, Vol. 29, No. 10 (October 1937), 1515–1525; Campbell and Davis, "Softening Municipal Water Supplies by Zeolite," 1035–

Reservoirs

The design and construction of water tanks and reservoirs evolved in the early twentieth century to make more efficient use of materials. In 1894, Horace E. Horton of the Chicago Bridge & Iron Works constructed the first steel plate water tank with a full hemispherical bottom. The curved shape required less steel and was more watertight than a flat-bottomed tank, and because the rigid bottom was self-supporting, it did not need to sit on a platform. By the early twentieth century, this had become the dominant type of elevated water-storage structure in the United States (**Figure 28**). In 1905, George T. Horton, son of Horace Horton, created the first tank with an elliptical bottom, which had a shallower profile than the hemispherical form. The ellipsoidal form became nearly flat at its center and allowed for using larger risers that provided greater support. Further innovation in 1922 allowed for using the ellipsoidal shape for both the top and bottom of the tank (**Figure 29**). This eliminated the need for the interior trusses that supported a conical roof and gave a more pleasing, modern form.[191]

1053; James M. Montgomery and William W. Aultman, “Water-Softening and Filtration Plant of the Metropolitan Water District of Southern California,” *Journal (American Water Works Association)*, Vol. 32, No. 1 (January 1940), 1–24.

[191] Gregory R. Mathis, “Steel Water Towers Associated with South Dakota Water Systems, 1894–1967: An Historic Context,” Prepared for South Dakota Historical Society, September 2012, 32–36.

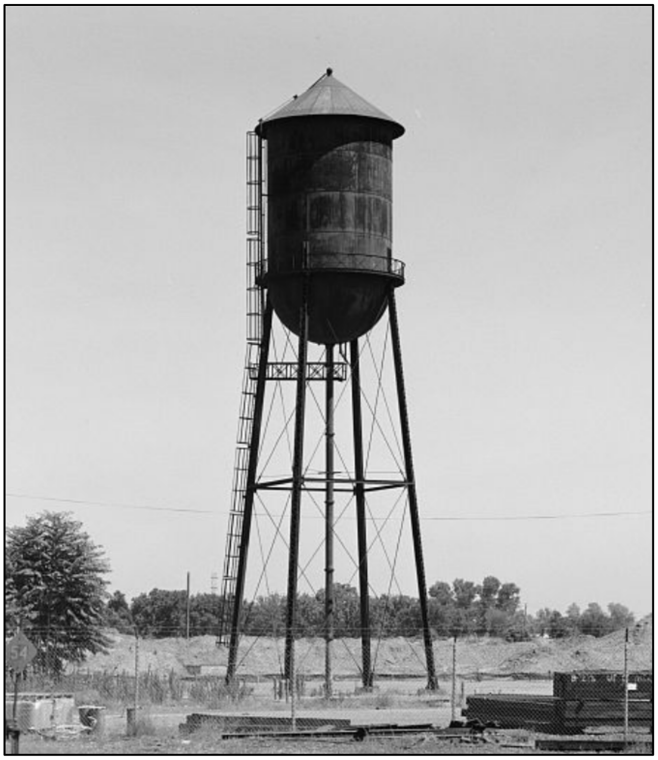

Figure 28: A 1931 Chicago Bridge & Iron Works water tower in the Sacramento railyards, seen in a 2002 photograph.[192]

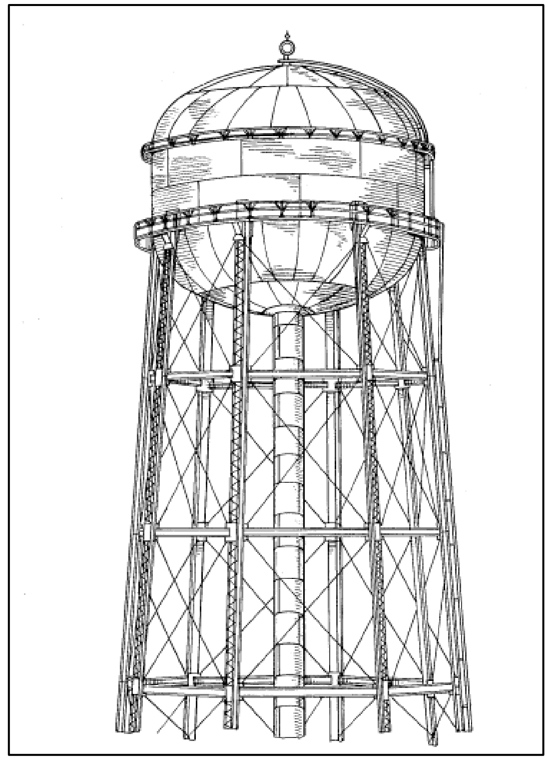

Figure 29: A 1933 patent design for double elliptical water tank**.**[193]

In 1928, Chicago Bridge & Iron (CBI) introduced the first true spherical tank. Set on single pedestal supports, these small tanks, trademarked under the name Watersphere, looked like golf balls sitting on tees. The use of welding, rather than riveting, to join tank plates beginning in 1933 allowed for greater flexibility in design and led to larger forms, including a 100,000-gallon capacity Watersphere introduced in 1939. The Watersphere became the most popular elevated tank design in the 1940s and were especially common for small systems with low storage needs. Other CBI advances allowed for constructing high-capacity tanks holding up to two million gallons.

[192] "Southern Pacific, Sacramento Shops, Water Tower, 111 I Street, Sacramento, Sacramento County, CA," Photos for Survey HAER CA-303-J, Historic American Engineering Records, Library of Congress.

[193] Bryan M. Blackburn, "Design for an Elevated Storage Tank," U.S. Design Patent 91508, February 20, 1934, United States Patent and Trademark Office.

These design types included radial-cone and toro-spherical tanks, both of which placed the convex steel plates under tension to allow for the use of thinner materials (**Figure 30**).

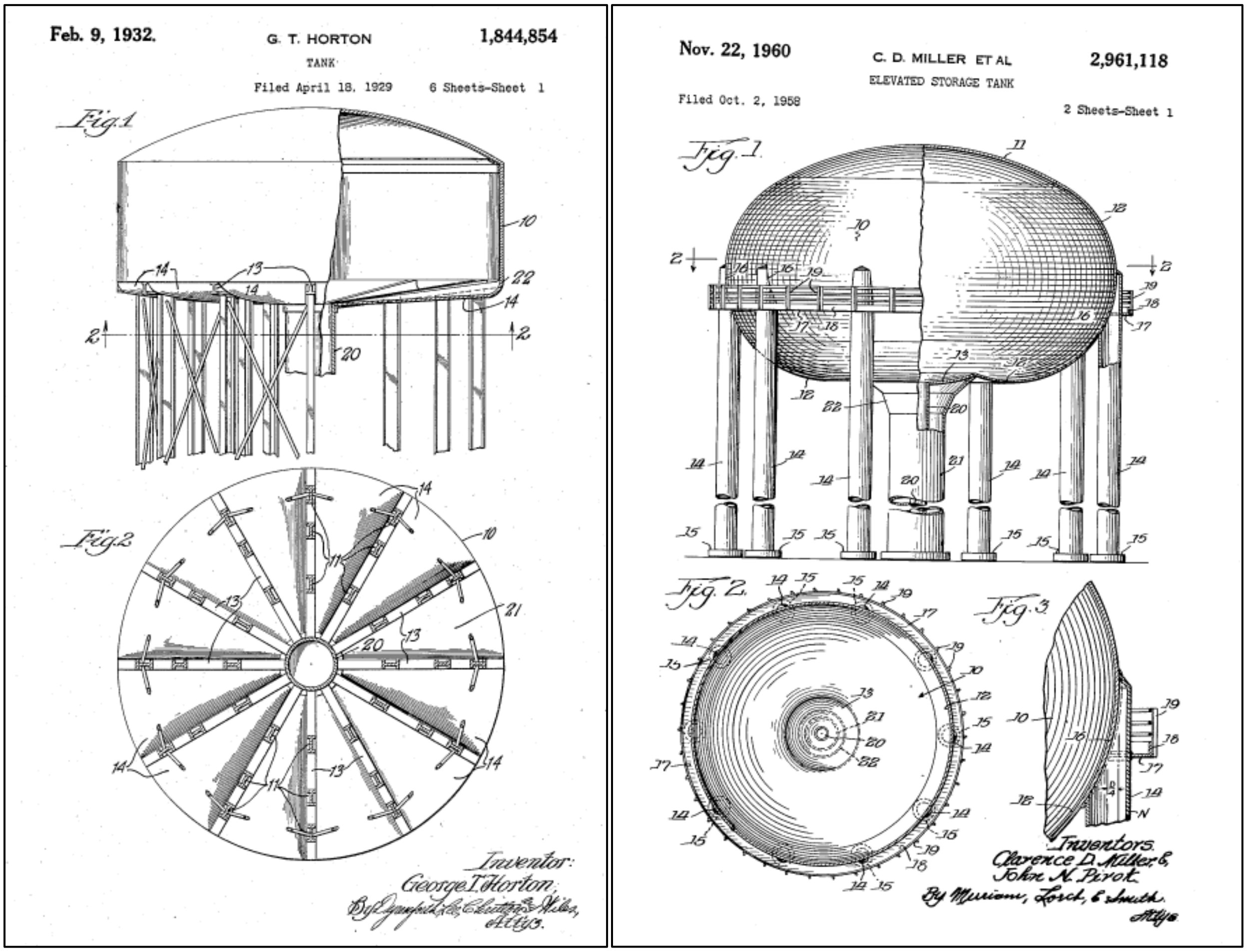

Figure 30: Patent designs for a radial cone tank on left and toro-spherical-type tank on right.[194]

The tubular steel legs that supported the large tanks also required less material than prior truss support systems. Central towers under the tanks housed risers, overflow pipes, and ladders for access. By World War II, tanks in these modern forms and

[194] George T. Horton, “Tank,” U.S. Design Patent 1844854, February 9, 1932, United States Patent and Trademark Office; Clarence D. Miller, “Elevated Storage Tank,” U.S. Design Patent 2961118, November 22, 1960, United States Patent and Trademark Office.

several other variations became common on large systems. Form followed function for elevated steel tanks, and while they were frequently painted with town names or high school mascots, they rarely had architectural decoration beyond their own striking industrial forms.[195]

Sewage Works

Public sewerage systems for collecting household waste became nearly universal among incorporated Californian communities in the first half of the twentieth century, while the treatment of sewage advanced somewhat less rapidly. By the eve of World War II, 95 percent of the state's urban population and about three-quarters of the total population benefited from public sewerage systems. However, nearly four in ten of those systems, including most of the older legacy works of Northern California, continued to discharge raw sewage without treatment. Where people had grown accustomed to disposing of raw sewage, state officials found it difficult to persuade them to abandon existing practices. Conversely, newer cities took it for granted that they would need to treat their sewage before disposing of it, and 80 percent of systems constructed after 1913 included treatment from the outset. Naturally, the communities most open to improvement attracted the engineers and managers who were prepared to deliver it.[196]

The location of sewage disposal—whether into freshwater, saltwater, or on land—was important in determining how rapidly a community advanced in sewage treatment. By 1920, state and local officials well understood the hazards of disposing of raw waste into freshwater streams. Nearly every new freshwater-discharge system included treatment, and many existing systems were overhauled to add treatment options. Land disposal at sewage farms remained common through the 1920s, although increasing regulation meant that most added partial or advanced treatment methods. Communities that discharged their waste to seawater were the slowest to advance. Two-thirds of the new disposal projects involving raw sewage through 1930 discharged into bays or

[195] Mathis, "Steel Water Towers," 36–41.

[196] Gillespie, "The Sewage Situation in California," 460–465.

sloughs, mostly in Northern California. No seawater location added advanced biological treatment methods prior to 1930, although partial treatment by screening or septic tanks became the norm along Southern California's recreational beaches.[197]

Sanitary engineers experimented with a wide variety of treatment methods as they sought practical means of implementing the scientific advances occurring in the field of microbiology. Septic tanks and the related two-chamber Imhoff tanks dominated the first decades of the twentieth century, but options soon diversified. The era of advanced biological treatment began with two designs by the Bureau of Sanitary Engineering for a trickling filter in Reedley in 1915 and an activated sludge plant at Folsom Prison in 1917. In 1929, Gillespie compiled an inventory of the various treatment plants in operation across the state (**Table 4**).

Table 4: Treatment systems in 1929. [198]

Treatment Method	No. of Plants
Sewage Ponding	2
Fine Screens	9
Septic Tanks	77
Imhoff Tanks	83
Intermittent Sand Filter	2
Contact Bed	1
Trickling Filter	33
Activated Sludge	6

Imhoff and septic tanks were by far the most common, although Gillespie described these as "mostly relics of the past." Trickling filters were the most common advanced

[197] Gillespie, "The Sewage Situation in California," 463–465.

[198] Gillespie, "The Sewage Situation in California," 461.

treatment option, producing a fully digested final effluent. While only six activated sludge plants were online, these were largely in joint sewerage plants that handled the waste of multiple communities. The somewhat older technologies of sand filters, contact beds, and fine screen continued to exist but in shrinking numbers. The survey did not include sewage farms, though a number remained in use in 1929. “All in all,” Gillespie noted, “California has adopted practically everything that has appeared on the horizon for sewage treatment.”[199]

Private consultants and equipment manufacturing firms played an increasingly important role in designing sewage treatment systems as their complexity advanced, even as the system remained in municipal or institutional ownership. Academic researchers worked extensively as consultants in the early period because there were few other practitioners experienced in the specialized design of water and sewage treatment plants. Professor Hyde, in particular, consulted on numerous treatment plants throughout the state. Eventually Hyde’s students organized their own consulting firms, with Clyde Kennedy (class of 1911) and Harry Jenks (class of 1917) being among the most prominent in Northern California. The larger equipment manufacturers, such as the Dorr Company, employed consulting engineers who could draw plant plans for small towns or institutions that utilized the company’s equipment.[200]

The reliance on private consultants had the disadvantage of pushing municipalities towards technologies that benefited patent holders more than the communities. Professor Harold Gray of UC Berkeley noted a tendency for sewage treatment methods to cycle in and out of fashion in a manner unrelated to obvious changes in knowledge or technology. Activated sludge treatment found favor in the late 1930s, followed by increased interest in chemical precipitation and then later a revival in trickling filters. Gray linked this pattern to changes in patent status. Several patents for activated sludge

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[199] Gillespie, “The Sewage Situation in California,” 461–462; Gillespie, “Twenty Years of Sanitary Engineering,” 1.

[200] Langelier, “Teaching, Research, and Consultation,” 29; Kennedy Jenks, “History,” accessed October 2020 at Kennedy Jenks History. Many of Hyde’s consulting reports are available in the collection of his papers at WRCA, UC Riverside.

treatment, for instance, ran out around the time that the trend away from it began, while the rediscovered interest in trickling filters coincided with the issuing of new patents for particular filter features.[201]

A P. Banta of the Los Angeles County Sanitation Districts commented drolly on the persistence of equipment salesmen, even as he relied upon their services:

> Larger treatment plants are the Mecca of budding inventive genius. Scarce a week goes by but that some gentleman or salesman arrives with a new panacea of sewage treatment. Sometimes it is the addition of tons of newspaper, or some patented chemical, or some mysterious settling media, or perhaps it is the simpler matter of just distilling the sewage. Paint and building material exponents are legion. Wonder-last-forever metals are nearly as common, and one must expect to have the lubrication system experted [sic] several times a year by all the oil companies.[202]

The following sections highlight the major treatment technologies that came into widespread use during the first half of the twentieth century.

Sewage Pumps

Communities resorted to sewage pumping plants, also called lift stations, in any situation where sewage needed to be lifted above where gravity flow would naturally carry it. This could occur in hilly cities where isolated low-lying districts could not be served by gravity flow outlets. All the sewage through the district would then be collected at a single convenient location and pumped through a force main to join a higher sewer main operating under gravity flow. In flat topography, the need to maintain

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[201] Harold Farnsworth Gray, discussion response to A. J. Fischer, "Current Developments and Trends in Sewage Treatment," *California Sewage Works Journal*, Vol. 13, No. 1 (1941), 54–55.

[202] A. P. Banta, "Los Angeles County Sanitation Districts' Activated Sludge Plant," *California Sewage Works Journal*, Vol. 5, No. 1 (1932–1933), 31.

an adequate grade for flow velocities required excavating continually deeper towards the sewage outlet. In some situations, it proved less expensive to raise the sewage by pumping at one or more places rather than to do deep excavation over long stretches. Pumping stations were also commonly used immediately ahead of treatment plants in order to generate adequate head for plant operation.[203]

A sewage pumping station consisted of a storage well, two or more pumps, and the engines required to operate them. Storage was necessary as pumps operated at a continual rate while sewage inflow varied with the time of day, day of the week, and other factors. Adequate storage capacity also allowed for pumps to be taken offline for maintenance. Pumps could be submerged within the storage well, but it was often preferable to locate them in an adjacent dry well to facilitate servicing (**Figure 31**). Screens at the sewage inlets removed large materials that could clog or damage pumps, but smaller materials including toilet paper and organic solids were allowed to pass through as these created odor problems at the stations if retained. Centrifugal pumps were favored over reciprocating pumps as they were less likely to clog from the smaller bits of trash. Any type of motor could be used to operate the pump, but electrical motors became standard as they were the easiest to automate (**Figure 32**).[204]

[203] A. Prescott Folwell, *Sewerage: The Designing, Constructing and Maintaining of Sewerage Systems and Sewage Treatment Plants*, 9th ed. (New York: John Wiley & Sons, 1922), 119–120; Harold E. Babbitt, *Sewerage and Sewage Treatment*, 2nd ed. (New York: John Wiley & Sons, 1925), 120.

[204] Herbert Patterson, “Pumping Sewage,” *California Sewage Works Journal*, Vol. 2, No. 1 (1929), 13–30; Babbitt, *Sewerage and Sewage Treatment*, 134.

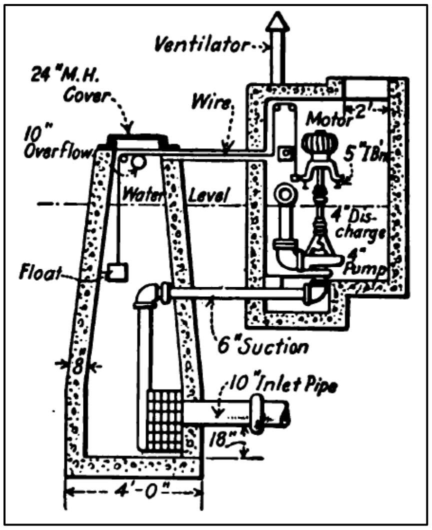

Figure 31: Sewage pump station with centrifugal pump and motor located in dry well adjacent to manhole storage well.[205]

Figure 32: Interior of Los Angeles sewer pump station showing two electric motors. The pumps were housed in a lower, below-ground level.[206]

Sewage pumps generally operated automatically by way of a switch connected to a float within the storage well. When the sewage rose above a certain level, the rising float started the pump, and it operated continually until the sewage fell back below the trigger level. If the sewage continued to rise during pumping, another float would trigger a second pump into operation. A third pump might be present as an emergency reserve and to add additional pumping capacity along lines with high peak flows.[207]

A properly maintained sewage pump plant would produce little odor and thus could be located wherever most convenient. Smaller plants could be contained in below ground vaults, while larger plants frequently had a motor room above ground and pumps below. Early pumping stations were crude, consisting of a wood or brick-lined tank, with a pump mounted on a platform above, and the whole system enclosed in a corrugated metal building. Greater attention was given to the stations as they started to encroach

[205] Babbitt, *Sewerage and Sewage Treatment*, 134.

[206] "Department of Public Works Sewer and Drain Maintenance Division," ca. 1927, California Historical Society Collection, 1860–1960, University of Southern California, Libraries.

[207] Folwell, *Sewerage*, 125–126.

on residential neighborhoods. Some pumping stations constructed in the 1920s adhered to the City Beautiful movement and often featured Neoclassical or period revival design elements and landscaped grounds to emphasize the dignity of municipal service. One design manual argued that "such structures tend to remove the popular prejudice from sewerage and to arouse interest in sewerage questions."[208] In other cases, pump stations were designed to blend in with their surroundings. A pump station of the Los Angeles County Sanitation Districts near the Palos Verdes Peninsula, for example, was set below ground and landscaped above with a pergola that hid ventilation outlets. Likewise, when Long Beach constructed 14 new pump stations, the city disguised some as common stucco bungalows (**Figure 33**) and built another into the central pier of a canal bridge.[209]

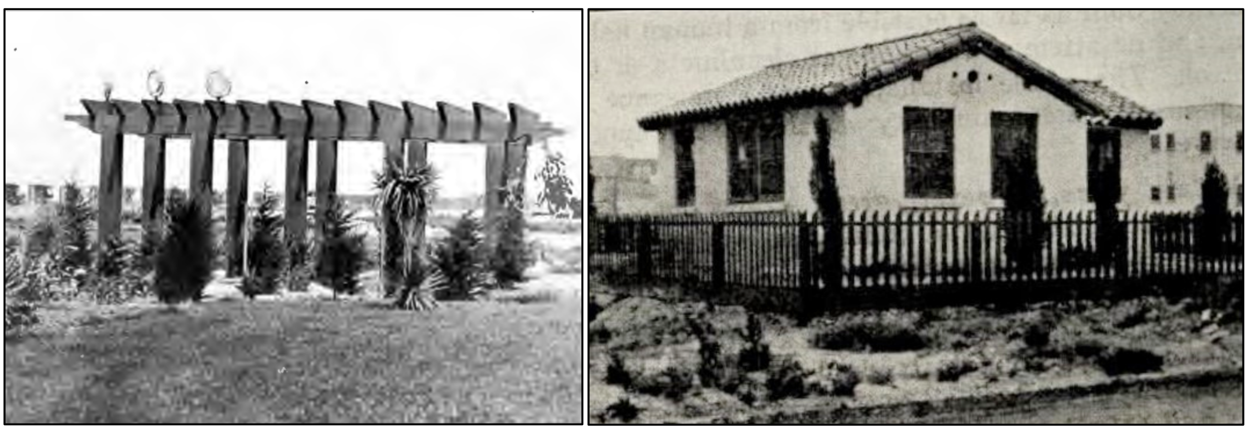

Figure 33: Disguised sewage pump stations: Hollywood Riviera pump station concealed with pergola at left and Long Beach bungalow-type station at right.[210]

Screens

Coarse or fine screens physically removed large items and some portion of the smaller suspended solids from sewage flows. Coarse screening was the first step in nearly all sewage treatment as it was necessary to remove large material—rags, timber, golf balls, and the like—that could clog or damage machinery. A bar screen, composed of parallel iron bars of one-quarter to one-half-inch thickness with openings of between

[208] Babbitt, *Sewerage and Sewage Treatment*, 21–22.

[209] Rawn, *Narrative—C.S.D.*, 41; Patterson, "Pumping Sewage," 13–30.

[210] Rawn, *Narrative—C.S.D.*, 41; Patterson, "Pumping Sewage," 14.

one-half and six inches, was the simplest device. The screen was set with the bars oriented vertically and at an angle of between 30 and 60 degrees so that captured materials were pushed up the screen for easier removal. The screen was cleaned either periodically by manual raking or continually by automated processes of various sorts. **Figure 34** shows a group of mechanically cleaned bar screens manufactured by the Dorr Company. Chain loops on sprocket wheels pulled a rake up the face of the screen and dumped collected materials into a receptacle for later disposal. Medium-sized mesh screens of galvanized wire fabric provided filtering for smaller objects such as toilet paper and leaves preparatory to passing sewage through reciprocating pumps, trickling filters, or other machinery that were readily clogged.[211]

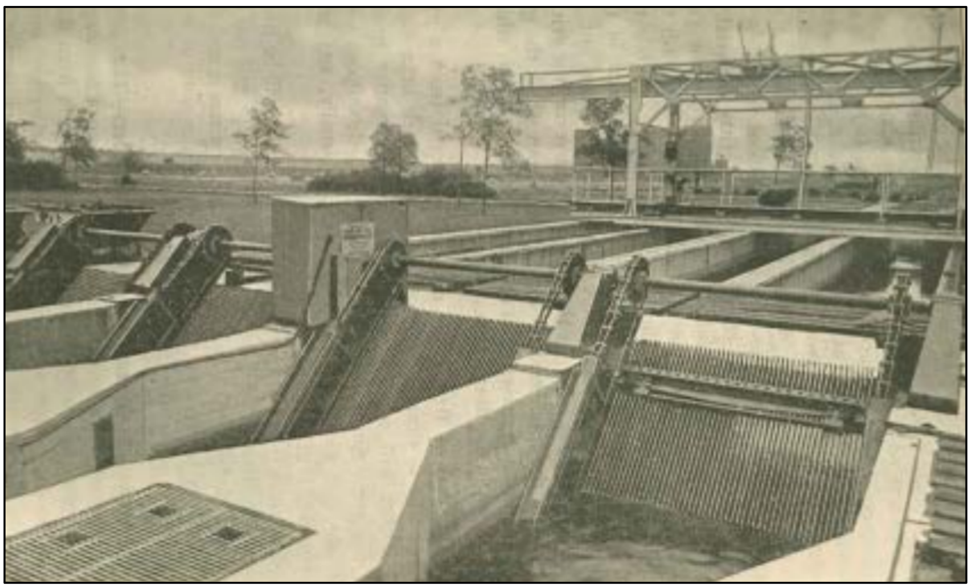

Figure 34: Mechanically cleaned bar screen at head of a typical sewage treatment plant.[212]

Fine screens provided a basic form of sewage treatment by removing a portion of the suspended organic solids. Long Beach was the first to use fine screens for sewage treatment in 1915, followed by Santa Barbara in 1916 and Stockton in 1919. Most fine

[211] Folwell, *Sewerage*, 335–342; Babbitt, *Sewerage and Sewage Treatment*, 356–364; W. A. Hardenbergh, *Operation of Sewage Treatment Plants*, Part 2 (Scranton, PA: International Textbook Company, 1939), 96–99.

[212] Hardenbergh, *Operation of Sewage Treatment Plants*, 96.

screens consisted of perforated metal plates, rather than wire mesh, for greater strength and ease of replacement in the machines. The perforations ranged between 1/32 and 1/14 of an inch wide by 2 to 4 inches long. Fine screens were estimated to remove approximately 20 percent of suspended organic materials, though results varied with circumstances and the screens often underperformed expectations. For planning purposes, they were used only for treatment requiring less than 10 percent removal of suspended solids. That low level of cleaning was considered sufficient when sewage was discharged into an environment where it would be diluted quickly, such as at the Santa Cruz screening plant designed by Charles Hyde that discharged into the ocean (**Figure 35**).

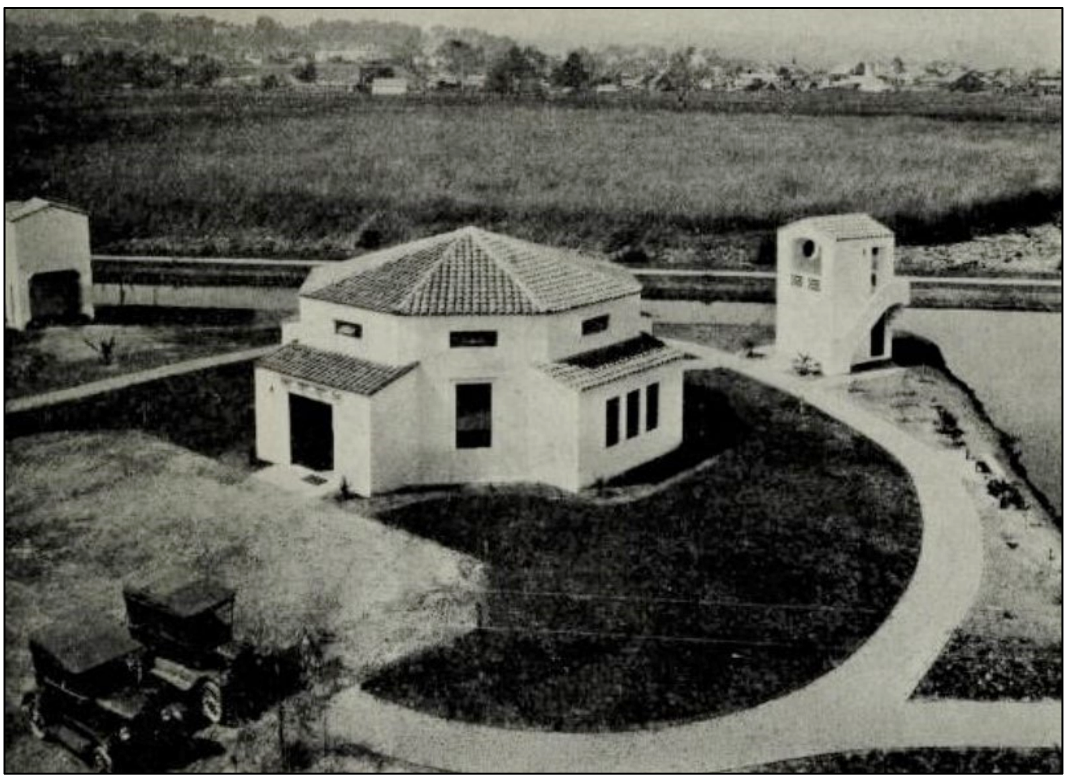

Figure 35: Santa Cruz screening plant, circa 1928.[213]

Screens were also widely used for industrial waste at pulp mills or fruit canneries where the finer organic material that passed through the screen did not pose an immediate health risk. Because screens removed fewer suspended solids than did sedimentation,

[213] "Beach Pollution can be Prevented—Positively; Dorr Company" [advertisement], *California Sewage Works Journal*, Vol. 1, No. 1 (1928), 142.

there was less sludge requiring disposal, and this could be an advantage where land use was at a premium.[214]

Fine screens operated continuously and were cleaned while in motion by brushes or jets of air, water, or steam. Equipment manufacturers marketed a wide variety of patented screen systems. Among the most common in the United States were the disc and drum types (**Figure 36**), though many variations existed. In large treatment plants, the fine screens were major pieces of equipment, with sizes ranging from 8–12 feet in length or diameter (**Figure 37**). Electric motors powered the screen as well as operated sewage pumps and water or air compressors. A dedicated operator was generally required to ensure smooth functioning.[215]

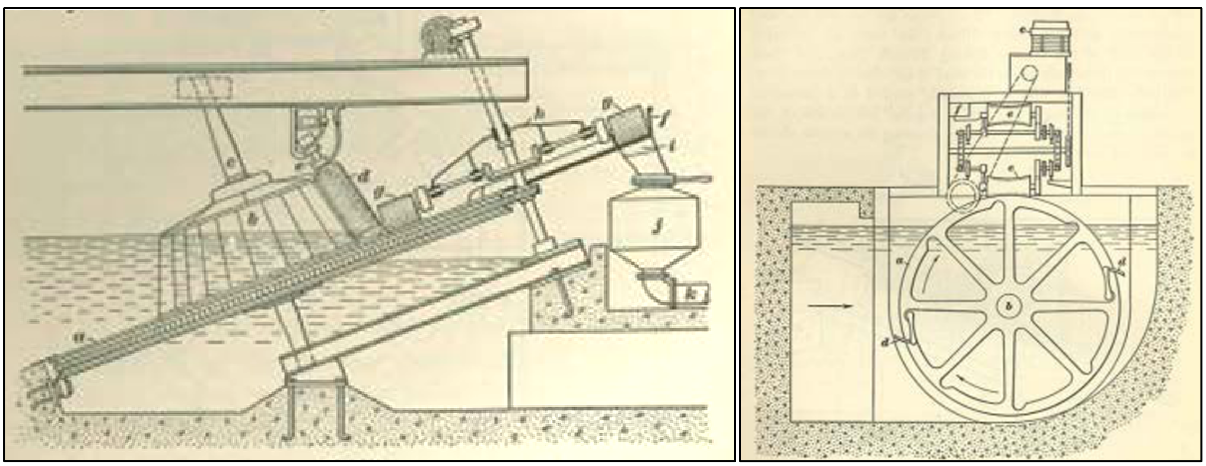

Figure 36: Fine sewage screens of the disk (left) and drum (right) types.[216]

[214] Folwell, *Sewerage*, 338–342; Babbitt, *Sewerage and Sewage Treatment*, 357–360; Hyde, “Pencil Manuscript, A Chronology of Sewerage and Sewage Treatment and Disposal,” 2.

[215] Kenneth Allen, “The Clarification of Sewage by Fine Screens,” *Transactions of the American Society of Civil Engineers*, Vol. 78 (1915), 880–953.

[216] Hardenbergh, *Operation of Sewage Treatment Plants*, 103–104.

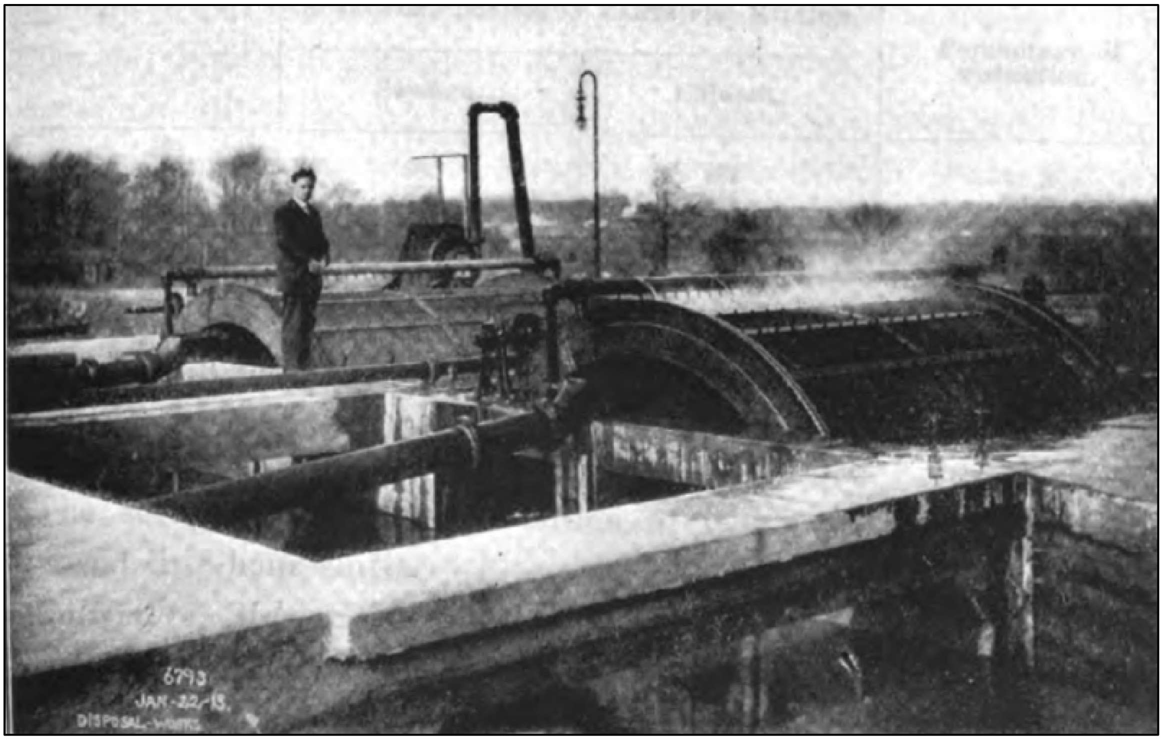

Figure 37: A drum-type screen in operation in Baltimore, Maryland, 1915.[217]

The materials removed by screening were disposed of by incineration or burial. The materials were sometimes dewatered by rolling presses or centrifugal units before disposal. The Hyperion plant in Los Angeles, for example, removed 30 tons of wet screenings per day which dried down to 4.2 tons requiring incineration. Alternately, the screened materials could be sent through a shedder or grinder. Small shredders reduced organic matter to a pulp that could then be fed back into the raw influent, while harder inorganic materials were separated for disposal. Large grinders used toothed disks or swinging hammers to reduce even the hardest matter into particles small enough to be discharged with the effluent. In some cases, grinders were used in lieu of screens so that everything entering the plant was pulverized prior to treatment.[218]

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[217] Allen, "The Clarification of Sewage by Fine Screens," 925.

[218] Hardenbergh, *Operation of Sewage Treatment Plants*, 99–105; H. G. Smith, "Proposed Changes and Improvement in Sewage Disposal at the Hyperion Plant of Los Angeles City," *California Sewage Works Journal*, Vol. 9, No. 1 (1937), 33–46; A. J.

Grit Chambers

In combined storm-sewage systems, large quantities of sand entered the pipes and needed to be removed to avoid clogging the system. Early grit chambers were crude retention basins located along the sewer lines that allowed sand and some organic matter to settle out of suspension. Because organic waste would putrefy in these chambers, they produced considerable odor and needed to be cleaned regularly. Later refinements allowed for greater control of the flow velocity, maintaining a current of around one foot per second, so that only the heaviest mineral materials settled out.[219]

In sewage treatment plants, grit chambers were generally located immediately behind bar screens at the entrance to the plant. The velocity of the influent was reduced through the grit chamber by gradually flaring the sides and bottom of the channel to increase its width and depth. Grit settled out to the depths of the chamber which was set below the bottom level of the incoming and outgoing pipes. To maintain proper velocity, two or more chambers could be constructed in parallel. During times of low flow, a single chamber was used and the other chambers were put into use as flows increased.[220]

Grit chambers needed to be cleaned periodically and particularly after storms. This could be done manually by temporarily taking the chamber out of service. Apparatuses for mechanical cleaning were introduced in 1927 and became common in the 1930s. Most of these consisted of a scraping device that ran over the bottom of the chamber and a moving rake or elevator that raised the material on an incline while agitating it to wash out any organic matter. Grit that retained any organic waste needed to be buried. Clean grit could be used as fill material or dumped as convenient.[221]

Fischer, “Current Developments and Trends in Sewage Treatment,” *California Sewage Works Journal*, Vol. 13, No. 1 (1941), 42–55.

[219] Hyde, “A Review of Progress in Sewage Treatment During the Past Fifty Years,” 4.

[220] Hardenbergh, *Operation of Sewage Treatment Plants*, 92–93.

[221] Hardenbergh, *Operation of Sewage Treatment Plants*, 92–93; Hyde, “A Review of Progress in Sewage Treatment During the Past Fifty Years,” 4.

Septic Tanks

The septic tank was the dominant sewage treatment technology of the early twentieth century, from 1900 to approximately 1913, after which it was superseded by the related Imhoff tank. Donald Cameron introduced the septic tank in England in 1896 and received a US patent in 1899. He organized the Cameron Septic Tank Company to license use of the technology in America at a fee of five percent of construction costs. However, Cameron immediately encountered resistance from engineers who objected to his effort to patent the septic process itself rather than a particular tank design. Municipalities refused his royalty demands on the grounds that the septic process was a natural one that relied upon anaerobic bacteria that was already in the sewage itself. The municipal engineers initially prevailed in the ensuing lawsuits, winning a 1907 court decision that generated a boom in septic tank construction, but an appeals court later reversed the ruling and declared the septic process patentable. The drawn-out suit and the uncertainty and animosity that surrounded it caused engineers to ultimately shy away from the technology and welcome the emergence of the Imhoff tank (see below) as an alternative. Only in 1919 did Cameron settle the final outstanding claims, but by then numerous competing technologies existed in the marketplace.[222]

The municipal septic tank was a one-story, continuous-flow sedimentation tank through which sewage was permitted to slowly pass so that suspended matter would settle to the bottom and undergo anaerobic decomposition. The tanks were designed to hold sewage from 6 to 12 hours before discharging the effluent. The tanks thus needed a volume equivalent to a quarter or half-day's average flow. If the tanks were too large and the sewage remained overlong in the chamber, undesirable levels of anaerobic activity would give the effluent an objectionably dark appearance and offensive odor. Too short of a stay and not enough organic matter would settle out of the effluent. As the volume of sewage flows varied, it was desirable to have two or more tanks so that

[222] Schneider, *Hybrid Nature*, 47–48.

capacity could be added or removed to match flows (**Figure 38**). Most small plants lacked that flexibility and thus produced results that were less than satisfactory.[223]

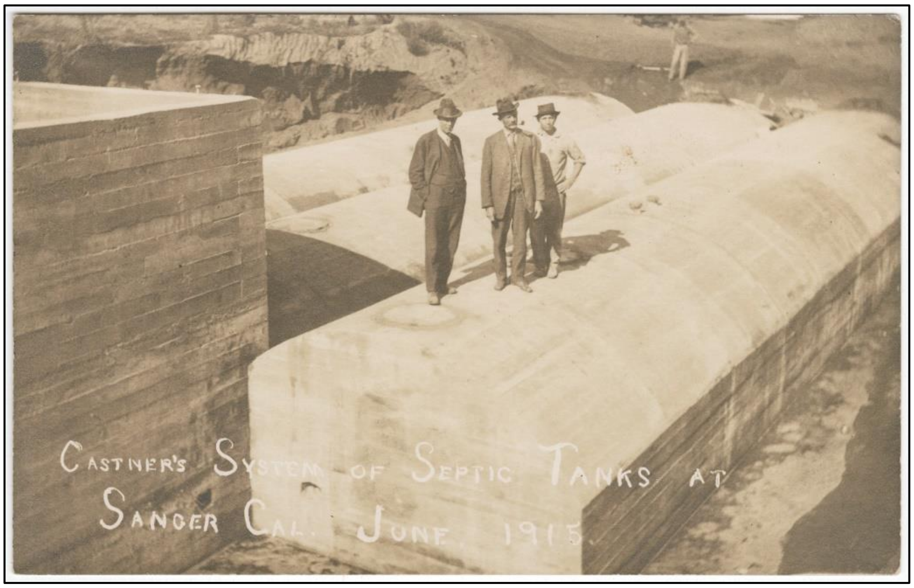

Figure 38: Three newly installed septic tanks in Sanger, Fresno County, 1915.[224]

Septic tanks were constructed of wood, brick, or concrete in all different sizes and plans. They could be rectangular, square, or circular; deep or shallow; roofed or open-topped. The bottoms could be horizontal, sloping, or contain hoppers for settled sludge. The chief concern in design was to reduce the velocity of flow through the tank and prevent material from moving directly from inlet to outlet. **Figure 39** shows a typical small septic tank. Sewage inflow is from the left by inlet ‘a’ into settling tank ‘b’. Effluent passed over weir ‘c’ into the siphon chamber ‘d’, from which it was discharged by automatic pump ‘e’ into the outlet pipe ‘f’. A baffle near the inlet slowed the sewage entering the tank, while a scum bar near the weir extended 6 to 18 inches below the surface to prevent floating materials from escaping the tank.[225]

[223] Folwell, *Sewerage*, 351-58; Babbitt, *Sewerage and Sewage Treatment*, 384–390.

[224] “Castner's system of septic tanks at Sanger Cal.,” 1915, California History Section Picture Catalog, California State Library.

[225] Hardenbergh, *Operation of Sewage Treatment Plants*, 109.

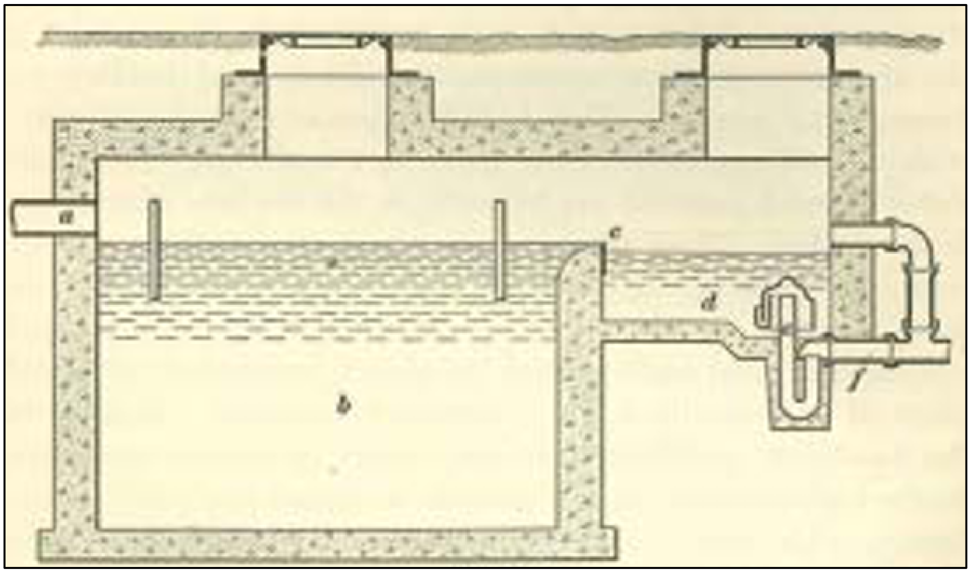

Figure 39: Small septic tank system.[226]

Anaerobic bacteria developed within a new septic tank over a period of a couple weeks to several months. It would then work continuously on the layer of sludge that settled to the tank bottom, digesting organic matter into gases of methane, carbon dioxide, and nitrogen as well as finely divided organic compounds that entered solution and left the tank with the effluent. Some organic matter resisted decomposition and formed a permanent layer on the bottom of the tank that needed to be drained or pumped out roughly once or twice a year. The effluent discharged from a septic tank had between 25 to 50 percent less suspended matter than raw sewage, including the bulk of the material that was most inclined to putrefaction and thus public offense. Septic tanks were used both as the sole sewage treatment prior to discharge or as a preparatory stage for further treatment.[227]

In California, Willits of Mendocino County was the first to employ a municipal septic tank in 1904, while Bishop, Santa Rosa, and Fresno added tanks the following year. The municipal use of septic tanks declined after the introduction of the Imhoff tank, though they remained in use for longer at institutions and small treatment works. Septic tanks remain ubiquitous in rural areas without sewage systems. Modern septic tanks are

[226] Hardenbergh, *Operation of Sewage Treatment Plants*, 109.

[227] Folwell, *Sewerage*, 351–358; Babbitt, *Sewerage and Sewage Treatment*, 384–390.

manufactured of concrete, plastic, or fiberglass. They generally operate in connection with a drain field in which subsurface perforated pipes discharge effluent into a porous underlayer.[228]

Imhoff Tanks

Karl Imhoff developed his namesake tank in Germany in 1907 to address a chief failing of the septic tank. As the sludge at the bottom of a septic tank decomposed, it gave off gases that bubbled up through the sludge layer and liquid sewage. During the heat of summer, the bubbling could become vigorous enough to stir up the sludge and mix it into the effluent. This greatly increased the quantity of suspended solids and prevented effective sedimentation.[229]

The Imhoff tank (also known as an Emscher tank) operated by dividing sedimentation and digestion into separate chambers across a two-story structure so that gases, scum, and regurgitate particles from the decomposing sludge could not agitate or reenter the flowing sewage above (**Figure 40**). The upper sedimentation chambers were long, narrow basins through which the liquid influent flowed at a rate of around a foot per minute, giving a retention period of two to three hours. The chambers had a maximum length of around 100 feet and a relatively narrow width to avoid creating crosscurrents in the flow. Angled bottoms on the sedimentation chambers sloped down to a narrow slot through which the deposited solids fell into the lower digestion chamber. The slot was designed in such a manner to prevent gas from entering from below. Concrete was favored for construction as its smoothness assisted the sludge in slipping down the sedimentation chamber walls. Still, it was necessary to include a walkway on top of the tanks so that workers could scrape the side walls of accumulated deposits twice a week or so. Two or more sedimentation chambers were sometimes used over a single

[228] Hyde, “A Review of Progress in Sewage Treatment During the Past Fifty Years,” 5; Hyde, “Pencil Manuscript, A Chronology of Sewerage and Sewage Treatment and Disposal,” 2.

[229] Folwell, *Sewerage*, 358–364; Babbitt, *Sewerage and Sewage Treatment*, 390–403.

digestion chamber to avoid the depths required by the long sloping of a single chamber.[230]

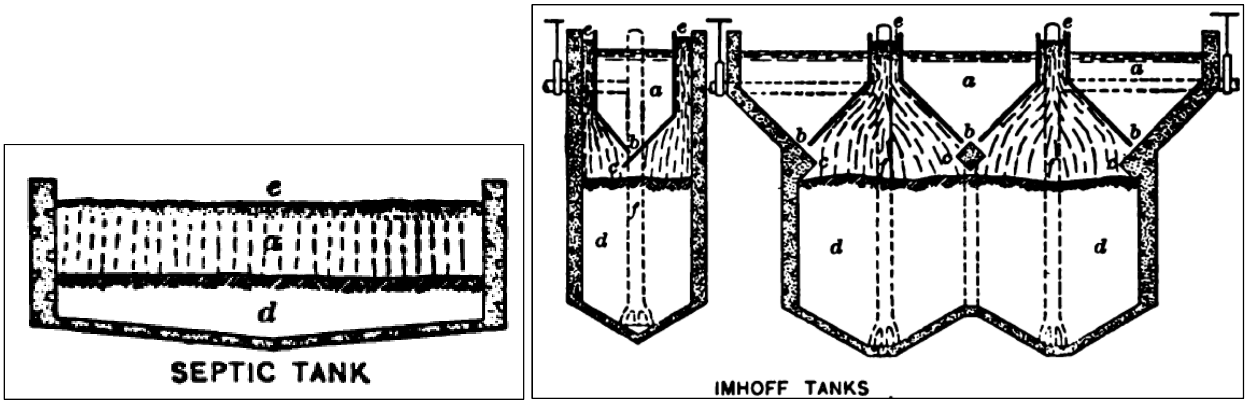

Figure 40: Imhoff tanks contrasted with traditional septic tank—‘a’ shows the sewage channel flow; ‘b’ slot through which sediment slides to chamber below; ‘c’ a gas deflector to prevent gas rising into the sewage chamber; ‘d’ sludge digestion chamber; ‘e’ gas vent; and ‘f’ sludge pipe for clearing.[231]

The digestion chambers stored sludge for between six and 12 months, with longer times required in small plants or during cold weather. It was desirable to make the digestion chamber as deep as possible as this improved decomposition by maintaining more uniform temperatures. This desire had to be balanced against the increased cost of deep excavation, and tanks generally had a maximum depth of 30 to 35 feet. Gas and scum produced by digestion bubbled up into spaces surrounding the exterior of the sedimentation tanks. Vents of various designs allowed the gas to escape. Digested sludge was removed from the bottom of the tank by gravity where feasible or more commonly by pumping. The bottom of the digestion chamber was in the form of a hopper. A vertical sludge pipe drew digested sludge from the hopper bottom and fed it into a horizontal pipe that led to sludge drying beds. A valve opened the pipe and pressure from the water above forced the digested sludge through the pipes. Operators closed the valve as soon as the emerging sludge showed signs of not being fully

[230] Folwell, *Sewerage*, 358–360; Babbitt, *Sewerage and Sewage Treatment*, 390–400.
[231] Folwell, *Sewerage*, 357.

digested. The sludge produced by Imhoff tanks was generally in better condition that than from traditional septic tanks and was more easily dried.[232]

Imhoff tanks gained quick popularity in America because of increasing dissatisfaction with septic tanks and weariness of the protracted patent litigation. Fullerton, Hanford, Mill Valley, and Winters constructed the first four tanks in California in 1912. The effluent released from an Imhoff tank was in most circumstances superior to that from septic tanks and lacked dark coloring and offensive odors. The improved quality of digested sludge also made Imhoff tanks attractive to municipalities that hoped to sell the material as fertilizer to partially recoup operating costs. However, the tanks had several notable drawbacks. Because of their great depth, Imhoff tanks required deep excavation during constructing, which made them more expensive than alternatives (**Figure 41**). Operating costs were also generally higher than for other tank types as Imhoff tanks could not be neglected for more than a few days at a time without detrimental results. The tanks tended to be temperamental and they sometimes failed to produce adequate digestion or generated excessive quantities of scum without clear cause. Imhoff tanks also lacked means of heating the sludge to aid digestion and the fixed relationship between settling capacity and sludge digestion space limited their flexibility. Some very large Imhoff tanks were constructed in the United States, including a 472 mgd tank in Chicago, but they eventually fell out of favor for all but small treatment plants, replaced by plain sedimentation tanks with separate digestors.[233]

[232] Folwell, *Sewerage*, 359–364; Babbitt, *Sewerage and Sewage Treatment*, 390–400.

[233] Folwell, *Sewerage*, 363–364; Babbitt, *Sewerage and Sewage Treatment*, 400–403; Harrison P. Eddy, “Imhoff Tanks—Reasons for Differences in Behavior,” *Proceedings of the American Society of Civil Engineers*, Vol. 50, No. 5 (May 1924), 616–645; Hyde, “A Review of Progress in Sewage Treatment During the Past Fifty Years,” 5; Hyde, “Pencil Manuscript, A Chronology of Sewerage and Sewage Treatment and Disposal,” 2.

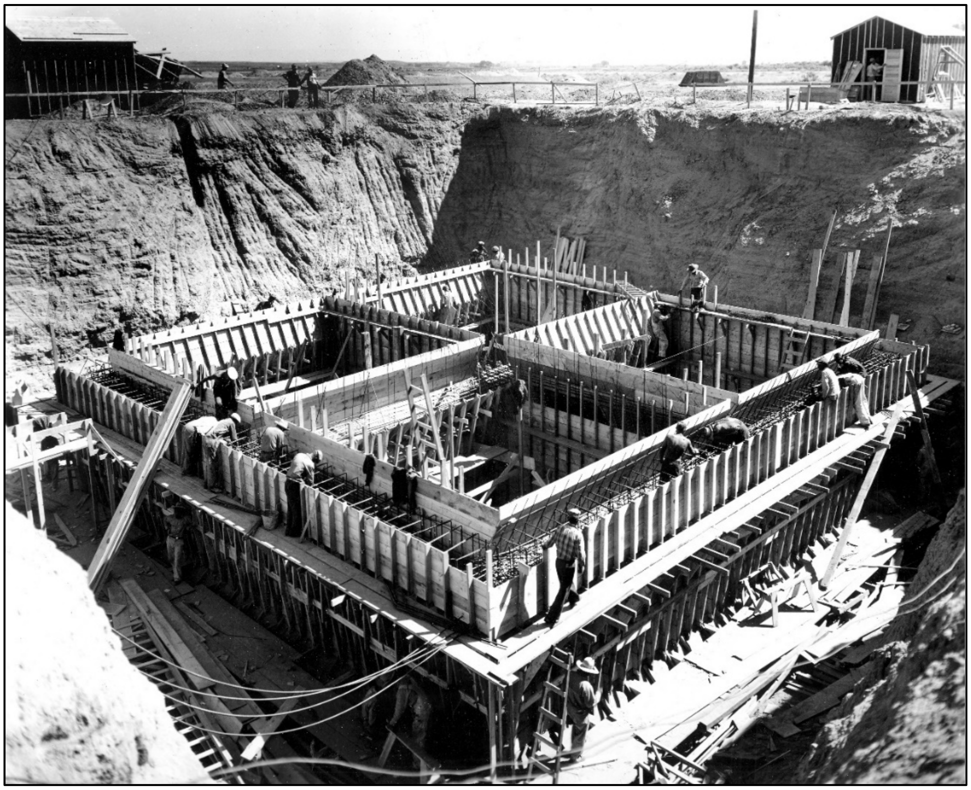

Figure 41: Imhoff tank under construction in 1943 at Heart Mountain Relocation Center, Wyoming. Note the depth of excavation required.[234]

Clarifiers

Clarifiers or plain sedimentation tanks followed the same basic principle inherent in septic or Imhoff tanks in using a controlled, slow flow of sewage to cause mineral and organic solids to settle out of suspension. They differed in that the sediments were removed before septic conditions could develop and the sludge was digested separately. Settlement basins (also called settling basins) were a basic technology that had been used in the nineteenth century to treat turbidity in drinking water and to provide minimal treatment of sewage before discharge. However, they did not come into wide use until after 1919 when mechanical equipment for removing sludge and grease from the tanks was introduced in the United States. In comparison to Imhoff tanks,

[234] U.S. Army Corps of Engineers, "Imhoff tank under construction," 1942, San Jose State University, Special Collections and Archives.

clarifiers were simple to operate as they did not require scraping or manual skimming and the separate digestion could be more readily controlled with less unpredictable foaming or digestive failures. A primary clarifier unit was used with raw sewage at the start of treatment, while a secondary or final clarifier unit was sometimes required to provide additional settlement at the end of treatment following a trickling filter or activated sludge tank. Sludge from final clarifiers was frequently returned by pipe back to the primary clarifier where it again settled and was removed.[235]

Early clarifier-style settlement tanks operated on an intermittent fill-and-drain schedule, but by 1904 it was known that a continual flow in, through, and out of the basin provided just as good results and with increased throughput capacity. Settlement periods were commonly between one and three hours. Less retention time was required ahead of trickling filters and more might be used on a small system with relatively fresh sewage and no secondary treatment. Settlement tanks for sewage systems followed similar designs to those used in drinking water treatment (see above section) and came in rectangular and circular plans. Square tanks featured rounded corners to facilitate sludge collection, but these proved difficult to fully clean and the design fell from favor (**Figure 42**).[236]

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[235] Samuel A. Greely, "Sedimentation and Digestion in the United States," in Pearse, ed., *Modern Sewage Disposal*, 28–50; Folwell, *Sewerage*, 342–344; Babbitt, *Sewerage and Sewage Treatment*, 368.

[236] Allen Hazen, "On Sedimentation," *Proceedings of the American Society of Civil Engineers*, Vol. 53 (1904), 45–71; Hardenbergh, *Operation of Sewage Treatment Plants*, 120–125.

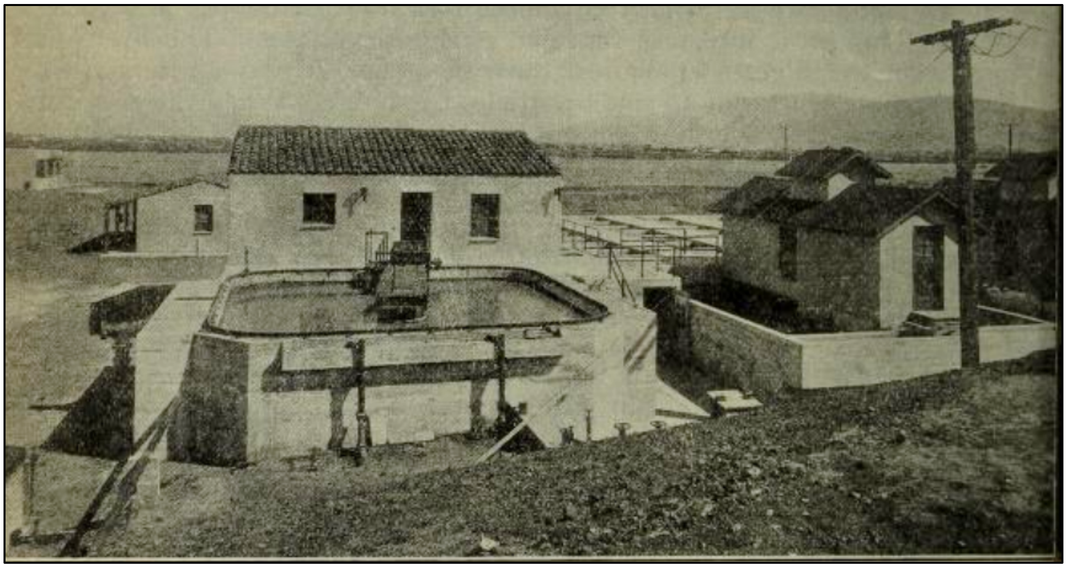

Figure 42: Salinas sewage treatment plant with square clarifier in foreground, circa 1930.[237]

A wide variety of devices for mechanical sludge collection were available that promised savings in construction, labor, and maintenance, or particular advantages with different types of sewage. These devices generally consisted of scrapers and skimmers that moved sludge and scum respectively towards collection points. In some designs, a scraper moved across the bottom of the tank from end to end before being raised on a chain loop and returning along the top of the tank as a skimmer. Rotary skimmers sometimes used jets of water rather than physical blades to collect fats from the surface. The collectors could operate continuously or could be used once or twice a day for around half an hour at a time. The collection sumps were pumped at least daily, and pumping continued until sewage started to flow through the outlet pipe.[238]

Intermittent Sand Filters and Contact Beds

Neither intermittent sand filters nor contact beds ever found wide use in California, though both were important transition technologies in introducing biological treatment methods. Intermittent sand filtration offered a refinement on sewage farming in which

[237] T. R. Haseltine, “Handling Sludge and Screenings at Salinas,” *California Sewage Works Journal*, Vol. 3, No. 1 (1930), 38.

[238] Hardenbergh, *Operation of Sewage Treatment Plants*, 123–124.

the wastewater flowed onto specially prepared beds of sand, gravel, or other porous materials (**Figure 43**).

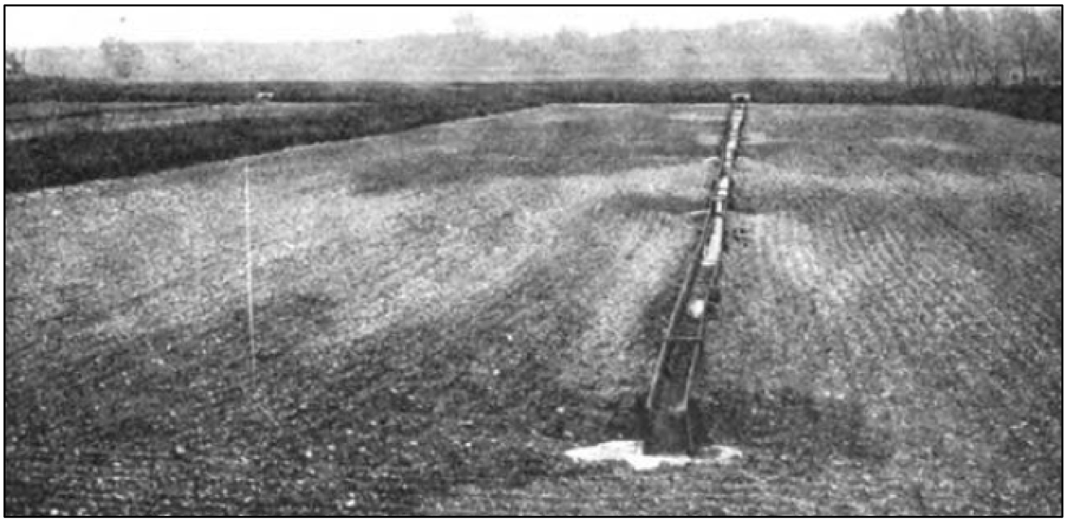

Figure 43: Example of intermittent sand filter with wood distributor.[239]

The practice was first developed in England in the late 1860s and was further studied at the Lawrence Experiment Station in 1886-87. The sand filter treatment area was commonly divided into three or more beds so that sewage distribution could be rotated between fields. This allowed beds to dry out and reabsorb oxygen between uses. Compared to sewage farming, intermittent filters could support ten times the population on the same amount of land, but required more intensive management. Workers needed to carefully grade and rake the beds to ensure even distribution. Organic waste that dried onto the surface of the soil needed to be scraped and removed periodically. In some cases, it was necessary to install drainage tiles beneath the bed surface. The tiles of hard-baked clay admitted water at their joints and removed excess moisture. Intermittent filtration was used extensively on the East Coast and particularly in New England where natural sand beds were abundant, but it was not widely adopted elsewhere in the United States and examples in California are limited. Redlands in San Bernardino County began disposing of raw sewage on natural sand filter beds in 1890,

[239] Folwell, *Sewerage*, 375.

and Monrovia, Manteca, Kingsburg, and Ojai all later disposed of septic, Imhoff tank, or trickling filter effluent on sand beds.[240]

The contact bed, developed by William Didbin in early-1890s London, involved a water-tight basin, four to eight feet deep, that was filled with particles ranging in size from a pea to a walnut. The maximum basin size was around one-half acre as anything larger required too much time to fill. On the bottom of the basin, a network of drains led to an outlet pipe (**Figure 44**).

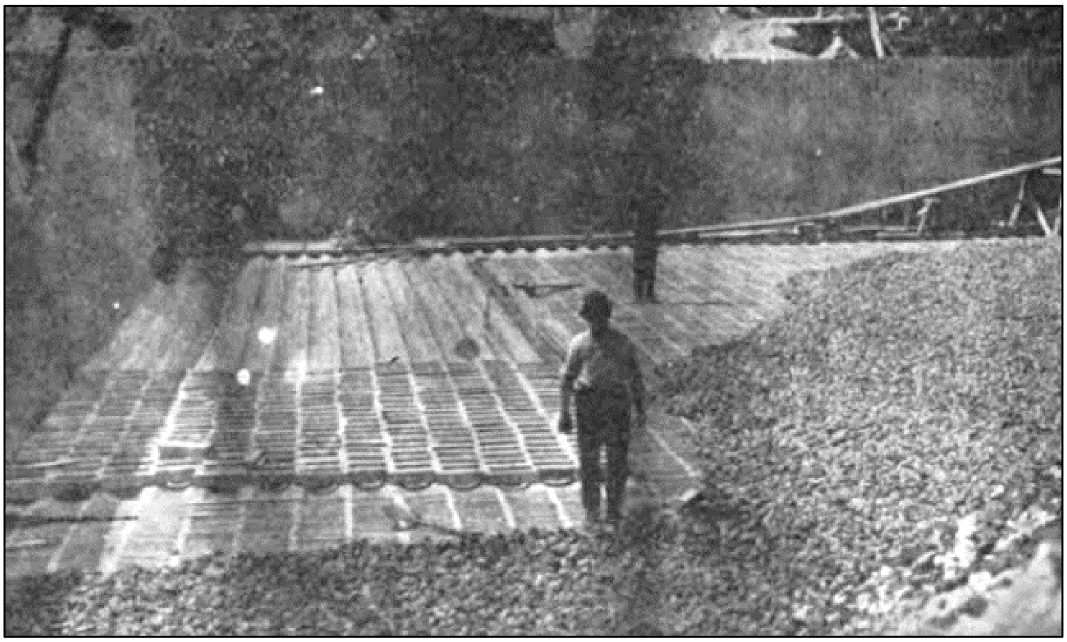

Figure 44: Contact bed under construction, showing drains and first layer of stone particles.[241]

Experiments were made with a wide variety of filter materials including coal, slag, cinder, gravel, burnt clay, glass, and broken bricks. Roughness, porosity, and small size were desired to increase the surface area to volume, though material that was too small led to clogging. The beds operated on cycles, allowing, for example, an hour for filling, two hours of standing full, an hour to drain, and four hours to stand empty. A degree of

240 Folwell, *Sewerage*, 374–379; Hardenbergh, *Operation of Sewage Treatment Plants*, 174–178; Melosi, *The Sanitary City*, 168; Hyde, "Pencil Manuscript, A Chronology of Sewerage and Sewage Treatment and Disposal," 2.

241 Folwell, *Sewerage*, 381.

sedimentation occurred during the period of slow filling, followed by a degree of anerobic decomposition while the pool was full. The majority of the digestion occurred aerobically on the wet surfaces of the filter materials while the tank stood empty. Aerobic digestion could be increased by operating basins in pairs and passing the effluent from the first-contact filter into a second-contract filter. An experimental plant in Marion, Ohio, achieved a high level of treatment by having sewage receive primary treatment in septic tanks prior to flowing in sequence into two contract beds followed by a final cleaning in a sand filter (**Figure 45**).

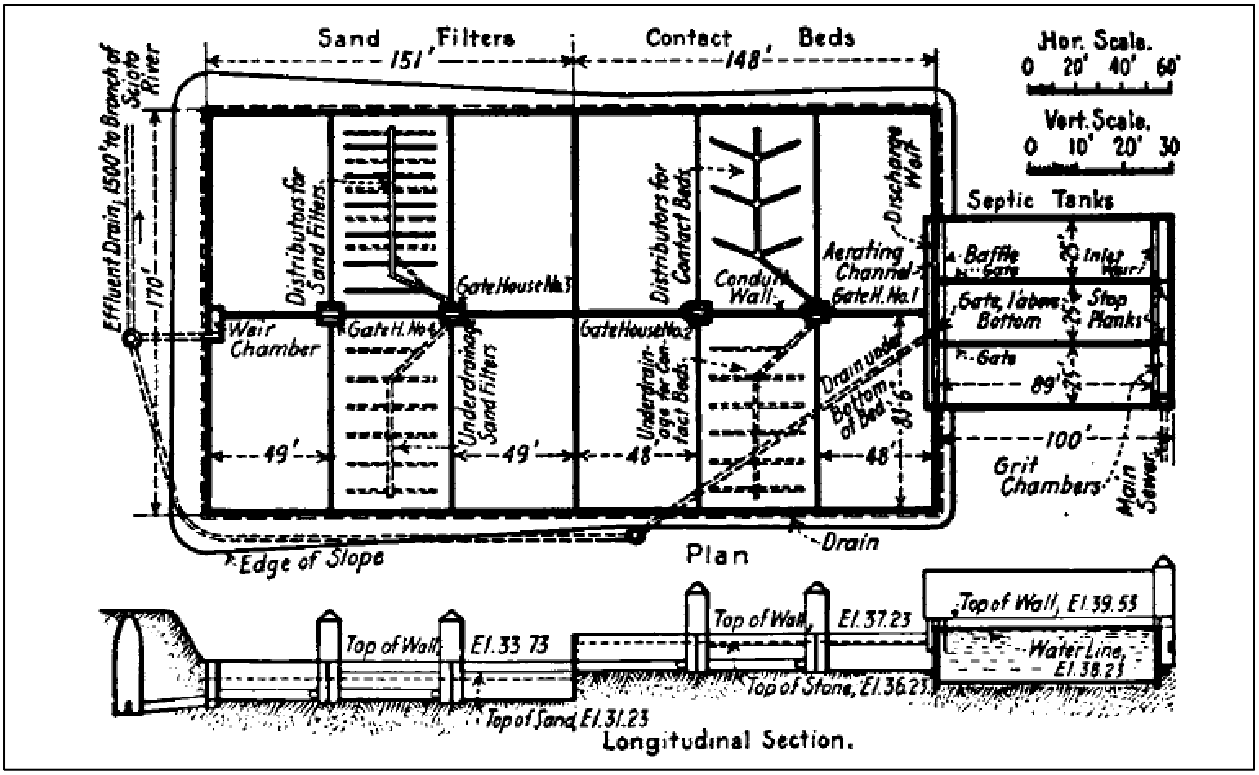

Figure 45: Marion, Ohio, treatment plant with septic tanks, contact beds, and sand filters.[242]

242 Babbitt, Sewerage and Sewage Treatment, 407.

Gillespie recorded a total of four contact beds constructed across California, with the first being a 1910 plant in Roseville, followed by Dixon in 1911. Only one contact bed remained in use by 1930.[243]

Trickling Filter

The trickling filter, also known as “trickle filter,” “sprinkling filter,” or “biofilter,” was the most common secondary treatment method employed in California prior to World War II. The method differed from a contact bed in that there was no period where the basin filled with sewage and engaged in anaerobic digestion. Tests at the Lawrence Experiment Station demonstrated that better results were obtained by maintaining a consistent environment that favored aerobic microbes. Early efforts were made at distributing sewage over a contact bed at a slow, trickling pace by use of troughs, but uniform and consistent distribution could not be obtained. Joseph Corbett of Salford, England, first made use of spray jets to create a true trickling filter in 1893. Madison, Wisconsin, constructed the first such filter in the United States for institutional use in 1901, and Redding, Pennsylvania, completed the first municipal plant in 1908. California’s Bureau of Sanitary Engineering designed the first trickling filter in the state in Reedley in 1915.[244]

Early trickling filters were built in much the same fashion as a contact bed. Concrete basins were constructed with depths between six and ten feet and filled with rough, hard, and angular particles, between 1.5 and 3 inches in size, over a drainage system (**Figure 46**). Multiple units were generally constructed in series to provide flexibility in operation.

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[243] Folwell, *Sewerage*, 379–383; Babbitt, *Sewerage and Sewage Treatment*, 405–415; Gillespie, “The Sewage Situation in California,” 461; Hardenbergh, *Operation of Sewage Treatment Plants*, 169–172; Hyde, “Pencil Manuscript, A Chronology of Sewerage and Sewage Treatment and Disposal,” 2.

[244] W. E. Stanley, “The Trickling Filter in Sewage Treatment,” in Pearse, ed., *Modern Sewage Disposal*, 51–67; Melosi, *The Sanitary City*, 169–170; Gillespie, “Twenty Years of Sanitary Engineering,” 1.

Figure 46: Trickling filter under construction, showing drainage tiles and concrete posts to hold sprinklers. Stone will later fill the bed to the top of the posts.[245]

The exterior dimensions of the tanks varied with local circumstances and needs. The tanks could be recessed in the ground or built up, as at the plant in Lemoore (**Figure 47**). The practice at early plants was to provide rest periods between applications of sewage. This required large surface areas as parts of the plant were regularly taken out of use. Later studies showed that the trickling filters could be used continuously around the clock, which allowed for higher rates of throughput and consequently smaller basins. Much of the innovation of design in trickling plants involved the nozzles and the quest to provide even spray coverage. Revolving distributors on circular tanks eventually replaced stationary nozzles in most plants (**Figure 48**). The distributors could be motorized to revolve or be propelled by the force of the spray emitted from the nozzles.[246]

[245] Folwell, *Sewerage*, 389.

[246] Stanley, "The Trickling Filter in Sewage Treatment," 51–59; Folwell, *Sewerage*, 383–96; Babbitt, *Sewerage and Sewage Treatment*, 416–432; Hardenbergh, *Operation of Sewage Treatment Plants*, 157–169.

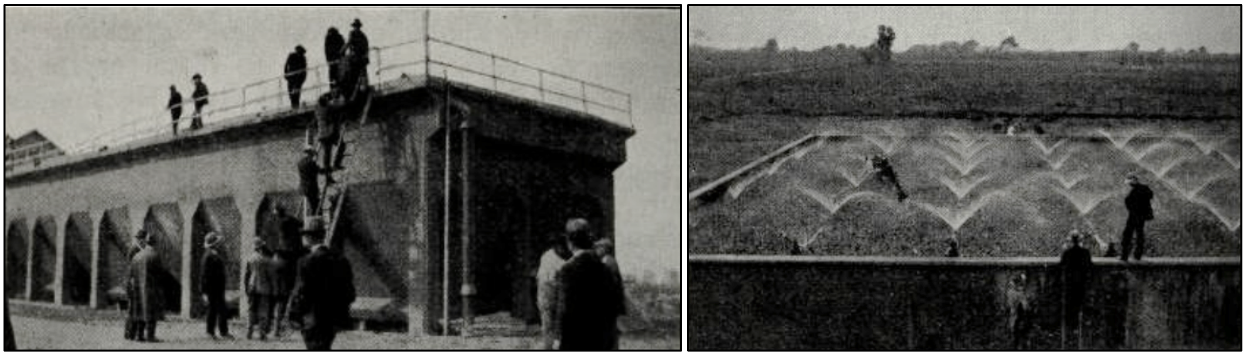

Figure 47: Trickling filter at Lemoore, 1929.[247]

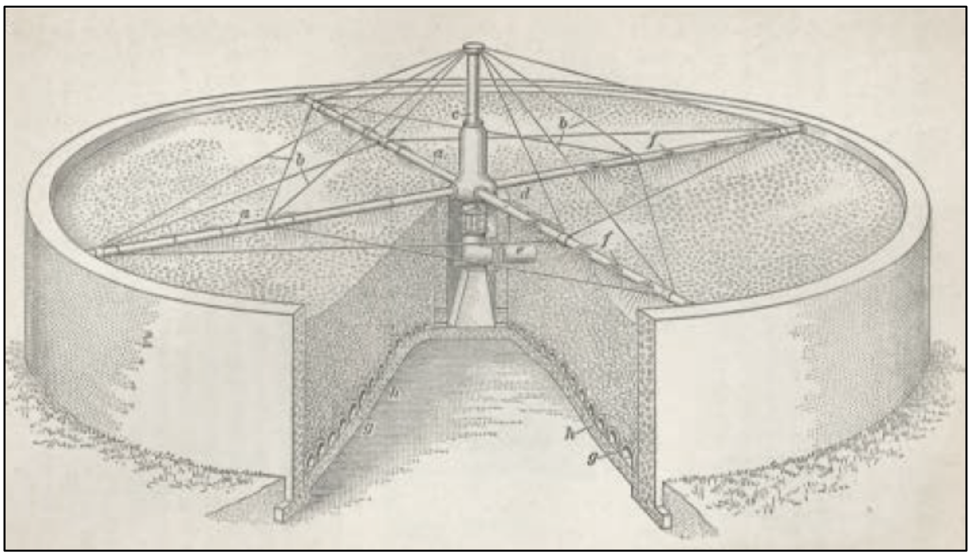

Figure 48: Trickling filter with revolving distributor.[248]

Trickling filters generally operated in conjunction with automatic dosing tanks to ensure an even spray distribution over the bed (**Figure 49**). The tanks filled with influent and automatically discharged through a siphon when full. Small air-lock piping (not depicted in the figure) opened and closed the siphon at set levels. The sides of the tanks were angled to cause the head to decline at a rate calculated for even spray distribution.

[247] C. C. Kennedy, “Sewage Treatment Plant, Lemoore,” *California Sewage Waste Journal*, Vol. 2, No. 1 (1929), 28.

[248] Hardenbergh, *Operation of Sewage Treatment Plants*, 159.

Dosing tanks were usually paired so that one tank was filling while the other was discharging.[249]

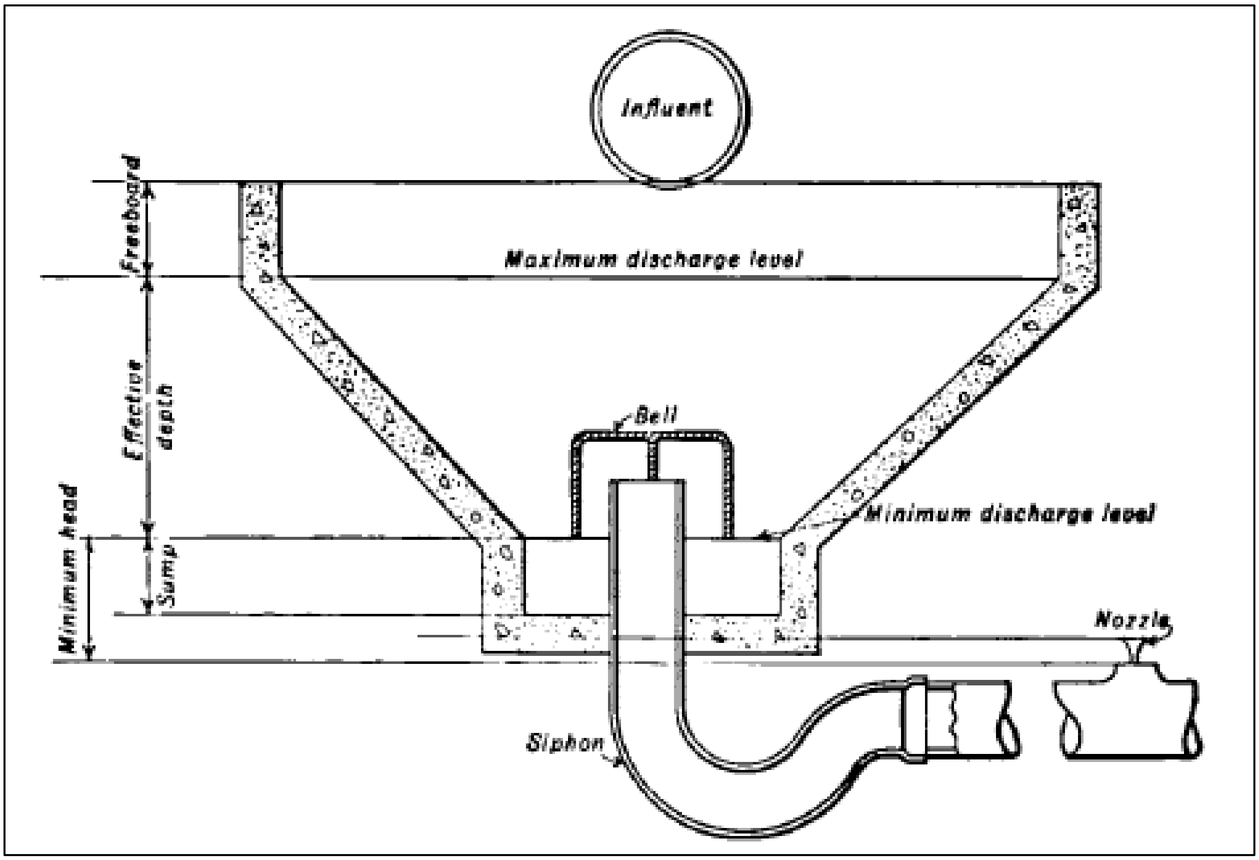

Figure 49: Dosing tank with automatic siphon.[250]

Activated Sludge Process

San Marcos, Texas, constructed the first American activated sludge plant shortly after the technology debuted in 1914. The first plant in California followed three years later when the Pasadena Tri-City facility completed an experimental pilot project in January 1917 (**Figure 50**).

249 Babbitt, *Sewerage and Sewage Treatment*, 424–431; Hardenbergh, *Operation of Sewage Treatment Plants*, 161–165.

250 Babbitt, *Sewerage and Sewage Treatment*, 428.

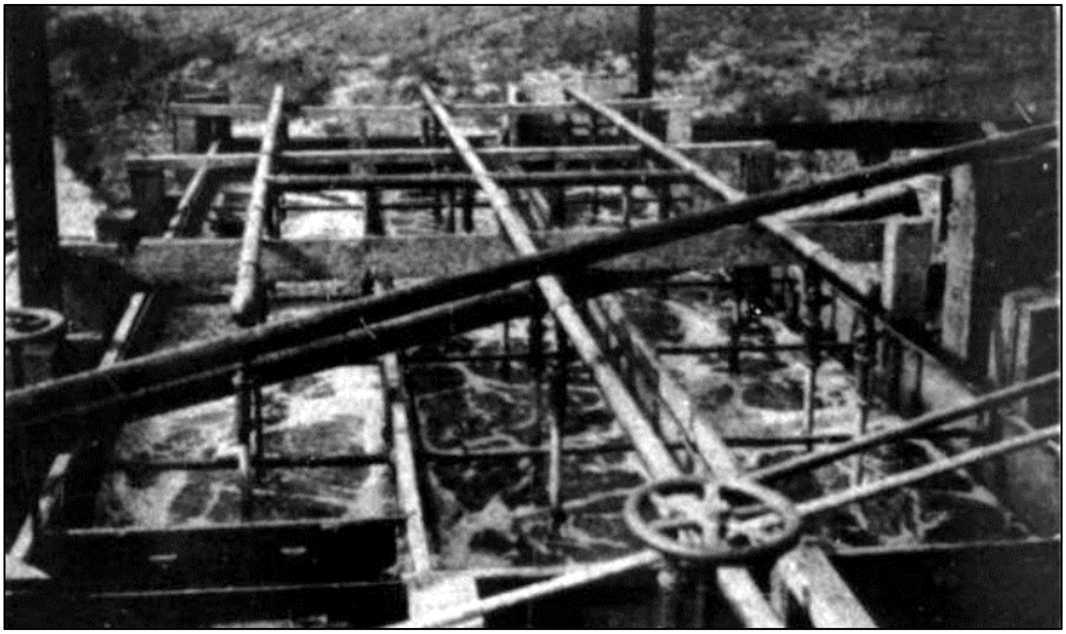

Figure 50: Pasadena activated sludge pilot plant showing aeration tank with air supply pipes overhead.[251]

Partitions divided the 9-by-20-foot aerating tank (also called an aeration tank) to produce 60 feet of channel for sewage to flow through, while blowers at the bottom of the tank mixed and aerated the liquid. Experiments showed promising bacterial reduction rates between 96 and 99.6 percent. The Bureau of Sanitary Engineering constructed the first full-scale treatment plant at Folsom Prison later in 1917 (**Figure 51**). As the bureau lacked experience with activated sludge treatment, they hired Ralph Hilscher away from the Illinois Water Survey. The prison plant answered the long-standing concern of the Bureau of Public Health with having minimally processed sewage dumped into the American River upstream from the state capitol.

[251] "Activated-Sludge Tests Made by California Cities," *Engineering News*, Vol. 79, No. 22 (November 29, 1917), 1009.

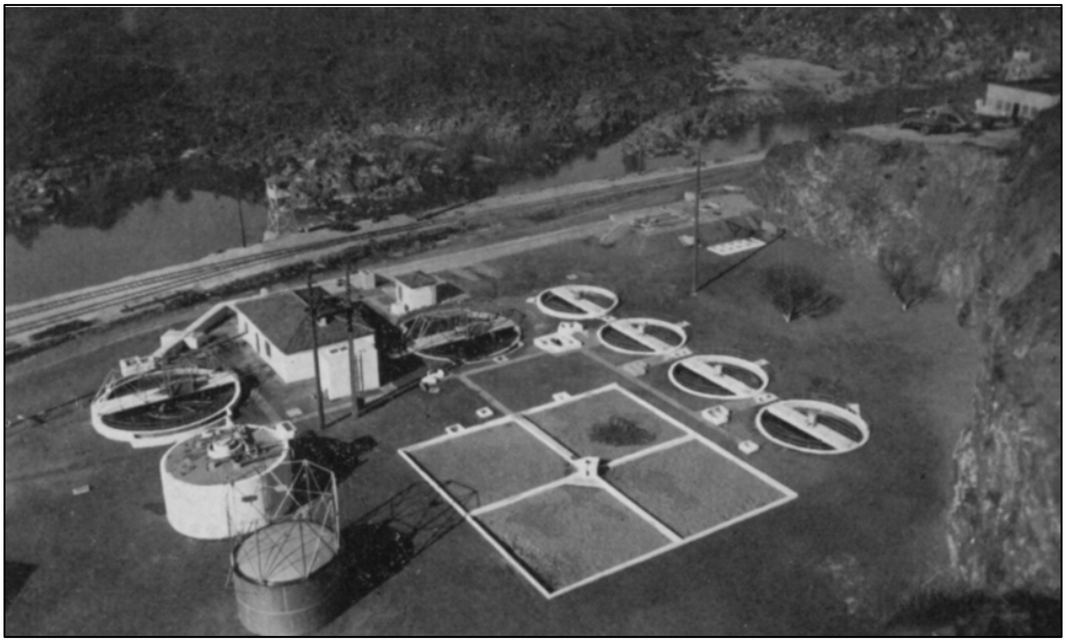

Figure 51: Folsom Prison treatment plant shown following a 1932 expansion. Four circular aeration tanks are at right. The circular tanks at rear (flanking the building) are primary and secondary clarifiers; sludge digestion and gas holding tanks are at front left; and the square sludge drying beds are front center.[252]

Municipal plants followed in Turlock (1921), Lodi (1923—**Figure 52**), Pasadena (1924—expansion of the pilot project), Los Angeles County Sanitation Districts (1928), and the City of Los Angeles (1930).[253]

[252] L. E. Rushton, "Folsom State Prison Sewage Treatment Works: First Four Months of Operation," *Sewage Works Journal*, Vol. 4, No. 4 (July 1932), 675.

[253] "Activated-Sludge Tests Made by California Cities," *Engineering News*, November 29, 1917, 1009–1010; Nicholas Pinhey, "Documenting the California Activated Sludge Centennial," CEWA, accessed August 2022 at CWEA: Activated Sludge Centennial; "Activated-Sludge Plant at California State Prison," *Engineering News-Record*, Vol. 84, No. 26 (June 24, 1920), 1260; Melosi, *The Sanitary City*, 172.

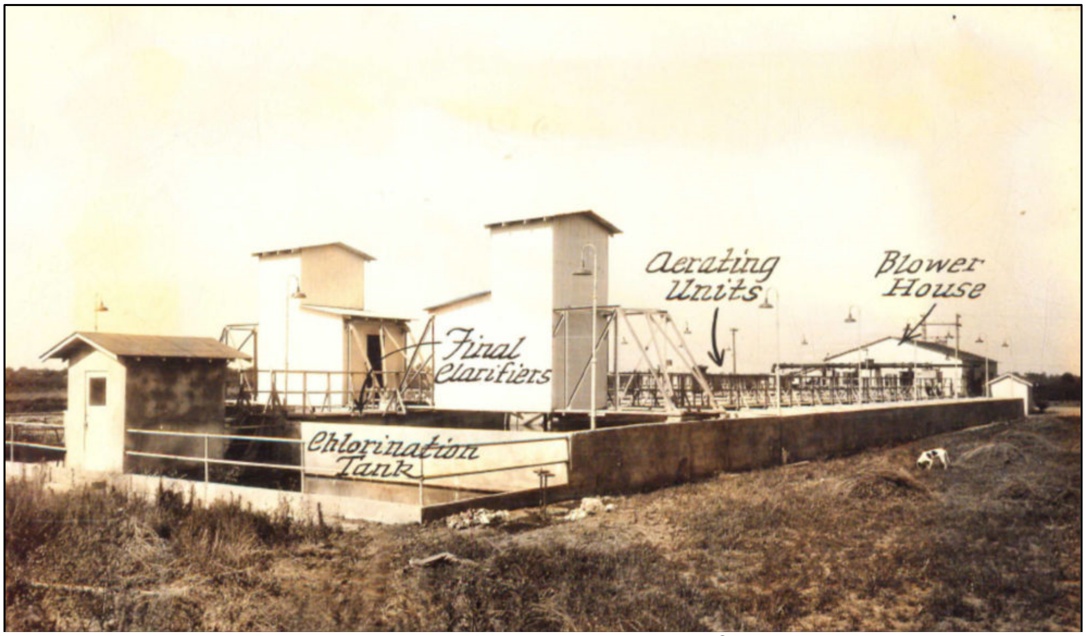

Figure 52: Lodi activated sludge plant, circa 1923.[254]

The activated sludge process was innovative in its biochemical approach but relatively simple in the required physical infrastructure. Sewage first passed through a primary clarifier or fine screen to remove the largest suspended solids before arriving in a concrete aeration tank. Activated sludge equal to about 20 percent of the sewage volume was added to the partially clarified sewage. Air blowers or (less commonly) mechanical agitators then mixed and aerated the sewage over a retention period of several hours. The concrete aeration tanks came in various shapes and sizes but usually included multiple chambers that could operate in series or independently. An air blower was located near the tanks, sometimes contained within a separate blower house. Perforated pipes or diffuser plates along the sides or bottoms of the chambers maintained a continual flow of air that generated a rotational motion in the liquid sewage (**Figure 53**).

[254] Nicholas Pinhey, "Pioneering the Activated Sludge Process in California: The City of Lodi's 1923 Sewage Treatment Plant," CWEA, accessed August 2022 at CWEA: Pioneering Activated Sludge in Lodi.

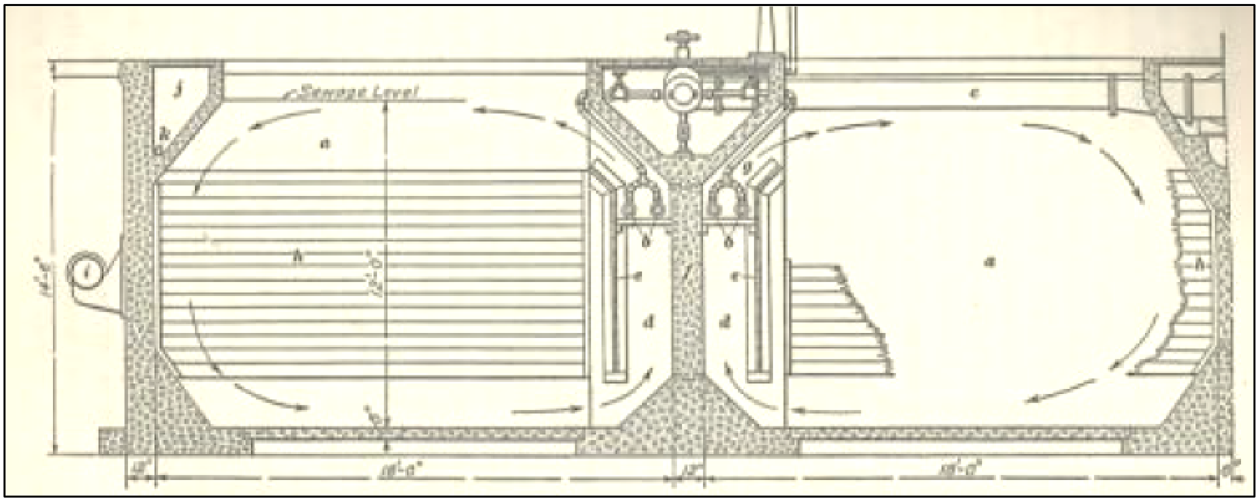

Figure 53: Cross-sectional view of two activated sludge chambers with perforated air pipes shown along rear walls to produce a rotational flow within the tanks.[255]

When these were used in rectangular tanks, the longitudinal flow of the sewage through the tank combined with the rotational motion to produce a spiral flow pattern that mixed the sewage and prevented sludge from accumulating on the tank bottoms. After the prescribed period of aeration, sewage flowed to a secondary clarifier to remove the large volume of sludge generated in the process. A portion of the activated sludge was then returned to the aeration tank to seed the next batch of influent while the remainder was sent to a sludge digestion tank or drying bed for further treatment and disposal.[256]

Sludge Treatment and Disposal

Early sewage management practices focused principally on the liquid effluent that was discharged at the end of treatment and gave comparatively little attention to the sludge that accumulated at the bottom of sedimentation tanks. The goal at most plants was simply to dispose of sludge as quickly and cheaply as possible, generally by burying it on land or dumping it at sea. Plants could manage this so long as the volume of sludge remained low. However, as operators gained efficiency in removing a larger share of suspended organic solids from liquid sewage, they invariably produced more sludge. The activated sludge process in particular produced very large quantities of waste that

[255] Hardenbergh, *Operation of Sewage Treatment Plants*, 130.

[256] Hardenbergh, *Operation of Sewage Treatment Plants*, 125–135.

required treatment and disposal. Sanitary engineers thus turned towards developing more effective methods of digesting and drying sludge.[257]

Sludge emerged from a sedimentation, Imhoff, or septic tank as a semiliquid slurry with a moisture content of around 95 percent and a strong, offensive odor. Basic treatment required dewatering the sludge to reduce the moisture content to 70 percent or lower, at which point it could be handled as a solid. Plants could then dispose of it through incineration, burial, dumping at sea, or by marketing it as fertilizer. Sludge drying beds, also called sand beds, were the essential tool for dewatering sludge and they remained common at smaller plants. Drying beds have the advantage of low capital costs and require little skill to operate, but need a large amount of land and are labor intensive to empty. In a conventional sand bed, a layer of sand approximately 12 to 24 inches thick lay over a bed of course gravel 6 to 8 inches deep that was drained from below by tile pipes. The walls of the bed could be of earth, wood, or concrete. The area of the bed would depend upon the population served, the characteristics of the sludge, and the local climate. In more recent practice, the beds are divided into multiple cells. Sludge was spread over the sand bed in a layer 8 to 12 inches thick to dry by drainage from below and evaporation from above. The organic matter continued to putrefy during this process and gave off strong odors, so a remote location was required. Greenhouse covers were sometimes installed over the beds to increase heat, keep out rain, and contain the odors. Drying times depended upon the weather. During cold, damp winters, sludge could take months to dry, while two weeks might suffice during summer. Workers could remove the sludge as soon as it was dry enough to be handled by a rake or fork. Sludge drying beds could also be paved with cement. Paved beds required more area than conventional sand beds, but involved lower maintenance costs and allowed for heavy equipment to be used in mixing the sludge for drying and for removing the dried cake. [258]

[257] Babbitt, *Sewerage and Sewage Treatment*, 480.

[258] Babbitt, *Sewerage and Sewage Treatment*, 480–495; Hardenbergh, *Operation of Sewage Treatment Plants*, 144–149.

Mechanical devices aided dewatering, though some time on a drying bed was still generally required. These devices consist of three basic types: presses, centrifuges, and vacuum filters. A sludge press consisted of metal plates that could be hand-tightened by screws or compressed by machine to force water out of sludge (**Figure 54**). Centrifuges placed wet sludge within a metal tub lined with porous cloth and then spun the tub at high rotation to force the liquid through the cloth. Centrifuges also made use of hollow drums lined with porous cloth but used vacuum pressure to pull liquid from the sludge (**Figure 55**).

Figure 54: Sludge press.[259]

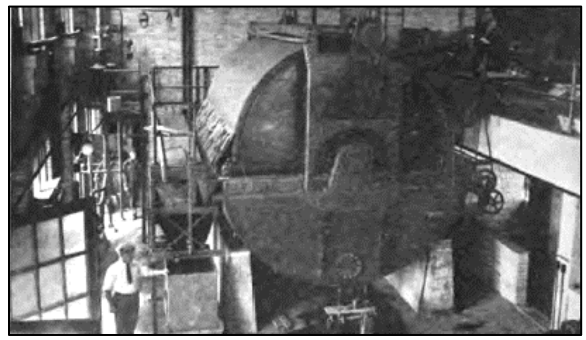

Figure 55: Sludge vacuum filter.[260]

Various chemicals including sulfuric acid, sulfur dioxide, alum, peat, lime, and bone ash could be added to the sludge prior to treatment to aid in drying. With all the processes, the removed liquid was returned to the plant influent for further treatment while the sludge went to the sand beds or drying basin. Manufacturing fertilizer required an exceptionally dry sludge and gas-powered heat dryers helped to reduce the moisture below 10 percent.[261]

Sludge digestion tanks allowed for a more thorough processing of the sludge. Anaerobic bacteria reduced the volume of sludge by liquifying organic matter and producing methane gas. Digestion shrank the sludge layer at the bottom of the tank to about a third of its original volume, while the liquid that bubbled to the top—referred to as

[259] Babbitt, *Sewerage and Sewage Treatment*, 489.

[260] Babbitt, *Sewerage and Sewage Treatment*, 494.

[261] Babbitt, *Sewerage and Sewage Treatment*, 488–495; Hardenbergh, *Operation of Sewage Treatment Plants*, 147–149.

"supernatant liquor"—accounted for most of the remaining two-thirds. The supernatant liquor overflowed the tank as new sludge entered and was piped back to the primary sedimentation tank for further treatment. In some cases, it was necessary to pretreat the liquor by running it through a sand bed filter or adding aluminum sulfate or other chemicals. The byproduct gasses of anerobic digestion, being between 60 and 80 percent methane, collected in a dome at the top of the tank. Plants commonly used the gas as fuel to heat the digestion tanks or to operate gas powered engines.

Early sludge digestion tanks took a variety of forms, including rectangular or square, though circular tanks later became the norm. Tanks were usually covered to minimize odors and allow for greater control. Floating covers helped to maintain a constant, uniform gas pressure and became increasingly common (**Figure 56**).

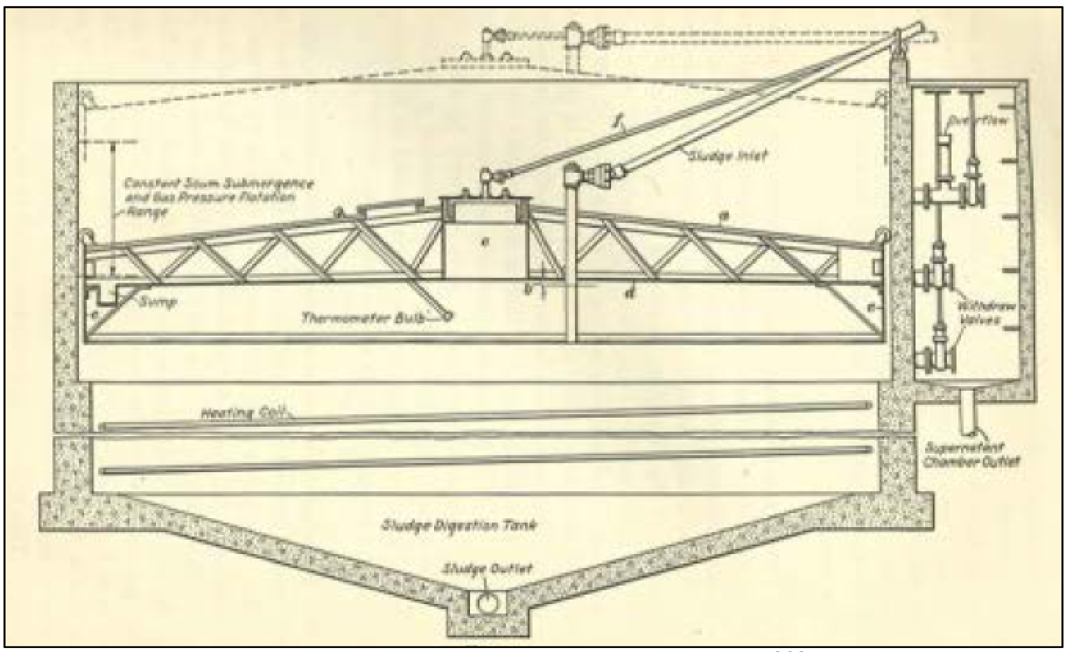

Figure 56: Sludge digestion tank with a floating cover.[262]

Heating and stirring the sludge aided digestion. Heating coils wrapped around the interior walls of the tank and were fed by water heated through the burning of the captured methane gas. Partially or fully burying the tanks helped to maintain uniform temperatures. Because heating increased the speed of digestion, smaller tanks could be used while still maintaining the same volume of processing. In cold climates, heating

[262] Hardenbergh, *Operation of Sewage Treatment Plants*, 140.

could reduce the tank size by around half, but gains were less significant in mild winter environments as prevailed through Southern California. A variety of mechanical stirring devices kept the sludge in circulation and ensured even heating and digestion.[263]

A two-stage digester divided the process between primary and secondary tanks. The primary tank handled approximately three-quarters of the digestion and most of the gas production before passing the partially digested sludge through a pipe to the secondary tank. Secondary tanks were larger than the primary tanks but were generally unheated. This allowed for a slow but economical digestion that produced a cleaner final product with lower disposal costs.[264]

2.3. The Era of Advanced Treatment, 1950–ca. 1980

Regulatory policy evolved rapidly in postwar America, catching up with the technological advances made in the first half of the century. The emergence of environmentalism as a political force compelled higher standards of water and sewage treatment that were codified in state and federal law. By the end of the era, secondary treatment was required for nearly all municipal wastewater discharges and most plants met this standard by using technologies that had been created in the early twentieth century. New environmental and health threats posed by synthetic nutrients and industrial toxins led to advanced wastewater treatment methods that processed effluent to near potable standards. These new processes largely built upon existing biological treatment methods, adding new bacterial populations or coagulating chemicals, rather than representing a fundamental break from established methods.

2.3.1. Knowledge

Environmentalism

Environmental concerns largely supplanted public health as the principal driver of sanitation policy in postwar America. Environmentalism emerged as a major force in popular culture in the early 1960s as it gave form to shifting attitudes about the

[263] Hardenbergh, *Operation of Sewage Treatment Plants*, 136–143.

[264] Hardenbergh, *Operation of Sewage Treatment Plants*, 139.

economic, recreational, scientific, aesthetic, and spiritual values of nature. It coalesced as a mass political movement in the 1970s and found expression in a series of state and federal acts that provided the basis for modern natural resource policy. For the managers of public drinking water and wastewater systems, this required meeting more exacting standards of chemical and biological purity and led to a greater degree of uniformity across systems. Still, the American public and policy makers continued to trust science and technology to overcome the problems of pollution, and the focus was on improving existing treatment methods to meet rising demands, rather than challenging deeply held ideals of economic growth and material progress.[265]

Environmental policy, as it related to water treatment systems, reflected changing understandings of health risks and new insights from the study of ecology. The advances of the early twentieth century had largely eliminated waterborne disease as an issue for public water systems. Focus thus shifted from biological contaminants to chemical toxins. Canneries, refineries, foundries, and chemical manufacturers had long dumped their waste products into coastal waters and interior rivers, but the scope and scale of industry expanded dramatically leading up to and during America's entry into World War II in 1941. Aircraft plants in Southern California and shipyards around the San Francisco Bay introduced novel chemicals into the water supply with little monitoring or regulation, owing to the emergency nature of wartime production. The thick, acidic smog that filled the Los Angeles basin in the late war years was the most visible sign of increasing pollution, but the problem was also evident in tests of surface and groundwater quality. The eutrophication (excessive growth of aquatic plants) of inland waterways, caused by an excess of synthetic plant nutrients, produced striking evidence of environmental harm in the form of reoccurring toxic algae blooms and fish kills.[266]

Cancer became the defining illness in the new era, replacing typhoid fever as the primary water-quality health concern among the public. By the late 1970s, it was estimated that one in four Americans would contract cancer during their lifetimes and

[265] Melosi, *The Sanitary City*, 283–295.

[266] Hays, *Beauty, Health, and Permanence*, 24–29.

two-thirds of those would die from it. Studies showing cancer rates to be twice as high in cities as in rural districts pointed to the polluted environment as a chief cause. For decades, federal and state authorities were unable to gather even basic data about the chemicals being released into waterways. Industrial interests strenuously resisted disclosing information about their chemical use for fear that it would reveal trade secrets and make them liable for cleanup efforts. Only with the passage of the Clean Water Act in 1972 did the federal government gain legal power to require reporting by industrial dischargers. Court action by the Natural Resources Defense Council later compelled the Environmental Protection Agency (EPA) to begin actively regulating toxic pollutants, and amendments to the Clean Water Act in 1977 established a list of toxins that were subject to strict control on a set timeline.[267]

The science of ecology, which matured during the postwar era, allowed for an intellectual understanding of the threat through its study of natural cycles and complex biological and chemical webs. The 1962 publication of Rachael Carson's *Silent Spring* on the danger of synthetic pesticides crystalized these concerns and alerted the public to the ability of persistent toxics to accumulate through the food chain. Support for environmental protection cut across partisan and demographic lines, but was strongest among the young, well-educated residents of New England and the Pacific Coast states. California, with its booming population and unrivaled natural riches, emerged as an obvious leader of the movement. The state pioneered environmental legislation including creating air pollution control districts in Los Angeles (1947) and the San Francisco Bay counties (1955); passing the nation's first automobile anti-smog law (1960); organizing regional planning bodies such as the San Francisco Bay Conservation and Development Commission (1965) and Coastal Zone Conservation Commission (1972); and enacting both the California Endanger Species Act and California Environmental Quality Act in 1970. The key water quality acts, the Dickey Water Pollution Act (1949) and Porter-Cologne Water Quality Control Act (1969), are discussed further below. Federal legislation often coincided with or followed the lead of

[267] Hays, *Beauty, Health, and Permanence*, 24–29, 77, 199.

California, including the Clean Air Act (1963), National Environmental Policy Act (1969), Clean Water Act (1972), and the Endangered Species Act (1973).[268]

Sanitary engineers struggled at times to keep up with the shifting focus. In the 1920s and 1930s, engineers had generally been ahead of the public in advocating for high standards of purity in the state's waterways. By the 1960s, however, the situation had reversed. The public treated almost all forms and quantities of pollution as illegitimate while engineers worried over the economic cost of rigid standards. Wilfred Langelier, the UC Berkeley chemist, expressed what he felt was a common belief among scientists that the public could not appreciate "the exorbitant cost" involved in attempting to remove "the last few degrees of pollution."[269] Advanced wastewater treatment methods (discussed below) were effective at removing heavy metals, excess nutrients, pathogens, and other potential toxins, but came with high chemical, energy, and construction costs. Langelier and others of his generation regarded environmentalists as lacking in the cleareyed pragmatism needed to confront the problems.[270]

Some younger sanitary engineers, however, found a new center of identity for the discipline in environmentalism. They critiqued the energy- and chemical-intensive methods required for conventional wastewater treatment and advocated for processes more integrated with ecological cycles. They developed an assortment of treatment systems using aquatic plants, natural or constructed wetlands, and various types of lagoons. The Arcata Marsh and Wildlife Sanctuary in Humboldt County is exemplary of this new approach. The City of Arcata and Humboldt State University began experimenting with wastewater aquaculture in 1969 and determined that juvenile salmon and trout could develop in mixtures of partially treated wastewater and

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[268] Melosi, *The Sanitary City*, 291–295, 311–313; Samuel P. Hays, *Beauty, Health, and Permanence: Environmental Politics in the United States, 1955–1985* (Cambridge: Cambridge University Press, 1987), 24–29, 435–445; James J. Rawls and Walton Bean, *California: An Interpretive History, Seventh Edition* (Boston: McGraw-Hill, 1998), 468–488.

[269] Langelier, "Teaching, Research, and Consultation," 32.

[270] Melosi, *The Sanitary City*, 292–294.

seawater, demonstrating that wastewater could enhance wildlife habitat rather than presenting merely a problem of disposal. Between 1979 and 1983, the city and associated partners developed a test program for using constructed wetlands to treat wastewater in a cost-effective and environmentally sound manner. By 1986, the city had completed 100 acres of freshwater and salt marshes, brackish ponds, tidal sloughs, and estuaries that received treated effluent from the adjacent existing wastewater treatment plant. The marshes further clarified the effluent while providing habitat for fish and wildlife. The wildlife sanctuary is now recognized as one of the premiere locations for seeing migratory birds along the Pacific Coast, and the innovative system has become an international model for ecologically responsible wastewater reuse.[271]

Advanced Wastewater Treatment

Advanced wastewater treatments target nutrients and contaminants that conventional primary and secondary treatments cannot fully remove. These treatments aim at two principal goals: preventing eutrophication in inland waters through the removal of nitrogen and phosphorous, and allowing for the reclamation of wastewater effluent by cleansing it of heavy metals, organic chemicals, inorganic salts, and pathogens. Advanced treatments differ in their specifics from conventional treatment but largely employ familiar processes of chemical coagulation, biological digestion, and mechanical filtration. While advanced treatment methods are sometimes identified as "tertiary treatments," the two terms are not strictly synonymous. Advanced treatments may follow secondary biological treatment in a plant's flow, but they may also consist of a modification or replacement of an existing conventional treatment step so that they operate concurrently with primary or secondary treatment. Research into advanced treatment methods began in the early 1960s and pilot plants were in operation by mid-decade in the most environmentally sensitive locations such as Lake Tahoe. The tightening of state and federal environmental standards, combined with improved

[271] Melosi, *The Sanitary City*, 292–294; Schneider, *Hybrid Nature*, 193–194; US Environmental Protection Agency, *A Natural System for Wastewater Reclamation and Resource Enhancement: Arcata, California* (Washington, D.C.: US Environmental Protection Agency, 1993).

technology and knowledge, spurred wider construction of full-scale plants in the late 1970s and 1980s.[272]

Nutrient Removal

Nitrogen and phosphorous are the primary culprits in human-caused eutrophication. Under natural conditions, algae populations are limited by the available supply of nitrogen and/or phosphorous, both of which are essential for plant growth. When human activities cause an increase in lake, river, or estuary nutrient levels, aquatic plant growth accelerates and the resulting algal blooms can interfere with water uses, in addition to being potentially toxic. Under severe conditions, the bacterial decomposition of algae depletes water of its oxygen supply, leading to fish kills and "dead zones" within water bodies. Eutrophication in the Great Lakes in the 1960s attracted national attention and was a major factor in the passage of the Clean Water Act.[273]

Manufactured fertilizers and synthetic laundry detergents were the chief source of excess nitrogen and phosphorous, respectively, and the production of both increased dramatically in the postwar decades. The United States government invested heavily in nitrogen production during World War II, building large nitrogen-synthesizing factories to manufacture high explosives for munitions; at war's end, these plants shifted to producing fertilizer. The first all-purpose synthetic laundry detergent appeared near the same time, in 1948, and by 1953 the sale of synthetic detergents surpassed those of traditional soaps. The American public made enthusiastic use of these cheap and effective marvels of modern chemistry, but the excess nutrients readily found their way into streams and groundwater basins.[274]

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[272] Hammer, *Water and Wastewater Technology*, 498–519; Roderick D. Reardon, "Advanced Wastewater Treatment," *Water Environment & Technology*, Vol. 7, No. 9 (September 1995), 66–73.

[273] Minnesota Pollution Control, "Biological Nutrient Removal," August 2011, 9–12; Hammer, *Water and Wastewater Technology*, 498–499, 504–505.

[274] Melosi, *The Sanitary City*, 333–334.

Conventional wastewater treatment removed only a portion of the dissolved nitrogen and phosphorous that entered a plant. Most of the forms taken by phosphorous are soluble and therefore plain sedimentation did not act upon them. In biological treatments, microorganisms absorbed some 20 to 30 percent of the phosphorous in support of their growth, but the remainder passed through to the effluent. Likewise, only about 25 percent of nitrogen was removable by sedimentation or biological uptake. These substances also caused problems within the treatment plants as operators blamed detergents for causing foaming within activated sludge basins and hindering sedimentation by emulsifying solid particles (**Figure 57**).[275]

Figure 57: Foaming at an activated sludge plant attributed to synthetic detergents.[276]

Engineers developed chemical methods for removing phosphorous and nitrogen from wastewater in the 1960s. Phosphorous removal was by chemical precipitation using metal salts or lime as a coagulant. Pickle liquor, a waste product of the steel industry, provided an inexpensive source of iron salt in industrial regions and was the most

[275] Hammer, *Water and Wastewater Technology*, 499–500, 505–506; Melosi, *The Sanitary City*, 333–334; Clair N. Sawyer, "Effects of Synthetic Detergents on Sewage Treatment Processes," *Sewage and Industrial Wastes*, Vol. 30, No. 6 (June 1958), 757–775.

[276] Sawyer, "Effect of Synthetic Detergents," 773.

commonly used coagulant. The salts could be added at any stage of the treatment process. Some plants mixed it with raw influent before primary clarification, others added it to their activated sludge tanks as part of secondary treatment, and still others mixed it with the secondary effluent for a tertiary stage of treatment prior to final clarification. Lime was used in either primary or tertiary treatment. When used as tertiary treatment, the chemicals required mixing and sedimentation basins and the effluent was commonly filtered before discharge.[277]

Nitrogen exists in a variety of forms including as ammonia, nitrate, nitrite, gaseous nitrogen, and bound to organic matter as in ammino acids and DNA. In wastewater, its principal forms were organic from fecal matter and kitchen or agricultural waste and as ammonia from urine. Biological decomposition as part of secondary treatment converted most of the organic nitrogen to ammonia. Ammonia could then be air stripped from wastewater if the pH was first raised to around 11 (extremely alkaline) with a heavy addition of lime. The water was pumped into a stripping tower where it dripped downward while forced air blew around it. This converted liquid ammonia to a gas and released it to the atmosphere, reducing effluent ammonia levels by 90 to 95 percent. This process was fairly simple but involved additional pumping expenses and functioned poorly at low temperatures. Heavy chlorination (called breakpoint chlorination) could also reduce ammonia by converting it to nitrogen gas, nitrous oxide, and other forms. However, the process raised the total level of dissolved solids in the effluent and could leave excessive levels of chlorine, both of which required additional treatment steps before effluent discharge. An ion exchange process, similar to that used in water softening, also existed for nitrogen removal, though it remained a poorly understood and experimental technology.[278]

Chemical treatments were successful and generally uncomplicated to manage, but they were also expensive as they needed continual large chemical inputs and produced

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[277] Hammer, *Water and Wastewater Technology*, 500–504; Minnesota Pollution Control, “Biological Nutrient Removal,” 12–13; Reardon, “Advanced Wastewater Treatment,” 66–67.

[278] Hammer, *Water and Wastewater Technology*, 504, 511–512.

copious volumes of sludge that required disposal. In the 1970s, James Barnard, a South African engineer, sought biological methods of nitrogen and phosphorus removal that would be better adapted to the requirements of his country. This required manipulating environmental conditions in biological treatment tanks to encourage the growth of microorganisms that could feed upon the nutrients. Biological treatment had developed with a narrow goal of reducing organic matter, but once the plants were in place, they provided the means for addressing other pollutant problems. Retaining and returning a greater volume of activated sludge to the aeration tanks allowed for slower-growing bacteria to develop. This exposed pollutants to a larger variety of organisms with unique biochemical strategies for converting organic and inorganic matter into the energy and materials needed to sustain life and reproduce.[279]

The digestion of nitrogen involved a two-part nitrification-denitrification process in which bacteria first oxidized ammonia to nitrate and then different groups of bacteria biologically reduced the nitrates to nitrogen gas. Nitrification occurred in presence of oxygen, while denitrification required anoxic conditions with very low oxygen levels. Phosphorous removal relied on microorganisms that stored phosphorous in excess of what they required for biological growth (known as phosphorous-accumulating organisms or PAOs). PAOs also had a two-phased growth cycle that required alternating anoxic and aerobic conditions. Generating the two-phase aerobic and anoxic environments required either modifying existing activated sludge aeration tanks to wall-off an anoxic chamber or constructing new anoxic tanks following the aeration chambers.[280]

By 1974, Barnard had established pilot projects capable of removing nitrogen and phosphorous separately. After several additional years of experimentation, he found means of combining the processes, allowing for the simultaneous removal of both nutrients through biological means. This process became known as Biological Nutrient

[279] Reardon, “Advanced Wastewater Treatment,” 67; Schneider, *Hybrid Nature*, 202–204.

[280] Reardon, “Advanced Wastewater Treatment,” 67; Hammer, *Water and Wastewater Technology*, 501–510; Minnesota Pollution Control, “Biological Nutrient Removal,” 12–22.

Removal or BNR. Florida constructed the first combined phosphorous-nitrogen BNR plant in the nation in 1979. A half-dozen BNR plants operated across the county by the mid-1980s, testing and refining the processes. Ultimately, BNR proved to be less expensive to operate than chemical methods and was capable of purifying effluent to a higher standard. However, these biological methods required much more monitoring and adjusting of environmental conditions, necessitating a high level of technical skill among operational staff. The combination of chemical and biological methods was often the most cost effective, particularly where it allowed for existing equipment to be modified without requiring new construction. By 1994, some 300 BNR plants were in operation, including 16 in California.[281]

Lake Tahoe, on the California-Nevada border, was one of the first bodies of water in the nation to benefit from advanced nutrient control. The clear blue waters of Lake Tahoe were a major tourist draw for the region and warranted a high level of protection. The Bureau of Sanitary Engineering had prohibited all direct sewage disposal to the lake since the 1920s, but effluent continued to be disposed of by spray irrigation to land within the Tahoe Basin and runoff from these sites contributed to eutrophication. In 1961, the South Tahoe Public Utility District began laboratory and pilot plant studies in Oregon to test the effectiveness of chemical coagulation, filtration, and carbon absorption on nutrients. The district constructed a small-scale plant in the Lake Tahoe Basin in 1965 and expanded it over the following years. The plant design mixed secondary effluent from activated sludge tanks with a lime coagulant and then passed it through filter beds and columns of activated carbon. The district added a nitrogen stripping tower in 1969. The plant served as a national testing ground for innovative technologies, both for the direct treatment process and for such secondary tasks as coagulant recovery and carbon regeneration (**Figure 58**). The recovery of lime saved little on chemical costs, but reduced the volume of sludge requiring incineration by about half.

[281] Reardon, "Advanced Wastewater Treatment," 67–68.

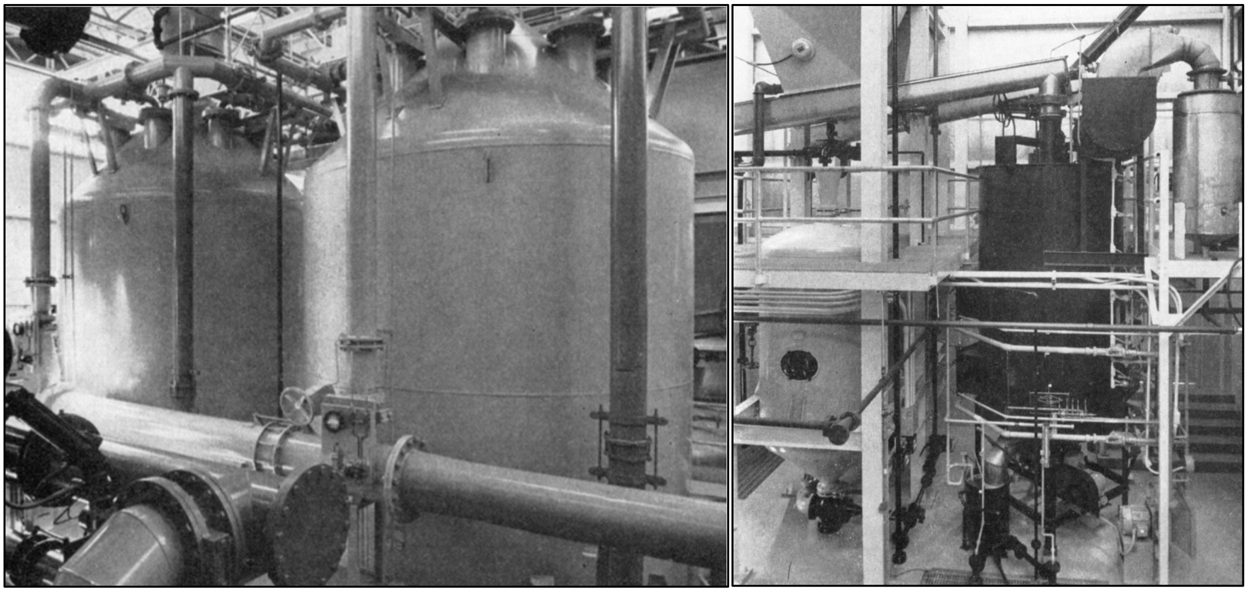

Figure 58: Carbon columns (left) and carbon regeneration furnace (right) in the South Tahoe plant.[282]

Additional facilities added throughout the Tahoe Basin in later years included a 1974 biological-chemical phosphorous removal plant to treat the waste returned from sludge digestion at the Truckee Meadows plant; tertiary chemical phosphorous removal and ion exchange ammonia removal facilities at Tahoe-Truckee in 1976; and a denitrifying trickling filter at Truckee Meadows in 1985. Cold winter conditions required that many of these processes be contained in covered tanks or sheltered in buildings. Biological processes later replaced most of the original chemical ones as technology continued to evolve.[283]

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[282] Culp, "Wastewater Reclamation at South Tahoe Public Utilities District," 88, 90.

[283] Reardon, "Advanced Wastewater Treatment," 66; R. L. Culp, "Wastewater Reclamation at South Tahoe Public Utilities District," *Journal (American Water Works Association)*, Vol. 60, No. 1 (January 1968), 84–94; Gordon L. Culp, Russell Culp, Daniel Hinrichs, and Robert Williams, "Land Treatment and Advanced Wastewater Treatment Alternatives for South Tahoe," *Journal (American Water Works Association)*, Vol. 51, No. 19 (October 1979), 2487–2498.

Wastewater Reclamation

Californians have made planned reuse of municipal wastewater since at least 1888, when Pasadena established the first municipal sewage farm in the state. The State Board of Health crafted regulations governing the agricultural reuse of wastewater in 1918, and ultimately more than 100 cities or institutions disposed of their wastewater effluent to agricultural users at some point prior to World War II. For the most part, however, these users valued sewage farms as a convenient means of disposing of wastewater and treated the reuse of water as only a secondary, almost incidental benefit. San Francisco's Golden Gate Park activated-sludge treatment plant, completed in 1932, was the first facility in the state specifically created to provide a source of recycled water. The purified effluent irrigated the park landscaping, filled scenic ponds, and cascaded down manufactured waterfalls. In 1961, the Santee County Water District outside of San Diego used treated effluent to fill a series of artificial lakes that provided public access for boating, fishing, and swimming, making it the first planned use of reclaimed water for recreational purposes. The Santee Lakes did not include tertiary treatment methods, which were not yet economically viable, but instead discharged the activated-sludge treatment plant effluent into a spreading basin a mile from the lakes. The effluent combined with subsurface creek flow and percolated horizontally through the gravel bed to fill the lakes. Extensive testing demonstrated that the water was safe for bodily contact, but the facility struggled with high nutrient levels that caused algae blooms and necessitated expensive deodorizing and disinfecting agents. The introduction of viable tertiary treatment methods in the 1970s increased the diversity of uses for reclaimed water in California to include industrial applications, groundwater recharge, landscape and golf course irrigation, and environmental enhancement.[284]

[284] California State Water Resources Control Board and Department of Water Resources, "Results, Challenges, and Future Approaches to California's Municipal Wastewater Recycling Survey," 2009, 1; Federal Water Pollution Control Administration, *Santee Recreation Project, Santee, California, Final Report*, Water Pollution Control Research Series (Cincinnati, Ohio: U.S. Federal Water Pollution Control Administration,

The term “recycled water” refers to wastewater that has been treated to a quality suitable for beneficial use in either potable (groundwater recharge) or nonpotable (irrigation, industrial) applications. In common practice, recycled water referred chiefly to purified wastewater originating from a municipal treatment plant, while “water reuse” applied to the repeated cycling of graywater at a single facility such as an industrial plant or golf course. Historically, the term did not specify a particular level or type of treatment, nor did it apply to highly treated water that discharged to natural waterbodies. All the processes used in nutrient removal were also employed in treating recycled water (and to a lesser degree vice-versa), so the two differed primarily in the handling of the final effluent by either discharge or reuse. However, because some applications of water reuse involved great probability of human contact, higher standards applied for the removal of organic matter, inorganic salts, heavy metals, and viruses. While recycled water could achieve high levels of purity, public perception remained an obstacle to greater use of the resource. Though some 300,000 visitors made annual use of Santee Lakes, the facility was still jokingly derided as “piss lake.” Only one comparable recreational project in Lancaster opened during the historic period and no domestic use was made of recycled water despite it exceeding drinking water standards.[285]

The wastewater recycling process started with conventional treatment in an activated-sludge tank, perhaps with iron-salt coagulant enhancement for nutrient removal. Coagulation with lime commonly followed, using tertiary mixing and sedimentation basins. The lime precipitated heavy metals, suspended and dissolved organics, and

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1967); Wesley Marx, “The Fall and Rise of Sewage Salvage,” *Bulletin of the Atomic Scientists*, Vol. 27, No. 1 (May 1971), 10–15.

[285] California State Water Resources Control Board and Department of Water Resources, “Results, Challenges, and Future Approaches to California’s Municipal Wastewater Recycling Survey,” 1–3; Wesley Marx, “The Fall and Rise of Sewage Salvage,” 11; Curtis J. Schmidt, Irwin Kugelman, and Ernest V. Clements, III, “Municipal Wastewater Reuse in the U.S.,” *Journal (Water Pollution Control Federation)*, Vol. 47, No. 9 (September 1975), 2229–2245.

phosphates, while the alkaline conditions at a pH above 11 killed bacteria and viruses. The alkaline solution could then be sent to a stripping tower for removal of ammonia and volatile organics. In cold climates, ionic exchange might substitute for air stripping. Recarbonization by injection of carbon dioxide returned pH levels to near neutral (7) to prevent the buildup of calcium carbonate scale in subsequent equipment and to recover some portion of the lime. Filtration beds or pressured tanks with activated carbon then removed fine matter and any remaining coagulant. Disinfection by chlorination, ozone, or ultraviolet (UV) exposure followed. Finally, reverse osmosis, a technology first developed for drinking water desalinization, removed inorganic salts, trace metals, and dissolved organics.[286]

The Central Contra Costa Sanitary District, in conjunction with the Contra Costa County Water District, constructed one of the first modern wastewater recycling plants in the early 1970s in order to supply nearby industrial users along the southern shore of Suisun Bay. The sanitary district constructed a full-scale test facility at its existing wastewater treatment plant in Martinez in 1971. The facility used preliminary lime treatment ahead of an activated sludge tank enhanced for nitrification, followed by ammonia stripping. On a larger scale, Orange County Water District completed its Water Factory 21 in 1975 (**Figure 59**). The plant, named for the belief that it would serve as a prototype for meeting twenty-first-century water needs, treated wastewater with chemical coagulation, air stripping, filtration, and reverse osmosis. The effluent was blended with deep well water and then injected into the groundwater basin through a series of wells to replenish local groundwater basins and buffer against saltwater intrusion.[287]

[286] Hammer, *Water and Wastewater Technology*, 512–515.

[287] Reardon, “Advanced Wastewater Treatment,” 67–68; G. A. Horstkotte, D. G. Niles, D. S. Parker, and D. H. Caldwell, “Full-Scale Testing of a Water Reclamation System,” *Journal (Water Pollution Control Federation)*, Vol. 46, No. 1 (January 1974), 181–197; Hammer, *Water and Wastewater Technology*, 515–19; *Orange County Water District*, “Water Factory 21,” brochure, n.d.

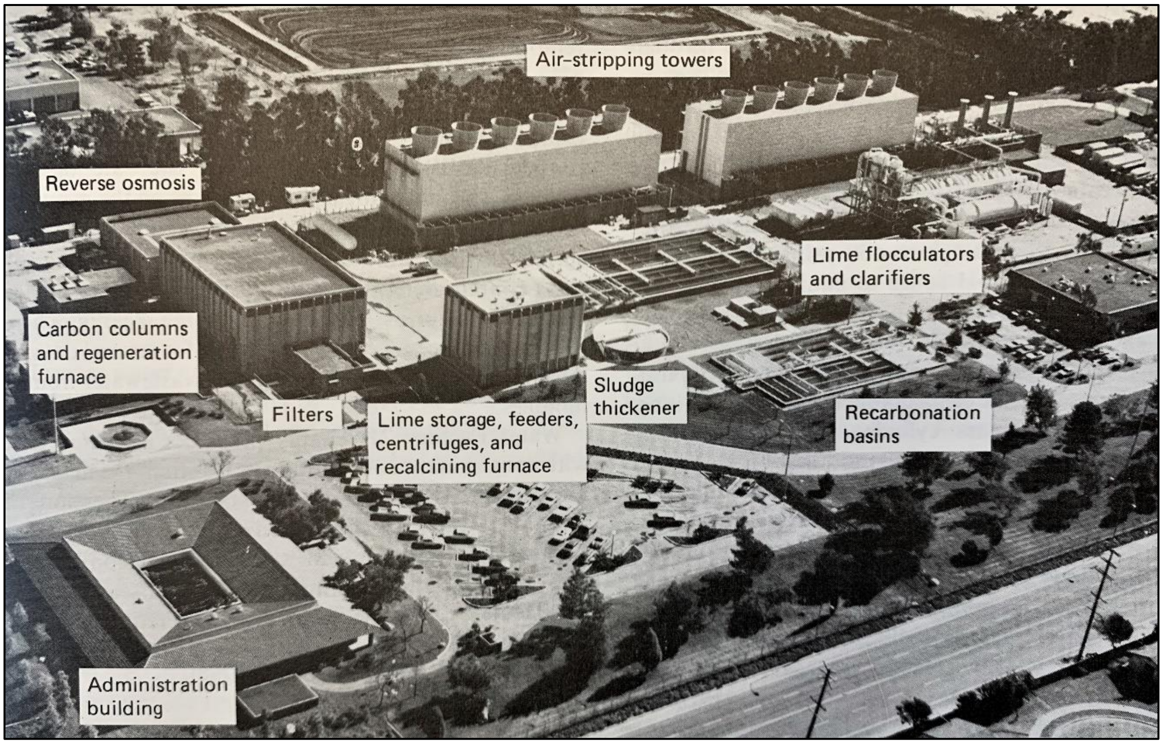

Figure 59: Aerial view of Water Factory 21, Orange County.[288]

Advanced Drinking Water Treatment

Drinking water treatment prior to World War II focused on the major public health impacts caused by pathogenic microorganisms. The heightened environmental consciousness of the 1960s and 1970s shifted attention to other pollutants, including synthetic organic compounds and such inorganic contaminants as arsenic, chromium, fluoride, lead, mercury, nitrates, and silver. These substances entered the water supply either as naturally occurring minerals or as industrial and agricultural waste byproducts. No single treatment method was effective for the removal of all contaminants, so different processes were developed to target particular problems. As relatively little was known about the effectiveness of removal technologies, the EPA conducted pioneering research at its Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio. The basic philosophy of treatment was to employ conventional techniques such as coagulation and lime-and-soda-ash softening first and to use more advanced techniques only as needed. These new technologies, discussed below, included ion exchange, reverse

[288] Hammer, *Water and Wastewater Technology*, 517.

osmosis, the use of activated carbon, and disinfection by ultraviolet (UV) radiation. Electrodialysis and distillation were also experimented with, but these methods were expensive and were employed only in special cases, such as for industrial processes that required high levels of water purity. All these technologies were also used in wastewater treatment, with some minor modifications of procedures.[289]

Ion Exchange

Ion exchange had been a common feature of water treatment since the early twentieth century when it was introduced for water softening (see **Section 2.2.4** above). Subsequent developments expanded the range of materials that ion exchange could strip from the water beyond just the hardwater minerals of calcium and magnesium to include nitrate, tannin, fluoride, barium, arsenic, and uranium. The earliest progress was made by altering the chemical and physical properties of greensand, the rock used in water softening, to increase its effectiveness. Later work experimented with other natural materials that had intrinsic qualities favorable to ion exchange, as for example with bone char's ability to absorb fluoride. USPHS constructed a full-scale deflouridation plant in Britton, South Dakota, in 1953 that utilized ground and charred animal bone for ion exchange with a caustic soda used for regeneration. However, natural materials had limits that were difficult to overcome. Because bone is soluble in acid, the South Dakota plant had to carefully regulate the pH levels of the raw water. This added expense that made the plant cost inefficient and it closed in 1971.[290]

The introduction of synthetic resins allowed for far greater control over the ion exchange process. English chemists manufactured the first synthetic resins in 1935. While greenstone worked only with positively-charged cations such as calcium, magnesium,

[289] Thomas J. Sorg, "Treatment Technology to Meet the Interim Primary Drinking Water Regulations for Inorganics," *Journal (American Water Works Association)*, Vol. 70, No. 2 (February 1978), 105–112.

[290] Sorg, "Treatment Technology," 110; W. C. Bauman, "Synthetic Ion-Exchange Resins," *Journal (American Water Works Association)*, Vol. 37, No. 11 (November 1945), 1211–1215.

and barium, the new synthetic material could be modified to attract negatively-charged anions such as nitrate, arsenic, and uranium. Extensive research conducted after World War II led to the discovery of organic polymers that produced a resin of superior strength and stability with less pH sensitivity. Having greater control over the molecular structure of the resin allowed for assembling materials with large surface-area-to-volume ratios, and the typical resins resembled beads with a porous whiffle ball structure. This permitted processing far greater quantities of water using the same sized tanks, and the tougher materials could withstand stronger salt brines so that regeneration occurred in a matter of minutes rather than hours. Customizable resins also allowed for engineering the ion exchange process to optimally target particular contaminants. By the late-1970s, dozens of different synthetic resins were commercially available to deal with a wide range of mineral removal needs.[291]

Municipalities began to construct full-scale facilities using the new ion exchange processes in the mid-1970s. A 1974 plant constructed by the Garden City Park Water District on New York's Long Island was indicative of these facilities. The plant design was based on a prototype facility operated by Oak Ridge National Laboratory in Tennessee beginning in 1970. Its innovative features included a process for continuous resin regeneration. A hydraulic pulse flow pushed the resin material through a closed loop that included treatment, regeneration, and rinse phases. Each phase lasted around 15 minutes, followed by a hydraulic pulse of a few seconds duration. The sodium chloride regeneration thus operated continuously, recharging a portion of the resin at a time, rather than requiring the ion exchange to halt while the full load of resin was recharged as in conventional batch operations. The continuous regeneration process

[291] Bauman, "Synthetic Ion-Exchange Resins," 1211–1215; Gary Battenberg, "A Brief History of Ion Exchange Water Treatment," *Water Conditioning & Purification International Magazine*, February 21, 2014; American Water Works Association, *Water Treatment*, Third Edition (Denver, CO: American Water Works Association, 2003), 363–367.

became standard in desalination plants and was later expanded to other ion-exchange facilities.[292]

The vessels used in the new ion exchange systems did not differ substantially from their water-softening predecessors (**Figure 60**). The tanks continued to resemble pressure filters with components to regulate the in- and out-flow of treatment water, regeneration solution, and backwash water, along with sampling taps.

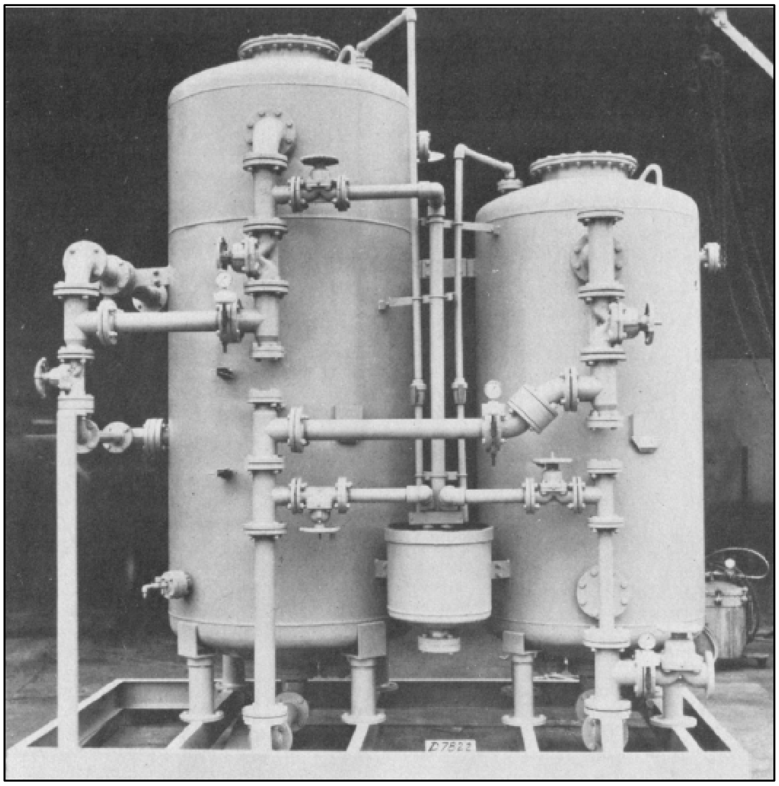

Figure 60: Ion exchange vessels used for fluoride removal.[293]

As with most treatment equipment, the tanks commonly were paired to allow processing to continue while one tank was regenerated. Two nearby holding tanks, constructed

[292] Sorg, "Treatment Technology," 107–108; Oak Ridge National Laboratory, *Continuous Counter-Current Ion Exchange Removal of Calcium from Sea Water to Prevent Scaling of Distillation Equipment*, Research and Development Progress Report No. 309 (Washington, D.C.: US Department of the Interior, 1967), 13–15.

[293] Sorg, "Treatment Technology," 111.

with special lining to resist corrosion, contained the fresh and used regeneration solution. As the ion exchange process became increasingly specialized, plants sometimes added multiple pairs of tanks in serial, with each pair focused on removal of a particular contaminant.[294]

Reverse Osmosis

Osmosis is the process by which a solvent liquid naturally moves from an area of low dissolved mineral concentration, through a membrane, to an area of high concentration until an equilibrium is reached with both sides having equal solvent to dissolved mineral ratios. In reverse osmosis, pressure is applied to the high concentration side of the membrane so that the flow of solvent is reversed. The semipermeable membrane was engineered to selectively allow water molecules to pass through but not larger mineral or biological molecules. This process could extract pure water from high-concentration inputs, such as salt water, or treat raw water to remove microbiological pathogens and essentially all dissolved organic or mineral contaminants. Reverse osmosis differed from ordinary water filtration in that it processed solutions at a molecular level and could remove dissolved chemicals, while filters could only screen suspended, not dissolved, matter. Filters also trapped the removed particles and thus required regular backwashing. Membranes acted as a barrier but did not physically capture the impurities, so they remained cleaner and required less maintenance. A chief disadvantage of reverse osmosis technology was its high energy inputs. The pressure required to purify water, using 1970s technology, was usually several orders of magnitude greater than the natural osmotic pressure, and ranged from 200 to 1,500 psi.[295]

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[294] American Water Works Association, *Water Treatment*, 368–370; Sorg, “Treatment Technology,” 111.

[295] H. S. Lim and H. Kirk Johnston, “Reverse Osmosis as an Advanced Treatment Process,” *Journal (Water Pollution Control Federation)*, Vol. 48, No. 7 (July 1976), 1804–1821.

Efforts to desalinate seawater drove innovation in reverse osmosis technology. Researchers at the University of California, Los Angeles (UCLA) and the University of Florida created the first workable membranes in the 1950s, though the practice remained impractical until improved membranes became available in the mid-1960s (see discussion of desalination below). Researchers recognized the potential for reverse osmosis to be of use in purifying drinking water, but technical challenges and energy costs prevented it from being widely adopted by public utility companies during the historic period. Instead, industrial manufactures were the leading adopters as they required high-purity water for making pharmaceuticals, semiconductors, and consumer food and beverage products.[296]

A typical reverse osmosis treatment unit consisted of a high-pressure pump connected to a rack of filter cartridges (**Figure 61**). The cartridges commonly contained two flat sheets of membrane material separated by porous sheets through which the feed water and treated water flowed. The sheets were laid flat then spiral wound within the cartridges like rolls of giftwrap. Most units were automated to regulate flow rates and pump pressure.[297]

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[296] Lim and Johnston, “Reverse Osmosis as an Advanced Treatment Process,” 1804; Sorg, “Treatment Technology,” 108–112; Paul D. Sinisgalli and James L. McNutt, “Industrial Use of Reverse Osmosis,” *Journal (American Water Works Association)*, Vol. 78, No. 5 (May 1986), 47–51.

[297] American Water Works Association, *Water Treatment*, 451–458.

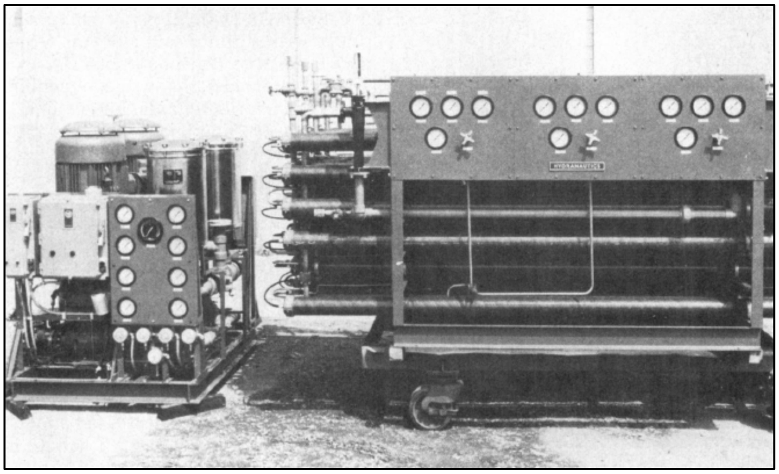

Figure 61: A small reverse osmosis system used for nitrate removal.[298]

Activated Carbon

Carbon's ability to purify water of foul tastes and odors has long been recognized. For centuries, sailors charred the inside of their wooden water barrels to keep the water fresh. However, only in the twentieth century did activated carbon begin to be produced on an industrial scale. Carbon could be made from a variety of substances including wood, nutshells, peat, and petroleum products. Much of the activated carbon used in water treatment was manufactured from coal that was converted to carbon by heating it in the absence of oxygen to prevent burning. The material was then exposed to steam at high temperatures, fracturing the carbon and forming many interconnected pores of various sizes. This gave the activated carbon a very large surface area, so that one pound of activated carbon could have a total surface area of more than 150 acres. Organic compounds of various sizes would adhere to the surfaces and thus be filtered from the water.[299]

[298] Sorg, "Treatment Technology," 109.

[299] Ferhan Çeçen and Özgür Aktaş, *Activated Carbon for Water and Wastewater Treatment: Integration of Adsorption and Biological Treatment* (Weinheim, Germany: Wiley-VCH, 2012), 1–3; American Water Works Association, *Water Treatment*, 377–380.

Activated carbon came in two commercially available forms, powdered or granular, determined by the particle size. Powdered activated carbon (PAC) was the first form to be used for water treatment beginning in the late 1920s. Plants mixed the dry powder or a prepared slurry into raw water prior to the normal coagulation and sedimentation step. With adequate contact time, the carbon absorbed the organic compounds that caused undesired tastes, odors, and colors. Sedimentation or filtration removed the PAC to prevent it entering the distribution system. The carbon could not be easily recovered, as it mixed with sedimentation sludge, so it was disposed of as a waste product. By 1943, about 1,200 American treatment plants made at least occasional use of PAC for odor and taste control.[300]

The advantage of granular activated carbon (GAC) was that it could be reused, allowing for continual removal of organics. GAC was first mass produced during World War I for use in gas masks, and further manufacturing improvements were realized during the 1940s. A Hopewell, Virginia plant installed the first major GAC filter for odor and taste control in 1961. Where the total organic load of the water source was not exceptionally high, GAC was simply added to an existing rapid sand filter. A layer of GAC, approximately two feet deep, was either laid on top of the filter layers or replaced the existing media, in which case it acted as both an absorbent and a filter. The effective life of GAC varied between a few months and several years, depending on the quantity and type of organics being removed.[301]

The early use of GAC focused on traditional issues of odor and taste, but by the late 1960s concern had shifted to the presence of synthetic organic compounds (SOCs) in the water supply. These included a wide variety of pesticides, industrial chemicals, and oils. By the late 1970s, the EPA had identified 253 SOCs in municipal water distribution systems, post treatment, that were suspected carcinogens. Reducing the concentration of these compounds to presumed safe levels required more intensive filtration. Carbon

[300] Çeçen and Aktaş, *Activated Carbon for Water and Wastewater Treatment*, 2–5; American Water Works Association, Water Treatment, 381–385.

[301] Çeçen and Aktaş, *Activated Carbon for Water and Wastewater Treatment*, 2–5; American Water Works Association, Water Treatment, 385–387.

columns, also known as GAC contractors, resembled pressure filters, being cylindrical tanks with beds of media through which the water was forced under pressure. These columns were similar in design to those used in wastewater treatment plants, as with the South Tahoe facility (see **Figure 58** above). Carbon columns were generally included at the end of the drinking water treatment process, just ahead of final disinfection. Portable GAC contractors, mounted on trucks or skids, allowed for emergency decontamination of small systems, as when a rural well was found to have high pesticide levels. These portable systems were designed for temporary use while permanent solutions were arranged.[302]

UV Disinfection

The use of UV radiation to disinfect drinking water and wastewater emerged from regulatory pressures in the late 1970s that discouraged an overreliance on chlorine. Scientists had known since the late nineteenth century that UV light could kill microorganisms, and UV radiation was used to disinfect drinking water as early as 1906. However, the introduction of chlorination two years later effectively ended experimentation with UV disinfection. Later, as environmental concerns grew, regulators sought to balance the need to control pathogens with the impact of chlorine residuals on the environment. In the late 1970s, the EPA began funding research into chlorination alternatives and making grant funds available for construction. Experiments were made with ozone, bromine chloride, and chlorine dioxide as disinfectants, but UV radiation emerged as the principal alternative to chlorine.[303]

UV light offered several advantages as a disinfectant, chief of which was that it did not produce any toxic by-products during the treatment process. UV light operated with relatively simple equipment, principally mercury arc lamps, and because it killed viruses

[302] American Water Works Association, *Water Treatment*, 387–390; John J. McCreary and Vernon L. Snoeyink, “Granular Activated Carbon in Water Treatment,” *Journal (American Water Works Association)*, Vol. 69, No. 8 (August 1977), 437–444.
[303] G. Elliott Whitby and O. Karl Scheible, “The History of UV and Wastewater,” *IUVA News*, Vol. 6, No. 3 (September 2004), 15–26.

and bacteria almost instantly, it required shorter retention times and thus smaller contact chambers. UV light also dispensed with the need to handle and store dangerous chemicals and there was no chance of overapplication. However, because UV light left no residual disinfectant in the water, it was necessary to still add a low dose of chlorine to handle any microorganisms living in the distribution system.[304]

Prompted by the EPA research and grant program, several small companies emerged to develop UV light systems that could handle the unique issues of drinking water and wastewater treatment. Many first-generation systems were made operational in the late-1970s and early-1980s, but most suffered from basic design flaws that rendered the equipment inefficient and unreliable. A lack of scientific information and industry standards made it difficult for plant operators to determine the right size and configuration for their equipment, and repairing the rapidly evolving equipment was challenging. As a result, even at the end of the twentieth century, less than one percent of the nation’s drinking water supply was treated with UV radiation.[305]

Fluoridation

The fluoridation of public water supplies proved to be the most controversial water treatment issue in the postwar decades. Fluoride occurs naturally in many groundwaters and is particularly prevalent in mountainous regions with volcanic geology. Where fluoride levels are exceptionally high, dental fluorosis can result, producing an aesthetically undesirable mottling of tooth enamel. It was such cases of excessive fluoridation that first attracted scientific interest, with the earliest studies occurring in Colorado Springs in 1909. Investigations by USPHS linked the condition to water supplies in the 1920s and identified fluoride as the culprit in 1931. During their studies, researchers had noted that children with mottled teeth also had low incidences of tooth decay. This led the National Institute of Health (NIH) to try to determine if there was an

[304] Whitby and Scheible, “The History of UV and Wastewater,” 16; American Water Works Association, *Water Treatment*, 164–166.
[305] Whitby and Scheible, “The History of UV and Wastewater,” 16–17; American Water Works Association, *Water Treatment*, 164–166.

ideal level of fluoride that would strengthen teeth without marring them. By the late 1930s, NIH had identified an upper limit of one part per million that would cause only minor fluorosis in a small portion of the population.[306]

In 1945, Grand Rapids, Michigan, installed the world's first municipal fluoridation facility, followed the same year by Newburgh, New York, and Evanston, Illinois. NIH and the US Surgeon General closely studied the pilot programs and found that the rate of tooth decay among children declined by as much as 60 percent. By the end of the decade, USPHS, the AMA, the American Dental Association, and the National Research Council all endorsed drinking water fluoridation as safe, effective, and inexpensive. A major public health breakthrough, fluoridation made tooth decay a preventable disease for the first time in history. Fluoridation of the domestic water supply expanded rapidly between 1950 and 1953. San Francisco and Antioch added fluoride to their water supplies in 1952, the first cities in California to do so.[307]

Popular opposition to fluoridation gained traction in 1953. Some 60 cities nationwide reversed themselves over the next decade, halting fluoridation programs that they had earlier begun. In California, 36 communities held referendums on the matter, and in 25 cases voters rejected beginning or continuing fluoridation. Opponents voiced a variety of concerns. Some objected in principle to the idea of forced medication or challenged the addition of any chemical to a natural water supply, echoing earlier complaints about the use of chlorine in water treatment. Others noted that sodium fluoride in large doses functioned as a rat poison and worried about the potential of accidentally providing a toxic dose to humans. In the context of the Cold War, some feared that saboteurs might use fluoridation as cover for introducing harmful substances into the water supply, while

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[306] Melosi, *The Sanitary City*, 303–06; National Institute of Dental and Craniofacial Research, "The Story of Fluoridation," July 2018, accessed October 2022 at The Story of Fluoridation.

[307] Melosi, *The Sanitary City*, 303–306; National Institute of Dental and Craniofacial Research, "The Story of Fluoridation"; Ernest Newbrun, "A History of Water Fluoridation in California: Lessons Learned," *Journal (California Dental Association)*, Vol. 47, No. 11 (November 2019), 705–711.

figures on the fringe insisted that fluoridation was a communist plot to weaken Americans.[308]

Nationally, the supporters of fluoridation prevailed in the long run, backed by the unwavering support of public health officials and the clear and measurable dental health improvements in towns that embraced fluoridation. The introduction of fluoridated toothpastes in the early 1970s lessened tensions around the issue and proponents benefited from the greater calm. By 1980, half of the national population consumed water enhanced with fluoride. California, however, lagged the national trend. In a much-watched campaign, Los Angeles voters strongly rejected fluoridation in 1974. As late as 1992, less than 16 percent of the state's population received fluoridated water, the fourth lowest percentage in the nation. That figure has since increased as a result of legislation in 1995, but California still ranks below the national average.[309]

Water treatment plants inject fluoride as one of the final steps of treatment following filtration to avoid any loss that could occur in reaction with other chemicals. For groundwater systems, injection is either at individual well pumps or in a common line leading to a storage reservoir. No specific type of injection equipment is standard across all plants. Small systems commonly use a solution tank and metering pump with a line to the watermain. Larger plants may use dry or solution feeders, depending upon what commercial form of fluoride is most economical for their purposes. The fluoride feed system is frequently automated, with flow meters used to regulate and adjust the feed rate.[310]

2.3.2. Political Organization

Prior to 1949, the California Department of Public Health had been the chief agency responsible for regulating water pollution and it issued permits for all new sewage

[308] Melosi, *The Sanitary City*, 304–305; Newburn, "A History of Water Fluoridation in California," 706.

[309] Melosi, *The Sanitary City*, 305–306; Newburn, "A History of Water Fluoridation in California," 708–711.

[310] Hammer, *Water and Wastewater Technology*, 271–273.

disposal sites in the state based upon the recommendations of its Bureau of Sanitary Engineering. The permitting process had originated as a means of providing technical engineering review of proposed treatment plants, and it was thus fundamentally oriented towards regulating the means of pollution abatement rather than the end results. The department did not establish general guidelines for the quantity and quality of sewage discharge, but undertook a site-by-site review to ensure that plants operated as designed and did not endanger the public health or cause a nuisance. By the end of World War II, this system was widely understood to be inadequate and in need of replacement.[311]

The California Legislature in 1949 passed the Dickey Water Pollution Act to overhaul the regulation of water quality. The act created a State Water Pollution Control Board and nine regional boards with authority over water pollution and nuisances. The State Board served as a review authority for appeals of regional board decisions, formulated state-wide policy, and directed a research and construction financing program, but it was to defer to the authority of the regional boards for prescribing and enforcing discharge requirements. The regional boards were established in the nine major drainages (hydrologic basins) of the state and each was composed of five individuals appointed by the governor. The boards were to represent the various regional water interests with the five board members drawn one each from the ranks of irrigated agriculture, industry, water supply organizations, municipal government, and country government. In theory, the conflicting interests of the board members would be so balanced as to prevent requirements from being overly stringent or lax.[312]

The Dickey Act repealed the earlier permitting system through the Department of Public Health and replaced it with a method that set overall standards of water quality, but did not specify what means were to be used to meet those ends. Municipalities no longer

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[311] "California's Water Pollution Problem," *Stanford Law Review*, Vol. 3, No. 4 (July 1951), 649–666.

[312] "California's Water Pollution Problem," 652–653; Adolphus Moskovitz, "Quality Control and Re-Use of Water in California," *California Law Review*, Vol. 45, No. 5 (December 1957), 586–603.

had to submit their treatment plant designs for technical review by the state so long as they could met the water quality standards. The act defined pollution as “an impairment of the quality of the waters of the State by sewage or industrial waste to a degree which does not create an actual hazard to public health but which does adversely and unreasonably affect such waters for domestic, industrial, agricultural, navigational, recreational, or other beneficial uses.” The pollution control boards thus had jurisdiction over the economic aspects of waste discharge. The definition excluded substances that created an actual hazard to public health through the spread of disease or introduction of a toxic poison, and these remained the jurisdiction of local and state health officials who could order an immediate abatement of such conditions.[313]

In 1969 the state legislature passed the Porter-Cologne Water Quality Control Act that substantially revised the Dickey Act. Described at the time as “the toughest water quality act in the nation,” Porter-Cologne added strong enforcement tools, created an enhanced role for public participation, and for the first time recognized aesthetic enjoyment as a legitimate value meriting protection.[314] The act retained the nine regional boards and the state board under a new name as the State Water Resources Control Board. The regional boards were expanded to nine members with additional representation from water quality experts and private associations concerned with recreation, fish, and wildlife. The act strengthened the state’s regulatory role by explicitly redefining the discharge of waste as a privilege that could be revoked, rather than as a right that might enjoy protection as a beneficial use. The definition of pollution was also rewritten so that it applied to any unreasonable impact to beneficial uses, without the requirement that it be an adverse effect, thus allowing for strict standards to protect future uses without having to show present harm. This broadened authority was

[313] “California’s Water Pollution Problem,” 652–653; Moskovitz, “Quality Control and Re-Use of Water in California,” 588–589.

[314] The characterization of the law came from the Soap & Detergent Association, quoted in Karl Phaler, “Water Quality Control in California: Citizen Participation in the Administrative Process,” *Ecology Law Quarterly*, Vol. 1, No. 2 (Spring 1971), 400–426.

necessary for protecting a body of water like Lake Tahoe, where the highest standards of treatment were needed to safeguard unique aesthetic values.[315]

The federal government had been slow to engage with water quality issues, historically treating the matter as a concern for local or state government, but this began to change in the postwar era. Through the first half of the twentieth century, Congress repeatedly debated establishing federal water quality standards, but none of the more than 100 introduced bills was ever passed and enacted into law. The US Public Health Service standards for water used in interstate travel, established in 1914, remained the only federal involvement in water quality issues. Then in 1948, Congress passed the Water Pollution Control Act, the first major federal involvement in water quality regulation. The act was limited in scope—it applied only to interstate waters and required consent of the participating states—but it established a precedent for a federal role in pollution disputes.[316]

Debate over the proper federal role in water issues continued through the 1950s and 1960s, coinciding with the emergence of environmentalism as a major political concern. The 1948 act had been regarded as an experiment and it had a sunset provision following a five-year trial period. After extensive negotiations, Congress extended the act in 1953 for another three-year period and then finally made it permanent in 1956, though with major amendments in 1961 and 1965. Federal involvement deepened every step along the way. Federal jurisdiction was extended from interstate waters to all navigable waters in 1961, encompassing every significant waterway in the country. In 1965, a new bureaucracy, the Federal Water Pollution Control Administration (FWPCA), was created to coordinate the federal role. The administration was placed under the Department of Interior in 1966, highlighting the environmental role of water regulation and downgrading the former importance of USPHS. Federal financial assistance also increased regularly, reversing the slump in spending that had come with the end of the New Deal programs and curtailment of emergency wartime funding. Most grant assistance was doled out in modest sums to standalone projects, so that small cities,

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[315] Phaler, "Water Quality Control in California," 402–408.

[316] Melosi, *The Sanitary City*, 315–316.

towns, and institutions were the primary beneficiaries, rather than more comprehensive, regional treatment programs.[317]

In 1972, Congress radically amended the Federal Water Pollution Control Act, creating the modern environmental law commonly known as the Clean Water Act. The act established the federal government's EPA as the leading actor in setting and enforcing water quality standards, with the states in a supporting role. Partially modeled on California's Porter-Cologne Act, the Clean Water Act asserted a wide range of uses that merited protection including wildlife conservation and recreation, the so-called "fishable-swimmable" goal. The declared objective of the act was "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters."[318] This meant rendering the waters safe for wildlife and recreation by 1983 and fully eliminating toxic discharges by 1985. To accomplish this goal, the act focused on individual dischargers rather than establishing general water quality standards that were measured in-stream. Every municipal or industrial point-source emitter of waste was required to obtain a federal permit from the EPA that placed specific limits on the discharged effluent.[319]

A distinctive characteristic of the Clean Water Act was its reliance on technology-based standards. In what was termed "technology-forcing," dischargers were obligated to adopt particular levels of technology regardless of their quantities of discharge or the existing levels of pollution in the absorbing body of water. For municipal treatment plants, this meant adopting secondary treatment methods prior to July 1977 (extendable to 1988). Higher levels of treatment could be required if the permitting agency (EPA or the state) determined secondary treatment to be inadequate. Approximately 86% of

[317] Melosi, *The Sanitary City*, 315–319.

[318] Federal Water Pollution Control Act Amendments of 1972, Pub. L. No. 92-500, 84 Stat. 91, October 18, 1972.

[319] Melosi, *The Sanitary City*, 387–389; Hays, *Beauty, Health, and Permanence*, 76–80; Alan S. Miller, "Environmental Regulation, Technological Innovation, and Technology-Forcing," *Natural Resources & Environment*, Vol. 10, No. 2 (Fall 1995), 64–69; Claudia Copeland, Congressional Research Service, "Clean Water Act: A Summary of the Law," (October 18, 2016), 2–4.

municipal plants nationwide met the 1988 deadline and others were placed under court-ordered schedules requiring compliance as soon as possible. The federal law allowed plants that discharged to seawater to apply for waivers from secondary treatment if they could show that natural conditions allowed for waste dilution without unreasonable risk to fish, shellfish, wildlife, or recreational use. California, however, enacted stricter standards in 1974 that prohibited discharge to bays or estuaries unless enhancement of the receiving waters was proven.[320]

Industrial dischargers were required to adopt "best practical technology" (BPT) by July 1977 and upgradable to the "best available technology" (BAT) that was economically available by 1989. In practice, BPT standards were used to control discharges of conventional pollutants that included biodegradable organic substances. BAT controls applied principally to toxic or persistent pollutants. The EPA had authority to define BPT and BAT standards and states had responsibility for enforcing the requirements. To aid compliance with the standards, federal grants were made available for up to 85 percent of construction costs for projects involving innovative technology, versus a maximum of 75 percent for more conventional treatments. These measures spurred innovation in the wastewater treatment industry and led to a fundamental redesign of many industrial processes to decrease the amount of water used, recapture waste byproducts for reuse, and reduce the effluent discharge.[321]

The Clean Water Act addressed only surface waters and did not directly apply to groundwater that provided the drinking water supply for many communities. Investigative reporting in the early 1970s upended assumptions about the safety of municipal water supplies by exposing the existence of potential carcinogens in the tap water of New Orleans and Pittsburgh and lead contamination in Boston. In response, Congress passed the Safe Drinking Water Act of 1974 to coordinate local, state, and

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[320] Melosi, *The Sanitary City*, 387–89; Hays, *Beauty, Health, and Permanence*, 76–80; Copeland, "Clean Water Act," 2-4; Reardon, "Advanced Wastewater Treatment," 66; *A Natural System for Wastewater Reclamation and Resource Enhancement.*

[321] Melosi, *The Sanitary City*, 387–390; Hays, *Beauty, Health, and Permanence*, 76–80; Copeland, "Clean Water Act," 2–4.

federal agencies in protecting drinking water supplies. The program built on the USPHS model of regulating contamination levels in drinking water, but it vastly expanded the scope of the law. While the USPHS regulations had applied to approximately 700 supply systems that provided water for interstate carriers, the Safe Drinking Water Act applied to approximately 40,000 community systems. Under direction of the EPA, the National Academy of Science conducted studies to determine the maximum contaminant levels (MCLs) that were fully protective of human health for biological, chemical, radiological, and physical contaminants. To protect groundwater aquifers, the act established a permit system regulating underground injections of wastewater, gases, brines, and other potential contaminates.[322]

Under the terms of the Safe Drinking Water Act, states assumed primary responsibility for monitoring public drinking water supply systems and enforcing compliance. States could establish their own MCL standards, so long as they were at least as stringent as federal criteria. The California legislature passed the California Safe Drinking Water Act in 1976. California initially defined a public water system as one having five or more service connections, in comparison to the 15 or more specified in federal law, though the legislature later amended the state code to match the federal definition. The Sanitary Engineering Section of the Department of Health (successor to the Bureau of Sanitary Engineering) regulated an initial 1,084 large water systems, defined as those with 200 service connections or more. Local health departments retained responsibility for the 8,887 smaller systems in the state. The State Water Resources Control Board assumed primary responsibility for the regulation of drinking water in 1994 and has

[322] Melosi, *The Sanitary City*, 390–394; James L. Agee, “Protecting America’s Drinking Water: Our Responsibilities Under the Safe Drinking Water Act,” *EPA Journal*, Vol. 1, No. 3 (March 1975), 2–5; Sorg, “Treatment Technology to Meet the Interim Primary Drinking Water Regulations,” 106.

continued to expand and refine the list of substances regulated by MCL criteria through regular updates to the Safe Drinking Water Plan.[323]

2.3.3. Technology

The wastewater treatment technologies developed in the early twentieth century—sedimentation basins, sludge digestors, trickling filters, activated sludge tanks, and the like—remain the primary tools in use today. A sanitary engineer transplanted from the 1930s would immediately recognize and comprehend the purpose and functioning of nearly every major piece of equipment found at a plant constructed in the twenty-first century, although there have been notable improvements to facilities, systems, and processes.

Automation

Automation came late to wastewater and drinking water treatment systems in comparison to such similar industrial processes as oil refining and chemical manufacturing. Basic mechanical automation had been a part of water and sewer systems since the nineteenth century in such forms as floats used for triggering well pumps or automatic flushing tanks used for clearing sewer laterals. Electrically powered systems were employed as early as the late 1920s when the Sanitary District of Chicago installed electric eye monitors in sedimentation tanks to regulate sludge levels. However, treatment plants remained overwhelmingly under manual control into the

[323] Jack S. McGurk Jr., "California Progress in Implementation of The Safe Drinking Water Act," *Journal of Environmental Health*, Vol. 40, No. 5 (March/April 1978), 268–270; State Water Resources Control Board, *Safe Drinking Water Plan for California: Report to the Legislature in Compliance with Health & Safety Code Section 116365*, June 2015; *Safe Drinking Water Plan for California: Report to the Legislature in Compliance with Health and Safety Code Section 116355*, September 2021.

postwar decades, with operators physically opening and closing valves and gates and taking laboratory measurements of turbidity and pH levels.[324]

Tightening municipal budgets in the 1970s prompted increased adoption of automation to economize on labor, real estate, chemical, and energy costs. The design of prewar plants had followed generally conservative standards and intentionally built-in excess capacity to handle unexpectedly high flows. This added to land acquisition and construction costs and permitted a more loosely controlled operation. Automation promised to maximize efficiency by continually adjusting flow rates, temperatures, pH levels, and other variables to remain within set parameters. This allowed adding treatment capacity to existing facilities, rather than building new plants, and offered savings on chemical, energy, and labor inputs. As an additional benefit, automation held the potential to increase the reliability of the treatment process, necessitating fewer shutdowns and enhancing the quality of the final effluent or water supply.[325]

Treatment plant instrumentation performed two chief tasks: monitoring conditions and automating processes. The first was much more widely practiced than the second. The principal sensors used in the 1970s measured hydraulic flow rates and levels. Of secondary importance were analytical instruments for measuring temperature, pressure, pH levels, turbidity, and chlorine concentrations. These more advanced sensors were not always economical to use as the difficult conditions inherent in sewage treatment generated heavy wear and tear. Air, liquid, and sludge pumps were the principal controllers to be automated. Used in conjunction with autonomous sensors, these could adjust flowrates through the plant and maintain consistent processing rates.

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[324] Schneider, *Hybrid Nature*, 183–84; Langdon Pearse, "The Operation and Control of Activated Sludge Sewage Treatment Works," *Sewage Works Journal*, Vol. 14, No. 1 (January 1942), 3–69.

[325] Schneider, *Hybrid Nature*, 183; Joseph J. Salvatorelli, "Value of Instrumentation in Wastewater Treatment," *Journal (Water Pollution Control Federation)*, Vol. 40, No. 1 (January 1968), 101–111.

Chlorination injections and sludge digester temperature controls were also automated successfully and produced savings in chemical and energy inputs.[326]

By the mid-1970s, every wastewater treatment plant other than the smallest systems had a centralized control room that displayed information gathered from remote sensors, showing the operational status of the plant at a glance (**Figure 62**). By allowing a single worker to monitor plant operations, control rooms produced labor savings and were the one form of automation almost universally justifiable on economic grounds. A standard control room had display panels and consoles with indicators, recorders, alarms, and automatic and manual controls. The graphic panels frequently were organized into a sequence that followed the plant layout, though as plants increased in complexity this became less feasible. Computers were common at most new plants constructed in the late 1970s, though these primarily served to display and record data, rather than to directly control the treatment process.[327]

[326] Allen E. Molvar, Joseph F. Roesler, Russel H. Babcock, "Instrumentation and Automation Experiences in Wastewater-Treatment Facilities," Prepared for EPA, October 1976, 5.

[327] Molvar, et al., "Instrumentation and Automation Experiences in Wastewater-Treatment Facilities," 5–14, 72–74; Salvatorelli, "Value of Instrumentation in Wastewater Treatment," 101–111.

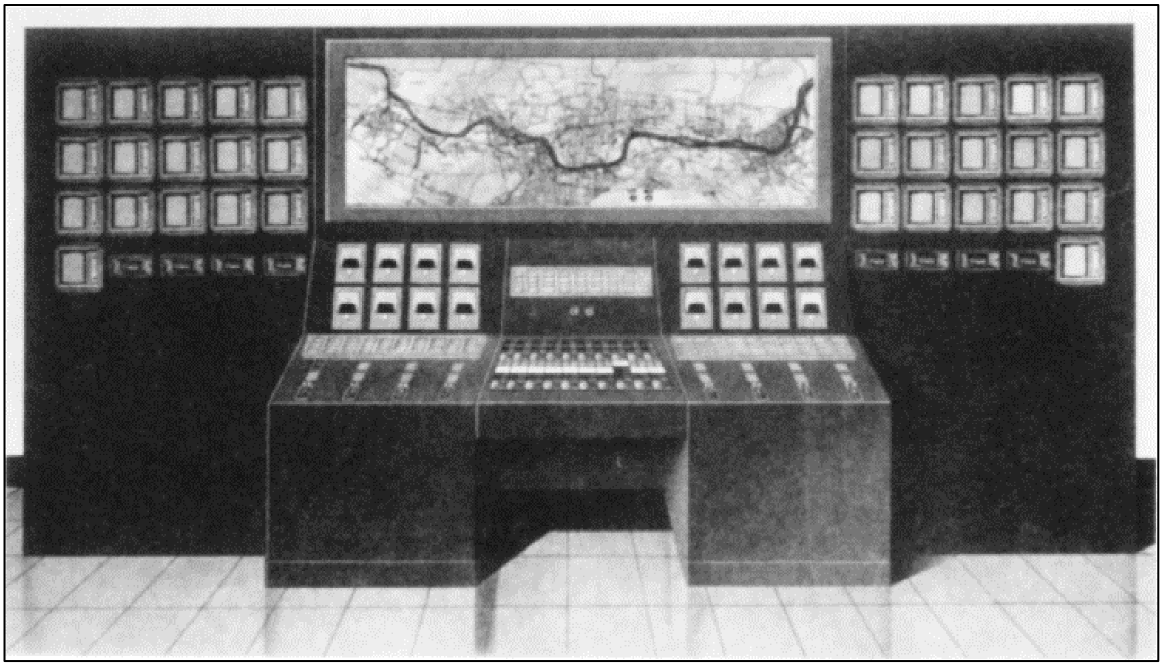

Figure 62: A circa 1968 instrument panel and control console for monitoring a complete wastewater disposal system including pumping stations and treatment plant.[328]

Still, automation proceeded more slowly than treatment plant operators and equipment manufacturers expected or desired. When the EPA sponsored a nationwide study of automation in 1976, they found few processes operating by automated control loops and a generally low level of technological adoption. Even where automated systems existed, operators had switched many off to allow for manual override. Experts initially thought that technological limits were the problem and that solutions would emerge as sensors improved, but the biological complexity of sewage treatment proved a larger obstacle. A plant never operated at complete equilibrium, but experienced constant variation as bacterial populations adjusted to diurnal and seasonal changes in inputs and ambient conditions. The underlying biology was only incompletely understood, and even sophisticated models were approximations at best. The objective of plant operations also changed with circumstance. What worked best during ordinary conditions was different from what was required during a storm or following an industrial

[328] Salvatorelli, "Value of Instrumentation in Wastewater Treatment," 110.

chemical discharge. The challenge of integrating all these variables presented real limits for automated systems and left most plant operations under human control.[329]

Desalination

Desalination is not a modern concept. Oceangoing vessels have supplemented their fresh water supplies by distilling seawater since at least the early seventeenth century, and humans have understood the principles of desalination for many centuries before then. Distillation methods continued to advance, with small seawater-purification machines becoming ubiquitous among naval ships by the Second World War, but large-scale land-based desalination remained in its infancy into the mid-twentieth century.[330]

In 1952, Congress passed the Saline Water Act, which Secretary of the Interior Oscar Chapman had promoted as a necessary response to an ongoing drought in the Southwest that had begun in 1949. The act initially allocated only $2 million over five years, but with the drought only worsening during that period, Congress increased funding fourfold and created the Office of Saline Water in 1958. They tasked the new office with constructing five demonstration desalination plants in different regions. Coastal regions would desalinate seawater while inland regions would desalinate brackish groundwater. Walter L. Badger Associates designed the first nation's first desalination plant in Freeport, Texas, and construction was completed in 1961. The U.S. Department of the Interior's Office of Saline Water operated the plant, supplying half of its production to Dow Chemical and the other half to the City of Freeport. As a result of the Freeport plants success, support for desalination continued growing over

[329] Schneider, *Hybrid Nature*, 183–186; Molvar, et al., "Instrumentation and Automation Experiences in Wastewater-Treatment Facilities," 1–5.

[330] Rolf Eliassen, "Water Desalting, Present and Future," *Journal (American Water Works Association)* Vol. 61, No. 11 (November 1969), 572–574.

the subsequent decade until the energy crisis of the 1970s made desalination appear less cost-effective.[331]

California's first desalination plant was constructed in Coalinga in 1965. Located in the San Joaquin Valley, the city's water supply came mostly from groundwater, which was growing increasingly brackish. The Freeport plant had purified salt water through distillation, but subsequent research had shown reverse osmosis to be more efficient for treating brackish groundwater. The technology passed the water through semipermeable membranes whose openings were of such a size and shape to permit only water molecules through them, thereby holding back salt and other impurities. Coalinga became home to the first Office of Saline Water demonstration plant that used reverse osmosis in 1965. Though experiments with reverse osmosis had already occurred elsewhere in the United States, two UCLA graduate students developed a new membrane that produced freshwater from saltwater ten times faster than the existing membranes. The Coalinga plant functioned as a test site for the viability of the new membrane, and as such, it was small, supplying only 5,000 gallons per day. Their new membrane was successful, and though only a few additional plants were built in California, they all adopted reverse osmosis. Orange County Water District, for instance, integrated reverse osmosis into its Water Factory 21 completed in 1975 (**Figure 63**). A Santa Barbara plant completed in 1991 had a capacity of 6.7 mgd and was the largest built to date in California. However, the plant was decommissioned after Santa Barbara received a connection to the State Water Project and could more easily import surface water than treat groundwater.[332]

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[331] David Sedlak, *Water 4.0: The Past, Present, and Future of the World's Most Vital Resource* (New Haven, CT: Yale University Press, 2014), 221; Jacob Roberts and Kenton G. Jaehnig, "Nor Any Drop to Drink," *Distillations*, November 12, 2018, accessed December 2022 at Science History Institute: Desalination.

[332] Joseph W. McCutchan and James S. Johnson, "Reverse Osmosis at Coalinga," *Journal (American Water Works Association)* Vol. 62, No. 6 (June 1970), 346–353; Sedlak, *Water 4.0*, 223, 233.

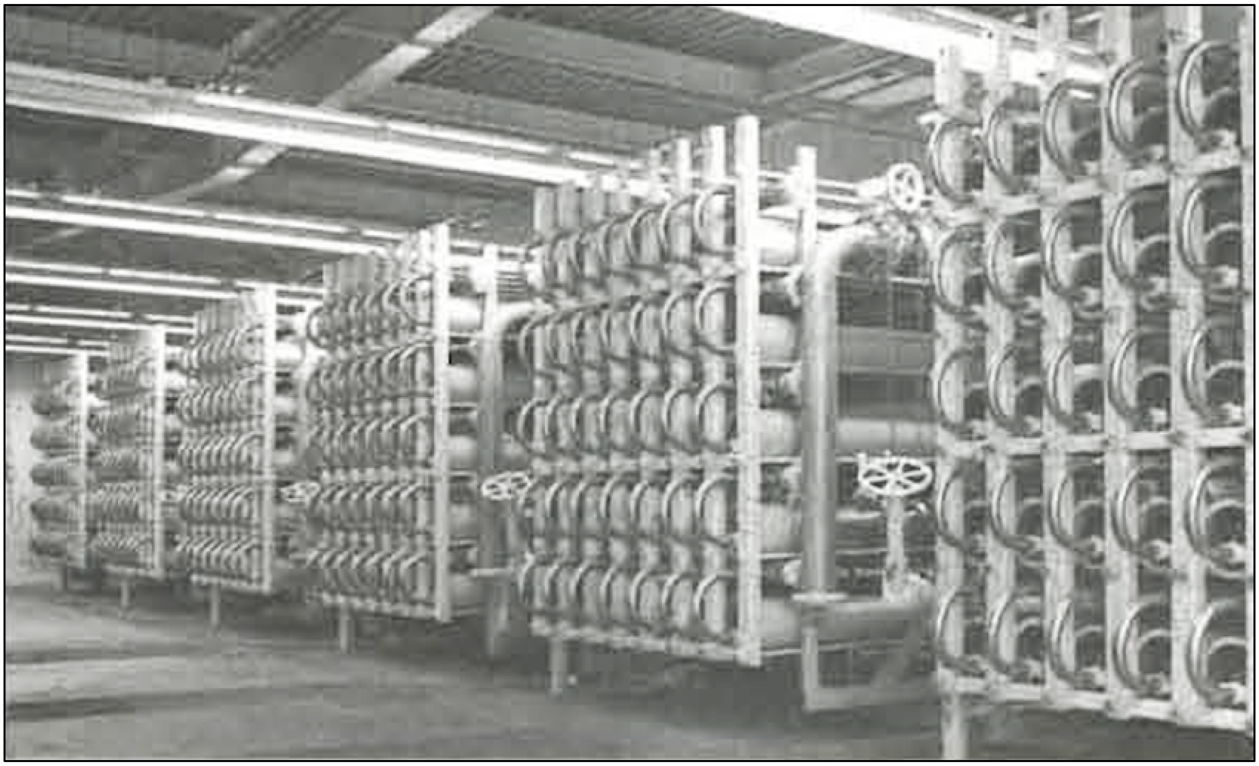

Figure 63: Large reverse osmosis cartridge racks at Water Factory 21.[333]

[333] Orange County Water District, "Water Factory 21," 14.

3. PROPERTY TYPES

California's historic-era drinking water and wastewater systems exhibit tremendous variety, and no two plants or facilities are identical. Each is the product of its age and particular circumstance. However, all the systems share a similar fundamental purpose of safely handling drinking water and wastewater for the benefit of their communities. All systems fulfill common basic tasks of collecting, purifying, and delivering or discharging water, and these shared functions give rise to similarities in processes, technology, equipment, and buildings and structures. Comparison of these similar design elements can assist in evaluating the systems and particularly in determining their potential historic importance as engineered resources. The following section describes typical property types that an evaluator might encounter in the field. It will help to identify common equipment and will draw attention to rarer items that may be uncommon features of public water system facilities in California.

Treatment plants are the centerpieces of drinking water and wastewater systems and are thus the major property type addressed in this section. The different types of plants and their overall layouts are covered, followed, in each case, by a brief discussion of their major subcomponent systems and pieces of equipment. The above historic context covers the development of standard treatment processes and should be reviewed for understanding how the major pieces of equipment function and how they are likely to appear over time.

Secondary property types that are associated with drinking water and wastewater treatment systems but are more directly part of the supply and distribution/collection systems, such as surface water intakes and storage tanks, are briefly covered as evaluators may encounter these components while recording treatment systems. Other historic contexts, particularly Caltrans' previously discussed "Water Conveyance Systems of California," provide further information on these components.

3.1. Drinking Water Systems

A typical municipal water system has three main divisions: a source of supply, a treatment plant, and a distribution system. The distribution system consists of transmission mains and service lines, but can also feature distribution reservoirs, pumps, hydrants, valves, and meters. The treatment plant is the hub of the system as the place where water is made safe and palatable for human consumption. The plant is also likely to be the headquarters for the local water department, where the system's operation is monitored, water quality tested, equipment repaired, and vehicles garaged, among other day-to-day functions.

The size and complexity of water plants varies depending upon the water source. Deep wells provide a supply that is usually clear, free of contamination, and of uniform quality. This allows for simple treatment and may require as little as chlorinating the water for residual disinfection. Surface waters generally contain more sediment and pollutants and will exhibit greater day-to-day and seasonal variation. These waters require greater treatment to reduce turbidity and remove contaminants, and the plants need more operational flexibility to handle the varying circumstance.

3.1.1. Groundwater Treatment

Californians presently draw around 40 percent of their total water supply from groundwater basins during an average year and as much as 60 percent during droughts. Communities through the San Joaquin Valley and along the Central Coast proportionally draw much or most of their municipal water from wells, and many other areas turn to groundwater seasonally as surface flows decline in the late summer. In all, an estimated 85 percent of Californians get at least some of their domestic water from groundwater sources.[334]

Groundwater treatment can occur at individual well sites or at a centralized treatment facility fed by multiple wells and perhaps surface water. A simple groundwater water facility may include a well, a small control building with chlorination equipment, and an emergency backup generator used during power outages. The wellhead may be out in the open or sheltered in a small structure. The site will be fenced for security and may be landscaped for beautification or to screen the sights and sounds from neighboring

[334] Water Education Foundation, "California Water 101," accessed December 2022 at California Water 101.

properties. A larger facility may group the wellhead and treatment rooms into a single building, as is the case with City of Pleasanton well treatment site that is used as a case study in this project (**Figure 64** and **Appendix A**). As constructed in 1967, the control building included a covered vehicle bay and three rooms for housing the well, chlorination feed, and fluoridation equipment, with water-softening tanks placed at the rear of the fluoridation room. A second nearby well fed into the treatment facility. Other equipment that could be present at such plants include filters for removing dissolved iron or manganese and distribution tanks for storing treated water on site. A larger facility might also include an office building, water testing facilities, and storage, shops, and garage spaces.

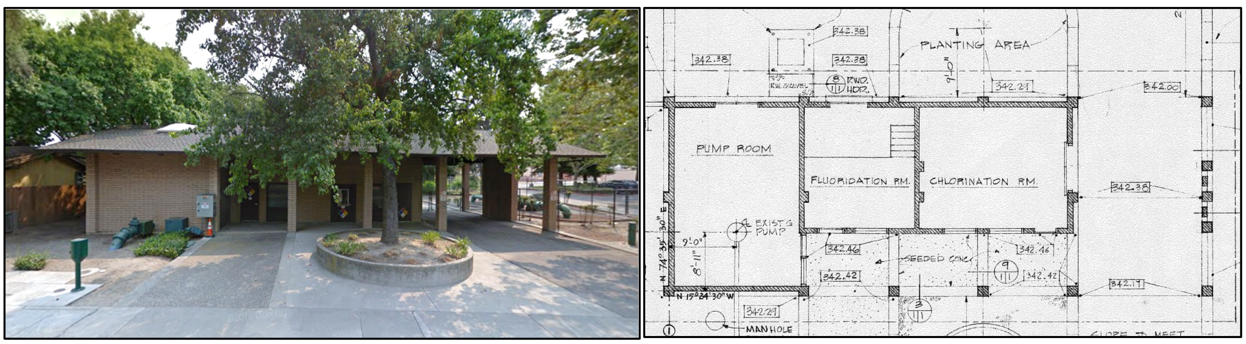

Figure 64: City of Pleasanton Wells 5 & 6 treatment facility with site plan at right showing three-room division.[335]

Components that may be encountered at a typical well water treatment facility include the following:

Wells: Modern wells are typically small structures that may not have much equipment visible at the surface. A small domestic well may present as a simple concrete pad with a contained small-bore steel casing. A larger municipal well will have more surface materials, including potentially a pump head, motor, discharge pipes, electrical equipment, backup generators, water-metering equipment, and taps for water-quality testing (**Figure 65**).

[335] Photograph: Google Streetview, imagery date August 2018; Plan: Kennedy Engineers, “Water Pumping Station, City of Pleasanton, Site Plan & Details,” Sheet A-1, October 9, 1967.

Figure 65: City of Pleasanton Well No. 6 shows a bullet-shaped motor atop the well head, a natural-gas reserve generator at left, discharge pipe right of center, and electrical supply at image right (JRP photograph, October 13, 2022).

Below ground, a typical well has a solid tubular casing with sections of perforated-metal or wire screen set at aquafer depth for collecting water. The turbine pump is commonly installed at the bottom of the shaft or suspended in the casing. It is powered by a motor located at ground level or submerged. The well may be out in the open or housed in a small shelter. Well buildings are often inconspicuous, appearing as a simple outbuilding distinguished only by its robust electrical connections and warning signs. Alternately, the well's role as a public utility may be highlighted through architectural embellishment, the style of which will reflect the era of construction and the expressive intent of the designer.

Chlorination Equipment: Chlorine is injected into raw or treated groundwater to provide residual disinfection against any microorganisms that may be in the distribution system. Chlorination is the most hazardous task in water treatment as the gas is a powerful toxin that would endanger plant personnel and surrounding neighborhoods in the event of an accidental discharge. To minimize this risk, small treatment facilities may use chlorine in a dried powdered form that is mixed with warm water to create small quantities of chlorine gas as required. Modern dry chlorination feeders are small pieces of equipment that connect to wall-mounted feed lines (**Figure 66**). Larger plants will use liquified chlorine gas that is stored in pressurized steel tanks with a one-ton weight being standard. These may be protected in secondary steel containment cylinders that will isolate any leak in the main tank (**Figure 67**).

Figure 66: A modern dry chlorine feeder (JRP photograph, October 13, 2022).

Figure 67: Two one-ton chlorine tanks within secondary containment cylinders with rolling loaders (JRP photograph, November 17, 2022).

The chlorine feed is automated in most plants by way of digitized, wall-mounted units that connect to water lines (**Figure 68**). Chlorine tanks are located outside or contained in dedicated rooms that generally have their own separate exterior access doors and are not directly connected to any other room in the treatment plant so as to limit the risk of exposure in case of a leak. Loading docks are standard at facilities dealing with heavy tanks. All vital equipment exists in duplicate so that operations may continue in the event of the failure of any one single apparatus.

Figure 68: A chlorination feed unit with pipes and pressure gauges (JRP photograph, November 17, 2022).

Fluoridation Equipment: Fluoride compounds are available in a variety of types including sodium fluoride, sodium silicofluoride, and fluosilicic acid. The first two are used in a solid crystalized form, while fluosilic acid is administered as a liquid. A range of feeding methods exist to meet varying plant needs and chemical availabilities. A simple solid feed system consists of a solution tank placed on a platform scale for ease of weighing during preparation and a metering pump that connects to the water main. Liquid fluosilicic acid may be fed directly from the storage tank or diluted with water in a solution tank before being piped to the water main (**Figure 69**).

Figure 69: Fluoride in liquid hydofluocilicic form contained in a plastic storage tank and a concrete spill containment wall, with a small electric feed pump (JRP photograph, October 13, 2022).

Water Softening Equipment: When water softening is required, small- or medium-scale municipal plants will typically use the zeolite process in pressurized steel tanks of commercial design. In most cases, these tanks will have been manufactured within the last 50 years and will not be of historic age. Plants may use lime and soda ash for water softening. On a large scale, this would require mixing basins to produce flocculation and sedimentation tanks for settling out the heaviest materials. A pressurized or basin filter would then remove the remaining coagulant. These larger structures are described in the following section on surface water treatment plants.

3.1.2. Surface Water Facilities

Municipalities may acquire surface water by direct diversion from a river, lake, spring, or reservoir, or by purchase from another supplier, as for example with State Water Project water conveyed over long distances. Surface water carries more sediment and pollutants than groundwater and thus requires more extensive processing. This necessitates larger plants with additional treatment steps. A typical municipal facility, such as the City of Redland Henry Tate Water Treatment Plant (**Figure 70**), consists of two interrelated process chains. The first treats the water through chemical coagulation, sedimentation, filtration, and disinfection. A second set of processes handles the waste byproducts of treatment by processing and disposing of sedimentation sludge and backwashing filters. As with all treatment plants, the major pieces of equipment will exist in pairs and generally may operate either in series or in parallel, offering flexibility to adjust the volume or thoroughness of treatment.

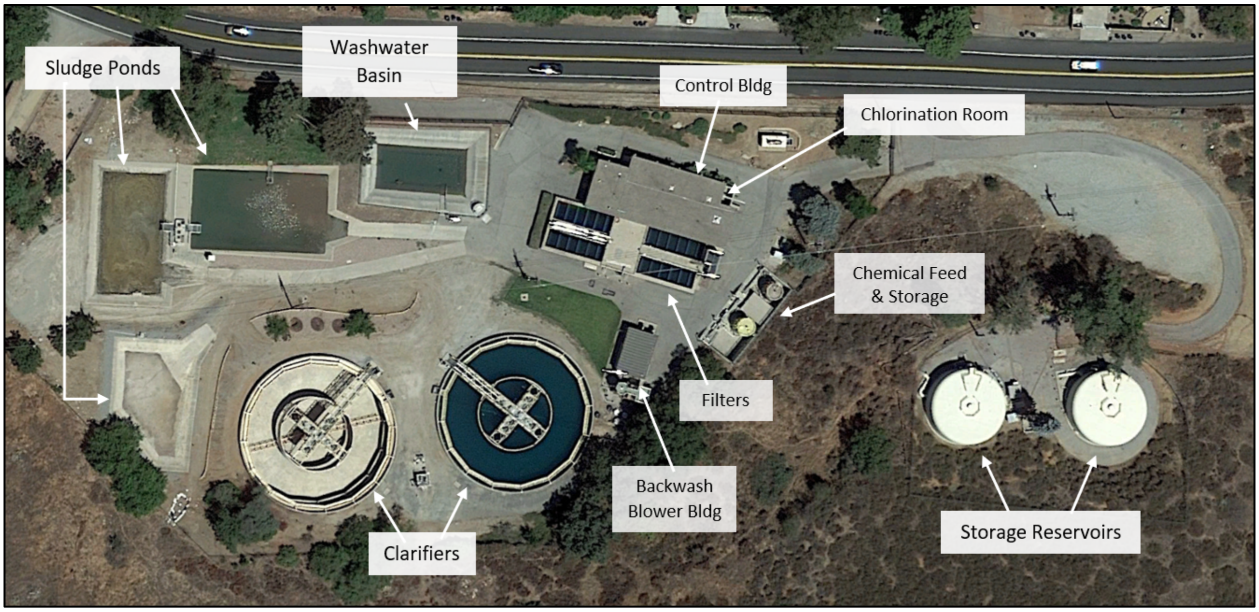

Figure 70: Aerial view of City of Redlands Henry Tate Water Treatment Plant with major elements labeled (Google Earth imagery, August 5, 2021).

Components that may be encountered at a typical surface water treatment facility include the following:

Trash Racks and Screens: Located at the head of the treatment process, these features prevent debris from entering a plant. Racks and screens commonly have mechanically operated cleaning devices, including rakes or jets of air and water, to prevent a build-up of debris. These may be absent from a plant if they are located upstream at a pumping station or diversion point.

Pre-sedimentation Basin: This feature, absent from the above plant illustration, serves to remove silt and settleable organic matter prior to beginning full treatment. Basins come in a variety of shapes and sizes but are generally either rectangular, with a continual flowthrough of water at low velocity, or circular, with water flowing from the center towards a weir at the rim and losing speed as it goes to deposit material. The basin may either have a self-cleaning mechanism or will require being periodically drained and mucked out. These features resemble clarifiers which are discussed further below.

Chemical Injection: As the first state of treatment, chemicals are injected into the water raw influent to aid in coagulation, pH adjustment, and dissolved mineral removal

(**Figure 71**). Alum, a coagulant, is the most common chemical additive. The equipment for chemical storage and injection will vary by plant size and needs. Steel or plastic tanks of commercial design are common. The chemical dosing will likely be controlled by modern digital equipment that can respond to changing conditions as these are monitored by other modern pieces of equipment. Plants may have additional storage tanks on site to hold reserves of chemicals (**Figure 72**).

Figure 71: Plastic tanks hold chemicals for injection into the raw water influent pipeline at left edge of image (JRP photograph, November 17, 2022).

Figure 72: Chemical storage tanks (JRP photograph, November 17, 2022).

Mixing Basin: The mixing basin is a small tank or chamber with motorized agitators or baffles that thoroughly blend the chemicals into the water. At the Redlands Tate plant illustrated above, the basin is below ground and uses fixed baffles for the mixing. At other plants, the basins may be above-ground concrete chambers with prominent motorized drives.

Clarifiers: From the mixing basin, water flows to a splitter box that sends the water to one of two clarifier tanks. These features may also be known as sedimentation tanks or settling basins, and all serve the same function of stilling the water to allow floc and sediment to settle out of suspension. As mentioned for pre-sedimentation basins above, clarifiers come in one of two common shapes—either circular with water motion from center to rim, or rectangular with a continual slow flow (**Figure 73**). Most, if not all clarifiers today will have mechanisms for continual removal of the deposited sludge. In circular tanks this consists of slowly rotating rakes that move sediment towards a center sump (**Figure 74**). Rectangular tanks commonly have scrapers on conveyor belts that slide along the tank bottom and then return at surface level to remove scum.

Figure 73: A circular clarifier (JRP photograph, November 17, 2022).

Figure 74: Interior view of clarifier shows rake arm at bottom of tank, a mechanical fan-shaped agitator, and a baffle wall for containing the agitation zone (JRP photograph, November 17, 2022).

Filters: After clarification, water passes to banks of rapid sand filters to cleanse it of any remaining small particles. Pumps force the water at high velocity through beds of carefully graded sand, gravel, and pebbles, or comparable synthetic materials (**Figure 75**). A pipe gallery beneath the filters collects the treated water into a clear well where it is chlorinated in a manner similar to well water (**Figure 76**). The filters quickly accumulate material and need to be backwashed near daily. Backwashing reverses the flow, forcing water up through the filter beds, suspending the sand and gravel in a churning mix to clean them. The resulting sludge is removed from the tanks and the beds of material naturally resettle by gravity back into their appropriate layers.

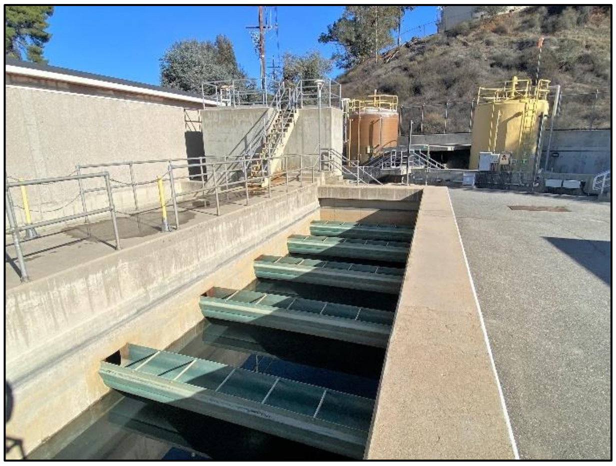

Figure 75: One of four rapid sand filter beds at the Redlands Tate plant. During normal operations, the filtering water would stand above the half-pipe troughs (JRP photograph, November 17, 2022).

Figure 76: The pipe gallery below the filter beds has pipes labeled for backwash flow and treated water effluent (JRP photograph, November 17, 2022).

Blower Buildings: At some plants, filter cleaning is enhanced by blowing air at high pressure through the suspended beds during backwashing. The blower equipment may be integrated into the filter structure, but at large plants it is commonly housed in a separate, dedicated building. These are generally utilitarian structures that show little evidence of their purpose on their exterior, but which will be located in proximity to the filter beds.

Sludge Beds: Sludge from sedimentation tanks and the backwashing of filters is the primary waste produced by a surface water treatment plant. Historically, this material was returned to a waterway without treatment, but tighter regulations now prohibit this practice. Depending on circumstance, a plant may discharge the wastewater to a municipal sewage system or pump it to a sludge lagoon or drying bed for dewatering prior to disposal. The beds may be earth or concrete lined, but are generally of simple design (**Figure 77**).

Figure 77: A sludge drying bed. Note the rampways providing access for material removal after drying (JRP photograph, November 17, 2022).

Backwash Tanks and Clearwells: Treatment plants may store water in reservoirs or tanks for use in filter backwashing and chlorination. These treatment reservoirs are distinct from the distribution system reservoirs that may also be located near to a treatment plant to regulate the release of water to the distribution mains. Backwash tanks will hold a large quantity of water and may be elevated or built on a nearby hill to increase pressure (**Figure 78**).

Figure 78: A steel tank for holding water for filter backwashing (JRP photograph, November 17, 2022).

Clearwell storage tanks serve to increase chlorine contact time in the disinfection process. Reservoirs may be of a number of different common types including water towers, steel or concrete tanks, and standpipes (see reservoir discussion in distribution section below).

Control Buildings: A large water treatment plant will likely contain a control building that allows for monitoring plant operations and may include offices, conference rooms, and laboratories for water quality testing. Other buildings may include vehicle garages, equipment repair workshops, and storage warehouses. Smaller control buildings may also be present at well sites to house pumps and chemicals. A large system may have many of these small control buildings with one at each well site. These buildings may be blandly utilitarian in design or be stylized in an architectural style befitting the era and municipal budgets (**Figure 79** and **80**).

Figure 79: Detail of the Redlands Tate control building showing its Modernist styling (JRP photograph, November 17, 2022).

Figure 80: Laboratory space for water quality testing located in Redlands Tate control building (JRP photograph, November 17, 2022).

3.1.3. Associated Property Types

Supply Systems

Drinking water supply systems consist of a water source, a means of acquiring the water, and a conveyance system for carrying the water to the point of consumption. These can be small-scale systems, for example one that delivers water to a single ranch complex, or some of the largest infrastructure systems ever constructed, as with those developed by EBMUD and the cities of San Francisco and Los Angeles. These systems have evolved though the state's history and are complex public works with numerous subcomponents. It is beyond the scope of this project to offer a full treatment of municipal water supply systems, but the discussion below highlights aspects of these systems that are most relevant to the context of water treatment.

Spring Boxes: Springs provide a groundwater source that may be developed with relative ease. Two general classes of springs exist. Gravity springs form where the land surface intersects the water table, forming a depression pond, or where a percolating underground flow encounters an impervious outcropping and is forced to the surface. Gravity springs are ordinarily low yielding sources of groundwater but may provide adequate supply for an individual household or livestock needs. The larger artesian springs are formed where a pervious, water-bearing strata of rock is confined between two impervious layers that hold it under pressure. The springs discharge where the pervious layer is exposed at the surface by the tilt of the bedrock or by fault-line raptures.[336]

A spring box provided a fairly simple means of collecting and storing the flow, while protecting it from contamination (**Figure 81**). Each site had its own characteristics of topography, subsurface flow, and nature of the water bearing material, so local knowledge and ingenuity were of greater importance in designing a spring box than fixed rules. A spring was developed by clearing the site of vegetation and obstructions. If the spring flowed from a hillside, the slope face might be tunneled into to expose the origin of the flow and ensure that all the water sources were collected. Springs that emerged from several openings or which seeped through porous material on nearly level terrain might require ditches or pipelines to collect the flow towards a central spring box. It was preferable to place a spring box so that water did not pond over the opening which might reduce flow, though this was sometimes necessary for gravity springs (**Figure 82**). Water could percolate directly into an open side of the spring box or be collected by a perforated pipe installed in permeable material at the spring site. A cap of impervious clay or concrete was commonly installed downslope of the spring to

[336] Babbitt and Doland, *Water Supply Engineering*, 102–107; U.S. Department of Agriculture, Soil Conservation Service, *Engineering Field Manual* (Washington, D.C.: U.S. Department of Agriculture, 1984), 12.7–12.11.

intercept as much water as possible. At large springs, the cap could take the form of concrete wingwalls that funneled water towards an angled apex.[337]

Figure 81: A 1930s-era concrete spring box captured water for a nearby labor camp in the Sierra Nevada range above Nevada City (JRP photograph May 8, 2019).

[337] Babbitt and Doland, *Water Supply Engineering*, 107–108; Soil Conservation Service, *Engineering Field Manual*, 12.11–12.15; Water for the World, *Constructing Structures for Springs*, Technical Note No. RWS 1.C.1. (Washington D.C.: U.S. Agency for International Development, n.d.), 1–10.

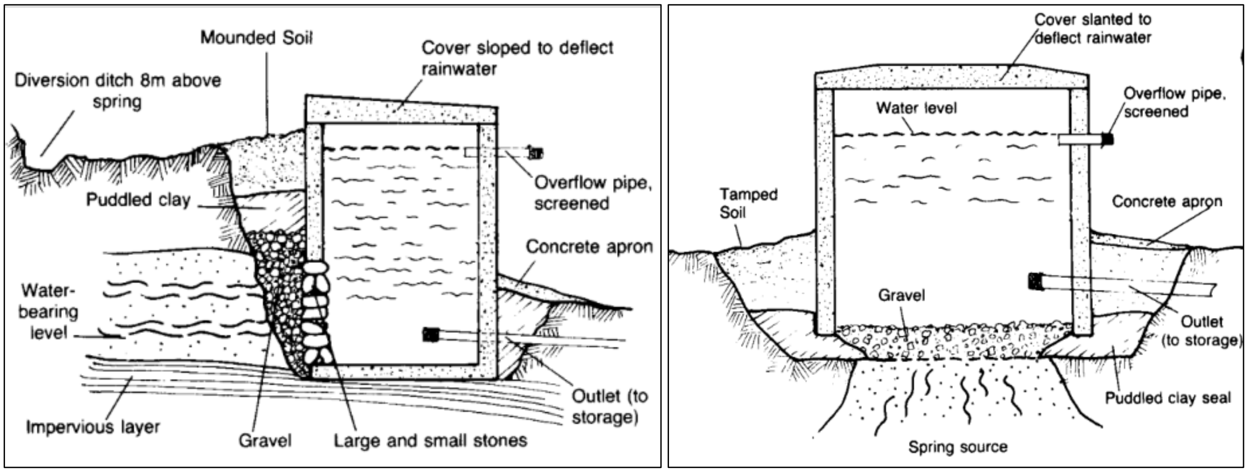

Figure 82: Sectional view of a spring box with side collection (left) and bottom collection (right).[338]

Builders historically used a variety of materials in constructing spring boxes, including compact earth, wood, stone, brick, and galvanized metal, though concrete was the most common owing to its durability and ease of shaping to form. Modern spring boxes may be of plastic, rubber, or other prefabricated materials. A tight-fitting lid protected the water from contamination and diversion ditches above the spring site guarded against flood waters. Where freezing was a problem, the entire spring box structure might be covered with earth. If the spring site was above the point of use, pipes could deliver the water by gravity flow. If the outlet was lower than the point of use, a pump powered by hydraulic ram, windmill, electric motor, or internal combustion engine could lift the water as needed.

Rainwater Cisterns: A cistern is a type of watertight receptacle used for holding liquids. The term “cistern” designates a type of storage reservoir, but it lacks a precise definition that would consistently differentiate it from other kinds of holding tanks. Enclosed reservoirs used for capturing and storing rainwater are nearly always designated as cisterns, but the term may also be used for tanks that store water pumped from other sources. Rainwater cisterns are covered in this section, while the more general cistern is discussed in the distribution storage section below.

[338] Water for the World, *Constructing Structures for Springs*, 4.

Rainwater cisterns are an ancient technology that were common in regions where water was scarce or difficult to access. Medieval mountain castles, for example, made use of cisterns as their locations made wells impractical. Cisterns have been constructed in a wide variety of forms. They could be located above ground, including on building roofs, but were most commonly constructed at least partially below ground to insulate the water from heat and cold. Above-ground tanks could be of wood-stave and iron-hoop construction or built entirely of corrugated metal. Underground cisterns were usually built of brick or concrete. The mouth of the cistern typically protruded out of the ground far enough to prevent surface water from entering. Early cisterns favored a “jug” shape, with an arched roof and manhole entrance, while more recent designs tended towards square or rectangular forms in reinforced concrete. When constructed of brick, two-course walls were preferred, and the walls and floors were made water-tight by an inch-thick coating of cement plaster. Cement walls required a thickness of six to eight inches. Modern cisterns are usually of prefabricated plastic.[339]

Cistern designs typically incorporated a simple filter to remove dust, leaves, animal droppings, and other waste that might enter with the rainwater (**Figure 83**). A wall of soft brick dividing the interior of a tank would suffice to slowly filter the water. Filters could also be set in holes in the floor so that the water percolated through sand, gravel, or charcoal before reaching the pump inlet. Some designs incorporated catch basins between the roof downspouts and the cistern in order strain leaves and large debris.[340]

[339] A. S. Keene, *Mechanics of the Household: A Course of Study Devoted to Domestic Machinery and Household Mechanical Appliances* (New York: McGraw-Hill Book Company, 1918), 151–152.

[340] Keene, *Mechanics of the Household*, 152–154.

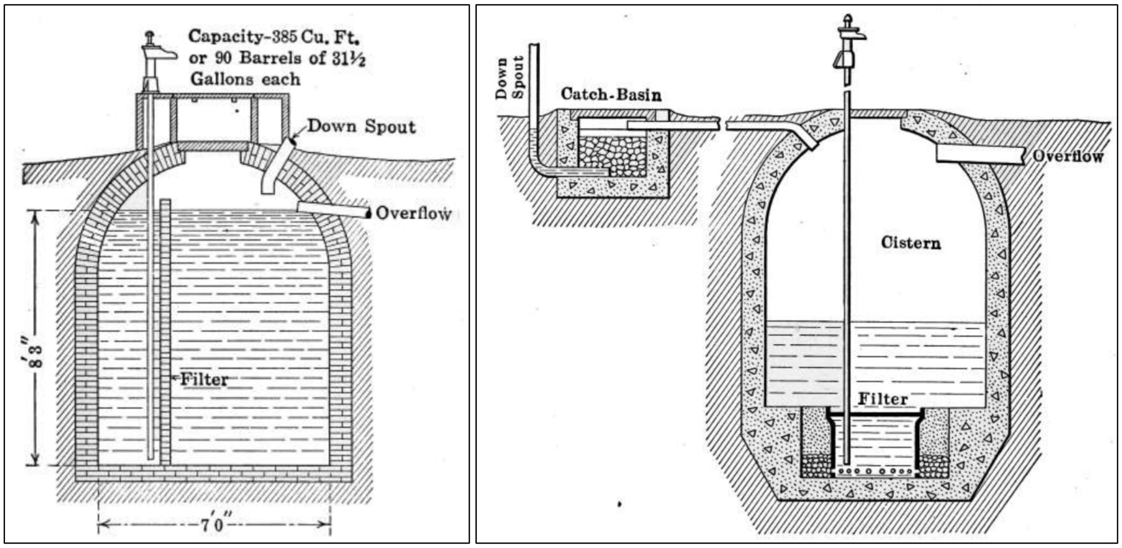

Figure 83: Section views of two cistern designs. At left is a brick cistern with an interior unlined brick wall for filtering rain. At right is a concrete basin with a catch-basin and floor filter.[341]

Rainwater was generally collected from the roofs of buildings by gutters, but more elaborate designs were possible. Lighthouses along California's north coast, for example, were like medieval castles in that they were sited on rocky promontories where water was difficult to procure. The stations needed large quantities of water to operate their steam-powered fog horns, in addition to routine domestic use. Rainwater was channeled over the natural rock features by way of low concrete walls and shallow furrows, and large concrete "watersheds" were completed to pool rainwater where it could be admitted to the cisterns. The Point Reyes Light Station, for example, completed a 100,000-gallon brick-and-concrete cistern with a 10,000-square-foot watershed in 1871, and later added two smaller cisterns, including a 25,000-gallon tank with a 6,000-square-foot watershed in 1900 (**Figure 84**).[342]

341 Keene, *Mechanics of the Household*, 153–154.

342 Dewy Livingston and Dave Snow, *The History and Architecture of the Point Reyes Light Station*, Historic Structure Report, Point Reyes National Seashore (Washington D.C.: National Park Service, 1990), 15–18, 39.

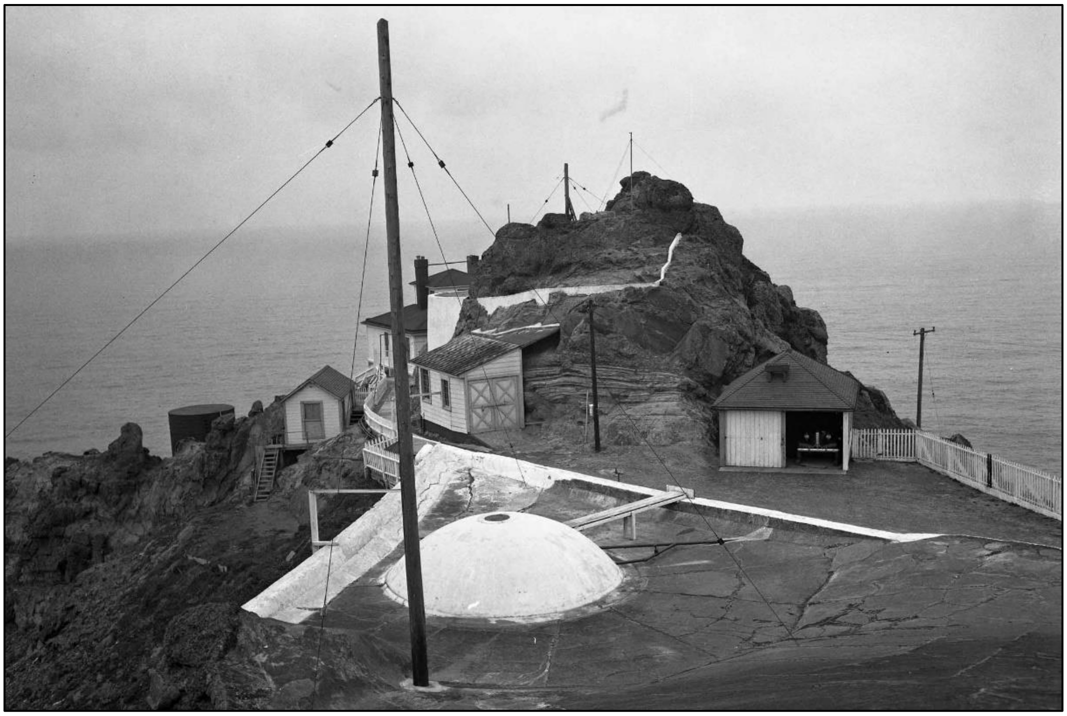

Figure 84: Cistern and 6,000-square-foot concrete watershed at Point Reyes Light Station.[343]

Infiltration Galleries: This property type, described in Section 2.1.4. of the historic context, can collect a large quantity of naturally filtered water from gravel beds beside and beneath waterways. The gallery consists of a horizontal tunnel bored through gravel or bedrock, sometimes with additional connecting vertical wells. Gravity flow or pumping removes the water from the downstream end of the gallery (**Figure 85**).

[343] Livingston and Snow, *The History and Architecture of the Point Reyes Light Station*, 80.

Figure 85: A pumping station for below-surface gallery collection along the Mad River in Humboldt County (JRP photograph, May 27, 2022).

Surface Water Intakes: Diversion from a surface water source requires a structure that can deliver the highest quality water possible, while at the same time protecting pumps and piping from damage and clogging. These commonly take the form of towers, submerged pipes, and shoreline structures. Towers are used in lakes or reservoirs, where they are often integrated into a dam. Towers may have ports at several levels to allow for taking water at different depths as conditions change through the year (**Figure 86**). A submerged inlet consists of a rock-filled crib or concrete block that holds and protects an intake pipe. These systems are relatively inexpensive to construct and are thus widely used, but have the disadvantage of being able to take only bottom-level water. Shore intakes are protected by bar racks for catching large debris and finer screens to prevent leaves and small fish from clogging the intake (**Figure 87**). The pumps are often housed in the same structure that holds the screens and commonly include duplicate equipment to ensure an uninterrupted water supply. Large modern systems are automated to allow for remote operation.

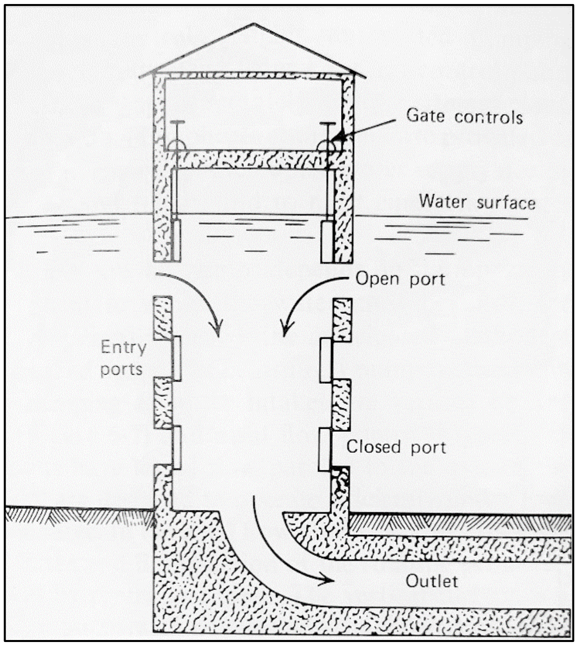

Figure 86: Tower water intake for a lake or reservoir supply.[344]

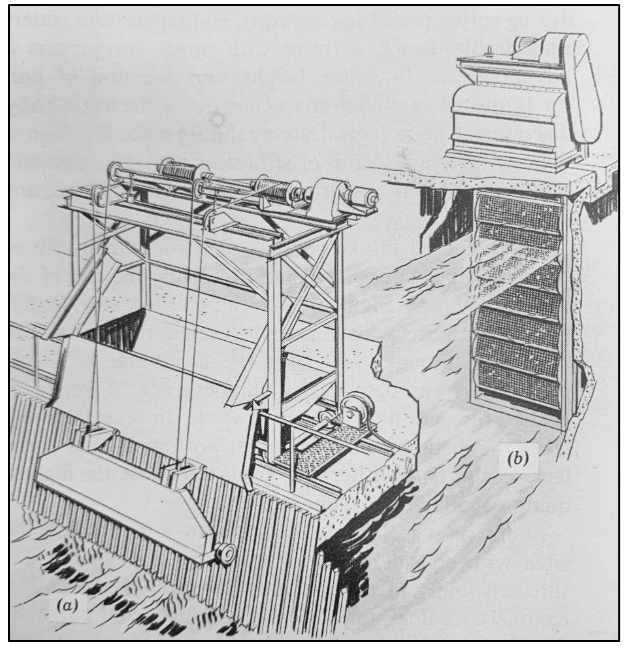

Figure 87: Shore water intake showing (a) bar rack with powered rake and (b) traveling water screens with automatic cleaning mechanism.[345]

Distribution Systems

Distribution systems carry water between the treatment plant and the end user. Nearly all the components of a distribution system are buried out of sight underground. This is done primarily to protect the pipelines from freezing and watermains are buried at greater depth in regions with cold winters than in more mild climates. Watermains and service pipes have been constructed from a variety of materials and the history of that evolution is discussed in the above historic context in **Section 2.1.4.** Valves, meters, and hydrants are the chief accessories of distribution systems and are discussed below. Discussion of pumping stations and storage reservoirs, the main above-ground distribution-system elements, follows.

Valves were located so that sections of pipe could be isolated and shut off in the event of a leak or needed repair. Water-system engineers favored more valves over fewer, but

[344] Hammer, *Water and Wastewater Technology*, 197.

[345] Hammer, *Water and Wastewater Technology*, 198.

the components were expensive and prone to leaking or sticking, so utility companies and municipal officials preferred to install no more than absolutely needed. By general convention, the compromise solution placed three valves at a four-way intersection and two valves at a three-way T intersection. In a straight pipe, a valve was to be inserted every 1,000 feet, or every 500 feet if densely settled. Gate valves were the most widely used valve type to control and stop the flow of water. Gate valves on small pipes were commonly placed in narrow underground valve boxes where they were operated by inserting and turning a long, forked key. Larger valves needed gearing to operate manually and these required placement in larger underground vaults (**Figure 88**). Gate valves were of two basic types (**Figure 89**).

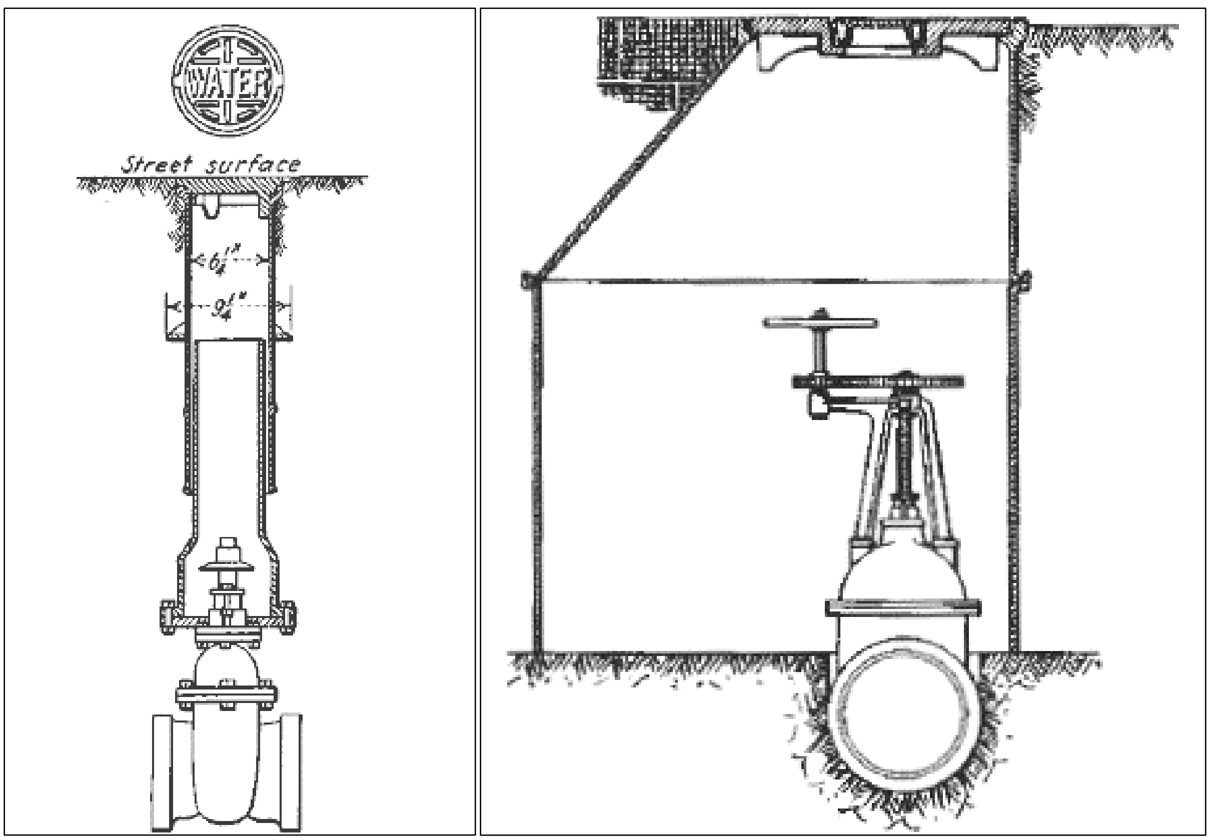

Figure 88: A small gate valve operated by turn key (left) and a larger valve with geared handle in cast iron vault.[346]

[346] Babbitt and Doland, *Water Supply Engineering*, 344–345.

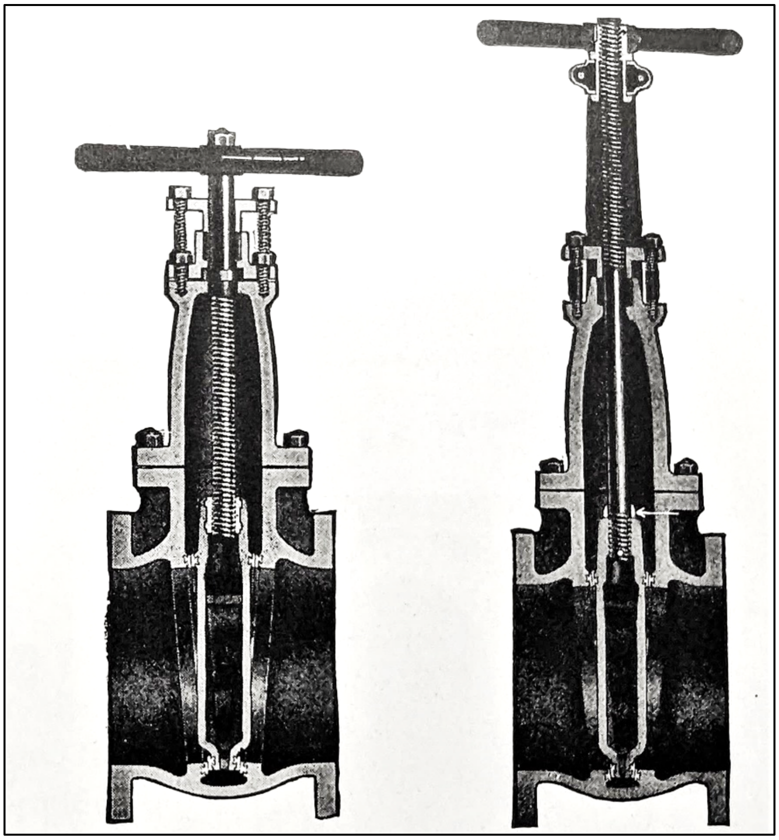

Figure 89: A non-rising stem gate valve at left and rising-stem gate valve at right.[347]

In a non-rising stem pipe, the gate disk was raised by a nut that climbed the threaded stem as it was turned, and the stem remained protected within the valve bonnet. In a rising-stem type, the hub of the hand wheel was threaded and as it was turned, the stem and gate rose with it. Non-rising stem types were used for underground valve locations, while the rising-stem valves were used above ground, where they could be accessed for maintenance and lubrication. Other valve types, including globe, check and balance valves, were used on smaller water fixtures or in specialized situations. Valves of all types were historically manufactured of cast iron with bronze mountings.[348]

Meters used on water distribution systems were of two types. Displacement meters measured the quantity of flow by recording the number of times a container of known

[347] Babbitt and Doland, *Water Supply Engineering*, 343.

[348] Babbitt and Doland, *Water Supply Engineering*, 343–357, 390–391.

volume was filled and emptied. Velocity meters measure the velocity of flow past a cross section of known area. Displacement meters were used primarily for low-volume connections, as for residences and commercial establishments. Velocity meters measured larger flows for industrial uses or large hotels. The displacement nutating-disk meter was the most commonly used type and was nearly the only meter found on residential connections. They operated by having a disk mounted on a central ball. When water entered the chamber, the disk rotated and the movement of a pin through the axis of the ball recorded the number of rotations. A 5/8-inch valve of this type would serve a connection of five families or less, with sizes increasing up to 1½ inches to serve 19 to 30 families. Velocity meters could be as large as 20 inches. Many individual manufacturers marked their own patented designs, but after 1923 all needed to accord with the Standard Specifications for Cold Water Meters of the American Water Works Association.[349]

The location and spacing of fire hydrants were dependent on an area's population, its property values, and the available water flow and pressure. The National Board of Fire Underwriters established minimum conditions to be met to ensure consumers a reduced fire insurance rate and most communities followed the standards. American fire hydrants are generally of the dry-barrel type, meaning that the valve to shut off the flow of water is located not in the exposed hydrant but underground where the hydrant barrel connects to the water main. This protects the hydrant from freezing and prevents a loss of water supply if the hydrant is broken off. Historically, hydrants were manufactured strong enough to resist breaking when hit by a vehicle, but modern hydrants are designed to break off at ground level to minimize harm to vehicle occupants. A standard hydrant will have three outlets. Two 2.5-inch outlets connect directly to hoses, while a single 4-inch "steamer" outlet allowed for connection to a pressurized pumping truck to increase the water pressure (**Figure 90**). All connections were to have a standardized 7.5 threads per inch to make possible mutual fire protection by neighboring communities. The American Water Works Association adopted Standard Specifications

[349] Babbitt and Doland, *Water Supply Engineering*, 359–362.

for fire hydrants in 1913 and updated them in 1937, introducing, among other things, a common color scheme that made the hydrant flow capacities easily identifiable.[350]

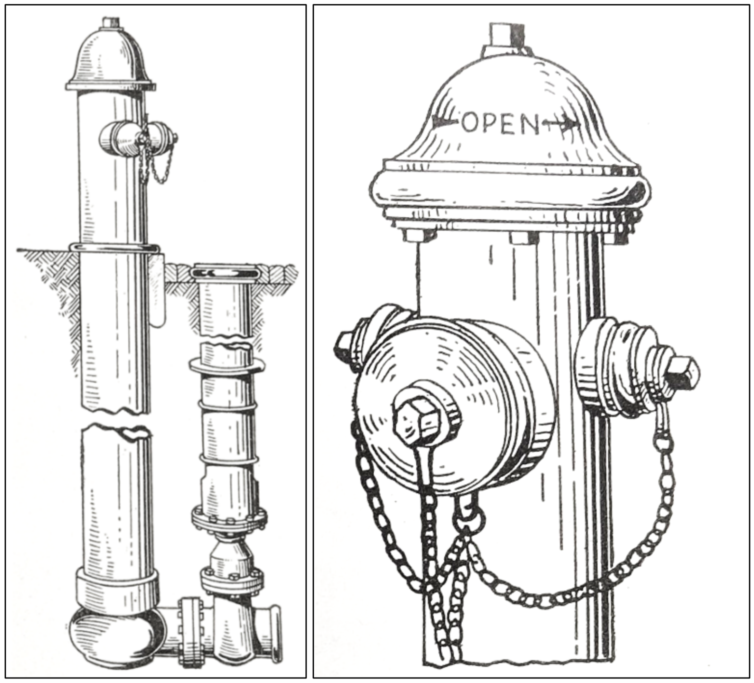

Figure 90: A dry-barrel fire hydrant showing gated valve at hydrant connection to water main (left) and the standard outlet arrangement of one steamer connection and two smaller hose connections (right).[351]

Pumping Stations: It is generally necessary, for a variety of reasons, to pump water at some point during the supply or distribution phases of a municipal water system. Groundwater needs to be pumped from wells, and reservoir water may require pumping to the treatment plant if the topography does not allow for gravity flow. In the distribution system, booster pumps lift treated water into elevated tanks or may distribute it directly without need for additional storage. Pumping stations have also historically supplied water under high pressure for emergency firefighting. Vertical turbine and split-case centrifugal are the most used pump types because of their efficiency and ease of

[350] Babbitt and Doland, *Water Supply Engineering*, 357–359, 389–391.

[351] Babbitt and Doland, *Water Supply Engineering*, 358–359.

maintenance. Early pumping stations operated under steam power, but electrical power with reserve generators has since become standard.

Pumping stations come in a wide variety of forms to meet the situational needs. There is no standard design that evaluators can expect to encounter across different projects. The number and size of the pumps will depend upon demand, though equipment will usually be paired to provide reserve in case of failure of one component. Many pumping stations are utilitarian buildings that meet the basic need to house the pumps and provide for their connection to a power source. A smaller number are embellished with architectural ornamentation that may celebrate the accomplishments of municipal public service engineering. Pumping stations are often components of larger complexes such as military bases or university campuses, for example, and their design may match the overall styling of the larger district.

The San Francisco Fire Department Pumping Station No. 2 is a National Register of Historic Places-listed property that exemplifies the higher end of pumping station design (**Figure 91**). Constructed in 1912, the plant was part of the city-wide rebuilding campaign after the 1906 earthquake that sought, in part, to fireproof the water system. The station provided emergency pumping capacity to maintain high pressure water through the city’s distribution network and had the ability to pump sea water to meet extraordinary firefighting needs. The steam-powered plant had its own boilers and turbines to supply it and neighboring Fort Mason with electricity. The building is of steel and concrete rectangular block construction with Mission Revival styling, including Spanish tile roof projections.[352]

[352] “San Francisco Fire Department: Pumping Station #2,” HAER CA-1, 1983, Historic American Engineering Record, Library of Congress.

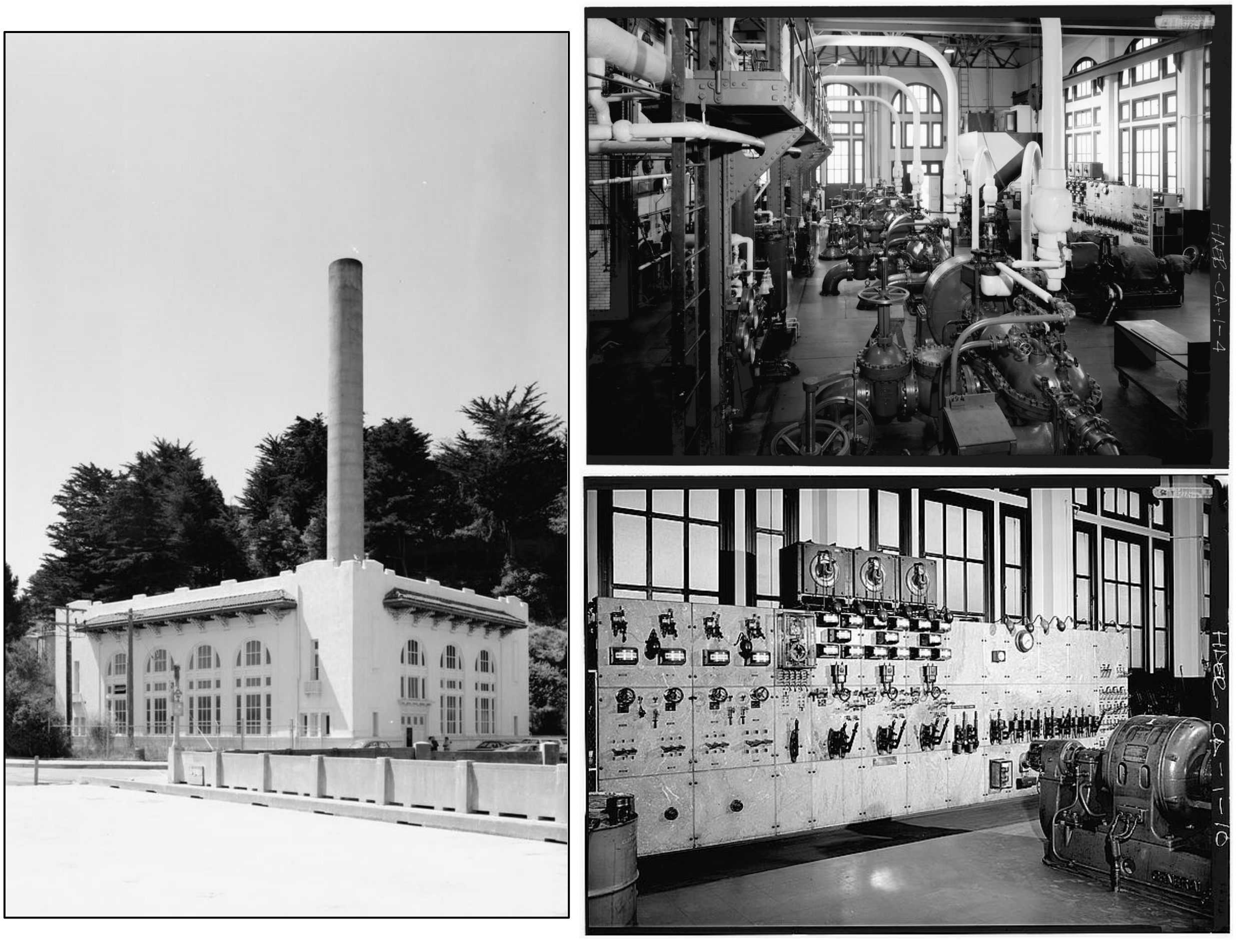

Figure 91: San Francisco Fire Department, Pumping Station No. 2. Exterior view above, general interior to view top right, and detail of panel switches at bottom right.[353]

Distribution Reservoirs: Reservoirs provide a reserve of water which allows pumps to shut down overnight to save on fuel and labor costs, to help balance pressure through the distribution system, and for use in firefighting. Reservoirs are highly variable and consist of standpipes, elevated tanks, tanks that sit on the ground, and subsurface or partially subsurface concrete reservoirs. Reservoirs and standpipes offer ground-level storage and are generally preferred where the topography offers locations at suitable elevation to provide pressure through a system. Storage in elevated tanks is suited to flatter terrain or where the required storage capacity is small enough so that the tank cost compares favorably to reservoir construction. Elevated tanks have experienced an

[353] "San Francisco Fire Department Pumping Station #2," HAER CA-!, 1983, Photo Nos. 1, 4, and 10, Historic American Engineering Record, Library of Congress.

evolution in design and materials over the past century-and-a-half as they have increased in capacity and efficiency. The above historic context covers the major design changes in **Sections 2.1.4** and **2.2.4**. Many older structures still survive, so evaluators may encounter tanks from a number of different eras. Water towers formerly owned by railroads have been incorporated into municipal systems in several communities.[354]

3.2. Wastewater Treatment Systems

3.2.1. Individual Systems

Privies and Cesspools: Privies and cesspools consist of refuse-filled holes dug into the native soil. Privies were used for human waste and were generally unlined. Cesspools collected graywater and were commonly lined with wood, brick, or stone. Mortar was not generally used in masonry work so that the water might leach into the surrounding soil. A privy hole was usually shallow and averaged around three feet square, though a communal privy with multiple seats would have a larger vault. A household privy had a lifespan of around five years. In rural areas, it was the usual practice to cap a filled privy and then dig a new hole and relocated the outhouse. In more developed areas, privies were emptied periodically and the same hole would be used over an extended period of time. Privies were located in close proximity to residences for convenience, so a rural residence might have many surrounding capped privy holes. Cesspools were larger than privy holes and were regularly cleaned to give them longer lifespans. Cesspools were commonly located in building basements or in rear yards.

Septic Tanks: Septic tanks were introduced at the start of the twentieth century to meet household, institutional, and community sewage disposal needs. The tanks were constructed of wood, brick, and concrete in a variety of sizes and plans to include rectangular, square, and circular forms. While septic tanks were generally roofed for odor control, some open-top models were constructed. Large institutions or

[354] For in-depth coverage of water tanks, see: Gregory Mathis "Steel Water Towers Associated with South Dakota Water Systems, 1894–1967: An Historic Context," Prepared for South Dakota Historical Society, September 2012.

communities might have two or more tanks located near to each other to provide treatment and maintenance flexibility. Septic tanks were usually buried and often only the top of the tank or a service access riser is visible (**Figure 92**). Modern septic tanks are commonly prefabricated from concrete, plastic, or fiberglass, and they remain ubiquitous in rural areas without sewage service. The tanks are often located next to drain fields for effluent disposal. These may be informal, consisting of nothing more than runoff to an empty field, or may be develop with perforated pipes laid in beds of stone and gravel and landscaping fabric and soil.

Figure 92: A concrete septic tank lid, approximately six by 20 feet, at the Mount Shasta Fish Hatchery in Siskiyou County (JRP photograph, May 22, 2019).

Imhoff Tanks: California institutions and communities began constructing Imhoff tanks in 1912 as they offered some advantages over septic tanks. Their popularity lasted for about a decade before they were superseded by more sophisticated secondary-treatment methods, though some remain in use today. The Imhoff tank was a two-story concrete structure that divided sedimentation and digestion into separate chambers. The upper sedimentation chambers were long, narrow basins that sloped at their bottoms to a narrow slot through which solids fell into the larger digestion chambers. The tanks generally had open tops with surrounding walkways for service access. The tanks were usually recessed into the ground to avoid the need for lifting the influent by pumps. The tanks had a maximum depth of between 30 and 35 feet, requiring deep excavation.

3.2.2. Sewage Collection

Sewage collection systems operate largely by gravity flow, unliked pressurized drinking water systems, and they must maintain a steady grade from the sewage connections in buildings to the community treatment plant or an intermediate pumping station. Sewer lines are usually the most deeply buried of all utilities and the lines are exposed only at such features as river crossings, where the pipes may be found attached to the undersides of bridges. Cast-iron manhole covers often provide the only visible evidence of a subsurface sewage line. The circular covers are manufactured as sand castings and include raised patterns for traction and vent holes for releasing methane gas. Many manhole covers identify both the utility company that owns the system and the foundry that manufactured the lid. Older systems also had smaller lamp holes that were wide enough to permit a lamp to be lowered into the line for illumination.

Mid-nineteenth-century sewage systems were commonly of the combined sewage-stormwater variety, which required large pipes to handle storm runoff. Californian cities began constructing separate sewage systems, using smaller diameter pipes, in the final decades of the nineteenth century. The oldest and largest pipes were constructed of brick in an egg-shape profile, while smaller lines were of vitrified clay and occasionally cast iron. Redwood pipes were occasionally used where sewage lines crossed marshy terrain. Twentieth-century sewage mains were commonly assembled from cast concrete sections.

Sewage pumping plants, also called lift stations, are used when gravity flow alone could not fully serve an area. Pumping stations are also commonly located immediately ahead of a treatment plant in order to generate adequate head for plant operations. Pumping stations consist of a storage well, two or more pumps, and engines required to operate them. While pumps may be submerged in a wet well, it was generally preferable to located them in a dry well, adjacent to the wet storage well, to facilitate servicing. Small pumping plants may be in underground vaults, while larger plants generally have the pumps below ground with a motor room above ground. Pumping plant buildings could be designed in any desired architectural style and ranged from purely utilitarian structures of cement block and corrugated metal sheeting to ornate Neoclassical or period revival styles. Some communities attempted to disguise pumping stations by making them resemble small residential bungalows or building them into the piers of bridges. See the historic context discussion in **Sections 2.1.4.** and **2.2.4.** above for more detail on sewerage systems and pumping plants.

3.2.3. Wastewater Treatment Plants

Municipal wastewater treatment plants resemble drinking water treatment facilities in many respects, and they use much of the same equipment for screening, clarifying, filtering, and disinfecting water. The wastewater plants differ chiefly in their use of biological methods during secondary treatment that have no parallel for drinking water systems. Wastewater plants are classified by the level of treatment that they offer. Older plants might offer only primary treatment, using clarifiers to decrease the quantity of suspended matter. All modern plants will also include secondary treatment with trickling filters or activated sludge tanks, and disinfection by chlorine contact. Some plants will include tertiary treatment for nutrient and contaminant removal using filters or modifications to the activated sludge tanks. As with drinking water plants, separate process chains handle effluent purification and the processing and disposable of sedimentation sludge. And, as always, most major equipment is duplicated to provide flexible capacity and to allow for treatment to continue while one piece of hardware is serviced. The Yountville Wastewater Reclamation Facility that is used as a case study in this project (**Figure 93** and **Appendix A**) offers a typical example of small-sized municipal plant combining historic-aged components with modern tertiary treatment refinements.

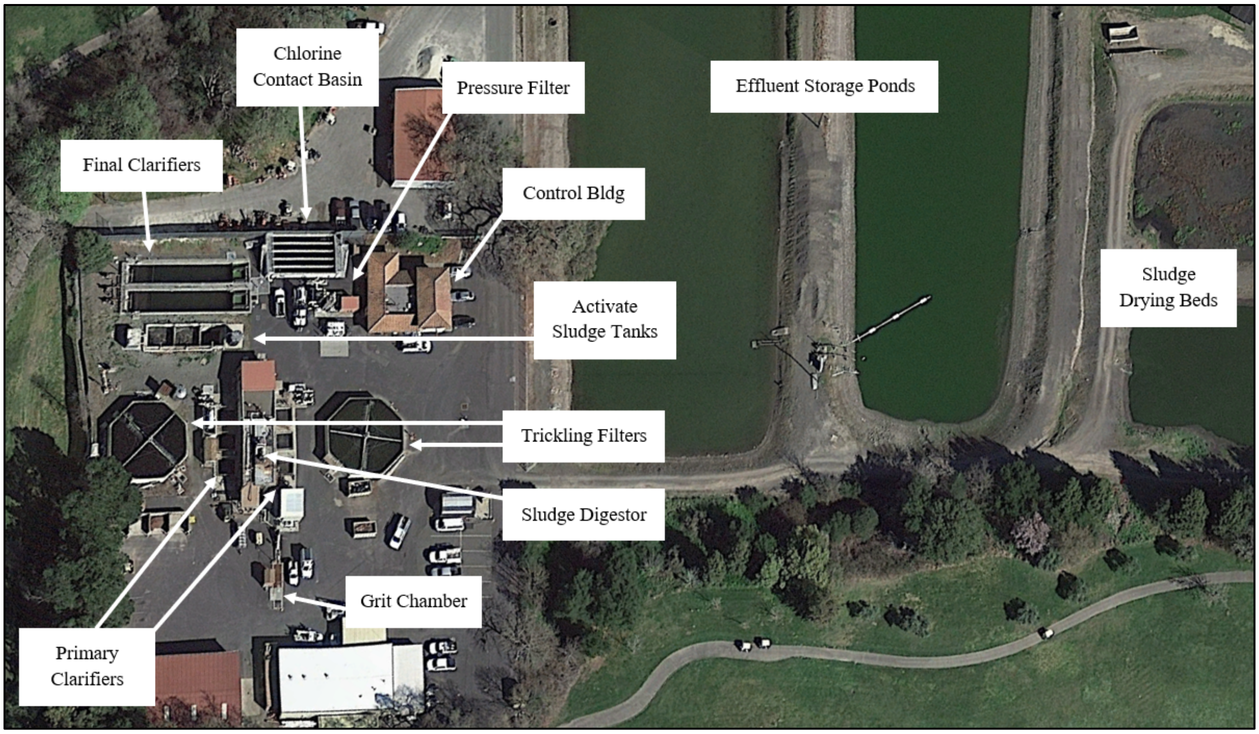

Figure 93: Aerial view of the Yountville Wastewater Recycling Facility with major elements labeled (adapted from Google Earth imagery, February 16, 2022).

The major elements likely to be encountered at a wastewater treatment facility include the following:

Trash Racks and Screens: Wastewater entering a treatment facility first encounters a grill or course mesh of metal bars that removes the large debris such as rags and golf balls. Most racks have some sort of automatic cleaning mechanisms that separates the incoming debris for disposal. Some plants will use comminutors, heavy garbage grinders, in addition to or instead of the trash rags. These devises reduce all debris to a size capable of being handled by the plant.

Girt Chambers: Located immediately behind the trash rack, the grit chamber separates large inorganic matter—sand and gravel—from the influent. This may be accomplished by a physical design that causes the influent stream to slow momentarily so that it loses carrying capacity, or by gently agitating the sewage with air bubbles. The removed grit joins materials separated by the trash for disposal (**Figure 94**).

Figure 94: An auger removes materials separated by the trash rack and grit chamber, located below grade at the head of the treatment plant process (JRP photograph, September 15, 2022).

Clarifiers: Also known as settling tanks or sedimentation basins, clarifiers in a wastewater treatment plant function much like those in a drinking water facility. They serve to calm the influent, holding it without agitation for a period of several hours while the larger suspended particles settle to the bottom of the tank. Mechanical skimmers and rakes collect buoyant grease and heavier sludge for subsequent processing and disposal. Clarifiers are often the largest structures at a treatment plant in their combined area, though many small tanks are preferred over a few large ones to provide flexibility. Older clarifiers favored a circular form from 20 to 200 feet in diameter. Modern tanks are more commonly rectangular as they can be clustered more tightly. Primary clarifiers treat wastewater at the start of the treatment process, while secondary or final clarifiers may be used after biological secondary treatment to remove any remaining bits of suspended material (**Figures 95** and **96**).

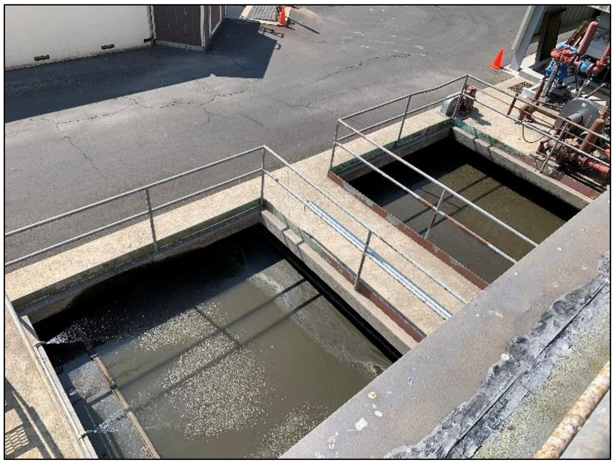

Figure 95: Primary clarifier using water spray and skimmer to separate grease layer (JRP photograph, September 15, 2022).

Figure 96: Final clarifier (JRP photograph, September 15, 2022).

Trickling Filter: A trickling filter consists of a raised, circular, concrete vessel filled with media over which wastewater is sprayed from rotating arms. Traditionally, crushed stone or brick filled the filters, but today they are likely to feature plastic media engineered for durability. Trickling filters act by biological process, so a layer of slime that coats the fill material is doing the actual work of cleaning the wastewater at a microscopic level (**Figures 97** and **98)**.

Figure 97: An octagonal trickling filter present a modest variation on the usual circular form (JRP photograph, September 15, 2022).

Figure 98: Radial arm, spray nozzles, and filter media (JRP photograph, September 15, 2022).

Activated Sludge Tanks: Activated sludge tanks operate by similar biological process to trickling filters except that the bacteria that does the cleaning work is suspended within the water column rather than growing on a solid surface. The concrete reactor tanks are divided into a series of cells, each of which hosts a slightly different bacterial community. The process may involve standard biological secondary treatment or advanced tertiary treatment with the use of specially selected bacteria that can metabolize nitrogen and phosphorus. Activated sludge tanks require vigorous aeration to maximize bacterial action. This may be accomplished by physical, washing-machine-like agitators or, more commonly, by air blowers. The tanks are easily recognized when in action by the roiling, frothy, dark brown liquid that churns through the chambers (**Figures 99** and **100**).

Figure 99: The typical frothy appearance of an activated sludge tank in action (JRP photograph, September 15, 2022).

Figure 100: Air blowers are seen at the bottom of an empty tank cell (JRP photograph, September 15, 2022).

Filters: Filters at a wastewater treatment plant serve the same function as those at a drinking water treatment facility, removing fine suspended particle matter as a final tertiary treatment step. Either rapid sand filters or pressure filters may be used, depending on the plant size and needs. Both filter types need to be backwashed regularly and will have water storage tanks and piping to accomplish that. Filter media may be sand, gravel, activated charcoal, or synthetic materials (**Figure 101**).

Figure 101: A pressure filter contained in a metal casing with piping for backwashing (JRP photograph, September 15, 2022).

Chlorine Contact Basins: Disinfection is the final treatment step for effluent prior to discharge. This is most commonly accomplished with chlorination, though UV radiation exists as an alternative. As with drinking water facilities, the chlorine tanks require special care in handling and will either be located outdoors or in a dedicated, well-ventilated room. A baffled concrete basin detains the wastewater flow for a prescribed contact period to ensure complete disinfection (**Figure 102** and **103**).

Figure 102: Raised chlorine contact basin (JPR photograph, September 15, 2022).

Figure 103: The baffled water course permits adequate contact time (JRP photograph, September 15, 2022).

Sludge Digestion: The liquid effluent is discharged after disinfection, but a treatment chain continues to process the sludge collected from the clarifiers and filters. Sludge digestion is generally an anaerobic process that occurs in the absence of oxygen, so it requires a sealed container. Heating coils on the tank interior provide temperature control. Methane captured by the tank lid frequently provides heating fuel. Circular digestion tanks with floating metal lids are common, but they come in a variety of shapes and sizes (**Figure 104** and **105**).

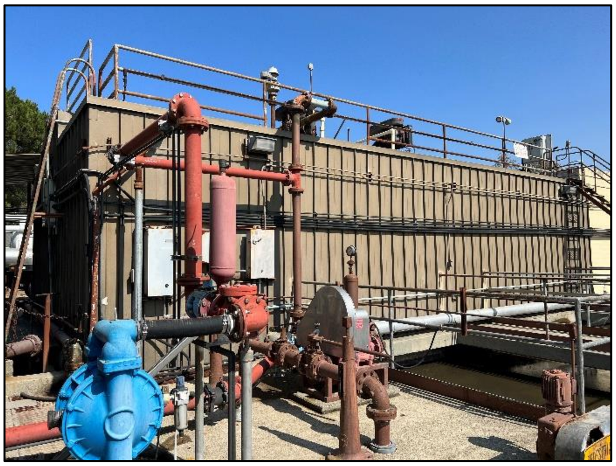

Figure 104: Sludge digestion tank (JRP photograph, September 15, 2022).

Figure 105: Rear of digestion tank showing pipe connections (JRP photograph, September 15, 2022).

Sludge Drying Beds: After digestions, the remaining sludge may be spread on a bed to dry. As the material loses water, it comes to resemble thick, cracked mud. The final material generally will be sent to a landfill or incinerator for disposal, though the material historically has also been sold as fertilizer. In environments that do not permit gradual drying, centrifuges, vacuum filters, or presses may be used to more rapidly dewater the sludge (**Figures 106** and **107**).

Figure 106: A sludge bed with material from prior year (JRP photograph, September 15, 2022).

Figure 107: Sludge bed scraped and prepared for disposal (JRP photograph, September 15, 2022).

Control Buildings: All but the smallest treatment plants will include a control building and administrative offices. These buildings may contain a control console that automates plant monitoring and operations, as well as laboratory testing space. Other buildings may include vehicle garages, workshops, and storage warehouses. The architectural styling on these facilities will vary depending on the era of construction and the resources committed to plant beautification (**Figures 108** and **109**).

Figure 108: Control building in Spanish Revival styling (JRP photograph, September 15, 2022).

Figure 109: Historic-era control panel and modern desktop computer in control building (JRP photograph, September 15, 2022).

3.3. Archaeological Property Types

Archaeological features—subsurface deposits or ruins, distinct from the historic built-environment features such as pumps, treatment facilities, distribution lines, etc. discussed above—are potential components of the drinking water and wastewater systems that may be encountered and recorded in the field. Occupation sites directly associated with the construction and operation of drinking water and wastewater systems, such as construction camps and operator housing or compounds, may contain archaeological deposits and features with the potential to provide important information. These associated resources are normally found in close proximity to the system itself and would date from the system's period of construction or use. Unlike other industrial site types (e.g., mines, oil extraction facilities, reservoirs/dams) that often required the construction of temporary or permanent housing for workers, wastewater and drinking water treatment facilities are inherently situated near population centers. As such, residential, recreational, or refuse disposal property types (artifact-filled pits, sheet scatters, etc.) are not anticipated to be associated with most municipal facilities. The exception may be in more rural contexts, where construction camps and residential features may be present.

Aside from domestic artifacts, which could be associated with the individuals that constructed or operated treatment facilities, other artifact types that may be encountered at wastewater and drinking water facilities include tools and industrial supplies (containers, chemical drums, etc.) used in the operation and maintenance of the facilities. As with domestic artifacts, these industrial artifact types are generally anticipated to be limited, as disposal likely occurred in off-site municipal facilities, more often than not. However, field recorders should be aware of the potential for such artifact types and endeavor to include them as part of the recordation of the facility, as they may inform our understanding of the industrial processes used in the operation and maintenance of facilities, and how those may or may not have conformed with standard processes or those identified in the documentary record.

Privies and cesspools, discussed above under "individual" wastewater treatment systems, are often treated as archaeological properties, rather than built-environment properties, as they often contain material evidence of the individuals or households who used those systems. These individual wastewater resource types, rather than being a component of a larger wastewater treatment system, are instead typically part of some other larger property type (domestic, agricultural, mining, etc.). In many ways, the potential archaeological features associated with drinking and wastewater systems—privies, cesspools, and remains of associated domestic facilities with artifact deposits (e.g., construction work camps and system operator housing) — are not unique to those systems, and have been discussed in detail in prior context documents (see section 4.3.1 for discussion of existing historic contexts and archaeological research designs). As such, they are given limited treatment here.

Any of the built-environment property types discussed in the preceding sections may also be present as archaeological features, in situations where older facilities have been upgraded, abandoned, and/or partially demolished. A small, otherwise unremarkable building pad, with unknown function, may “read” as a former pumphouse or chemical storage facility when viewed in the larger landscape context of the drinking and wastewater systems discussed above. It is possible that unique design features may be present in the archaeological record that deviate from typical construction techniques and provide insight into engineering and availability of resources at a specific place and time.

4. RESEARCH DESIGN

This section offers guidance on field recording and researching historic drinking water and wastewater systems in California. The processes for recording and researching sanitary water systems are fundamentally similar to those employed for other historic archaeological and built-environment resources. Researchers should ensure that they are familiar with the standard guides to historic property surveys including the relevant *National Register Bulletins* (NRBs) of the National Park Service (e.g., *NRB 15: How to Apply the National Register Criteria for Evaluation*; *NRB 36: Guidelines for Evaluating and Registering Archeological Properties*; and *NRB 39: Researching a Historic Property*), along with the California Office of Historic Preservation's "Instructions for Recording Historical Resources." The guidance offered below is supplementary to the general guidelines and is intended to address the particular issues that arise with documenting drinking water and wastewater systems.[355]

4.1. Field Inspection and Recordation

Property types such as a treatment plant, well house, or pumping plant may themselves be important primary sources of information about the historic development of sanitary infrastructure and services. The field inspection and recordation process offer an invaluable tool for understanding the history and particular role played by the subject property. As with all historic resources, surveyors should carefully and systematically examine all buildings, structures, and grounds features of the resource and note evidence of additions, alterations, and demolitions. Treatment plants occasionally repurposed existing infrastructure—converting, for instance, a conventional activated-

[355] U.S. Department of the Interior, *National Park Service, National Register Bulletin 15: How to Apply the National Register Criteria for Evaluation* (Washington, D.C.: U.S. Government Printing, 1997); *National Register Bulletin 36: Guidelines for Evaluating and Registering Archeological Properties* (Washington D.C.: U.S. Government Printing, 2000), *National Register Bulletin 39: Researching a Historic Property* (Washington, D.C.: U.S. Government Printing, 1998); California Office of Historic Preservation, "Instructions for Recording Historical Resources," August 1997.

sludge aeration tank into one capable of removing nitrogen and phosphorous—so care must be taken to identify the original purpose for which a feature was constructed. The siting of the subject property in relationship to natural waterways, infrastructure, industry, and residential areas should be noted. Photography should include multiple views of each of the plant's individual components, including interior views of buildings when accessible, as well as contextual views showing the physical relationship of components to one another and landscape elements such as roads, walkways, parking areas, gates and fencing, ornamental plantings, and the like. Sufficient locational information—such as GPS coordinates and measurements—should be collected during the visit to assist with preparation of site maps and sketch plans.

Underground features present a special category of concern for drinking water and wastewater systems. Sewer lines, watermains, valves, and other underground components may not require recordation for projects that focus on above-ground equipment, but when a project involves a large part or the entirety of a system, it may be necessary to consider the underground features. During recordation, attention should be paid to valves, meters, above-ground pipelines, and visible right-of-way features that may provide information on the location, routing, and possible age and materials of below-ground pipelines and any subsurface features that might exist such as infiltration galleries, automatic flushing systems, grit screens, mixing chambers, or the like. This information should be supplemented by documentary sources such as diagrams, as-builts, construction and maintenance reports, or GPS-based mapping of the underground system. It will rarely be possible to be certain about the location, age, and materials of underground components without conducting excavation, and surveyors should explicitly acknowledge the limits of their knowledge. Effort must be made to avoid uncritically conveying information that might prove misleading in later work.

The following additional suggestions may help make fieldwork more productive and allow the surveyor to get the most out of a site visit.

Define appropriate resource boundaries.

Prior to beginning fieldwork, it is necessary to consider what will be included as part of the recorded and evaluated resource. In most cases, drinking and wastewater treatment plants, and other water-related complexes, should be considered as a whole, rather than as a series of individual components that are evaluated separately. Because a plant functions as a complete system in which each part plays a contributing role, it is preferable to treat it as a single, multi-component resource. So, for example, a trickling filter would not be evaluated independently of the grit chamber, screens, and sedimentation tanks that precede it in the plant process flow. Exceptions may occur where an older core of the plant remains intact while newer equipment has been added on the periphery, or where only one or two historic-aged components of potential significance remain at a plant that has been otherwise modernized. However, the entire plant still needs to be evaluated as one resource. In these cases, the evaluator needs to consider how the later additions may have altered the composition and function of the historic-aged resource. These types of resources undergo continual use, maintenance, and alteration, so considering the historical integrity of these sites is crucial in the evaluation process.

Some components, such as the final holding tanks for treated drinking water, exist at a transition point between systems (in this case, between the treatment and distribution systems). The physical location and built date of the component may help determine to which system it more naturally belongs. If the component serves any direct role in the treatment process—doubling, for instance, as a holding tank for filter backwash water—then it should be included in the treatment plant recordation.

Individual resources such as wells and pumping stations that are physically distant from other related properties may be independently evaluated or grouped as part of a larger system. Ordinarily, the practical solution will be to treat the individual resources separately, while giving research attention to the context of the larger system in which they operate. In most cases, it is not necessary to record the entirety of a municipality's water collection and treatment system in order to evaluate the historic importance of a single pumping station or group of wells. However, if the whole system was designed and built at one time and had shared engineering or architectural features, then it might be necessary to consider the full system for recordation as a historic district or Multiple-Property Listing (MPL). Likewise, a group of wells that are geographically clustered and feed into a single disinfection station might be considered as a multiple-component well field.

Drinking water and wastewater systems on the grounds of institutions such as state hospitals, prisons, military bases, or other, similar campuses or complexes, will likely need to be considered as possible contributors to a potential historic district. Many of these institutions were designed to be self-sufficient in their water and sewage needs, so the systems have direct relevance to the functioning of the institutions. Such is the case, for example, with components of the drinking water and wastewater systems at the Sonoma Developmental Center, a state-run developmental-disability care institution in Sonoma County, which have historical significance as contributing features to an eligible historic district.[356] Understanding the historic boundaries of the institution and the period of significance (if any) will be important in properly recording and evaluating the water systems.

Seek out knowledgeable operators.

Whenever possible, drinking and wastewater systems should be recorded in the presence of a plant operator or manager who is familiar with the system's operation. While most plants follow a conventional process order and have recognizable, familiar components, there are aspects of the treatment process that might not be readily visible to the surveyor. Many advanced treatment processes occur within steel tanks or common aeration basins without giving obvious indication of their function. Plants also commonly repurpose older components as they modernize, so that dating a tank to a particular era does not necessarily identify its current function. Operators with first-hand

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[356] JRP Historical Consulting, LLC, with Denise Bradley, Cultural Landscapes, "Historical Resources Inventory and Evaluation Report, Sonoma Developmental Center," Prepared for Department of General Services and Department of Developmental Services, February 2018.

experience with the plant are of great assistance in recognizing these unusual cases. It can also be useful to ask about how a plant operates under unusual conditions, such as following a storm or during a drought, to understand its full functionality.

Recording personnel should request information on potential safety hazards at a plant and any areas where there may be sensitivities about plant security. Chlorination rooms, chemical storage areas, confined spaces, and the like may require special procedures, equipment, or permission to safely access. As historic built-environment studies frequently become public documents, it is necessary to consider if any photographs, reproduced construction plans, or written descriptions contain information that might potentially compromise plant security.

Request on-site documentation.

The historic importance of drinking water and wastewater treatment facilities is not always recognized or widely reported, and primary source materials related to their planning, construction, and operation may not make their way to historical archives or local history collections. Older design and construction plans and operation manuals are frequently still stored on site, perhaps tucked into a bottom desk drawer or back storage room. Letting plant staff know in advance how valuable these materials are may help uncover them. Staff sometimes misbelieve that only the oldest documents are of interest to historians, so it is worth specifying that your interest extends to recent alterations made to older equipment or additions to the plant that would alter the setting. Administration buildings frequently display historic aerial photographs, maps, or diagrams that may be of assistance. Early centralized control consoles commonly had layouts that mirrored the plant process flow, and these can provide evidence of historic operations.

4.2. Research Themes

Identifying themes relevant to a resource’s potential historical significance can help structure the research process by clarifying the issues that will need to be addressed. This section identifies three main focuses of investigation for sanitary water resources:

- First, how did the resource relate to the development of sanitary science, technology, and policy?
- Second, what importance did the resource have in improving and protecting public health and environmental conditions?
- And third, what impact did the resource have on community development through providing (or withholding) an essential service?

These three themes are by no means comprehensive, but merely offer a place to initiate investigations. Not every research theme will apply in all situations. Individual researchers may modify and supplement these themes as appropriate, given the specific site conditions and historic context.

4.2.1. Sanitary Technology

As a first step in evaluating the historical significance of a drinking water or wastewater system, researchers will want to situate the property within a context of the development of sanitary science, technology, and regulation. This requires identifying the technologies being used and their date of construction. Water system infrastructure is routinely maintained, updated, and modified, so evaluators should be attentive to later alterations. Understanding the history of adaptation can be important in defining a period of significance which might not encompass the entire life of the resource.

Once identified, the technology can be slotted into one of the eras of development as outlined in the above historic context. For a wastewater system, this means placing the subject property within one of several eras: the earliest period of unplanned and decentralized waste disposal; the later practice of systematized waste collection and disposal without processing; the early treatment era of sewage farms, fine screening, and sedimentation basins; the long period of biological secondary treatment; or the recent age of advanced sewage treatment. The property may represent a transition between eras or be firmly ensconced in a particular period. It should be determined if the subject property replaced an earlier system, and if so, whether the improvement was in type (from collection to treatment) or if it simply added capacity, efficiency, or convenience to existing practices.

The evaluator must then determine if the subject property was innovative in its use of technology or treatment process. The voluminous trade press and publications of state and federal regulators called attention to projects that were on the forefront of development. Engineers wrote at length about experiments with new processes, designs, and technologies such as activated sludge treatment at the Pasadena Tri-City plant or zeolite water softening at the Metropolitan Water District's La Verne facility. Plants that received less attention generally made use of existing processes that were already adequately understood. Identifying the principal engineer or contractor behind a project can also be useful as a fairly small number of individuals were directly involved in the most innovative projects (many such individuals in the early and mid-twentieth century being former students of Charles Hyde), while the large equipment manufacturers typically stuck closer to standardized plans.

Historic accounts such as these may help the evaluator assess if the innovation, if any, represented a scientific breakthrough, a less-fundamental technological refinement, or simply an ad hoc approach to meeting community needs using available materials. Advances in the underlying biological and chemical science of water purification were comparatively rare and generally well documented in the trade and scientific press. While some scientific discoveries resulted from experiments conducted in university laboratories, many of them flowed from practical experience with pilot project or full-scale treatment facilities as with Donald Cameron's work with septic tanks or William Dibdin's testing of contact filters. Smaller technological refinements allowed for a known scientific process to operate more efficiently or at less cost. This category included adjustments to existing processes (a new mechanical means of stirring water within a mixing basin, for instance), as well as entirely new procedures for such secondary processes as coagulant recovery that did not directly involve the purification of water. Innovations could also be regulatory in nature as a known process was applied in a new context, as with the Clean Water Act requiring secondary treatment for wastewater effluent discharged to estuaries.

Innovation occurred on different geographical scales, from global to local. Evaluators will need to determine the appropriate level of classification for any innovative features of their subject property. Regional variations of potential importance existed between

Northern and Southern California, between coastal and inland areas with wastewater effluent discharge respectively to salt and fresh water, and between urban and rural districts. A process that had become common in coastal urban Southern California, for example, might still be innovative when first applied in rural northeastern California. Research may thus be required to establish not just the first date that a process was used internationally, but how rapidly it diffused to communities comparable to that under study.

4.2.2. Public Health and Environmental Protection

The fundamental purpose of modern sanitary drinking water and wastewater systems is to improve and protect community and environmental health. From the adoption of basic sanitation measures to the implementation of sophisticated treatment processes, these systems have mirrored the progress of scientific understanding and societal values. Evaluators need to understand their subject properties in relationship to the public health and environmental campaigns that made this progress possible, and then to determine if the properties directly or meaningfully contributed to the advancement of standards, or rather simply followed guidelines that had been established elsewhere.

Public health and environmental protection standards in California have changed considerably since the state's founding in 1850. In the nineteenth century, local boards of health focused on abating such public nuisance of offensive odors and sights as they lacked the scientific understanding needed to more effectively combat sanitary illnesses. With the adoption of the germ theory of disease, the early twentieth century saw the rise of sanitary engineering as a profession that applied scientific principles and biochemical technologies to treat drinking water and sewage. Public health campaigns successfully reduced typhoid fever rates by making the chlorination of drinking water supplies a standard municipal service. Sanitary engineers early on recognized and deplored the environmental impacts of discharging raw or minimally treated sewage into the state's waterways, but they lacked the political or popular support required to implement more expensive treatment programs. In the post-World War II era, the environmentalism movement emerged as a political force and the public demand for higher water quality standards led to advanced drinking water and wastewater treatment methods.

Evaluators need to understand their subject properties within these broader public health and environmental protection trends. This requires understanding what standards, explicit or implicit, existed at a given time and how those goals had evolved and been debated in the recent past. This historic context provides a starting point for understanding that larger context by identifying key scientific discoveries, policy innovations, and public health and environmental campaigns. Publications from the state and local boards of health and sanitary engineers, along with historic newspaper coverage, can offer finer grained detail on changing standards, and may identify if these concerns were an explicit part of the planning of a property. The campaigns to improve public and environmental health occurred at a local, state, and national level, and all could influence the planning of drinking water and wastewater systems.

Researchers should then attempt to identify if the property played a direct role in public health or environmental campaigns, or if it was merely indirectly influenced by larger developments. Facilities that pioneered new public health measures, such as the early chlorination of drinking water supplies, had a direct and important role in establishing and validating new standards. Likewise, pilot projects for nutrient removal from bodies of water like Lake Tahoe or for the recycling of wastewater were of importance for determining the feasibility of advanced treatments. Conversely, upgrades made to existing plants to comply with higher standards might hold less importance if the tighter requirements had already been devised and tested elsewhere. Most system designers did not set out to solve novel problems, but merely sought to efficiently and economically achieve standards that higher-level political and policy bodies set.

Finally, evaluators should remain attentive to the social inequities involved in extending new public health and environmental protections to some but not all communities. A basic public health measure like chlorinating drinking water may quickly cease to be noteworthy in many communities but remain out of reach for impoverished or rural settlements. Therefore, researchers need to consider each property within its local social context and be aware of the factors that might lead to an innovation arriving late to a given community. The adoption of even routine public health and environmental protections might be historically significant if it required a concentrated campaign to overcome obstacles of discrimination and neglect.

4.2.3. Community Development

Placing a drinking water or wastewater system feature in its full and appropriate historic context requires thinking beyond its expression as a piece of sanitary technology to understand the social role it played in the creation of community. Municipal governments exist largely to provide essential services and they make a major investment of public dollars in water and sewage infrastructure. The decisions behind what to construct, how to fund it, and where to extend service can be intensely political and reflect competing visions of a region's future. Essential infrastructure may announce its presence proudly in the form of City Beautiful or Art Deco architecture or hide behind a bland utilitarian front, but it is rarely silent on the issue of community formation and development.

Addressing these issues requires determining who constructed a particular facility and with what funding. This may be an individual, private corporation, municipal government, institution, utility or service district, or real estate developer. Governing bodies were sometimes created explicitly to build and manage a water or sewer system so that their institutional histories connect directly to those of the built-environment resources. Their territorial and jurisdictional limits may inform why a particular technical solution to infrastructure needs was selected over other options. Available funding sources also influenced what sort of projects were viable and in what form, as with the New Deal programs of the 1930s that favored small, shovel-ready projects over comprehensive systems, and called for conspicuous, evocative architecture to highlight the federal government's role. Political conflict on a large scale sometimes determined who controlled and benefited from large infrastructure projects as was seen in the Progressive Era battles between private and public utility companies. Sarah Elkind's study of the politics of water and sewerage provisioning in Oakland and Boston, *Bay Cities and Water Politics,* provides an example of how a historian can connect pipelines and pumping plants to the largest political disputes of their era.

Municipalities did not act in isolation in making water infrastructure decisions, but often responded to the actions and demands of surrounding communities. This was particularly evident in Southern California where communities competed to receive services, particularly related to a clean, reliable water supply, but also acted to exclude construction of sewage treatment facilities. On occasion, this led to areas incorporating simply to frustrate the sewage planning of neighboring municipalities. With individual pieces of infrastructure—pumping stations and isolated wells—it is important to consider if they opened new territory to service, perhaps at the expense of a neighboring jurisdiction, or merely expanded upon existing capacity. Researchers may therefore need to situate the developments of any one town within a larger context of regional growth. When the state and federal government emerged as more powerful actors after World War II, they exerted influence down to a local level. Thus, the shifting regulatory context became another factor to consider in understanding municipal developments.

A facility may or may not physically display the political and cultural assumptions behind its creation. The architectural design of key buildings sometimes conveyed an intended message, emphasizing the ennobling role of public health services through Greek Revival or Beaux-Arts architecture, for example, or the modernness of the sanitary sciences with Art Deco and International styles. The landscaping of grounds could serve a similar function. A facility's name might also work to define it by conveying a message of cooperation as in the Tri-City Plant, emphasizing the future as with Water Factory 21, or by honoring a politician or engineer behind its creation. Therefore, the evaluator must consider a facility's appearance not as an isolated feature, but as part of its overall role in the community.

Likewise, non-structural archaeological resource types (i.e., artifacts) discussed in the preceding chapter are ultimately the result of domestic activities, associated with the individuals that constructed and/ or operated the drinking and wastewater treatment facilities and, as such, are peripherally related to those systems themselves. Archaeological deposits associated with larger sewage and water systems may be a reflection of both individual and corporate choices, and can provide insight into the lifeways of the individuals associated with these systems at an individual human scale, rather than the larger engineering achievements of the entire system reflected in the built environment features discussed above.

Communities are defined both by inclusion and exclusion. Researchers therefore need to be cognizant of what areas and which people were left out of drinking water and wastewater planning. Those decisions had an immediate, direct impact on many lives and shaped the long-term development of some communities in important ways. Cultural biases are readily apparent in some primary sources, but in other cases, it is necessary to view the seemingly mundane decisions about where to lay pipes or draw district boundaries within a larger context of neighborhood demographics and racial or class divisions to recognize their importance. Investigations of sewage and water systems should therefore be grounded in a nuanced understanding of local history.

4.3. Research Resources

Evaluators need to conduct research to develop a property-specific history of the subject property and to situate it within the general historic context of drinking water or wastewater developments in California. Property-specific research should determine basic information about the facility, including its intended purpose, any involved engineers or architects, builder or construction contractor, date of construction, and the history of use and alterations. A variety of sources may address these issues including historic maps, plans, aerial photographs, newspaper coverage, trade publications, and local histories.

The historic context presented in this report will aid evaluators in relating their specific properties to the larger history of water and wastewater innovation in California. Additional research will help to definitively identify what role the property played within that context. The following sections highlight the major works and collections that treat the larger context, and that the evaluator may use to supplement their property-specific research. The reader is also referred to the Bibliography of this study for a full list of works cited, many of which may be of interest to future researchers.

4.3.1. Related Historic Contexts

The California Department of Transportation (Caltrans) has prepared several historic context studies that touch upon subjects related to water or wastewater development. These works provide historic contexts for their subject area and offer guidance on property type classification, research design, and resource evaluation. The following studies are available:

- "Water Conveyance Systems in California: Historic Context Development and Evaluation Procedures," 2000; jointly prepared with JRP Historical Consulting.
- "A Historic Context and Archaeological Research Design for Agricultural Properties in California," 2007.
- "A Historic Context and Archaeological Research Design for Mining Properties in California," 2008.
- "A Historic Context and Archaeological Research Design for Townsite Properties in California," 2010.

The context for water conveyance systems may be particularly useful in its coverage of diversion structures, conduits, flow control, and cleaning devices that can overlap with elements of drinking water or wastewater systems.

Local historic context studies, such as the Los Angeles Conservancy's "SurveyLA: The Los Angeles Historic Recourse Survey," include some water and wastewater related features and should be consulted when available.

4.3.2. Secondary Sources

No single secondary source or study gives complete coverage to the history of development and use of sanitary water systems in California. Rather, works that cover an extended history of development adopt a national or international perspective, and those with a California focus tend towards more limited case studies. Most academically oriented works use sanitation as a lens for examining larger political or cultural issues, and their coverage of the built environment is thus not as focused or complete as users of this document might wish. Nonetheless, the following secondary sources are indispensable for building an understanding of sanitary water systems and they can point researchers towards further primary and secondary data sources:

- Martin Melosi, *The Sanitary City: Urban Infrastructure in America from Colonial Times to the Present,* 2000. This monumental work is the starting point for an investigation of urban water supplies, wastewater management, or solid refuse disposal. Melosi covers the major figures—Sanitarians, physicians, scientists, engineers, and politicians—behind the creation of modern sanitary infrastructure. He outlines the major demographic, economic, social, political, and legal developments across eras, and explains the various technologies with a fair level of detail. While his coverage of California is limited, he provides the essential national and international context.
- Joel Tarr, assorted works. Tarr is the most important recent writer on American sanitation after Melosi. His essays—some of which have been collected in *The Search for the Ultimate Sink: Urban Pollution in Historical Perspective* (1996)—cover select aspects of sanitation development in rich detail. He is less oriented towards major figures than Melosi, with a greater feel for the day-to-day context of water use. His work is particularly important for understanding the unintended consequences of water development and he first identified the way in which the delivery of piped water undermined the cesspool-privy vault system. He is also valuable on sewage farming and the conflict between combined and separate storm-sewer systems.
- Daniel Schneider, *Hybrid Nature: Sewage Treatment and the Contradictions of the Industrial Economy,* 2011. An academic work, this book is more interested in theories of nature than in practical sanitation works. Nevertheless, it gives an insightful reading to the development of biological sewage treatment that is based on deep research in primary sources.
- Sarah Elkind, *Bay Cities and Water Politics: The Battle for Resources in Boston and Oakland,* 1998, and Blake Gumprecht, *The Los Angeles River: Its Life, Death, and Possible Rebirth,* 1999. These two cases studies, discussed earlier in this section, provide models for situating water developments in a larger

context. Both are also finely detailed and convey a sense of the concrete appearance and functioning of water systems.

4.3.3. Published Primary Sources

The following four types of published primary sources are particularly valuable:

- Sanborn Fire Insurance Company maps. Sanborn and similar maps prepared by other fire insurance companies present a large-scale, building-level graphical depiction of hundreds of California cities and towns from 1867 through to the mid-twentieth century. The Sanborn company intended the maps to assist insurance agents in determining the fire hazards associated with particular properties. This include assessing the overall level of firefighting preparedness in a community. The first page of a map set generally included a detailed written description of the community's water supply and collection, storage, and distribution systems. The maps depicted the size and materials of water mains, as well as wells, pumps, tanks, and fire hydrants. The company periodically updated the maps, so it is possible to follow the development of a municipal system over a period of decades. The Library of Congress has digitized a large share of the published maps, and local libraries and historical societies may have other map editions that are not available through the Library of Congress's website.
- Biennial Reports of the State Board of Health, 1870–1926. These reports provide an understanding of the regulatory environment governing early sanitary developments and offer detailed looks at selected water and sewage systems. Most of the volumes are available digitally through the HathiTrust digital library or similar sources and can be searched by subject or keyword. The bulletins of the succeeding State Department of Health cover a wider range of issues and generally give fewer details about practical infrastructure developments. Worth locating are the historical overview articles written by Chester Gillespie that are cited in the bibliography for this report.

- *Sewage Works Journal* and *California Sewage Works Journal,* both starting in 1928. These trade journals are the principal source of information on developments in wastewater treatment during the period of rapid growth at the start of the twentieth century. The articles commonly focused on single plants, providing details on their planning, construction, and operation. Most of the volumes have been digitized and are searchable through JSTOR or other online repositories.
- Construction manuals. Numerous textbooks and manuals provided instruction on the planning, construction, and operation of drinking water and wastewater systems. These are extremely useful in understanding the technologies of the nineteenth and early twentieth century and are written in a manner that is accessible to the lay reader. The volumes prepared by W. A. Hardenbergh for the International Text Book Company, covering sewage and water treatment systems separately, are particularly helpful, though many other good guides exist. More recent textbooks are generally technical in nature, presenting long strings of chemical equations without as clear a treatment of the built environment.

4.3.4. Archival Sources

The records of the Bureau of Sanitary Engineering constitute the most important archival source for drinking water and wastewater projects. These records are split between two locations:

- The California State Archives in Sacramento has the Records of the Department of Public Health (Collection no. R384), which include records from the Bureau of Sanitary Engineering. Most valuable within these records are the sanitary engineering surveys conducted between 1930 and 1935. The reports, which cover most of the state’s cities and large towns, offer historical background and narrative descriptions of community water and sewer systems. Many reports include blueprints and a few contain historical photographs. Less useable are the sanitary inspections that were conducted beginning in 1913. While these are rich in detail, they often apply only to single establishments and are not arranged in a manner that allows for easy searching.

- The Water Resources Collections and Archives (WRCA), within Special Collections & University Archives at UC Riverside, has the Records of the Bureau of Sanitary Engineering (Collection no. WRCA 095), which contains sanitary surveys and other reports prepared on communities throughout the state. The surveys are conveniently arranged by county and city. The majority date to the 1940s to 1960s, though earlier reports are available. The mid-century reports are detailed and include historical and engineering information. A finding aid is available online and reports may be ordered remotely for duplication. Anyone working in one of the covered communities should consult the relevant reports.
- WRCA additionally has the Bureau of Sanitary Engineering Papers (WRCA 148). This presently unprocessed collection contains two boxes of material, most of which consists of general reports on such topics as the permit process, sewage enabling acts, and water well construction. This material is not likely to be of high priority for researchers focused on a specific project.

Additionally, WRCA retains the Charles Gilman Hyde Papers (WRCA 046). The 23 boxes collect Hyde's published and unpublished writings. These cover such general topics as the effect of earthquakes on water distribution systems and reviews of recent developments in the field, as well as the reports that he prepared as a consultant for various cities. WRCA also has the Wilfred F. Langelier Papers (WRCA 112) and P. H. McGauhey Papers (WRCA 084) that consist primarily of reprints of published journal articles.

Finally, the Regional Oral History Collection at the Bancroft Library, UC Berkeley has oral history interviews with Langelier, McGauhey, and Chester Gillespie. These are valuable for understanding the development of sanitary engineering in California and were used extensively in preparing this historic context. Transcripts of all three interviews are available online at Oral History Center.

5. EVALUATION PROCEDURES

The following section offers guidance on evaluating drinking water and wastewater facilities and features for individual or historic district eligibility within a context of the historic development of sanitary drinking water and wastewater services in California. Water features might also have importance in other contexts related to their history of use, if, for example, they were important to the development of a mining region, ranching complex, ethnic settlement, or military outpost. Evaluators will need to independently assess if the subject property possesses significance arising from a history of use in contexts unrelated to the delivery of sanitary services.

5.1. Eligibility Criteria

The eligibility criteria for designating historic properties to federal and state registers are essentially the same. The criteria for listing properties in the NRHP are codified in 36 Code of Federal Regulations (CFR) 60 and expanded upon in numerous guidelines published by the National Park Service. Buildings, structures, objects, sites, and districts listed in, eligible for listing in, or that appear eligible for listing in the NRHP are considered historic properties under the regulations for Section 106 and Section 110 of the National Historic Preservation Act (NHPA). Eligibility for listing buildings, structures, objects, sites, and districts (i.e., historic properties) in the NRHP rests on twin factors of *historic significance* and *integrity*. A resource must have both significance and integrity to be considered eligible. Loss of integrity, if sufficiently great, will overwhelm the historic significance a property may possess and render it ineligible. Likewise, a property can have complete integrity, but if it lacks significance, it must also be considered ineligible. Integrity is of special concern for working drinking water and wastewater systems as these properties are routinely altered over the course of their functional lives.

Historic significance is judged by applying the NRHP criteria, identified as Criteria A through D. The NRHP guidelines state that a historic property's "quality of significance in American history, architecture, archeology, engineering, and culture" must be determined by meeting at least one of the four main criteria. Properties may be significant at the local, state, or national level. The NRHP criteria are:

Criterion A: association with events or trends that have made a significant contribution to the broad patterns of our history;

Criterion B: association with the productive lives of persons significant in our past;

Criterion C: resources that embody the distinctive characteristics of a type, period, or method of construction and are important examples of such, or that represent the work of a master, or that possess high artistic values;

Criterion D: resources that have yielded, or may be likely to yield, information important to history or prehistory.[357]

Integrity is determined through applying seven factors to the historic resource: location, setting, design, workmanship, materials, feeling, and association. These seven can be roughly grouped into three types of integrity considerations. Location and setting relate to the relationship between the property and its environment. Design, materials, and workmanship, as they apply to historic buildings, relate to construction methods and architectural details. Feeling and association are the least objective of the seven criteria and pertain to the overall ability of the property to convey a sense of the historical time and place in which it was constructed or gained significance. Archaeological resources may be eligible under Criterion D if they have the potential to yield important information and retain enough integrity to do so. Consideration will usually focus on location, design, and materials, although it is possible that other elements of integrity may sometimes apply.

To apply these criteria, it is necessary to address both significance and integrity because the period of significance establishes the baseline or standard against which integrity is measured. In addition, a resource must be at least 50 years old in order to be eligible to the NRHP, unless it meets specific and exacting criteria for exceptional

[357] National Park Service, *National Register Bulletin 15: How to Apply the National Register Criteria for Evaluation*, 2.

importance under Criteria Consideration G (Properties that Have Achieved Significance within the Past Fifty Years).

The California Environmental Quality Act (CEQA) requires consideration of the possible impacts to and the evaluation of historical resources using the criteria set forth by the California Register of Historical Resources (CRHR). In order to be determined eligible and considered a historical resource for the purpose of CEQA, each resource must be determined to be *significant* under the local, state, or national level under one of four criteria (Criteria 1 through 4) and retain historic *integrity*. The CRHR criteria closely parallel those for the NRHP (Criteria A through D) outlined above.[358]

5.2. Application of Criteria

Drinking water and wastewater systems or components may be found eligible under any of the NRHP/CRHR criteria, although some criteria are more commonly relevant than others. These systems are more likely to have significance under Criterion A/1 (events) and C/3 (type or style of construction), while Criterion B/2 (people) and D/4 (information potential) will apply in fewer cases. More than one of the criteria may apply to a system or feature, for example when a treatment plant is eligible under both A/1 and C/3 for its association with important events and its engineering values.

The case studies presented in the appendix of this report are used as examples to illustrate the application of the criteria.

5.2.1. Criterion A/1

A drinking water or wastewater system may qualify for listing in the national and/or state register under Criterion A/1 if it has a demonstrably significant association with an important historic event, trend, or theme. Like other kinds of public-works facilities, sanitary water systems are inherently important to the communities they serve, providing infrastructure essential for municipal development. Such value, however, does not necessarily equate to historical significance under Criterion A/1, least every

[358] California Code of Regulations, Title 14, Chapter 11.5, “California Register of Historical Resources,” effective 1 Jan 1993.

treatment plant, pumping station, and the like be judged historically important. Rather, this type of infrastructure is best evaluated for significance based on its impact relative to other comparable, contemporaneous systems. This requires determining if a water system feature had historic importance above and beyond fulfilling its ordinary role of purifying water or disposing of sewage as was done by similar systems in innumerable communities.

A wastewater or drinking water facility may have significance if it introduced or proved the efficacy of an important new technology (may also be applicable under Criterion C/3, see below), public health measure, or environmental treatment standard; if it is closely associated with the creation of a type of political organization, such as a municipal utility district, that itself has importance in comparison to earlier organization models; or if it was the clearly identified focus of important social or political conflicts.

This document has established historic contexts for these themes at a state-wide level, but other events may also be significant, and evaluators will need to consider the potential for local historic importance.

Mere coexistence with an important historic trend is not enough to grant a resource significance. Rather, the property must be an important example of the trend or theme. Thus, for example, a plant that provided chlorination of a drinking water supply is not automatically significant merely because disinfection was an important public health advancement. The plant must have fulfilled an important role in the introduction of chlorination by being a site of experimentation, quelling a major disease outbreak, validating a new regulatory regime, or similar such measure. A resource such as a cistern or pumping station might be eligible under Criterion A/1 if it was important to providing a significant new public service.

If a water or sewer system is evaluated as having significance, it is further required to determine what parts of the system are most directly associated with the significant contribution. A program of drinking water chlorination requires a treatment plant but also watermains, laterals, service connections, and a source of supply. Not all of these are equally important to the chlorination program. The waterlines are necessary for disinfection, but they are not by themselves sufficient for disinfection, as the mere existence of waterlines does not presuppose chlorination treatment. Conversely, the chlorination equipment is both necessary and sufficient for disinfection as the existence of a treatment plant does presuppose a functioning water supply and distribution system. Therefore, while all the parts of the water system—supply, treatment, and distribution—participate in the historically significant introduction of chlorination, as used in this example, only the treatment plant itself might have direct and important association with that significance necessary for individual eligibility under these criteria. Other components could demonstrate a direct, significant association if, for example, they were constructed at the same time and as part of a single program of modernization. An evaluator needs to use judgement in assessing how broadly or narrowly to ascribe direct association with a significant innovation, but should avoid bringing in unrelated system components.

The technologies of drinking water and wastewater purification involve the engineering of both physical structures (mixing basins, sedimentation tanks, etc.) and biological and chemical components (nutrient-digesting microorganisms and flocculants, for example). Engineering innovation is generally recognized under Criterion C/3, but that applies principally to the physical features of a property. If the engineering innovation was primarily of a biological or chemical nature, and the physical structure shows few specific modifications, the innovation might be better recognized under Criterion A/1 if, for example, it demonstrably changed patterns of development of the community it served. A property may qualify under both sets of criteria if the engineering combined structural and biochemical elements.

None of the case studies evaluated on DPR 523 forms for this project qualified for significance under Criterion A/1 (see Appendix). In the case of the City of Pleasanton Water Pumping Station and the City of Redlands Henry Tate Water Treatment Plant, the facilities replaced existing infrastructure. This modernized and, in the case of Pleasanton, expanded the existing drinking water supply system, but it did not introduce any new services or fundamentally change the nature of the municipal water systems. Indeed, the construction of new, modern infrastructure is a routine function of municipal public service departments to account for population growth. The Yountville Wastewater Recycling Facility had stronger claim to significance under Criterion A/1, as the trickling filters and sludge digestor at the plant were first constructed in 1940 by the Veterans Home of California. This provided the first secondary treatment of sewage in the Napa Valley and began the process of cleaning up the badly polluted Napa River. This was a meaningful contribution to both public health and environmental protection in the region. However, planning for a larger valley-wide sewage improvement program had been in the works prior to the plant's construction and it was merely the first of the facilities to be completed. The Veterans Home plant allowed the larger plan to progress, but it was not responsible for inspiring the effort, which depended more on pressure applied by state regulators. So, while it coexisted with an important trend, it was not individually important in directing it and thus does not rise to a level of historic significance under the criterion.

5.2.2. Criterion B/2

A drinking water or wastewater system that is closely associated with an individual of historic importance may be found eligible for listing in the national and/or state register under Criterion B/2. Standards of significance under Criterion B/2 are very specific and relatively few properties meet them. Eligible properties must be associated with the productive life of the historically important individual and must be the best representation of the person's historic contributions. NRHP guidelines emphasize that Criterion B is only applicable to the achievements of individuals, not groups of persons. Further, if an individual's association with a property was through his or her role in its engineering design, this would be better captured under Criterion C/3 as the work of a master engineer.

A drinking water or wastewater system feature may have significance under this criterion if it is directly associated with a scientific, public policy, or social change that best represents the productive life of an historically important individual. This historic context has specifically identified individuals of importance within the context of the development of water sanitation including Thomas Logan, Charles Hyde, Wilfred Langelier, Chester Gillespie, and C. E. Grunsky, though other pioneering or influential individuals in the field may certainly exist. The association of one of these individuals with a property could confer historical significance under Criterion B/2 if their involvement was primarily in the realm of science or policy, rather than engineering, and if the property was an important one within the context of their career and contributions to their profession or field. Individuals must also be considered for importance at a local level and might be recognized for such actions as campaigning to extend sanitary services to a neglected community or adding protection for a natural resource.

Drinking water and wastewater systems do not commonly have strong, direct association with single individuals. They are instead usually the creation of municipal governments where credit and responsibility for the planning and construction of infrastructure are diffused among elected officials, city managers, and public works departments. Of the case studies, only the City of Redlands Henry Tate Water Treatment Plant had any potentially meaningful association with an identifiable individual. The city named the plant for Henry Tate, a long-term city employee who operated an earlier Mill Creek plant for 33 years. However, that association between Tate and the plant named for him was tangential. He had urged the city to construct a new treatment plant, but he retired prior to work beginning on the modern facility. He played no role in planning the plant and never worked there. In naming the new facility for Tate, the city council honored his decades of work at the former plant, but he did not make any direct contribution to the new facility. The plant thus lacked meaningful association with Henry Tate's productive life and is not significant under Criterion B/2.

5.2.3. Criterion C/3

A drinking water or wastewater system or water system feature that exhibits important engineering or design characteristics may qualify for listing in the national and/or state register under Criterion C/3. A property can qualify either by being an important representative example of its type, period, or method of construction, or by having unique value as the work of a master or one that possesses high artistic value.

A water system feature may qualify if it is the earliest, best preserved, or a rare surviving example of its type; if it introduced a design innovation; or if it represents a transition between different expressions of the property type. Examples could include a nineteenth-century sewerage pipe if it is of a type that survives in few locations; an early trickling filter that shows transition between fill-and-drain practices and later continual spray methods; or the first water softening plant constructed in the state. Trade press publications can help to determine if a property was innovative for its time or exceptional for its size, expense, design challenges, unique combination of features, or in some other way. To be considered a good representative of its type, a property must possess "distinctive characteristics" that illustrate either a pattern of features common to the type or an important variation on the common features. It should be kept in mind that many water systems followed standard designs that were widely constructed. It is thus necessary to compare the subject property to other similar surviving examples to establish its importance as a representative of its type.

A water system feature can be significant as the work of a master if it was designed by a figure of acknowledged greatness in the field and is an important example of their work. The individuals listed in Criterion B/2 above were all major figures in the field of sanitary engineering who worked at times as consultants in designing drinking water and wastewater systems. Research will reveal other designers whose importance is evident by the number and types of projects they engaged in or by the testimony of their contemporaries. Not every building or structure designed by a master has historic importance, and it is necessary to situate the evaluated property within the context of the individual's body of work to determine if it was one of their highest achievements or marked an important phase of their career.

A property with high artistic value is one that articulates a particular concept of design so well that it expresses an aesthetic ideal. While many water systems features were of utilitarian design, it was not uncommon for municipalities to carefully consider issues of architectural style when constructing buildings and structures that required considerable public investment and represented a commitment to the civic good. In general, the styling of water systems followed architectural trends employed in other contemporaneous public or utility buildings, using, for example, Neoclassical design around the turn of the century, the Art Deco style in the 1930s, and Modern styles in the 1940s and later. A water system feature might have significance for its design if it expressed one of these styles with a purity of form and a level of sophistication that exceeded that used in other comparable buildings. A property would not qualify if it made superficial use of a style or was of only average execution.

Not all features of drinking and wastewater systems are equally likely to possess significance under this criterion. Some water system components perform routine functions that remain consistent across treatment eras without showing more than incremental refinement. These include such features as sewer lines, waterline laterals, service connections, and wells. Technological innovation is more likely to be found in the principal components of treatment plants and in such property types as large water storage towers. Ubiquitous property types that were constructed using common designs and materials for their era are highly unlikely to be significant for their engineering. Note, however, that if the significance was for architectural styling, then even the most common storage shed could share in the design and contribute to the property's significance. Additionally, these features may contribute to the significance of a larger historic property (such as a historic district; see below) comprised of multiple elements working in concert as part of a larger system.

The case studies all required careful consideration of their potential significance under Criterion C/3, but none ultimately rose to a level of historic significance for their engineering innovations or architectural merit. The Yountville Wastewater Reclamation Facility, as first constructed in 1940, employed a "Biofiltration System" that was a patented modification of existing trickling filter technologies. Sanitary engineer Harry Jenks, a former student of Charles Hyde at UC Berkeley, developed the technology through the late 1920s before bringing it into commercial production in 1936. The equipment installed at Yountville was the seventeenth Biofiltration System to be installed in the United States and came four years after the commercial introduction of the technology. Had the evaluated equipment been the first of its kind, it might qualify for significance as an engineering innovation. As the seventeenth such system, however, it lacks importance as an early or influential example of its type.

Both the Redlands and Pleasanton case studies had control buildings that were attractive and well-designed examples of Modernist architecture (see **Figures 64** and **79** above). The architectural firm of Kitchen and Hunt designed the Pleasanton pumping station and the firm's partners had potential to qualify as master architects for their work on large-scale projects, including most notably the 1960 winter Olympic games at Squaw Valley (known today as Palisades Tahoe). However, neither case study building was particularly elaborate or architecturally ambitious, and this is to be expected of essentially utilitarian buildings at municipal drinking water facilities. In both cases, the architects responsible for the building did more creative work elsewhere, and these control buildings did not stand out as major works or represent important aspects of their careers. Both buildings thus lacked historic significance under Criterion C/3.

5.2.4. Criterion D/4

Drinking water and wastewater systems may be eligible for listing under Criterion D/4 if they are likely to yield information important to the study of history or prehistory. The properties most commonly found eligible under Criterion D/4 are archaeological sites, though historic built-environment features might also qualify for their information potential. These properties must be situated within an appropriate historic context, and they must possess the potential to answer specific important research questions through a study of their physical features. Potentially relevant research issues for water system features include those related to vernacular practices and construction methods and might apply to indigenous, Spanish, Mexican, and early Euro-American systems. For instance, remnants of drinking and wastewater infrastructure from nineteenth century California may exhibit a local variation of a standard construction technique and provide insight into the availability of materials or construction expertise at a time when drinking and wastewater infrastructure were more localized and potentially non-standard. In order to make such a determination, construction dates would need to be ascertained using either the built-environment or archaeological record to identify associated temporally sensitive architectural elements of standing resources, documentation in primary sources, and/or temporally sensitive artifacts.

Certain water sanitation systems may possess research value for their associations with other types of resources. As the use of water and disposal of waste are essential to every form of settlement and most economic activities, establishing the location and time period of a water feature's use may aid in the broader study of a region's development.

However, oftentimes the archaeological remnants of water and waste disposal features or the material culture of the people that operated these systems, do not contain enough data to impart new knowledge about the design or operation of a facility. As at the Mokelumne Hill Sanitary District Treatment Plant (see Appendix A-4), this mid-twentieth century waste disposal plant operated a standard Imhoff Tank and leach fields along the contours of the surrounding area to treat the small, Sierra Foothills town's waste before it entered Mokelumne Creek (**Figure 110**). The material culture (artifacts) present on site was minimal and was the result of incidental use of the facility after it had been abandoned, rather than associated with the operation and maintenance of the facility itself.

Figure 110. Overview of the 1947 Mokelumne Hill Sanitary District Treatment Plant.

Similarly, the 1920s-era Mill Creek Filtration Plant in Redlands (see Appendix A-5) was of a simple, utilitarian design of that era that is documented in archival sources and historic-era newspapers (**Figure 111**). The Works Progress Administration (WPA) labor that was used in the 1938 flood repairs of the facility was not evident in the material culture as the WPA crews resided off-site and closer to other areas of the region that were affected by flooding and in need of repairs. Again, artifacts identified on site appeared to be the result of incidental occasional visits to the facility, rather than directly related to the construction, maintenance, or operation of the facility.

Figure 111: Overview of the filtration plant at the Mill Creek Filtration Plant, Redlands.

5.2.5. Integrity

Working drinking water and wastewater systems will almost invariably have been altered to meet expanded demand, incorporate new technologies, replace worn-out components, and comply with changing regulations. Over time, these incremental changes leave most working systems with few original components that have not been modified or expanded. It is thus critical that evaluators carefully consider the integrity of historically significant systems and components under consideration. Even when systems meet one or more NRHP/CRHR criteria for significance, they will be ineligible for listing by state and federal standards if they do not retain the integrity needed to convey the significance they may once have possessed.

To retain historic integrity, a system must possess at least several, and usually most, of the seven aspects of integrity: location, design, setting, materials, workmanship, feeling, and association. Determining which of these aspects are most critical to a property requires clearly defining why the property is important and the time period (period of significance, see below) of that importance. The evaluator must weigh the cumulative loss of integrity across the seven aspects, balancing each by its relative importance, and arrive at a conclusion to what is ultimately a yes-or-no question: Does the resource retain adequate integrity to its period of significance to convey its significance? An answer of “yes” makes a significant resource eligible for listing in the NRHP and/or CRHR, while a “no” answer means that the resource is ineligible for listing in either register despite having historical significance.

As with other types of historic properties, the fundamental test of the integrity of a drinking water or wastewater system consists of the relationship between its current appearance and its appearance during the period of significance, which the evaluator will establish after placing the resource in its appropriate historic context and determining which significance criterion or criteria it meets. Integrity will not be lost as the result of modifications made during the system’s period of significance, and indeed, these alterations may actually contribute to its importance if they illustrate the adaptability and evolving role of the property. Modifications made after the period of significance may adversely affect the resource’s integrity. However, these modifications must be assessed to determine if they are of a scope, scale, and nature sufficient to cause the loss of one or more aspects of integrity.

It will not always be possible to assess the integrity of underground resources. Construction plans or other documentary materials may record the type, age, and materials of below-ground pipes, vaults, and other such features, but it might not be possible to determine if the original items have been replaced or altered without exposing the resource through excavation. The evaluation may then contain language to indicate the uncertainty, noting that the resource would contribute to the significance of the larger property if it was constructed during the period of significance and maintains historic integrity to the period.

Not all alterations made to a system are of equal importance in assessing integrity. Changes that result from routine maintenance are usually less detrimental to integrity than are alterations made to the plant’s fundamental processes, and especially so when the changes affect only smaller, secondary components such as motors, pumps, electronic sensors, and computer systems. However, it is necessary to consider the cumulative effect of various additions and alterations over time. At the other extreme, replacing a major component of the treatment process, for example, replacing a septic tank with a separate clarifier and sludge digestor, would greatly degrade resource integrity of design and would likely disqualify it for listing in state and national registers.

5.2.6. Historic Districts

Drinking water and wastewater features may be evaluated as independent resources or as contributors to a historic district composed of related elements. A historic district consists of a significant concentration, linkage, or continuity of sites, buildings, structures, or objects that are interrelated visually or by function. A district may contain resources that are also individually eligible for listing or consist entirely of resources that lack individual distinction, but which achieve significance when grouped as a whole. A drinking water system district might consist of a treatment plant and related support features such as pumping stations and storage tanks, or of a series of wells that are united by common design and function. A district usually consists of a definable geographic area that is distinguishable from surrounding properties, but it may also be discontiguous (composed of two or more areas separated by nonsignificant areas) if the elements are spatially discrete and the space between them is not significant to the district. A discontiguous district may work well for a water system where the piped connections between resources are below ground and not of visual or historic importance to the district. Note, however, that if the district was significant for its engineering achievement and the subsurface pipe configuration or materials were an important part of that accomplishment, then the district might need to include the non-visible pipes within the property boundaries.

Drinking water features may also contribute to historic districts that are significant for reasons unrelated to water development. Indeed, the majority of California water features that have been determined eligible for listing in the NRHP and/or CRHR are of this type and owe their significance to the role they played in a larger enterprise rather than for their merits as engineered water features per se. Examples of this include the water system and sewage treatment plant within the Sonoma State Home Historic District and the water treatment plant in the Presidio National Historic Landmark

District.[359] It is thus always necessary to consider how water or sewage infrastructure was used in the pursuit of other economic, social, and cultural ends and to assess if the larger context has independent historic importance.

5.3. Eligibility Details

If a drinking water or wastewater system appears to be eligible for NRHP and/or CRHR listing, then the following details of property boundaries, level of significance, period of significance, and contributing and noncontributing components must be specifically identified and listed.

5.3.1. Property Boundaries

A historic drinking water or wastewater system's boundaries should be selected to encompass the full extent of contributing components, while excluding noncontributing elements that might reasonably be considered independent of the resource. In most cases, the entirety of a treatment plant should be included within the property boundary if the facility functions or functioned as a single unit. Noncontributing components within that boundary should be designated as such, but the boundary should not be artificially drawn to exclude the noncontributing elements. If a large number of noncontributing elements exist within the plant boundary, the resource might lack the necessary integrity for eligibility. Exceptions to this general guidance may exist where there is a clear spatial and operational distinction between older and newer portions of a plant.

Isolated property types such as wells or pumping stations may be given their own individual property boundaries or be grouped with like resources in the area. For instance, a series of wells that feed into a single disinfection plant might be treated as a well field with a property boundary encompassing all the well heads. An eligible infiltration gallery or length of sewage pipe could be treated as a linear resource.

[359] JRP, "Historical Resources Inventory and Evaluation Report, Sonoma Developmental Center," 2018; Architectural Resources Group, "Presidio Water Treatment Plant," Historic American Engineering Record (HAER) No. CA-155, July 1994.

While the system's setting can contribute to the property's integrity, the setting is by definition outside the boundaries and should not be included as a specific component of the resource.

5.3.2. Level of Significance

Significant resources will be associated with aspects of history important at the local, state, or national level. The level of significance reflects the resource's primary claim to importance. For example, a treatment plant that was the first of its kind to be built in California, but which was preceded by several similar facilities around the country, would likely have state-level significance. A plant that made early (but not first) use of advanced nutrient removal technologies, but which was most important for its beneficial environmental impact on a nearby waterway, would likely have significance at the local level.

5.3.3. Period of Significance

The period of significance will encompass the span of time when the property was associated with the aspect of history that gives it importance, or when it attained its important physical qualities or characteristics. Care should be taken in assigning a period of significance because it becomes the benchmark for measuring whether changes are part of the property's history or constitute a loss of integrity.

The period of significance begins with the construction date or the earliest important activity of which tangible historic characteristics remain today. It ends with the date when the important event, activities, or construction ended. Resources eligible under Criterion A/1 will have a period of significance tied to the dates of the important events, while those eligible under Criterion C/3 generally use the date or span of dates of construction. If the important event lacks a clear end date, as for example with the introduction of advanced wastewater treatments, then the period of significance might include only the beginning of treatment or extend through a period of trial and adjustment, if such can be identified through research and analysis.

To be eligible, a resource must normally be over 50 years old and have achieved its significance within the period that ended 50 years ago. If the resource is younger or its period of significance is extended into the last 50 years, then it must meet NRHP Criteria Consideration G for exceptional significance. This could apply to a drinking water or wastewater system that was associated with an event of extraordinary importance. Such resources are exceedingly uncommon and would likely require that the resource have been involved in a pivotal scientific breakthrough, public health catastrophe, major social justice campaign, or other event of unquestionable historic importance.

5.3.4. Contributing and Noncontributing Components

When a drinking water or wastewater system is evaluated as an eligible district or as an individually eligible property with multiple components (as with a treatment plant), contributing and noncontributing elements must be identified. Contributing buildings, structures, objects, and sites (inclusive of landscape elements) are those components associated with the resource’s period and area of significance, and which also possess an adequate level of integrity. Noncontributing components would be those that lack association with the resource’s documented significance, were not present during the period of significance, or have lost integrity to the period of significance and no longer convey the important historic character of the larger resource. For a historic district to be eligible, it must contain a high proportion of contributing to noncontributing elements.

6. CONCLUSIONS AND MANAGEMENT SUGGESTIONS

The history of drinking water and wastewater treatment is surprisingly short. Though there are ancient antecedents for piping water into and removing waste from cities, modern drinking water chlorination and the biological treatment of sewage emerged only at the start of the twentieth century. Recording and preserving this history is an important part of acknowledging the progress made. That history reflects important, though underrecognized, contributions from university scientists, public health officials, and community advocates laboring in an unglamorous field. The development or neglect of public infrastructure also speaks to underlying issues of ethnicity, class, and community power that form the broad patterns of California history. It is the hope that this historic context and evaluation guidance will encourage archaeologists and architectural / built-environment historians to treat water and sewage utilities as central components of community life that reveal much about their time and place.

6.1. Preservation Goals and Priorities

The following section provides a broad framework for prioritizing recordation and preservation efforts for drinking water and wastewater systems. The intent of this section is to help evaluators recognize when their property might be of a high priority type for state or local recognition. It is hoped that it might also prompt proactive identification, recordation, and evaluation of high priority properties. This section, like the historic context, is organized by era.

6.1.1. Nineteenth Century

All nineteenth century drinking water and wastewater systems should be fully and carefully recorded. Written documentation and construction plans are less common to this era than in later times and the physical properties are important sources of information. Construction techniques had not yet been standardized and considerable regional and local variation existed in practice, so even common property types may yield useful comparative information. Much of this work will take the form of historical archaeology as most of the systems have been long since abandoned.

Distinctive works of this era that warrant strong consideration for inclusion in the NRHP and CRHR include the water systems of Spanish and Mexican-era California, the combined sewerage systems in Northern California, and sewerage farms. Less distinctive systems may also have importance if they include unusual materials such as wood-stave pipe or automatic flushing units. Sewage farms are of particular historical interest as they were an early form of wastewater recycling that has contemporary relevance. A sewage farm is likely to have relatively few built-environment elements so its recordation may focus more on landscape features and spatial relationships. Historians or archaeologists recording nineteenth century settlements such as ranches, labor camps, or townsites should pay particular attention to water and sanitation systems to document the evolution of practices and technologies.

6.1.2. Early Twentieth Century

The pioneering works of modern sanitary engineering from the early twentieth century should be identified, recorded, and preserved when feasible. Through the nineteenth century, California had followed established sanitation practices, but with the creation of a department of sanitary engineering at UC Berkeley in 1905 and the State Bureau of Sanitary Engineering in 1915, the state moved to the forefront of innovation. Californians constructed early and important activated sludge plants (as, for example, at the Pasadena Tri-City Facility and Folsom State Prison), tricking filters (Reedley), and water softening facilities (La Verne). These early works were often experimental in nature and showed variations on designs that would later take a more standardized form. Works that were first examples of a particular technology in the state are a high priority for preservation. Some of these are no longer extant, as with the Pasadena Tri-City activated sludge pilot project facility, but others, such as the first full-scale activated sludge plant at Folsom Prison, appear to remain in a condition that would allow for recordation and preservation.

At a local level, the recordation and preservation of early-twentieth-century facilities provides an opportunity for communities to trace the development of their public health systems. Municipalities commonly organized for the express purposes of providing public water and sanitation services. As treatment plants and their associated supply and distribution systems are utilitarian in function and often in appearance, there has been a tendency to underappreciate them as examples of civic formation and growth. Priority of effort at a local level should go to early works that spurred incorporation, the first generation of treatment plants, buildings and structures with architectural distinction showing a public investment in civic beautification, and facilities funded by New Deal public works programs as examples of federal investment at a local level.

6.1.3. Latter Twentieth Century

Historical features of post-World War II plants should be carefully considered during modernization projects. The first generation of treatment plants constructed in response to the environmental laws of the mid-1970s (for example, at Lake Tahoe and the Santee County Water District) are only now beginning to approach the age for historic evaluation, and many of these facilities remain in use. Evolving technology and treatment standards require that equipment be regularly updated, but care should be taken that historically important features, such as those described below, are not lost in the process. The history of this era continues to be written and evaluators should be alert to new knowledge and changing interpretations. Properties of high priority include those that introduced new technologies and pioneered practices such as desalination and wastewater recycling. Projects that expanded service to previously neglected communities or were integral to environmental restoration efforts could also be of high priority.

6.2. Resolution of Adverse Effects

Federal and state regulations require that public agencies identify the significant environmental impacts of their actions and either avoid or mitigate those impacts. The federal requirements are contained within Section 106 of the NHPA of 1966, as amended, and its implementing regulations under CFR, Title 36, Part 800. The state regulations are detailed in the Guidelines for Implementation of the CEQA in the California Code of Regulations (CCR), Title 14, Chapter 3.

Both federal and state regulations define adverse effects for historical resources in similar terms. 36 CFR 800.5 (a) (1) states:

> An adverse effect is found when an undertaking may alter, directly or indirectly, any of the characteristics of a historic property that qualify the property for inclusion in the National Register in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association.

Specific examples of adverse effects, as listed in 36 CFR 800.5 (a) (2), include the following:

(i) Physical destruction of or damage to all or part of the property;

(ii) Alteration of a property, including restoration, rehabilitation, repair, maintenance, stabilization, hazardous material remediation, and provision of handicapped access, that is not consistent with the Secretary's standards for the treatment of historic properties (36 CFR part 68) and applicable guidelines;

(iii) Removal of the property from its historic location;

(iv) Change of the character of the property's use or of physical features within the property's setting that contribute to its historic significance;

(v) Introduction of visual, atmospheric or audible elements that diminish the integrity of the property's significant historic features;

(vi) Neglect of a property which causes its deterioration, except where such neglect and deterioration are recognized qualities of a property of religious and cultural significance to an Indian tribe or Native Hawaiian organization.

The CCR, beginning with Section 15064.5(b), defines significant impacts for historical resources as a substantial adverse change in the significance of an historical resource that results from “physical demolition, destruction, relocation, or alteration of the resource or its immediate surroundings such that the significance of an historical resource would be materially impaired.”

When an undertaking includes one or more adverse effects, federal regulations under 36 CFR 800.6 require that the agency "develop and evaluate alternatives or modifications to the undertaking that could avoid, minimize, or mitigate adverse effects on historic properties." At the state level, CCR Section 15091 similarly requires that "changes or alterations" be incorporated into the project that "avoid or substantially lessen the significant environmental effect."

A project may generally avoid an adverse effect by following the Secretary of the Interior's Standards for the Treatment of Historic Properties (SOI Standards). The SOI Standards for Rehabilitation are as follows:

1. A property will be used as it was historically or be given a new use that requires minimal change to its distinctive materials, features, spaces, and spatial relationships.
2. The historic character of a property will be retained and preserved. The removal of distinctive materials or alteration of features, spaces, and spatial relationships that characterize a property will be avoided.
3. Each property will be recognized as a physical record of its time, place, and use. Changes that create a false sense of historical development, such as adding conjectural features or elements from other historic properties, will not be undertaken.
4. Most properties change over time; those changes that have acquired historic significance in their own right shall be retained and preserved.
5. Distinctive features, finishes, and construction techniques or examples of craftsmanship that characterize a property shall be preserved.
6. Deteriorated historic features will be repaired rather than replaced. Where the severity of deterioration requires replacement of a distinctive feature, the new feature will match the old in design, color, texture, and, where possible, materials. Replacement of missing features will be substantiated by documentary and physical evidence.

7. Chemical or physical treatments, if appropriate, will be undertaken using the gentlest means possible. Treatments that cause damage to historic materials will not be used.
8. Significant archeological resources affected by a project shall be protected and preserved. If such resources must be disturbed, mitigation measures shall be undertaken.
9. New additions, exterior alterations, or related new construction will not destroy historic materials, features, and spatial relationships that characterize the property. The new work shall be differentiated from the old and will be compatible with the historic materials, features, size, scale and proportion, and massing to protect the integrity of the property and its environment.
10. New additions and adjacent or related new construction will be undertaken in such a manner that, if removed in the future, the essential form and integrity of the historic property and its environment would be unimpaired.[360]

When an adverse effect cannot be avoided, it should be minimized, and when appropriate, mitigated. The project lead agency and the State Historic Preservation Officer (SHPO) will jointly determine the appropriate mitigation measures, and these will be stipulated in a Memorandum of Agreement (MOA). Potential mitigation measures may include, but are certainly not limited to, the following possibilities:

1. Documentation of the property to the standards of the Historic American Buildings Survey (HABS) and/or Historic American Engineering Record (HAER). The documentation would include large format photography, reproduction of historic construction plans, archival research, and a detailed report on the property history.

[360] U.S. Department of the Interior, National Park Service, *The Secretary of the Interior's Standards for Rehabilitation & Illustrated Guidelines for Rehabilitating Historic Buildings* (Washington D.C.: U.S. Government Printing, 1997), v.

2. Conducting archaeological data recovery excavations to document the important archaeological features and artifacts associated with the property, that may contribute to our understanding of history (if the property is eligible under Criterion D/4)
3. Preparing a NRHP Nomination Form to formally list the property in the National Register.
4. Contributing to public education through development and installation of interpretive panels at or near the historic property.
5. Installing exhibits or presentations at a local museum or historical society.
6. Developing an interpretive website documenting the resource.
7. Preparing booklets or pamphlets/brochures for distribution to visitor centers, local historical societies, museums, and/or public libraries.
8. Producing a documentary focusing on the planning, design, construction, and operation of the resource.

6.3. Recommendations for Future Work

We conclude this report with three recommendations for future work that may build upon the foundation laid here.

6.3.1. Multiple Property Nomination

The development of a National Register Multiple Property Documentation Form (NPS 10-900-b) for drinking water and/or wastewater systems in California would facilitate the recordation and nomination of these resources. The form is a cover document that serves as the basis for evaluating the NRHP eligibility of properties that are related by historic context and property types. It provides a written historic context narrative that details the thematic framework uniting the properties and offers a compendium of property types. This information must be detailed enough to support the historic context statements for individual properties, establish relationships between related properties, and assess their relative importance.[361]

The Multiple Property Documentation Form streamlines the nomination process because the cover document provides much of the context for evaluation, which then does not have to be repeated in individual forms. The form may be used to nominate a related group of historic properties simultaneously or to establish the registration requirements and evaluation criteria for properties that may be nominated in the future. The nomination of individual buildings, structures, objects, sites, or districts is made on a National Registration Form (NPS 10-900). The term for a thematic group is a Multiple Property Listing (MPL), and the combination of the Multiple Property Documentation Form together with individual registration forms is referred to as a Multiple Property Submission (MPS). MPLs have been prepared in California around such themes as African Americans in Los Angeles, Civilian Conservation Corps in California State Parks, and Historic Highway Bridges, Light Stations, and US Post Offices in California.

This historic context report has already provided most of the information required for writing a Multiple Property Documentation Form. Decisions would need to be made about the scope of the document. For example, would drinking water and wastewater facilities be treated together or separately, and should the document focus on treatment plants alone or include entire systems of supply, treatment, and distribution? It would also be appropriate to identify at least an initial group of important properties to be nominated to the National Register as an MPS. A challenge of using the Multiple Property Documentation Form for these resource types is that the process naturally focuses on the comparative importance of properties at a fairly high regional or state level. It is less useful for assessing the local importance of a resource, where a comparison to like property types in other communities may not reveal its purely local significance. The multiple property process would also not identify drinking water or wastewater facilities that had significance as contributing components to a historic

[361] See U.S. Department of the Interior, *National Park Service, National Register Bulletin 16B: How to Complete the National Register Property Documentation Form* (Washington D.C.: U.S. Government Printing, 1991, Revised 1999).

district that was historically important for reasons not centrally related to water resource development, as for example with state hospitals or military bases.

6.3.2. Specific Narrower Historic Contexts

This report was necessarily broad in scope to cover a wide timeframe, expansive range of historic issues, and diversity of property types. Many subjects touched upon in this report warrant more detailed study than could be reasonably offered here. These topics include the design and construction of facilities by the Bureau of Sanitary Engineering, sanitation experiments and plant development at public institutions such as prisons and universities, the historic use of lead piping in California, the intersection of sanitation and environmental and social justice campaigns, and architectural merits of a specific subject property. Topics such as these might also provide the basis for an MPL, as for example one that identified and nominated the most important works completed by staff of the Bureau of Sanitary Engineering.

6.3.3. The Recent Past

By convention, public historians generally define historic-age resources as those 50 years old or older.[362] That takes the historic age, at the time of this report's preparation, to 1973. This is shortly after the enactment of the Clean Water Act in 1972 and slightly before passage of the Safe Drinking Water Act in 1974. These two federal measures spurred the modernization of drinking water and wastewater systems and introduced new treatment standards, methods, and technologies. This report has covered those developments so that it may be useful for the evaluations that will soon need to be performed for the facilities that were constructed in the mid and late-1970s. However, in covering this more recent era, the report did not have the benefit of a body of secondary historical literature that could place developments in a well-developed larger context.

[362] According to National Register guidance, "Fifty years is a general estimate of the time needed to develop historical perspective and to evaluate significance." See: U.S. Department of the Interior, National Park Service, *National Register Bulletin 15: How to Apply the National Register Criteria for Evaluation* (Washington, D.C.: U.S. Government Printing, 1997), 41.

Academic historians have written numerous, valuable studies of American sanitation practices, but these monographs tend to conclude around the time of World War II. The more recent past is currently visible primarily in primary sources and in the sort of career retrospectives written by practitioners in the sanitary engineering fields. As the 1970s recede deeper into the past, professional historians will increasingly turn their attention to the era, and studies of the period’s public health development will eventually be written. Evaluators of facilities from that time need to remain alert to new scholarship, and this study would benefit from being updated to incorporate fresh information and perspectives.

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APPENDIX A

PRIMARY RECORD

Primary # ______
HRI # ______
Trinomial ______
NRHP Status Code 6Z

Other Listings ______
Review Code ______ Reviewer ______ Date ______

 ***Resource Name or #** (Assigned by recorder): Henry Tate Water Treatment Plant

P1. Other Identifier: City of Redlands Henry Tate Water Treatment Plant

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County**: San Bernardino
and (P2b and P2c or P2d. Attach a Location Map as necessary.)
***b. USGS 7.5′ Quad**: Yucaipa, CA **Date**: 2021 **T**:15N; **R**:2W; **Sec**: 22; Mount Diablo Meridian
c. Address: 3050 Mill Creek Road City: Mentone Zip: 92359
d. UTM: (give more than one for large and/or linear resources) Zone: _____; ______mE/ ______mN
e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)
Assessor Parcel Number (APN): 302-171-06

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)

This form serves to record and evaluate the Henry Tate Water Treatment Plant in the City of Redlands, San Bernardino County. The facility is located on Mill Creek Road, south of the Mill Creek floodplain and approximately six miles east of downtown Redlands (see **Location Map**). The drinking water treatment facility consists of a control building, a rapid sand filter bed, two clarifiers, three sludge drying beds, a washwater settling basin, two storage reservoir tanks, a blower building, and several other ancillary buildings and structures (**Sketch Map**). The control building (**Photograph 1**) has a generally rectangular footprint, approximately 34 feet by 105 feet, with a partial-width, central projection on its north façade. It has a flat asphalt roof with boxed eaves. The reinforced-concrete building is of post-and-beam construction with precast concrete columns and beams at frieze and plinth level. The regularly spaced beams are articulated only on the north façade, where they project slightly beyond the wall surface. Sandblasted concrete panels fill the structural grid and the exposed aggregate gives texture to the walls. Metal signage identifying the plant is on the west wall. The raised building foundation has a façade of river stones collected from Mill Creek. (See Continuation Sheet.)

***P3b. Resource Attributes:** (List attributes and codes) HP9—Public Utility Building; HP11—Engineering Structure

***P4. Resources Present:** ☒ Building ☒ Structure ☐ Object ☒ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5a. Photo or Drawing (Photo required for buildings, structures, and objects.)

P5b. Description of Photo: (View, date, accession#) **Photograph 1.** Henry Tate Water Treatment Plant, control building; facing southeast; November 16, 2022.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
1967-1968 (*Redlands Daily Facts*, April 13, 1968, 3)

***P7. Owner and Address:**
City of Redlands
35 Cajon Street
Redlands, CA 92373

***P8. Recorded by:** (Name, affiliation, address)
David Hickman and Bryan Larson
JRP Historical Consulting, LLC
2850 Spafford Street
Davis, CA 95618

***P9. Date Recorded**: November 16, 2022

***P10. Survey Type:** (Describe)
Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") None

***Attachments:** ☐ None ☒ Location Map ☒ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record
☐Other (list) ______

Primary #
HRI #

BUILDING, STRUCTURE, AND OBJECT RECORD

***NRHP Status Code**: 6Z

***Resource Name or #** (Assigned by recorder): Henry Tate Water Treatment Plant

B1. Historic Name: Henry Tate Water Treatment Plant
B2. Common Name: Tate Plant
B3. Original Use: Drinking Water Treatment B4. Present Use: Drinking Water Treatment
***B5. Architectural Style**: Modernist Post and Beam, Utilitarian
***B6. Construction History**: (Construction date, alteration, and date of alterations) Built in 1967- 1968; second settling basin and reservoir added in 1986; wash water recovery basin, sludge pond, and blower building added between 2004-2005.
***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown** **Date:** ______ **Original Location:** ______
***B8. Related Features:** ______
B9. Architect: Neste, Brudin and Stone; James E. Calkins b. Builder: Allied Mechanical Contractors
***B10. Significance: Theme**: N/A **Area**: N/A
Period of Significance: N/A **Property Type**: N/A **Applicable Criteria**: N/A
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

The Henry Tate Water Treatment Plant does not meet the criteria for listing in the National Register of Historic Places (NRHP) or the California Register of Historical Resources (CRHR), and it is not a historical resource for the purposes of California Environmental Quality Act (CEQA). This resource has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code. (See Continuation Sheet.)

B11. Additional Resource Attributes: (List attributes and codes) ______

***B12. References**: Department of Public Health, Bureau of Sanitary Engineering, "Redlands Sanitary Survey," (1955); Ron Kibby, "Mill Creek water plant to start flowing through treatment plant Monday," *Redlands Daily Facts*, April 13, 1968, 3; Glenn Cunliffe, "The city's water system, there are problems and solutions," *Redlands Daily Facts*, April 9, 1982, 1; See also footnotes.

B13. Remarks:

***B14. Evaluator**: David Hickman
***Date of Evaluation**: May 2023

(This space reserved for official comments.)

(Sketch Map with north arrow required.)

See Continuation Sheet.

P3a. Description (continued):

The main entrance is at the building's northwest corner in a recessed porch (**Photograph 2**). The entrance consists of double metal doors fully framed by plate glass set into metal frames. The window wall wraps around the north corner of the entrance, where it is covered by a louvered metal grate. A projecting roof corner shelters the porch and is supported by an exposed column and beam. A secondary entrance at the building's northeast side provides access to a chlorine storage dock (**Photograph 3**). Metal gates secure the dock and a set of concrete steps with metal railings provide access. Double hollow-metal doors open into the building from the above-grade dock. A third entrance with a hollow-metal door is located on the building's rear (south) side, opening onto the sand filter deck (**Photograph 4**). The building has no windows other than at the main entrance.

The control building's architectural motifs continue in the principal interior spaces of the lobby and conference room (**Photographs 5** and **6**). The columns and beams are left exposed in these spaces and some walls are of sand-blasted concrete with visible aggregate texture. A waterfall feature, encased in glass, is located in the partition wall between the lobby and conference room. A memorial plaque for Henry Tate, the long-term city water plant operator, is wall-mounted in the lobby. The other office (**Photograph 7**) and laboratory (**Photograph 8**) rooms have drywall, tile floors, and drop ceilings, some with acoustic tiles. The east end of the control building serves treatment functions with a chemical storage and dosing room, where the water is tested and chlorine administered (**Photographs 9** and **10**). The one-ton chlorine canisters are held within modern containment vessels on the partially enclosed loading dock at the building's northeast corner. An overhead crane rail and modern loading system assist with chlorine deliveries (**Photograph 11**). The basement of the building contains the filter gallery with piping and pumps to operate the rapid sand filters located above (**Photograph 12**).

Raw water entering the plant from the Mill Creek pipeline first has chemicals injected for disinfection and to aid in coagulation, pH (acidity) adjustment, and the removal of dissolved minerals. Modern digital equipment controls the dosage administration in the treatment room of the control building (see **Photograph 10**). Storage tanks outside the control building hold additional chemical supplies to reduce the frequency of deliveries. These modern tanks are located in a concrete structure that was completed in 2016 (**Photograph 13**). The chemicals blend with the influent in a below-ground mixing basin with fixed baffles.

From the mixing basin, water flows to a splitter box (**Photograph 14**) that sends the water to one of two circular clarifier tanks, each 106 feet in diameter and 26 feet tall, though the majority of the structures sit below grade (**Photograph 15**). These reinforced concrete structures, also known as sedimentation tanks or settling basins, still the water to allow sediment to settle out of suspension. The clarifier superstructures, including the bridges, hubs, and rakes, were replaced in 2016 (**Photograph 16**). The rakes rotate slowly around the hub to collect and remove deposited sediment.

After clarification, water passes to a bank of four rapid sand filters to cleanse it of remaining suspended matter. Water enters the beds from above and stands at a specified height required to generate the pressure to force the water through beds of graded sand, gravel, and anthracite coal (**Photographs 17** and **18**). Clear wells beneath the beds collect the treated matter, where it may again be chlorinated if needed before being released into the distribution main. The filters quickly accumulate material and need to be backwashed daily. Backwashing reverses the flow, forcing water up through the filter beds, suspending the sand, gravel, and anthracite in a churning mix to clean them. The half-pipe troughs remove the backwash water without capturing any of the filter media (**Photograph 19**). Blowers drive air through the suspended beds to enhance the cleaning. A modern corrugated metal building, constructed in 2016, houses the blower equipment (**Photograph 20**).

Sludge collected from the clarifiers and backwashing of filters is sent to drying beds for dewatering prior to disposal (**Photographs 21** and **22**). These beds are concrete lined and accessed by ramps. A washwater recovery basin is sited between the control building and the sludge drying beds (**Photograph 23**). The concrete-lined bed allows for sediment to settle out of the backwashing water before it is recycled.

Two above-ground reservoirs that hold water for the backwashing process are located on a hillslope rising above the plant's east edge. Both cylindrical metal tanks, approximately 49 feet in diameter, were installed in 2016 to replace earlier equipment (**Photograph 244** and **25**).

10. Significance (continued):

The City of Redlands constructed the Henry Tate Water Treatment Plant in 1967-1968 to replace an early filter plant located within the Mill Creek floodplain. The treatment plant was expanded in 1986 and overhauled in 2004 to modernize operations and increase its capacity.

Historic Context

The development of the Redlands area has been closely tied to the management of water in the semi-arid climate of Southern California. Spanish missionaries from the Mission San Gabriel established an agricultural outpost at Guachama in 1819, just west of the area that later developed as the City of Redlands. At the direction of the missionaries, the indigenous Serrano inhabitants constructed an irrigation ditch to run from Mill Creek to the fields. Known as the Mill Creek Zanja, this canal provided essential water for crop irrigation, livestock, and domestic needs. It became a defining feature of nineteenth-century Redlands and is now a recognized historical landmark, symbolizing the significance of water management in the San Bernardino Valley and the resourcefulness of early residents. When Mormon colonists settled the area in 1851, they constructed a second ditch to bring water from the Santa Ana River, north of Mill Creek. Settlers living along both ditches shared water rights and coordinated diversions through an informal and cooperative process.[1]

In 1881, E. G. Judson and Frank E. Brown platted the town of Redlands. Understanding that the success of their settlement depended on water availability, they also established the Redlands Water Company to expand the ditch network and acquire additional water sources. They completed the Bear Valley Dam to store and divert waters on the Santa Ana River in 1885, leading to a boom in citrus orchards throughout the valley. By the time the city incorporated in 1888, a substantial water system was already in place, serviced by private water companies and a network of ditches and reservoirs. In 1912, the city took ownership of its municipal water supply by purchasing the Domestic Water Company and elements of the Redlands Water Company. They also drilled a series of municipal wells. In 1926, a bond issue enabled the city to acquire 45 percent of the Mill Creek water supply rights and construct a water treatment plant in the river floodplain north of the modern Henry Tate plant.[2]

The Mill Creek Treatment Plant, the remnants of which have been recorded separately, consisted of a sand filter plant, coagulation and aeration basins, a regulation tank, and supporting weirs, channels, and pipes, located within the river floodplain.[3] The location of the city's Mill Creek intake, about one-quarter mile above the Zanja head, allowed water to be distributed throughout the town via gravity flow, eliminating the need for pumping from wells or the Santa Ana River. However, the creek experienced dynamic seasonal flow patterns, leading to low water levels during the summer when demand was highest. Additionally, major winter storms occasionally made the water too turbid for treatment. The plant also repeatedly suffered damage during floods. Nonetheless, the creek provided nearly all the city's water through the winter months and between 20 and 50 percent during the summer. By the mid-1950s, the plant was in a deteriorated state and increasingly had to be taken offline during winter storms. At the urging of Henry Tate, the long-term water plant operator, city management began looking for a safer location and initiated the planning process for a new plant.[4]

Henry Tate Water Treatment Plant

In March 1965, Redlands hired the civil engineering consulting firm Neste, Brudin and Stone to make recommendations on a new water treatment plant. Norman A. Neste, a University of California, Berkeley engineering graduate, started the company

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[1] Architectural Research Group, "City of Redlands: Citywide Historic Context Statement," Prepared for City of Redlands, Development Services Department, August 15, 2017, 15-17, 24-28. The Zanja is California Historic Landmark No. 43, registered on August 1, 1932. It was listed in the NRHP on May 12, 1977, with Register No. 77000329.

[2] Architectural Research Group, "City of Redlands: Citywide Historic Context Statement," 17-28.

[3] AECOM, "Mill Creek Filtration Plant," California Department of Parks and Recreation (DPR) 523 form (draft), December 8 and 13, 2022.

[4] "The City's Water System, There are Problems and Solutions," *Redlands Daily Facts*, April 9, 1982, A1; California Department of Public Health, Bureau of Sanitary Engineering, "Redlands Sanitary Survey," April 1955, 4, Water Resources Center Archives, University of California, Riverside; "Water Treatment Plant Tops Needs," *Redlands Daily Facts*, October 8, 1966, 3; "Mill Creek Water Plant to Start Flowing Through Treatment Plant Monday," *Redlands Daily Facts*, April 13, 1968, 3.

in 1958 and took on John B. Brudin and Raymond V. Stone, Jr. as partners in the early 1960s. The Hemet-based firm analyzed the various filtering systems then in use at drinking water treatment plants and evaluated them for their technical and economic compatibility with the city's requirements. Their report recommended a rapid sand filter plant with an initial capacity of ten million gallons per day that was theoretically expandable to an ultimate capacity of twenty million gallons per day. The city had purchased a hilly parcel along Mill Creek Road adjacent to the Zanja crossing in 1954 as a potential site for a new facility. The consultants determined this to be the most advantageous location available, and the city annexed the property into the city boundaries in January 1966. In March, the City Council authorized the preparation of final construction drawings.[5]

Sand Filters

The plans prepared by Neste, Brudin and Stone called for four sand filter beds as the principal treatment equipment, with two clarifiers, a sludge drying bed, a reservoir, and a control building in supporting roles. British engineers had begun experimenting with sand filters in the early nineteenth century, and in 1829, a private water company in London constructed a sand filter that provided the world's first treated municipal water supply. These British filters, known as slow sand filters, differed in design and operation from the later rapid sand filters that became dominant in America in the early twentieth century, but they provided a model for subsequent developments.[6]

A slow sand filter consisted of a large watertight basin, generally of concrete, that contained a layer of sand of uniform small size over a bed of gravel with drainage tiles below. The slow percolation of water through the sand caused suspended materials to settle out, depositing a thin layer of sediment on the surface of the sand bed. When the sediment layer became too thick, the operators drained the tank, scraped off the top layer of sand, and began the process again with a fresh bed. The layer of sediment, known as *shmutzedecke* (German for "dirty skin"), functioned as a biofilm that digested organic matter in the water, serving to purify as well as clarify it, though the nature of this biological treatment was not understood in the nineteenth century. Because of their creeping rate of infiltration, slow sand filters required large basins of at least a quarter acre in size, with a half-acre or full acre being more common.[7]

Americans constructed their first slow sand filter in 1872 in Poughkeepsie, New York, and completed several similar plants throughout New England over the following decades. However, the design proved ill-adapted for American conditions where rivers were far more turbid than the sedate English streams. The filters rapidly choked on sediment, making them inefficient and uneconomical. In the 1890s, the eminent sanitary engineer George Fuller experimented with rapid sand filtration techniques in Louisville, Kentucky, to treat Ohio River water. By introducing a coagulant immediately prior to the sand filter, Fuller was able to process a large quantity of water in a relatively small tank. The coagulant caused small suspended particles to clump together in a mass known as floc and then settle out of the water column under gravity. However, the great quantity of floc that fell onto the sand bed required more frequent cleaning than did British slow sand filters, up to several times a day versus a monthly cleaning. To address this problem, Fuller adopted a system of backwashing that forced water under pressure up through the sand layer to cleanse it. This combination of features—small basin size, use of a coagulant, and backwashing—distinguished the American rapid sand filter from the predecessor models.[8]

Several decades of incremental improvement gradually refined Fuller's process until it operated with enough consistency and efficiency to be widely adopted. Much of the effort focused on improving the backwashing process to avoid forming mudballs that could clog the filter. In the 1920s, John Baylis developed a system of auxiliary scour that used horizontal water spray from a grid of pipes to enhance the cleaning action during backwashing. A decade later, the introduction of rotary sweeps improved the cleansing of the sand bed surface. Both scour types allowed for using aerated water, with air injected under

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[5] "Filter Plant Engineering to be Started," *Redlands Daily Facts*, March 4, 1965, 4; "Norman Arnold Neste [obituary]," *Pomerado News*, April 28, 2016,14; "Norman Arnold Neste (Civil Engineer)," *Pacific Coast Architecture Database*, accessed May 2023 at https://pcad.lib.washington.edu/person/2016/; "Step Taken Towards New Filter Plant," *Redlands Daily Facts*, March 2, 1966, 9; "Water Treatment Plant Tops Needs," *Redlands Daily Facts*, October 8, 1966, 3.

[6] Gary S. Logsdon, Michael B. Horsley, Scott D.N. Freeman, Jeff J. Neemann, and George C. Budd, "Filtration Process—A Distinguish History and a Promising Future," *Journal (American Water Works Association)*, Vol. 98, No. 3 (March 2006), 150–164.

[7] W. A. Hardenbergh, *Operation of Water-Treatment Plants* (Scranton: International Textbook Company, 1940), 174–175; John Goodell, *Water-Works for Small Cities and Towns* (New York: The Engineering Record, 1899), 185–192.

[8] Logsdon et al., "Filtration Process," 150–152.

pressure to enhance the scrubbing action. Researchers also adjusted the ordering of the filtration process, adding clarifiers, also known as sedimentation basins, ahead of the filtering which slowed the water and allowed larger matter to settle out, thus reducing the frequency of cleaning. By the late 1920s, the treatment chain of chemical coagulation, mixing, flocculation, clarifying, and then filtration became known as "conventional treatment" and was used wherever muddy surface rivers were a principal water source.[9]

The layout of municipal rapid sand filtration plants followed some general conventions, even as the particulars responded to the individual demands of the site, water source, available funding, and the decisions of the designer. Most large plants grouped small, rectangular, concrete tanks into two rows and placed a pipe gallery between the rows and beneath the floor of the tanks (**Figure 1**). During normal operations, the water level in the beds stood at a prescribed height to generate sufficient pressure to force the water through the filter beds. After trickling through the sand, gravel, and underdrains, the water filled a reservoir or clear-water well below the beds. During backwashing, water from an elevated tank was forced up through the filter beds and drained through the half-pipe troughs, which were set high enough to remove water without capturing any of the filter media. The plant operators generally piped the removed sludge to a drying basin, where the water content was drawn down prior to disposal. Small plants were more likely to use circular units of concrete or steel, and equipment manufacturers sold many such patented apparatuses ready for rapid assembly and use.[10]

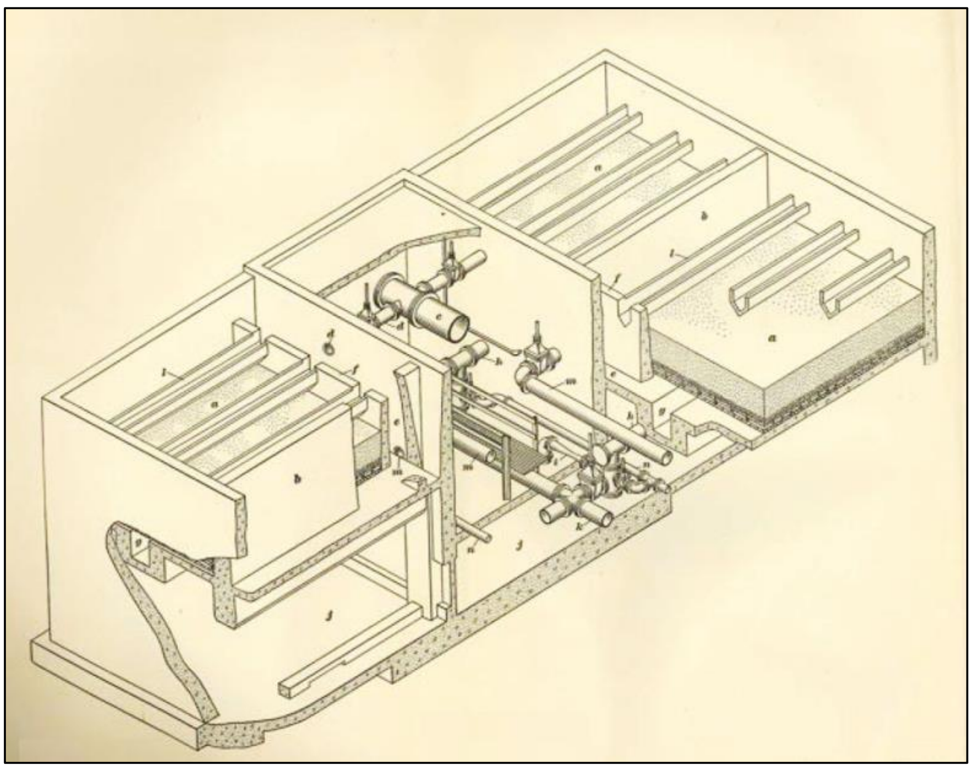

Figure 1: Schematic of a representative rapid sand filtration plant showing parallel filter bed rows at the outside of the concrete structure with a pipe gallery in between and clear-water wells below. Half-pipe troughs run through the filter bed. [11]

Neste, Brudin and Stone planned three of the four filter beds to use sand and gravel as the filter media. The sand was laid in beds five feet deep and was selected to be of uniform grade and with sharp rather than rounded edges. The fourth bed was dual media, which involved laying a layer of finely crushed anthracite coal on top of the sand and gravel. The designers believed

[9] Logsdon et al., "Filtration Process," 151–152.
[10] Hardenbergh, *Operation of Water-Treatment Plants*, 179–182.
[11] Hardenbergh, *Operation of Water-Treatment Plants*, 179.

that the anthracite coal could filter water at twice the speed of conventional sand beds alone and this would allow for doubling of the plant's capacity. It would require several years, however, to ascertain the cost effectiveness of the anthracite bed and the city initially viewed it as an experiment. The model ultimately proved viable and all the filter beds today use the dual anthracite and sand media.[12]

The new Redlands plant design employed gravity alone to move water through the treatment process, avoiding pumping expenses. Water would enter the facility near the control building at the northeast corner of the plant and be treated with aluminum sulfate for coagulation and chlorine for disinfection. The water would next flow to two large clarifiers where the larger suspended solids settled out as flocculant. The partially cleaned water was then piped to the four filtering beds to remove the remaining matter. If required, a final chlorination treatment could be administered before the plant released the water into the main distribution line leading to the city. A reservoir tank perched on the hill slope above the plant held water for use in backwashing the filters, and a drying bed at the west end of the plant dewatered sludge that was collected from the clarifiers and in the backwashing processes. The dried sludge could then be disposed of at a landfill. The plant had an anticipated construction cost of approximately $750,000.[13]

Control Building

Redlands city officials directed Neste, Brudin and Stone to design a plant that would require a minimum of maintenance and could be constructed at the lowest possible initial cost, but they also requested that the plant's appearance "be given more careful attention than usual" so that it might be "a credit to the City."[14] The facility's proximity to residential neighborhoods and its location along a major road ensured it would be highly visible and care thus went into the grounds and particularly the control building that sat at the front of the plant along Mill Creek Road.

James E. Calkins, staff architect for Neste, Brudin and Stone, designed the building. Calkins was born in Los Angeles in 1923 and received an architectural degree from the University of Southern California (USC) in 1952. He worked for a decade as a draftsman and then associate at Ruhnau, Evans & Steinmann, an architectural and engineering firm. He joined Neste, Brudin and Stone in 1963 and stayed there for five years before starting his own office in 1968. He continued to practice in Hemet until his death in 2017. His principal projects included Hemet Federal Savings and Loan (circa 1970, now Hemet City Hall with later expansions and alterations), the Covell Memorial Public Library (1971, now Hemet Fire Department Administration), Our Lady of the Valley Catholic Church (1968, Hemet), and Mt. San Jacinto College Library (1970) (**Figure 2**). These major projects were all larger and more ambitious than his work at the treatment plant. He also designed multiple medical office buildings, mortuaries, and churches, as well as numerous private homes. Most of his work occurred in and around Hemet, though his residential designs took him to Oregon, Washington, Florida, and Mexico. He was active in the Hemet Chamber of Commerce, Rotary Club, and Planning Commission, and served as president of the Inland Chapter of the American Institute of Architects (AIA).[15]

Calkin worked in a variety of Modernist styles, as was common during the era of his principal public designs in the late 1960s and 1970s. Modernism, as a broad architectural movement, emerged in the United States in the 1930s and 1940s. The movement marked a departure from conventional modes of architectural tradition, which emphasized historic models and aesthetic ornamentation, toward a new approach wherein architects designed buildings for purity of form and function while employing the latest in building materials and technologies. Modernistic design trends evolved from Art Deco and Moderne styles in the 1920s and 1930s, which emphasized the streamlined appearance of automobiles and machines, to the International

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[12] "Mill Creek Water to Start Flowing Through Treatment Plant Monday," *Redlands Daily Facts*, April 13, 1968, 3.
[13] "Mill Creek Water to Start Flowing Through Treatment Plant Monday," *Redlands Daily Facts*, April 13, 1968, 3; "Water Treatment Plant Tops Needs," *Redlands Daily Facts*, October 8, 1966, 3.
[14] "Planners Approve Site for New Filter Plant," *Redlands Daily Facts*, November 9, 1966, 3; "Mill Creek Water to Start Flowing Through Treatment Plant Monday," *Redlands Daily Facts*, April 13, 1968, 3.
[15] John F. Gane, ed., *American Architects Directory, Third Edition, 1970* (New York: R. R. Bowker Company, 1970), 130; "James Edwin Calkins [obituary]," *The Press-Enterprise (Redlands)*, May 11, 2017.

Style in the 1940s and 1950s that was defined by the careful massing of highly angular forms with flat roofs and horizontal window bands and a near complete absence of ornamentation.[16]

Figure 2: James Calkins' major projects; Top row: Hemet City Hall and former Covell Library. Bottom Row: Our Lady of the Valley Catholic Church and Mt. San Jacinto College Library.[17]

Architecture in the late 1950s and 1960s saw a reaction against the starkness and radical simplification of the International Style. Architects reintroduced allusions to historical forms and reemphasized the aesthetic appeal of textured wall surfaces, while remaining modern in their embrace of new building technologies and restraint of ornamentation. Modernist architecture branched out into several more-or-less distinct substyles as designers explored various paths for developing and expanding the tradition. The Post-and-Beam style, a subtype of Modernist architecture that Calkin employed for the new Redlands treatment plant control building, evolved from the construction technique that used load bearing columns and beams to frame a structure rather than solid bearing walls. Architects turned the technique into an aesthetic by giving strong, even exaggerated,

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[16] Alan Colquhoun, *Modern Architecture* (Oxford: Oxford University Press, 2002), 9-11; Kenneth Frampton, *Modern Architecture: A Critical History*, 4th ed. (London: Thames & Hudson, Ltd, 2007), 248; Planning Resource Associates, Inc, "Mid-Century Modernism Historic Context," September 2008, prepared for the City of Fresno, 67.

[17] Bob Pratte, "Hemet City Hall (file photo)," c. 2021, *The Press-Enterprise (Hemet);* Google Streetview, February 2019; Our Lady of the Valley Catholic Church, Hemet, California, n.d., https://www.olvhemet.org/; Craig Ess, "Mt. San Jacinto College," c. 1985, https://www.flickr.com/photos/socraig/3408123908/in/photostream/.

expression to the structural system on the building surface, and by filling the frames of the grid structure with large windows or panels of concrete, metal, or wood with unusual finishes.[18]

Calkin designed the control building to be of post-and-beam, reinforced-concrete construction on a stone façade foundation. Regularly spaced columns and beams at frieze and plinth level frame the building. The structural system is articulated on the building exterior and through most interior spaces, where the beams and columns remain visible. The concrete panels that fill the grid were sandblasted to expose the aggregate and give the walls an aesthetically pleasing texture. This effect continues on interior walls in the lobby and main room. The stones used for the foundation façade were collected from Mill Creek to tie the building to its location and emphasize the point of origin for the city's water supply. Calkin characteristically mixed Modernist design elements, so while the building principally draws on the Post-and-Beam style, it also shows vague influences of another subtype, New Formalism, in the abstracted columns and cornice line, as well as in the metal grill used at the entryway. The building's stylish use of concrete won it recognition as one of five San Bernardino County buildings honored at the industry-sponsored Creative Concrete Awards, hosted in 1971 by the San Bernardino-Riverside Counties Rock Products Association and the Portland Cement Association.[19]

Construction

To finance construction of the plant, the City of Redlands looked to a combination of federal grants and municipal bonds. The city drafted a $3 million bond issue that was expected to ultimately finance the construction of two filter plants, including the subject plant, as well as five storage reservoirs, distribution lines, and booster plants. Existing water fees would pay the entirety of the revenue bond and it did not require new taxes or a water rate hike. The measure passed by a 4-to-1 margin in the October 1966 election. The day prior to the election, the city also learned that it had received $410,000 in a Federal Economic Development matching grant that could pay half the cost of construction.[20]

The city called for bids in late 1966, following the election, and awarded contracts in early 1967. Allied Mechanical Contractors of Chula Vista received the principal construction contract on a bid of $717,800. This made the treatment plant the largest single municipal construction project in the city's history to the time. Milton Nichols owned and operated Allied Mechanical Contractors. The apparently short-lived company did work on US Navy facilities in the San Diego area, but did not leave a record of participating in other large projects. Subcontracts were awarded to the Smith-Scott Company of Riverside for supplying pipe materials and to A and P Pipeline of Upland for installing pipelines into and out of the treatment plant. Brandow & Johnston Associates of Los Angeles were selected as structural engineers for the control building.[21]

In March 1967, the Redlands City Council announced they would name the new plant in honor of Henry Tate, the city's water treatment plant operator for 33 years. Tate had retired in 1963, but the city credited his long-term advocacy for the eventual construction of the new facility. He participated in the ceremonial groundbreaking for the plant on March 30, 1967. Today, a bronze plaque at the building entrance recognizes Tate's contributions to the city's water development (**Figure 3**).[22]

[18] Planning Resource Associates, Inc, "Mid-Century Modernism Historic Context," 69-79; Robinson & Associated, Inc., *Growth, Efficiency, and Modernism: GSA Buildings of the 1950s, 60s, and 70s* (Washington, D.C.: U.S. General Service Administration, 2005), 14-15.
[19] "Mill Creek Water to Start Flowing Through Treatment Plant Monday," *Redlands Daily Facts*, April 13, 1968, 3; "5 County Projects Selected in 'Creative Concrete' Awards," *The Sun (San Bernardino County)*, April 15, 1971, D-16.
[20] "City Water Bond Issue Passes by Big Majority," *Redlands Daily Facts,* October 19, 1966, 3; "City Gets $410,00 Filter Plant Grant," *Redlands Daily Facts,* October 18, 1966, 3.
[21] "Filter Plant Contract Awaits Federal Review," *Redlands Daily Facts,* February 15, 1967, 24; "City Council Awards Filter Plant Contract," *Redlands Daily Facts*, March 2, 1967, 4; "L.B. Navy Job Let," *Long Beach Independent*, July 15, 1967, A-4; "Nichols Gets Job," *Chula Vista Star-News*, June 13, 1968, B2.
[22] "Henry Tate Water Filter Plant Started," *Redlands Daily Facts*, March 30, 1967, 3; "Henry Tate Breaks Ground for New Water Filter Plant Named for Him," *San Bernardino County Sun*, March 31, 1967, B4.

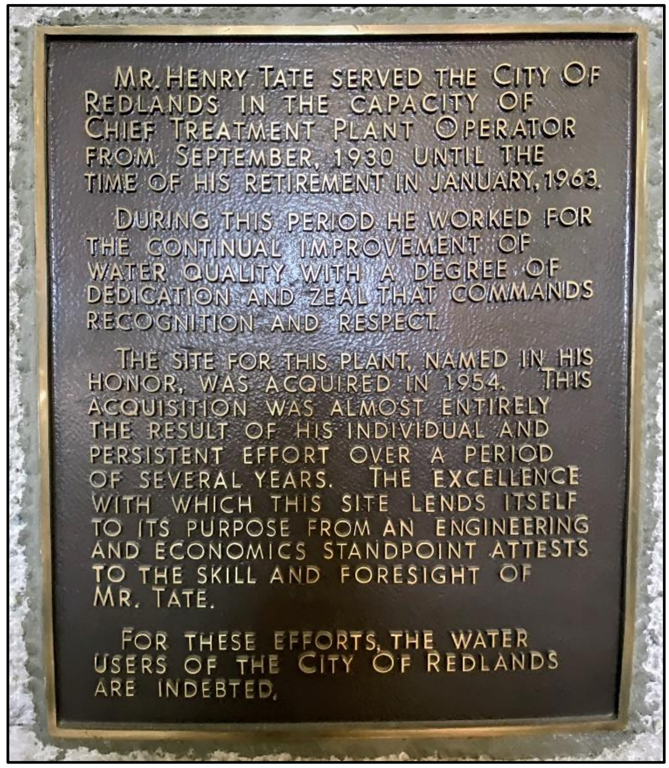

Figure 3: Above: Redlands Mayor Waldo F. Burroughs (left) and Henry Tate (right) both holding shovels at the "First Shovels" ceremony. Milton Nickols, Jr. of Allied Mechanical Contractors is visible behind Burroughs wearing a hard hat; Right: Dedication plaque to Henry Tate in lobby of control building.[23]

The new plant began operating on April 15, 1968, at a final cost of $815,611 (**Figure 4**). The dedication ceremonies drew attention to automation at the plant. Whereas the prior Mill Creek facility required attendants twenty-four hours per day, the new plant required only periodic inspections (**Figure 5**). Newspapers noted the irony of naming the plant for Tate, while its automation threatened to render the operator role obsolete. The city anticipated public interest in the plant's technological features and intended the control building to host school and civic groups on visits. A clear-glass waterfall feature in the wall of the lobby entrance was indicative of the way that city officials saw the building as a way to showcase the city's investment in its water system.[24]

Automation had come relatively late to drinking water treatment in comparison to such similar industrial processes as oil refining and chemical manufacturing. Basic mechanical automation had been a part of water and sewer systems since the nineteenth century in such forms as floats used for triggering well pumps or automatic flushing tanks used for clearing sewer laterals, and electrically powered systems were employed as early as the late 1920s. However, water treatment plants remained overwhelmingly under manual control into the postwar decades, with operators physically opening and closing valves and gates and taking laboratory measurements of turbidity and pH levels. In the mid-1960s, treatment facilities began to use instrumentation to monitor plant conditions and automate select processes, such as operating air and sludge pumps. By the 1970s, virtually every new treatment plant had a centralized control room that displayed information gathered from remote sensors, showing the operational status of the plant at a glance. By allowing a single worker to monitor plant operations, control rooms produced labor savings and were the one form of automation almost universally justifiable on economic grounds.[25]

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23 "First Shovels," *San Bernardino County Sun*, April 1, 1967, B4; JRP photograph, November 16, 2022.
24 "Mill Creek Plant to Start Flowing Through Treatment Plant Monday," *Redlands Daily Facts*, April 13, 1968, 3.
25 Daniel Schneider, *Hybrid Nature: Sewage Treatment and the Contradictions of the Industrial Economy* (Cambridge: MIT Press, 2011), 183–84; Allen E. Molvar, Joseph F. Roesler, Russel H. Babcock, "Instrumentation and Automation Experiences in Wastewater-Treatment Facilities," Prepared for EPA, October 1976, 5.

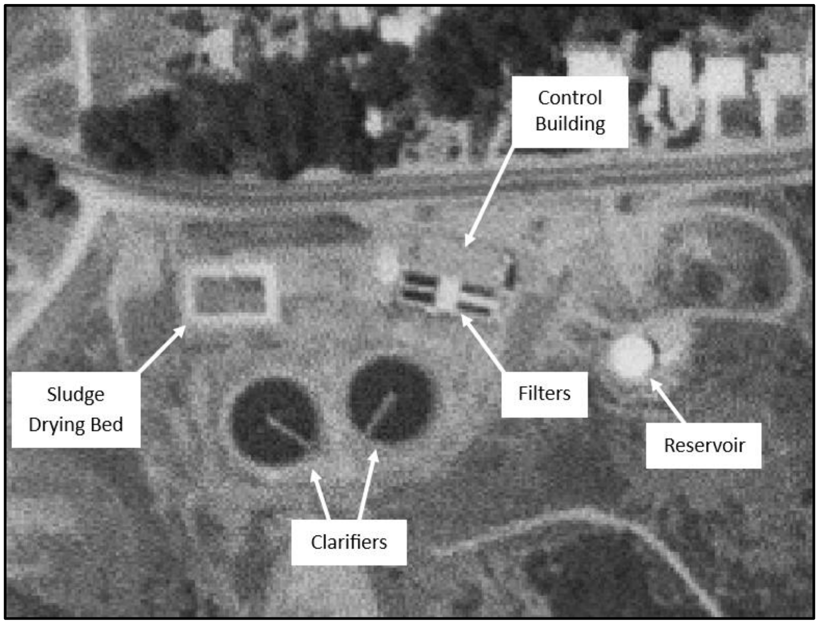

Figure 4: A May 1968 aerial photograph shows the Henry Tate plant one month after opening.[26]

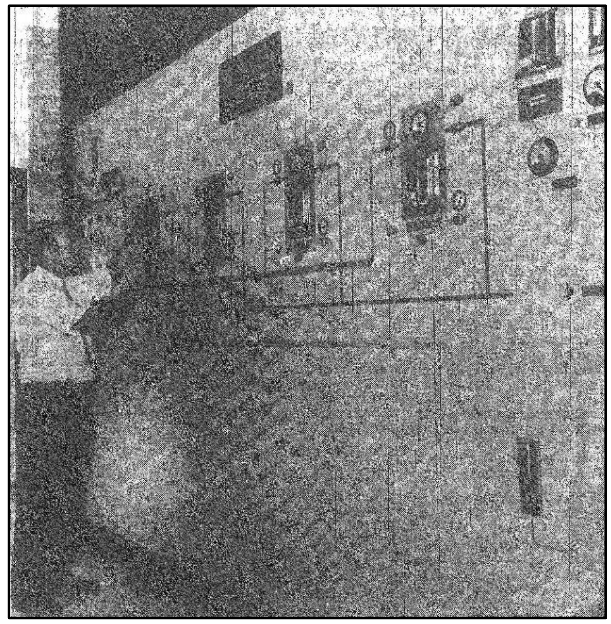

Figure 5: Newspaper photograph showing Bob Coates, assistant water superintendent, inspect a gauge on the "master control panel" (no longer extant).[27]

Expansions and Alterations

The completion of the Henry Tate Water Treatment Plant in 1968 allowed the City of Redlands to meet its water needs for a couple decades without requiring major new construction. In the early 1980s, the plant worked in concert with 31 city-owned wells, 15 reservoirs, and 250 miles of distribution mains to provide the city with up to 33 million gallons of water per day. Mill Creek surface flows treated at the Henry Tate plant could provide around 11 million gallons per day during the winter and 7.5 million gallons per day during the summer. However, problems loomed for the city. Water demand was growing more rapidly than supply, and the city expected to soon fall short of total demand during the peak of the summer season. The city's wells also became less reliable as the heavy use of nitrogen fertilizer in the region's citrus groves led to nitrates leaching into the groundwater. At times, high chemical levels forced nearly a third of the city's wells offline. Drawing more water from Mill Creek to make up for the deficiency caused water to stop flowing through the Zanja. The upset residents who lived along the ditch ultimately brought suit to keep water flowing past their properties.[28]

The city held rights to two other surface water sources with the Santa Ana River and deliveries through the State Water Project (SWP), but in the early 1980s it lacked means of filtering the additional water. In late 1985, the city broke ground on a second water treatment facility, the Horace P. Hinckley Water Process Plant, situated towards the north end of town, to handle Santa Ana River and SWP water. The city simultaneously sought to expand treatment capacity at the Henry Tate facility to increase their operational flexibility and balance the demands for pumping through the distribution system. The San Bernardino Valley Municipal Water District constructed a booster station near the Henry Tate plant that could lift water from either alternate surface source to the facility. The distribution system was the principal limit at the Henry Tate plant as the original water main had a 12 million gallon a day capacity. Installing a larger pipeline cost approximately $2 million and was the largest expanse

[26] Cartwright Aerial Surveys, Flight AXL-1968, Frame 9JJ-75, 1:20,000, May 27, 1968, annotations by JRP.
[27] "Mill Creek Plant to Start Flowing Through Treatment Plant Monday," *Redlands Daily Facts*, April 13, 1968, 3.
[28] "The City's Water System, There are Problems and Solutions," *Redlands Daily Facts*, April 9, 1982, 1; "Redlands Council Meets, Sets its Priorities for Coming Year," *San Bernardino County Sun*, January 20, 1985, B3; "Redlands on Verge of Water Rationing," *San Bernardino County Sun*, July 23, 1985, B3; "Angry Residents Protest Zanja Water Diversion," *San Bernardino County Sun*, August 16, 1985, B1; "Redlands Zanja-area Residents Sue to Restore Water," *San Bernardino County Sun*, November 13, 1985, B1.

in the 1986 facility upgrade. An additional $500,000 was spent on the plant itself, adding another sludge drying basin and a second reservoir for storing filter backwash water. Additional filter beds were proposed but not constructed.[29]

In 2004, the nearly 40-year-old plant was overhauled to modernize its operations and adhere to tighter regulations. Several major new components were constructed including a third sludge drying basin, a backwash water settling basin, a building to house blowing equipment for the backwash process, and chemical storage and feed tanks (**Figure 6**). The two existing storage reservoirs were replaced, as was the superstructure and rakes on both clarifiers. The control building added a chlorine gas room and backup generator to improve safety. Other changes were less visible but were fundamental to the operation of the plant. Most of the piping and several pumps were replaced with new components. Polymers superseded the alum clay previously used for coagulation. Automated controls that had been operated by pneumatic power were replaced with electrical components. Adding all the new equipment changed the landscaping of the grounds as asphalt replaced original lawns. The plant has been only lightly altered since the 2004 project.[30]

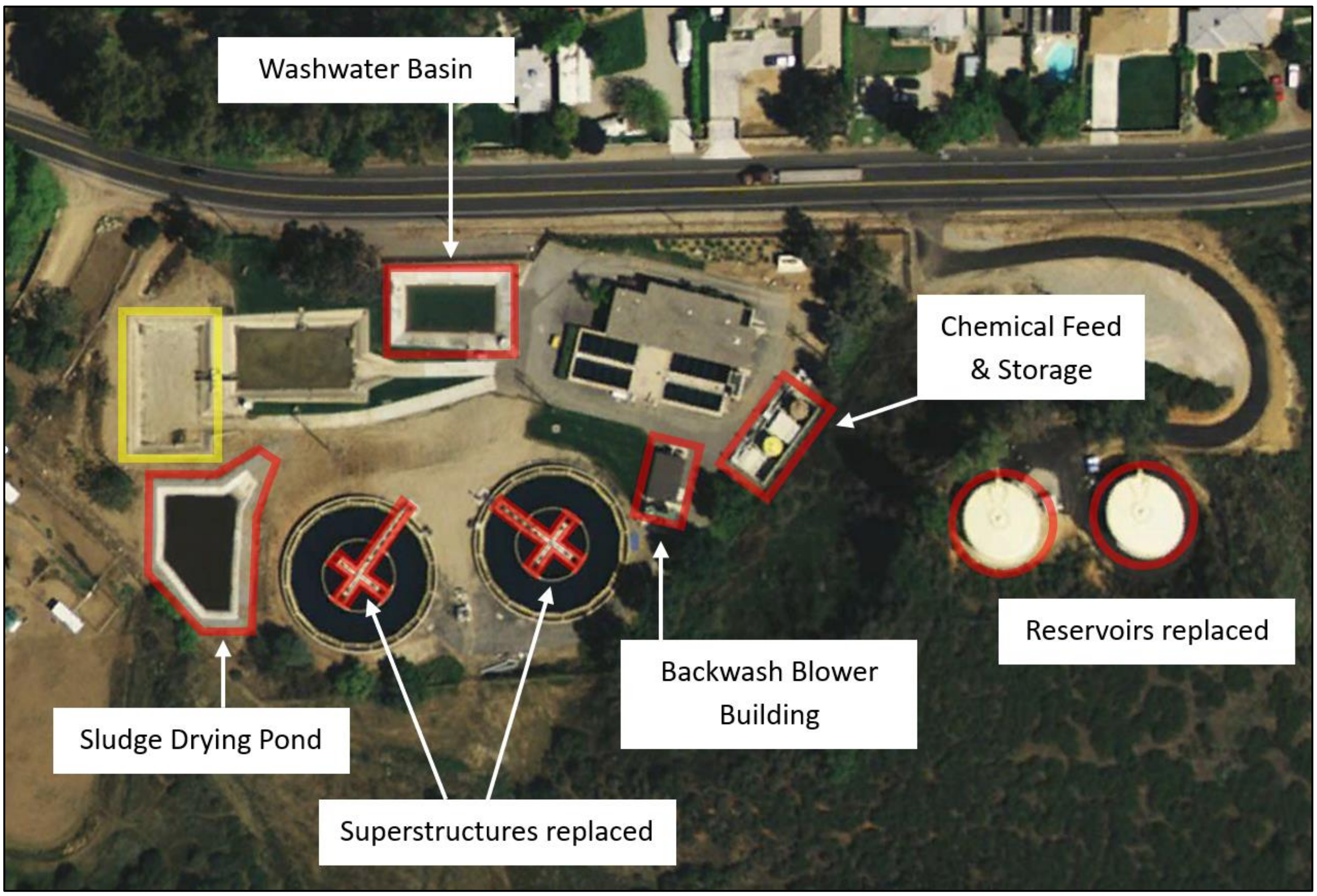

Figure 6: A 2007 aerial images shows features added to or replaced at the plant during the 2004 modernization (highlighted in red). The drying bed outlined in yellow was added in 1986.[31]

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[29] "The City's Water System, There are Problems and Solutions," *Redlands Daily Facts*, April 9, 1982, 1; "Redlands Council Calls for Bids on Controversial Water Plant," *San Bernardino County Sun*, September 18, 1985, B2; "Study Ordered on Increasing Water Production," *San Bernardino County Sun*, April 10, 1986, B3; City of Redlands, Department of Public Works, "Henry Tate Treatment Plant Plot Plan: Sludge Pond & Recirculation Pump Station," March 7, 1986; City of Redlands, Department of Public Works, "Tank Detail for Mill Creek Reservoir No. 2" March 7, 1986.

[30] City of Redlands, Municipal Utilities Department, "Upgrades to the Henry Tate Water Treatment Plant," July 2003, Project No. 130535, Sheet 12.

[31] Google Earth imagery, March 30, 2007, annotated by JRP.

Evaluation

The Henry Tate Water Treatment Plant is not eligible, either in whole or for any separate element, for inclusion in the NRHP or CRHR as it does not possess historic significance.

The subject property lacks important associations with significant historic events or trends, and it is not eligible under NRHP Criterion A / CRHR Criterion 1. The City of Redlands constructed the Henry Tate Water Treatment Plant in 1967-1968 to replace an earlier 1926 filter facility located in the Mill Creek floodplain. Construction of the plant modernized the city's treatment system for Mill Creek surface water and improved its reliability, but it did not add any additional supply. During the summer months, the treatment plant met between 20 and 50 percent of the city's water demand, while wells and diversions from the Santa Ana River supplied the remainder of the water. The completion of the plant thus did not spur new growth in Redlands, but merely allowed the city to continue to meet its existing water demand. Alterations to the plant in 1986 allowed it to treat Santa Ana River water and water deliveries through the SWP, but this too did not mark a profound change in the city's water system. Rather, it was part of the gradual, planned development of the city's water infrastructure that is a routine part of municipal growth.

The subject property lacks clear association with any individual important to history and it is not significant under NRHP Criterion B and CRHR Criterion 2. Though the facility is named for Henry Tate, a long-term water plant operator for the city, he had only tangential association with the plant constructed in 1967-1968. Tate operated the earlier, nearby Mill Creek plant from 1930 to 1963, when he retired. He had urged the acquisition of the subject property to build a new plant, and city management credited him for their decision to buy the land in 1954, more than a decade prior to construction. In naming the plant for Tate, the city council was acknowledging his long years of service at the earlier facility that was to be decommissioned. However, Tate had no direct association with the new plant and never worked there or played any role in designing the facility. No other individual is known to have played a prominent individual role in advocating for or operating the plant. Contemporary newspaper coverage treated the plant's construction as a routine function of municipal government. City staff members have operated the plant since its completion, but none appear to rise to a level of historic significance.

The subject property lacks significance under NRHP Criterion C and CRHR Criterion 3 as it is not an important example of its type, period, or method of construction; nor is it a work of high artistic value or an important example of the work of a master architect or engineer. The rapid sand filters that comprise the primary sanitary engineering features of the plant were first developed in America in the 1890s and entered wide use by the 1920s. They were well established, common pieces of equipment at water treatment plants by the time they were selected for the subject plant. The other pieces of treatment equipment used in the 1967-1968 construction were also common for their time and did not involve any important modifications from standard practice. The automation at the plant attracted attention at the time of its dedication, but none of that material, including the master control panel and pneumatic controls, is extant, all of it having been replaced as the plant was updated over the decades.

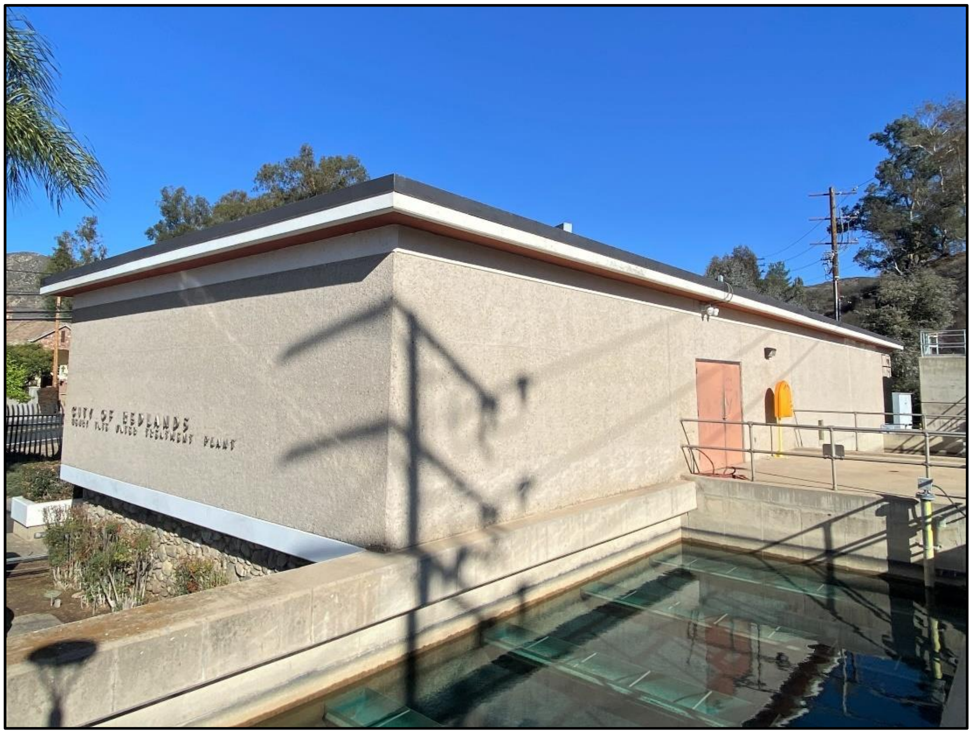
While the main control building is an attractive and well-designed example of Modern architecture, it is not so exceptional as to merit significance under NRHP or CRHR criteria within the context of the municipal use of Modernist styles. The Post-and-Beam style and other Modernist forms were widely employed in the 1950s and 1960s, and many larger, more elaborate, and more innovative works exist. The architect, James Calkins, designed several more substantial and ambitious buildings around the same time as the control building and the subject property does not stand out among his major work. Neither Calkins nor the plant engineering consultants, Neste, Brudin and Stone, would qualify as master architects or engineers. Both worked principally on local projects and followed the design trends of their era without producing truly distinctive work.

Finally, the property is not significant under NRHP Criterion D or CRHR Criterion 4 as it has not yielded, and is not likely to yield, data important to the understanding of history. The materials and construction and engineering techniques employed on this property were common in their time and are well documented in a wide body of written sources.

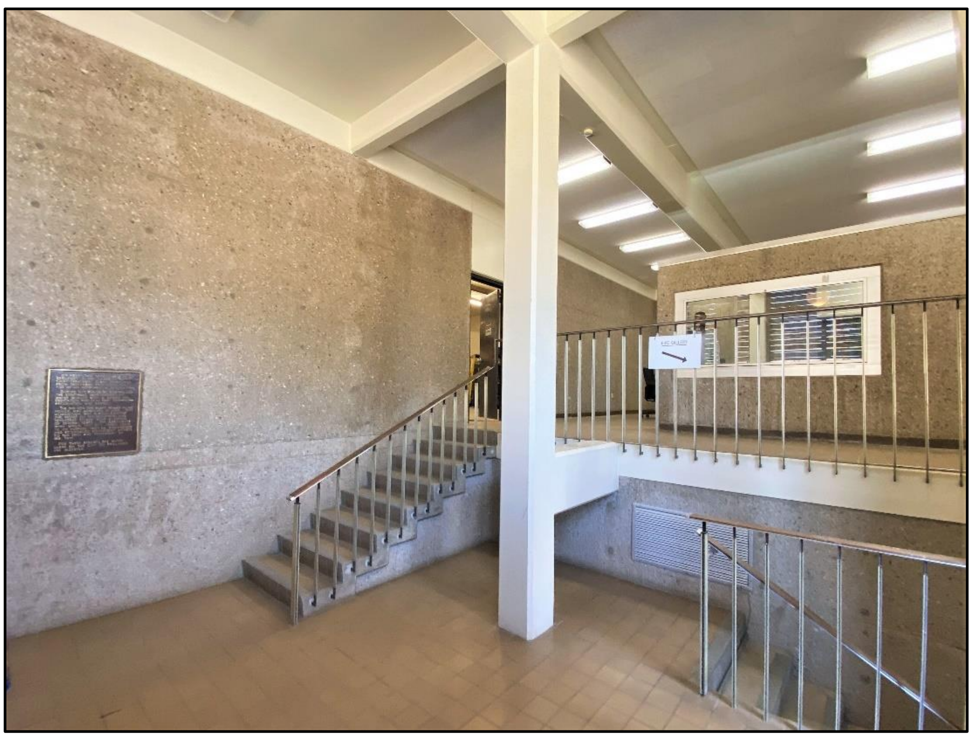
Photographs (continued):

Photograph 2: Control building primary entrance; camera facing southeast and east; November 16, 2022.

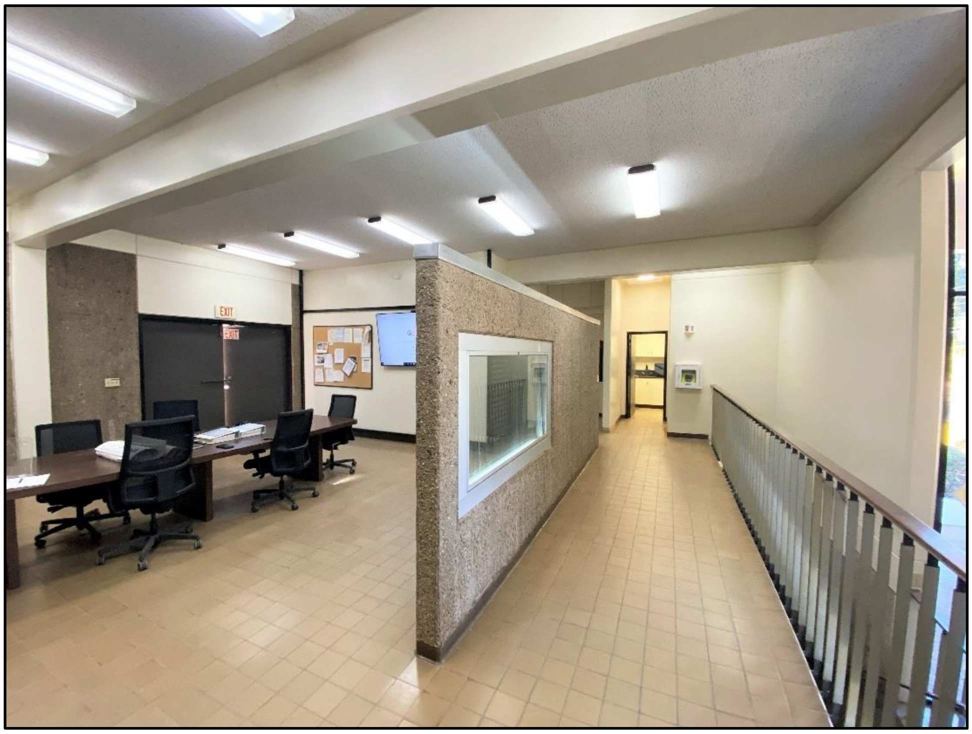
Photograph 3: Northeast corner of control building showing chlorine room entrance; camera facing southwest; November 16, 2022.



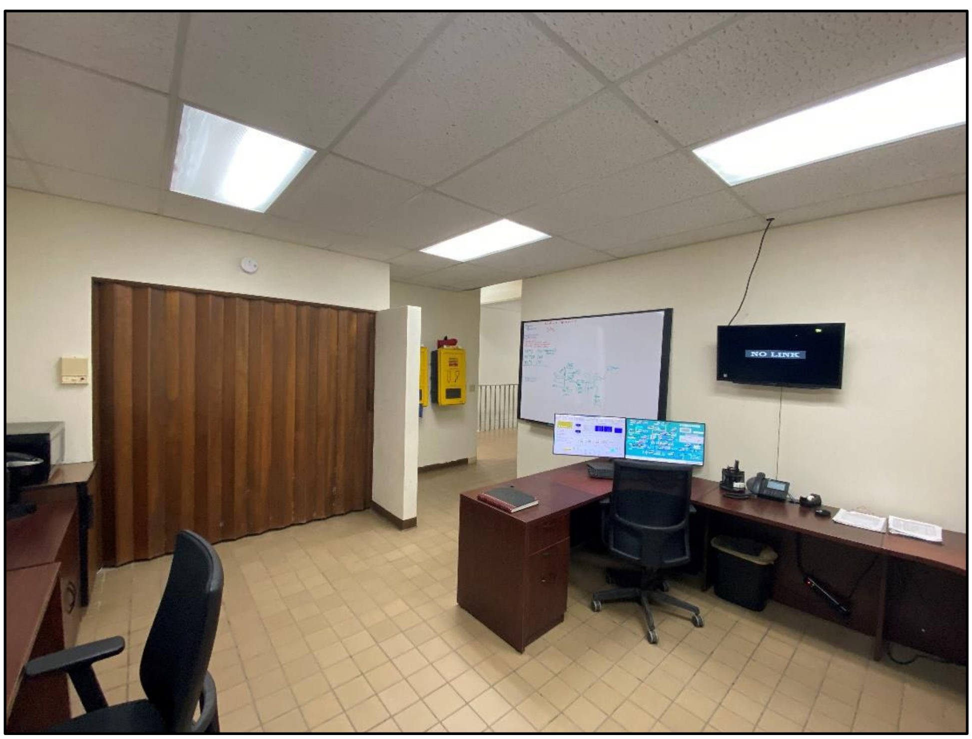
Photograph 4: Southwest control building corner with filter bed in foreground. Note the lack of column articulation on the sides and rear of building; camera facing northeast, November 16, 2022.



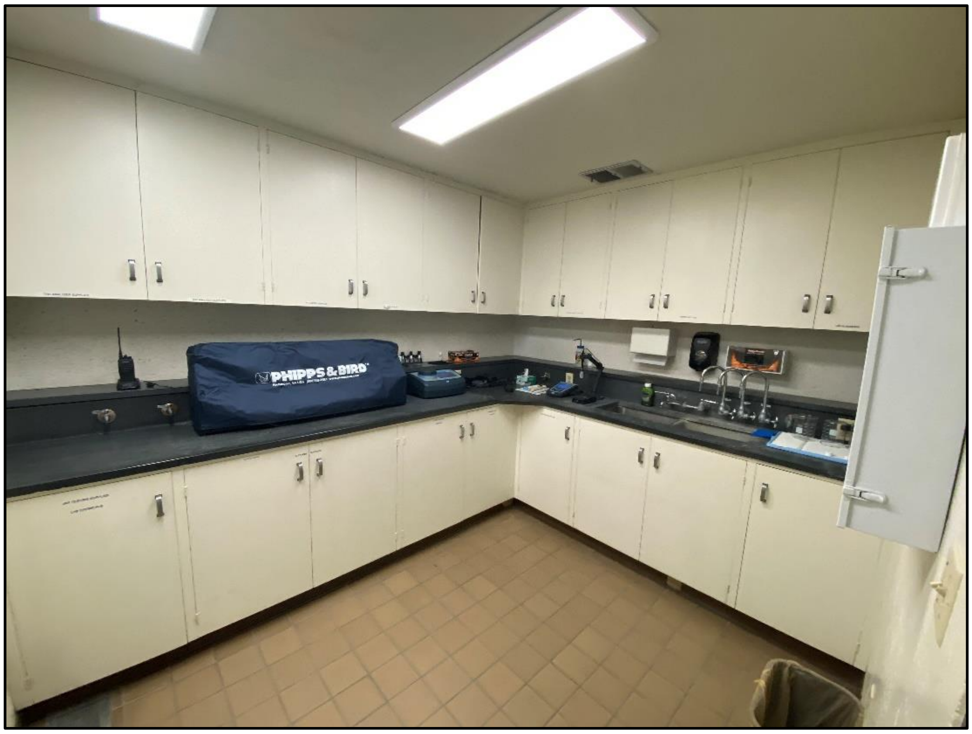
Photograph 5: Lobby of the control building with post-and-beam construction, sand-blasted concrete walls, and memorial plaque at left; November 16, 2022.



Photograph 6: Entrance hallway with conference room at left and (non-operating) waterfall feature in partition wall at center of image; November 16, 2022.



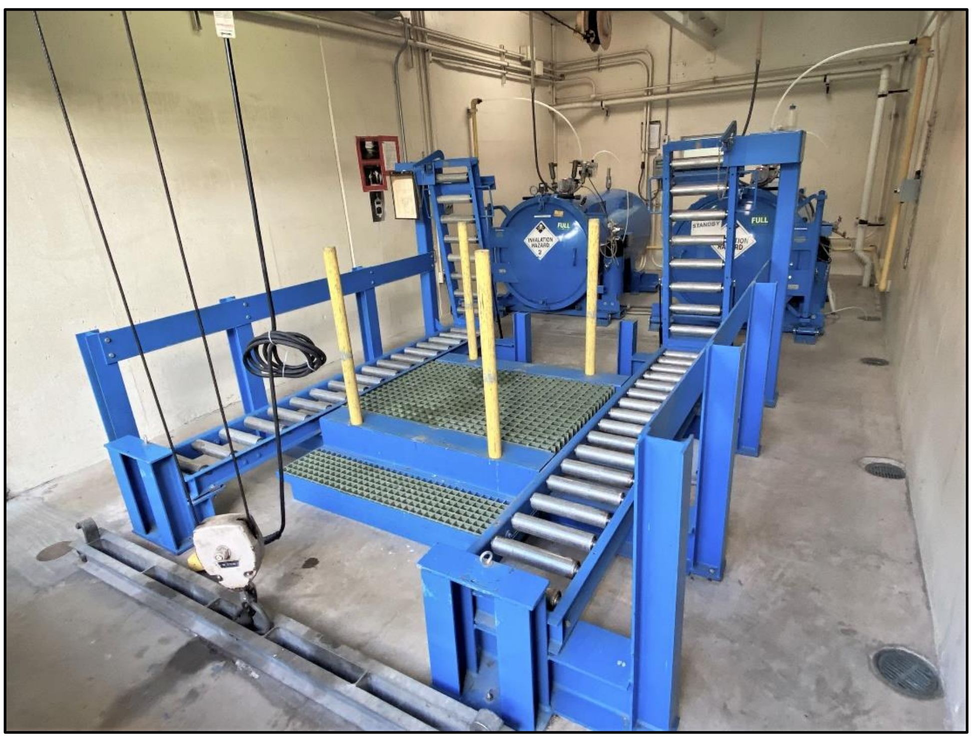
Photograph 7: Office with tile floors, drop acoustic ceiling, and drywall; November 16, 2022.



Photograph 8: Laboratory; November 16, 2022.

Photograph 9: Chemical dosing room at east end of control building; November 16, 2022.

Photograph 10: Plastic storage tanks hold chemicals for injection into the raw water influent pipeline at left edge of image; November 16, 2022.



Photograph 11: Chlorine cylinders in containment tanks with loading system on partially enclosed loading dock; November 16, 2022.

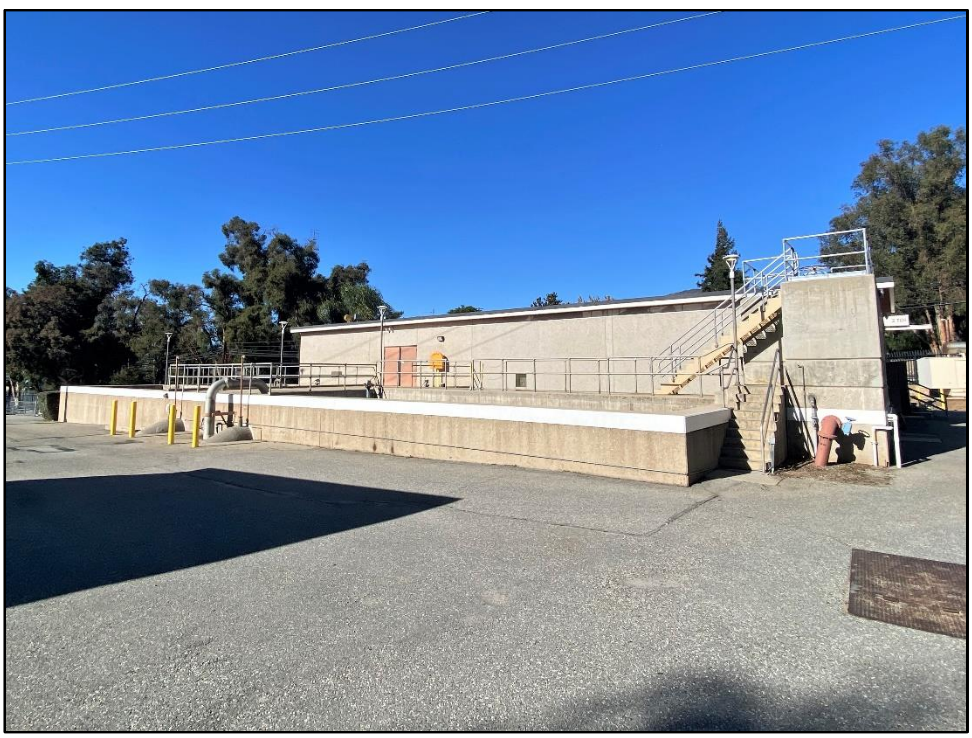
Photograph 12: Filter gallery in basement of control building; November 16, 2022.

Photograph 13: Modern chemical feed and storage tanks; facing northeast, November 16, 2022.

Photograph 14: A splitter box diverts water to one of two clarifiers; camera facing southeast, November 16, 2022.

Photograph 15: Clarifier, camera facing northeast; November 16, 2022.

Photograph 16: Interior view of clarifier shows rake arm at bottom of tank, a mechanical fan-shaped agitator, and a baffle wall for containing the agitation zone; November 16, 2022.



Photograph 17: View of the filter beds in raised concrete structure with control building behind; camera facing north; November 16, 2022.

Photograph 18: Overview of filter structure, showing four filter bed; camera facing west, November 16, 2022.

Photograph 19: View of one of four filter beds, showing half-pipe troughs; November 16, 2022.

Photograph 20: Southeast corner of modern blower building, camera facing northwest; November 16, 2022.

Photograph 21: View of sludge pond basins, camera facing southeast; November 16, 2022.

Photograph 22: Sludge pond; camera facing northwest; November 16, 2022.

Photograph 23: Washwater recovery basin, camera facing northeast; November 16, 2022.

Photograph 24: Storage reservoirs, camera facing southeast; November 16, 2022.

Photograph 25: Overview of water treatment plant from storage reservoirs on hilltop to the east, camera facing west; November 16, 2022.

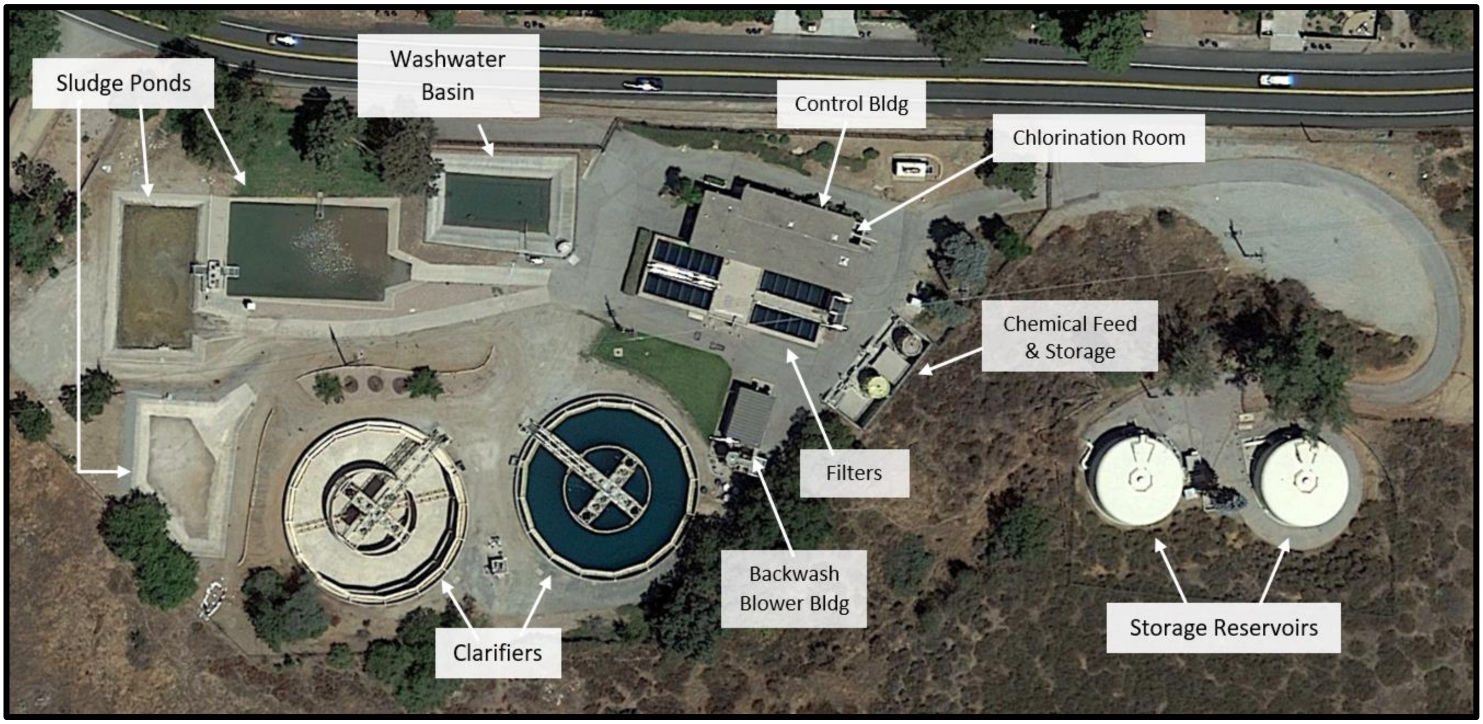
State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
LOCATION MAP

Primary # ______________________
HRI # ______________________
Trinomial ______________________

Page 26 **of** 27 ***Resource Name or #** (Assigned by recorder) Henry Tate Water Treatment Plant

***Map Name:** USGS National Map ***Scale:** 1:24,000 ***Date of Map:** 2019

source: JRP (2023); Esri, et al. (2023).



Henry Tate Water Treatment Plant
Google Earth imagery, August 5, 2021
Annotated by JRP

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # ______
HRI # ______
Trinomial ______
NRHP Status Code 6Z
Other Listings ______
Review Code ______ Reviewer ______ Date ______

 ***Resource Name or #** (Assigned by recorder) City of Pleasanton Water Pumping Station

P1. Other Identifier: City of Pleasanton Wells 5 & 6

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County** Alameda

and (P2b and P2c or P2d. Attach a Location Map as necessary.)

***b. USGS 7.5′ Quad** Livermore **Date** 2021 **T** 3S; **R** 1E; **Sec** 16; Mount Diablo Meridian **B.M.**

c. Address 1530 Santa Rita Road City Pleasanton Zip 94566

d. UTM: (give more than one for large and/or linear resources)

Zone 10S; 599454 mE/ 4170116 mN (Well 6); Zone 10S; 599461 mE/ 4170030 mN (Well 5)

e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

Accessor Parcel Number (APN): 094-215-035 (Well 6 and treatment building); 094-215-037 (Well 5)

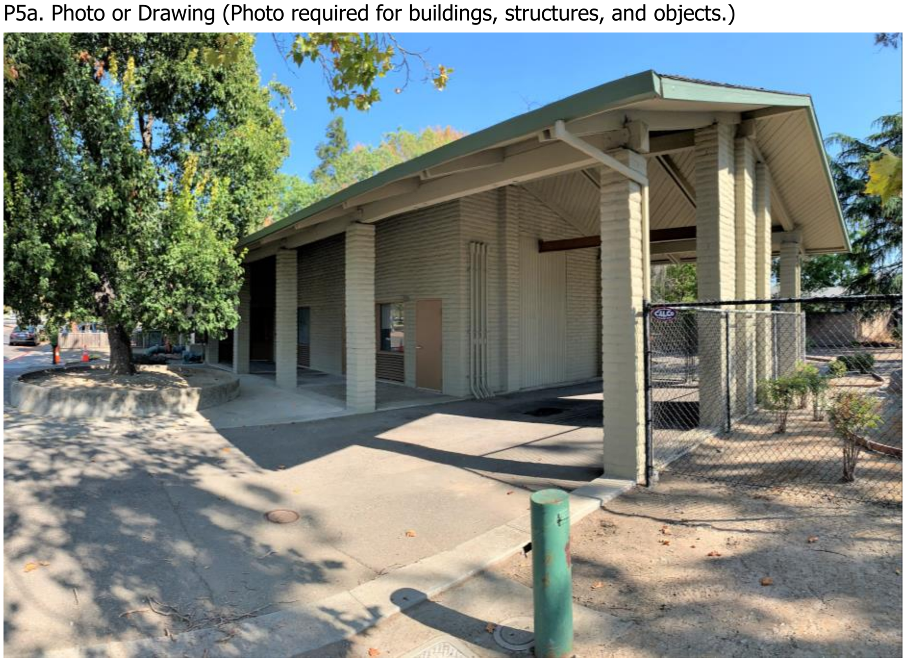
***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)

This form serves to record and evaluate the City of Pleasanton Water Pumping Station, a facility that includes two groundwater wells (Wells 5 and 6) and a single-story water treatment building. The station is located at the intersection of Santa Rita Road and Black Avenue, adjacent to Alisal Elementary School. Well 6 is contained within the treatment building at 1530 Santa Rita Road, north of the school's circular entry drive (**Photograph 1** and **Sketch Map**). Well 5 is enclosed within an underground vault with a concrete apron and metal doors located on a grassy knoll south of the entry drive and approximately 250 feet south of the treatment building (**Photograph 2**) (see Continuation Sheet).

***P3b. Resource Attributes:** (List attributes and codes) HP9: Public Utility Building; HP14: Government Building; HP39: Other (Wells)

***P4. Resources Present:** ☒ Building ☒ Structure ☐ Object ☐ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5a. Photo or Drawing (Photo required for buildings, structures, and objects.)



P5b. Description of Photo: (View, date, accession #) **Photograph 1**: City of Pleasanton Water Pumping Station treatment building, facing northeast, October 13, 2022

***P6. Date Constructed/Age and Sources:** ☒ Historic ☐ Prehistoric ☐ Both

Well 5: 1962; Well 6: 1964; Treatment building: 1967 (Kennedy Engineers, "City of Pleasanton, Water Pumping Station," October 9, 1967)

***P7. Owner and Address:**

Pleasanton City Water Services
3333 Busch Road
Pleasanton, CA 94566

***P8. Recorded by:** (Name, affiliation, address)

David Hickman & Danielle Baza
JRP Historical Consulting, LLC
2850 Spafford Street
Davis, CA 95618

***P9. Date Recorded:** October 13, 2022

***P10. Survey Type:** (Describe) Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") None

***Attachments:** ☐ None ☒ Location Map ☐ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐ Other (list) ______

***NRHP Status Code** 6Z

***Resource Name or #** (Assigned by recorder) City of Pleasanton Water Pumping Station

B1. Historic Name: City of Pleasanton Water Pumping Station
B2. Common Name: Well Pump 5 & 6
B3. Original Use: Groundwater wells and treatment B4. Present Use: Groundwater wells and treatment
***B5. Architectural Style:** Modernist with elements of Second Bay Tradition and New Formalism
***B6. Construction History:** (Construction date, alteration, and date of alterations) Well 5 bored 1962; Well 6 bored and pump installed 1964; treatment building constructed 1967; treatment building chlorination room subdivided and new door replaced original window circa 1999; sliding bay doors replaced with grooved-plywood siding near same time; well control piping added south of building in 1999; composition shingles replaced original wood shake at unknown date; signage lettering on west façade removed at unknown date.

***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown Date:** ______ **Original Location:** ______
***B8. Related Features:** n/a
B9. Architect: Kennedy Engineers / Kitchen and Hunt b. Builder: Unknown
***B10. Significance: Theme** n/a **Area** n/a
Period of Significance n/a **Property Type** n/a **Applicable Criteria** n/a
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

This property does not meet the criteria for listing in the National Register of Historic Places (NRHP) or the California Register of Historical Resources (CRHR) and is not an historical resource for the purposes of the California Environmental Quality Act (CEQA) because it does not meet the significance criteria. This property was evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code. See Continuation Sheets for the historic context and evaluation of the property.

B11. Additional Resource Attributes: (List attributes and codes) ____

***B12. References:** Kennedy Engineers, "City of Pleasanton, Water Pumping Station," October 9, 1967; *The Daily Review* (Hayward); Sanborn Fire Insurance Maps; aerial photographs; San Francisco Estuary Institute, *Alameda Creek Watershed: Historical Ecology Study*, prepared for the San Francisco Public Utility Commission and the Alameda County Flood Control & Water Conservation District, February 2013; see also footnotes.

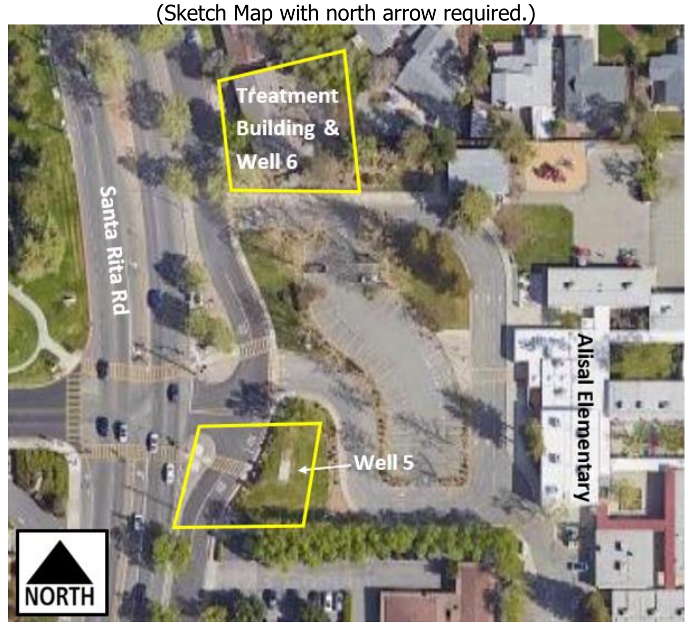
B13. Remarks:

***B14. Evaluator:** David Hickman

***Date of Evaluation:** April 2023

(This space reserved for official comments.)

(Sketch Map with north arrow required.)



(Yellow annotations show legal parcel lines and do not indicate the size or location of equipment)

P3a. Description (continued):

The treatment building has an L-shaped footprint, protruding at its northwest corner, with approximately 1,065 square feet of interior space and an 18-foot-wide porte-cochère on its south side (**Photograph 3**). The moderately pitched side-gable roof has wide eaves and exposed beams and joists (**Photograph 4**). The roof extends to cover the porte-cochère and the west façade where it is set back from the protruding northwest corner. Brick pillars and a partial south wall support the roof extensions (**Photograph 5**). The roof sheathing of six-inch-wide, diagonally-laid, tongue-and-groove boards is visible on the building exterior and in original, unrefurbished interior spaces. The roof is clad in composition shingles that replaced original wood shake. A skylight is located towards the northwest roof corner, illuminating the interior pump room.

The building is constructed of 8 x 14 x 16-inch slump bricks (concrete block units that were removed from their molds before fully setting to give a rough, uneven appearance similar to adobe brick). Brick pilasters are located on all sides of the building. Their spacing is somewhat irregular and does not align with the interior room divisions (**Photograph 6**). The building sits on a concrete slab foundation.

The building's main entrance is on the west side (**Photograph 7**). The door to the pump room opens on the south side of the protruding northwest building corner and includes upper glazing. The middle door on the west façade is an addition that replaced an original window. It also has upper glazing and is surrounded by grooved-wood siding used to fill the wider original window opening. The other two doors on the west side have no glazing. There are two, double, flush, hollow-metal doors on the rear east side, both with metal vents. The north door, opening onto the pump room, is at foundation level, while the south door, opening to the fluoridation room, is raised four feet to a delivery dock apron (see **Photograph 6**). On the south side, within the porte-cochère, two sliding, hollow-metal bay doors previously opened to provide access for delivering one-ton chlorine cylinders by overhead hoist rail. The hoist rail remains in place but the doors have been removed and the bay opening filled with grooved-plywood siding (**Photographs 8** and **9**). There are three plate glass windows on the west side, all above redwood louver vents. Vertical louver vents also fill the full wall above the pump room door and window, extending to the roof line. Additional vent screens and mechanical ventilation equipment are located on the rear east side and on the roof. The north wall has no fenestration.

The building interior is divided into four rooms. The pump room is at the north end, followed by a fluoridation room, tablet chlorine room, and an ammonium sulfate room at the south end. The pump room contains the Well 6 wellhead and motor, a natural gas backup generator, control panels for both Wells 5 and 6, and equipment for chemical analysis (**Photograph 10**). The fluoridation room includes a modern chemical storage tank and dosing unit (**Photograph 11**). A raised loading dock with metal handrail at the rear of the room originally contained water softening tanks that have since been removed. The dock is reached by stairs at the south side of the room. The original chlorine room was subdivided around 1999 by constructing a partition wall to create separate spaces for the tablet chlorine unit and ammonium sulfate feeder (**Photographs 12** and **13)**. The south ammonium sulfate room has a modern drop ceiling.

The building site is landscaped with planting areas in front and back and an asphalt lot at the rear of the treatment building (**Photograph 14**). The front, raised, circular, concrete planter has a diameter of 17 feet and now contains a mature tree. The rear planting areas include a semicircular bed against the building and linear beds along the property margins. An electrical transformer sits on a concrete pad at the building rear. The front walkways are of concrete seeded with small river stones. Well control piping was added south of the building around 1999 (**Photograph 15**). Similar piping was added to Well 5 within the belowground vault.

B10. Significance (continued):

Historic Context

The City of Pleasanton constructed the treatment building in 1967 as part of the expansion and modernization of its municipal water system. The two wells at the site were bored earlier: Well 5 in 1962 and Well 6 in 1964. The city had used the subject location since at least 1950 and two prior wells—Wells 3 and 4—had operated there but were abandoned and capped when the new pumping station was constructed. The historic context below summarizes the history of municipal water development in Pleasanton and provides background on the engineering and architectural firms that designed the subject building. The water treatment techniques and technologies used in the subject building are also placed in historic context.

Groundwater Development in Pleasanton

Pleasanton is located at the west end of the Amador Valley in eastern Alameda County. The area is bound by the East Bay Hills to the west, the Diablo Range to the north and south, and Livermore Valley to the east. Prior to European settlement, a vast wetlands complex filled the lower end of the valley, northwest of where downtown Pleasanton later developed on slightly higher ground (**Figure 1**). The marsh was the largest non-tidal wetlands in the Bay Area with 2,600 acres of year-round lagoons and sloughs, surrounded by a belt of seasonal wetlands that swelled and contracted with the rains to a maximum size of around 10,000 acres. Surface streams flowed only intermittently, making the marsh a valuable source of summer water. The waterway known as Arroyo Valle (also identified as Arroyo del Valle) flowed along the north edge of downtown Pleasanton and carried a mean annual runoff of approximately 26,000 acre-feet, with nearly all of it passing between October and April. In its winter floods, the stream ran in a broad and braided channel that divided into multiple distribution threads at its west end before merging with the marsh. The winter flows also recharged groundwater aquifers by percolating through the course streambed gravels.[1]

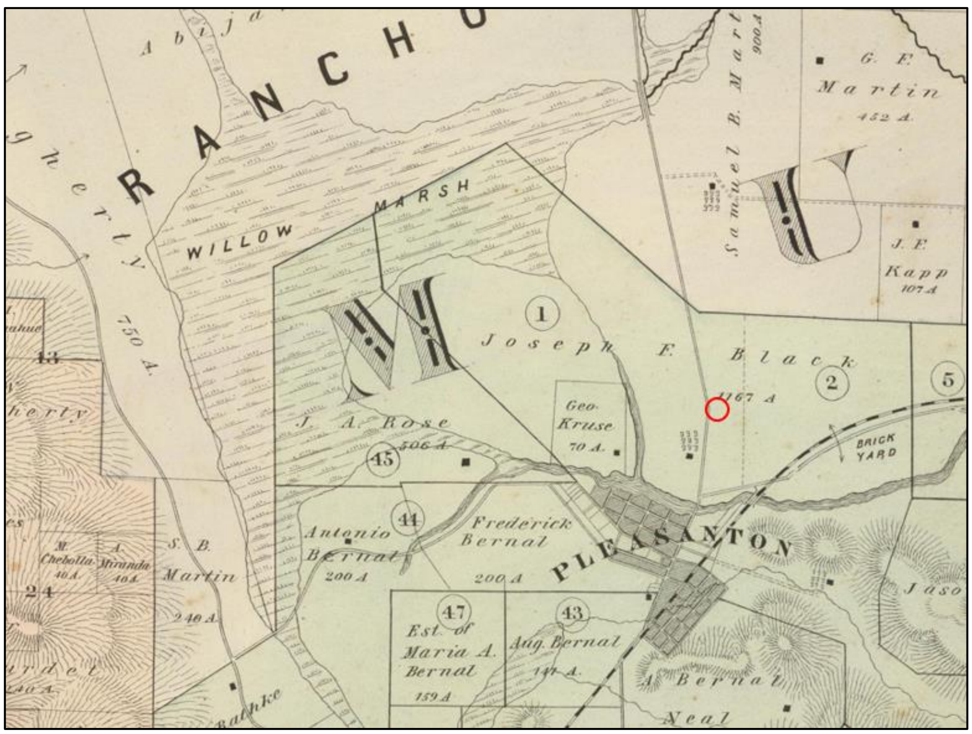


Figure 1: This 1878 Thompson & West map of Alameda County shows extensive marsh lands northwest of Pleasanton. Arroyo Valle flows along the north edge of town. The approximate location of the Pleasanton Water Pumping Station is indicated by the red circle.[2]

[1] San Francisco Estuary Institute, *Alameda Creek Watershed: Historical Ecology Study*, prepared for the San Francisco Public Utility Commission and the Alameda County Flood Control & Water Conservation District, February 2013, 3, 8–12, 87–95; U.S. Geological Survey (USGS) and California Department of Water Resources (DWR), *Alameda Creek Watershed Above Niles: Chemical Quality of Surface Water, Water Discharges, and Ground Water*, Federal-State Cooperative Water Quality Investigation, January 1964, 13–14.
[2] Thompson & West, *Official and Historical Atlas Map of Alameda County, California: Compiled, Drawn and Published from Personal Examinations and Surveys* (Oakland: Thompson & West, 1878), Map No. Seven, 53.

The Livermore Valley Groundwater Basin is composed of multiple distinct gravel aquifers at different depths separated by relatively impervious clay layers. The basin has a total storage capacity of approximately 500,000 acre-feet, larger than either Hetch Hetchy or Padre reservoirs, used respectively by the San Francisco Public Utility District (SFPUC) and East Bay Municipal Utility District (EBMUD). A joint report by the U.S. Geological Survey (USGS) and California Department of Water Resources (DWR) referred to the complete network of aquifers as comprising "a vast underground reservoir and transmission system."[3] The underground flow is north, away from the river and the Livermore Uplands, and then west towards the historic marsh. As the water percolates horizontally belowground, it gradually becomes trapped beneath and between sloping clay layers (aquicludes). The upper aquiclude keeps out rainwater, surface flow, and return irrigation water. At the west end of the valley, the water is squeezed beneath a clay cap, some 30 feet thick, creating artesian conditions as pressure forces the water up through fault line fractures. An 1871 observer travelling through the marsh district noted "hundreds of natural wells, which are full to the brim in the driest season" and overflow during the wet season to "inundate a large surface."[4]

Settlers began to clear the edges of the marsh in the mid-1800s, during the Mexican land grant era, but the intensive use of groundwater resources did not begin until the 1880s. The Pleasanton townsite was surveyed in 1867–1868, in anticipation of the arrival of the transcontinental railroad a year later. The town became a center of agricultural shipping as wheat fields stretched across the valley floor and into the surrounding hills. The dry-farmed grain, however, did little to spur irrigation development. It was the larger Bay Area cities of Oakland and San Francisco that first sought to develop the valley's water resources in a systematic way. In the 1880s, Oakland's Anthony Chabot purchased Pleasanton properties for his Contra Costa Water Company. He began constructing canals to drain the marshlands and directed the water north into his reservoir on San Leandro Creek. Streams that previously had discontiguous channels, like Arroyo Valle, were channelized to form a continuous drainage network. In the 1890s, San Francisco's Spring Valley Water Company (SVWC) followed suit, buying land and boring more than 100 wells west of town to extract groundwater and funnel it south by Alameda Creek through Niles Canyon and the Sunol Water Temple.[5]

As the marsh was drained in the 1890s and 1900s, farmers planted the rich soil with hops, grapes, sugar beets, and truck gardens. The area also gained a reputation for breeding thoroughbred horses and its racetrack attracted visitors from throughout the world. These activities required a regular supply of water, so property owners began developing artesian wells (**Figure 2**). In 1890, Pleasanton's residents subscribed $1,350 to develop wells and erect windmills along Main Street, providing the first public water supply, though there were no watermains to deliver the supply directly to homes and businesses (**Figure 3**). The town incorporated four years later and made improving the water supply a priority. In 1897, the town trustees purchased an artesian well with a strong 42,000-gallon-per-day flow about half a mile east of the city center. They constructed a 51,000-gallon sump and reservoir around the spring to collect the flow and a pumping plant that forced the water uphill 128 feet to a 200,000-gallon reservoir. This provided for pressurized water delivery through town by way of two riveted sheet steel pipes, one eight inches and the other 10 inches in diameter, and allowed installing 10 fire hydrants on Main Street. Distribution in town was by cast iron pipe. In the following years, two additional springs were tapped at the same location, which developed as the city picnic grounds (today's McKinley Park on Kottinger Drive), and a second 16,000-gallon sump and reservoir was added at the base of the hill.[6]

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[3] USGS and DWR, *Alameda Creek Watershed Above Niles,* 30.
[4] John Scott, *Information Concerning the Terminus of the Railroad System of the Pacific Coast* (Oakland: Daily Transcript Book and Job Printing Office, 1871), 18; USGS and DWR, *Alameda Creek Watershed,* 21–36; San Francisco Estuary Institute, *Alameda Creek Watershed,* 87–88.
[5] Joseph Eugene Baker, *Past and Present of Alameda County, California* (Chicago: S.J. Clarke Publishing Company, 1914), 443–445; Mary-Jo Wainright and the Museum on Main, *Pleasanton* (Charleston: Arcadia Publishing, 2007), 57, 64; San Francisco Estuary Institute, *Alameda Creek Watershed,* 60; S. Figuers, Norfleet Consultants, "Groundwater Study and Water Supply History of the East Bay Plain, Alameda and Contra Costa Counties, CA," prepared for The Friends of the San Francisco Estuary, June 15, 1998, 31.
[6] San Francisco Estuary Institute, *Alameda Creek Watershed,* 50–51; Baker, *Past and Present of Alameda County,* 444–445; Sanborn Map Company, *Pleasanton, Alameda Co., Cal.* (New York: Sanborn Map Co, May 1903), Sheet 1.

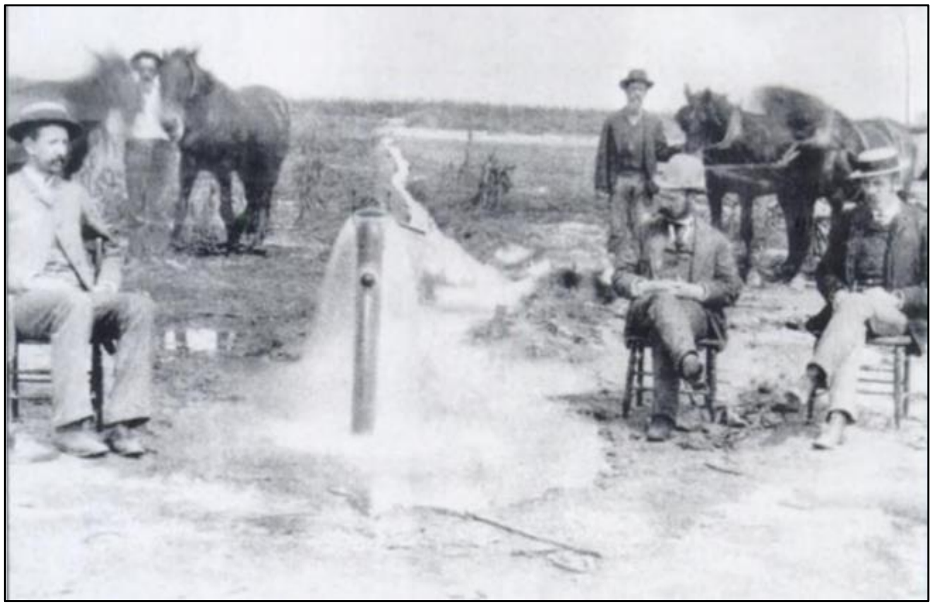

Figure 2: Artesian well along the west side of Amador Valley, undated photograph.[7]

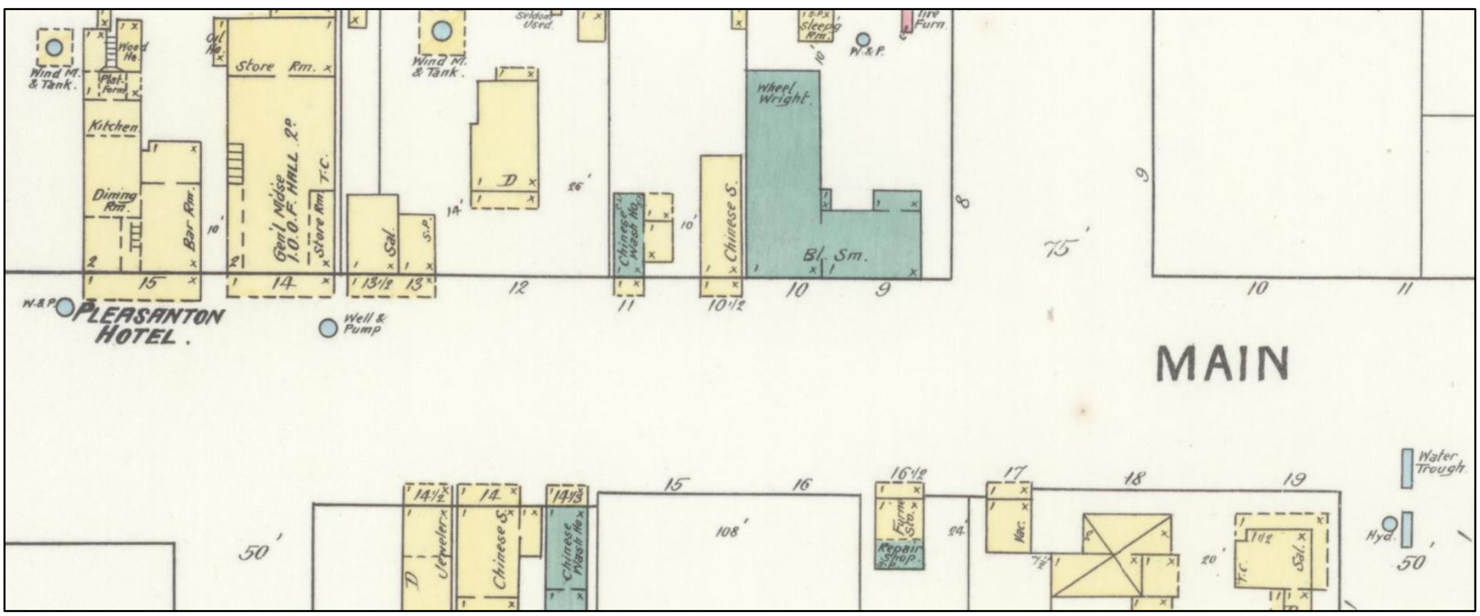

Figure 3: An excerpt of the 1893 Sanborn Fire Insurance Map for Pleasanton shows wells, pumps, and water troughs along Main Street, as well as windmills and tanks on private property.[8]

The rate of groundwater extraction in the region increased rapidly in the first decades of the twentieth century, aided by improved centrifugal pumps and rural electrification. At the start of the century, some artesian springs near Pleasanton still rose to four feet above ground under their own pressure, and the groundwater level through the former marsh area was less than three feet below the surface. However, by 1916 the water table had fallen noticeably, and artesian wells needed to be pumped in the dry season. City leaders added new water sources to compensate for the declining artesian flows. They developed three additional artesian wells at the picnic grounds site, bringing the total to six in 1907, with depths ranging from

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[7] Wainright and the Museum on Main, *Pleasanton*, 36.

[8] Sanborn-Perris Map Company, *Pleasanton, Alameda Co., Cal.* (New York: Sanborn-Perris Map Co., April 1893), Sheet 3.

170 feet to 228 feet. Around 1905, they constructed a supplemental electrical-powered pumping plant at the north end of the Main Street bridge over Arroyo Valle (**Figure 4**). The plant drew from two wells located in the creek bed. Running 12 hours a day, the plant pumped 100 gallons a minute (72,000 gallons per half day) directly into the water mains. Sections of cast iron water main gradually replaced the original riveted sheet steel lines.[9]

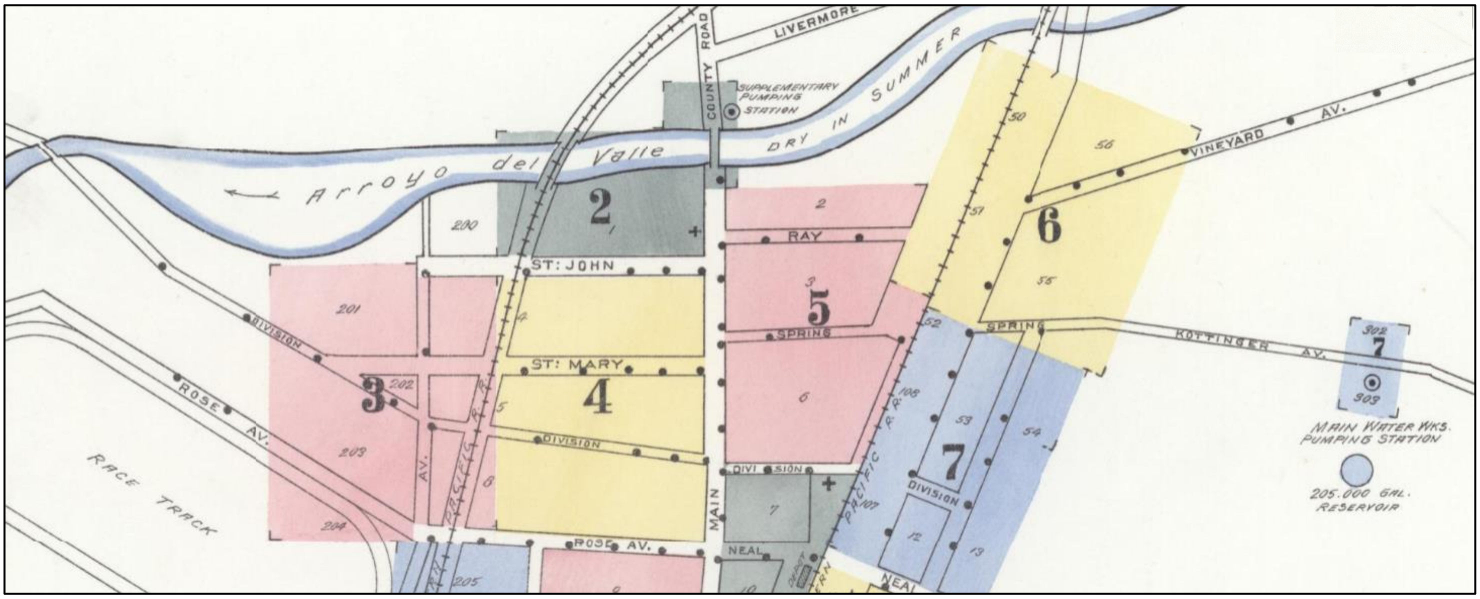

Figure 4: A 1907 Sanborn Map shows the main water pumping station and reservoir east of town and the supplemental pumping station north of the Arroyo Valle bridge.[10]

Groundwater levels continued to fall through the 1920s and 1930s, owing to drought and continued heavy pumping by SVWC and other users. By 1929, the city had abandoned two of the artesian wells in the picnic grounds. The yield from the remaining four wells had fallen to a little over 10,000 gallons per day, less than a quarter of the original volume. The city ceased using the artesian wells entirely by 1943. The main pumping operation shifted north of Arroyo Valle (**Figure 5**). The city bored a series of new wells in the hunt for a sufficient supply. A total of six or seven wells were developed, but by the mid-1920s only three remained in operation, each around 270 feet deep and located between 25 and 45 feet back from the river bank. In 1926, the water level within the wells fell below the effective reach of the surface centrifugal pumps. City leaders blamed the SVWC pumping for intefering with the town's vested riparian water rights. The parties reached an agreement for SVWC to drill a new well, 168 feet deep, about a half mile north of the bridge, along Santa Rita Road opposite Amador Valley High School. The city added a 50,000-gallon concrete cistern at the bridge station and pumped water from there directly into the city mains, with any excess lifted to the hilltop reservoir above the picnic grounds. SFPUC (successor to SVWC) finally ceased pumping Pleasanton groundwater in 1948 as Sierra Nevada water became available through the Hetch Hetchy reservoir and Amador Valley water tables continued to fall.[11]

[9] San Francisco Estuary Institute, *Alameda Creek Watershed*, 60; Sanborn Map Company, *Pleasanton, Alameda Co., Cal.* (New York: Sanborn Map Co, December 1907), Sheet 1; C. G. Gillespie, "Pleasanton Sanitary Engineering Survey," December 3 and 17, 1929, 1–4, File folder 66-22: Sanitary Engineering Surveys, Pasadena–Pomona, 1930–1932, 1944, Box 22: Dept. of Public Health, Division of Environmental Sanitation, Bureau of Sanitary Engineering, 1930–1950, Collection No. R384, California State Archives.
[10] Sanborn Map Co., *Pleasanton* (December 1907), Sheet 1.
[11] Gillespie, "Pleasanton Sanitary Engineering Survey," 1–4; Sanborn Map Company, *Pleasanton, Alameda Co., Cal.* (New York: Sanborn Map Co, December 1907, Updated April 1943), Sheets 1, 7, and 12; San Francisco Estuary Institute, *Alameda Creek Watershed*, 60; "Pleasanton, S.F. Agree on Water Pact," *Oakland Tribune*, August 5, 1960, 21.

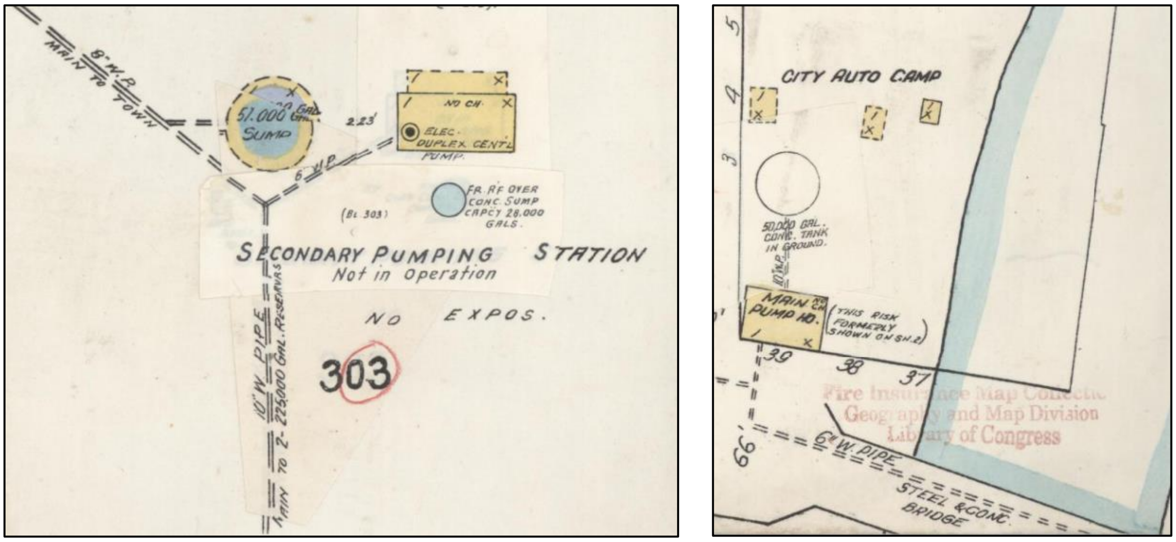

Figure 5: A 1943 update to the Pleasanton Sanborn Fire Insurance Map series shows the picnic grounds artesian well station (left) as no longer in operation. The pumping plant north of the Arroyo Valle bridge on Main Street (right) was then identified as the main pump site with a 50,000-gallon concrete storage cistern.[12]

On the eve of World War II, Pleasanton remained a small rural community. The town's population had increased only very modestly, from 1,100 in 1900 to 1,278 in 1940. California's postwar population boom quickly changed that situation and drove a major expansion of numerous East Bay communities. The completion of the Interstate 580 and 680 freeways allowed suburbanites to commute from the interior East Bay bedroom communities to jobs in Oakland, Berkeley, and San Francisco. The population of the Livermore-Amador Valley tripled from 1950 to 1960 and again from 1960 to 1970, by which point Pleasanton had 18,328 residents, a more than 10-fold increase from 1940. Much of that growth came through the annexation of new territory. At one point during the spring of 1964, Pleasanton city officials had 14 separate subdivision proposals under review, including the 38-acre, 180-home development on Santa Rita Road that surrounds the subject property today.[13]

To meet the increased demand for water, the City of Pleasanton developed new wells on Santa Rita Road north of the Arroyo Valle bridge. This included at the existing site opposite Amador Valley High School, where a second well was bored to 305 feet to tap deep aquifers, and a new site a quarter mile farther north on Santa Rita Road, at the subject property location. A 1950 aerial photograph shows small pump houses at both sites (**Figure 6**). The city designated the first well bored at the subject property as Well 3. A second well at the site, Well 4, was added immediately north of Well 3 at some point between 1950 and 1962 (neither remain in use today). To increase the available groundwater supply, the Pleasanton city council opened negotiations in 1954 to purchase the San Francisco underground reserves that were no longer being used. It required six years to finalize the agreement, but Pleasanton ultimately received rights to pump up to 15 million gallons a day from the basin. In 1961, the City of Pleasanton agreed to purchase wholesale water from the Pleasanton County Water District (PCWD), which served unincorporated outlying areas beyond the town. The agreement charged PCWD with developing new water sources, while the city handled the retailing of water to customers. Later, in 1966, the city also contracted with the Alameda County Flood Control and Water Conservation District, Zone 7 (Zone 7) to purchase wholesale water deliveries that consisted of a mixture of groundwater, local surface sources, and California State Water Project (SWP) supplies delivered via the South Bay

[12] Sanborn Map Company, *Pleasanton* (April 1943), Sheets 7 and 12.

[13] Wainright and the Museum on Main, *Pleasanton,* 7–8, 36; San Francisco Estuary Institute, *Alameda Creek Watershed,* 3; "Pleasanton to Ponder Annex," *The Daily Review (Hayward),* March 15, 1964, 6; "Pace Faster in Pleasanton," *The Daily Review (Hayward),* March 3, 1964, 22.

Aqueduct. Today, Pleasanton sources approximately 80% of its potable water from Zone 7 and 20% from the subject city Wells 5 and 6.[14]

Figure 6: A 1950 aerial photograph shows a small pump house at the subject property location, circled in red, and the pump station opposite Amador Valley High School circled in blue. Both utilities are no longer extant.[15]

[14] USGS and DWR, *Alameda Creek Watershed*, F-18 and F-44; "Pleasanton, S.F. Agree on Water Pact," *Oakland Tribune,* August 5, 1960, 21; "Pleasanton to Act on Water Pact," *The Daily Review (Hayward),* April 23, 1961, 6; "Pleasanton is Asked to Sign Again," *The Daily Review (Hayward)*, November 19, 1966, 15.
[15] Aero Explorations Company, aerial photograph, Flight BUT-1950, Frame 180, 1:20,000, March 12, 1950.

Figure 7: A 1965 aerial photograph shows Well 6 prior to construction of the treatment building, circled in red, and the fenced grounds for Wells 3, 4, and 5 in blue.[16]

In the early 1960s, the City of Pleasanton hired Kennedy Engineers to prepare a master plan for a water system expansion to accommodate the rapid growth by annexation. Kennedy Engineers was already at work planning for the sewage needs of the city and eastern Alameda County and had an extensive history working in the area (see further discussion below). The firm released its report in May 1964, coinciding with the peak of annexations. The plan called for expanding and modernizing the entire water distribution system. A new pumping station, well, and treatment plant at the subject property site would replace the existing station north of the Arroyo Valle bridge. The new 1.5-million-gallon capacity Bonde Reservoir and lift station southeast of town would meet storage needs, and new watermains would distribute supplies to the rapidly multiplying housing tracts. Voters approved a $750,000 revenue bond issue to finance the project in the summer of 1965. At $246,000, the new pumping station was the largest single item included in the package. Two years later, the city secured an additional $189,000 from the Department of Housing and Urban Development to upgrade and expand its water and sewer facilities, using part of the funds to connect the older city center to the new treatment and pumping station.[17]

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[16] Cartwright Aerial Surveys, aerial photograph, Flight CAS-65-130, Frame 13-64, 1:12,000, May 17, 1965.

[17] "Ordinance on Unsafe Buildings," *The Daily Review (Hayward),* May 6, 1964, 44; "Razeto Warns Agencies on Sewage Plight," *The Daily Review (Hayward),* June 14, 1961, 17; "Pleasanton Election Tomorrow," *The Daily Review (Hayward),* October 4, 1965, 5; "Pleasanton Bond Proposal Backed," *The Daily Review (Hayward),* August 25, 1965, 5; "Plan Enters Feud," *The Daily Review (Hayward),* October 27, 1967, 4.

The plan called for abandoning the existing Wells 3 and 4 at the subject property and establishing two new wells. Well 5 was bored in 1962 to a depth of 650 feet and had a submersible turbine pump. The wellhead was in an unground vault located directly between Wells 3 and 4. The Alisal Elementary School had opened in 1956 and the wells sat directly in front of the school parking lot. A 6-foot chain link fence surrounded the three wells. Well 6 was bored in 1964 north of Wells 3, 4, and 5, at the future location of the treatment building (**Figure 7**). It also had a depth of 650 feet. Both wells had 14-inch steel casings with perforations spaced in depths between 149 and 650 feet. Gravel was packed around the casing for its full depth and the upper 135 feet were enclosed in a wider conductor casing that was filled with cement grout after drilling was completed (**Figure 8**). The initial Well 6 work did not include installing a pump or engine, and the well did not become operational until 1966, after the bond issue was passed. The City of Pleasanton then contracted with Kennedy Engineers to design the pump station and treatment building, and they in turn subcontracted with the architectural firm Kitchen and Hunt to design a building with a modern appearance. The plans were completed and the treatment building constructed in late 1967. Lettering on the front of the building (since lost) identified it as "City of Pleasanton Water Pumping Station."[18]

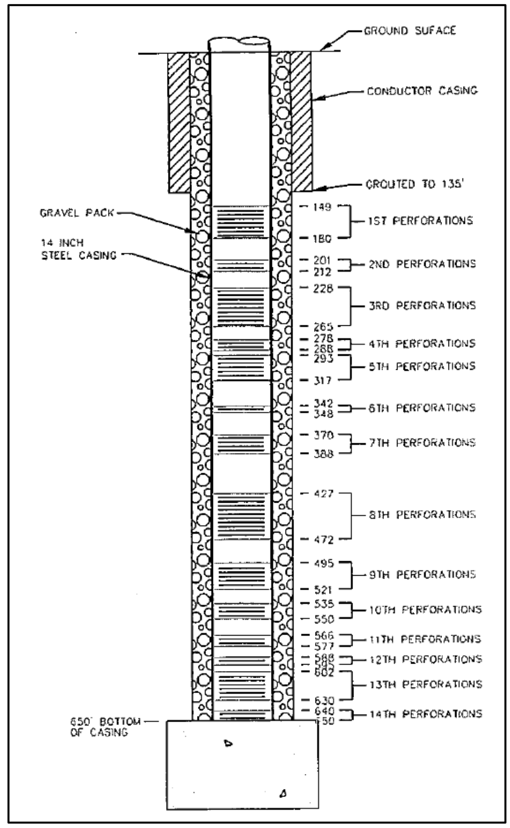

Figure 8: Well 5 schematic showing casing and perforations.[19]

[18] City of Pleasanton and Carollo, "State Revolving Fund (SRF) Application: Technical Package, T1-Project Report, City of Pleasanton PFAS Treatment and Wells Rehabilitation Project, Final," May 2022, 9–10; City of Pleasanton, Department of Public Works, "Well No. 6 Tie-In," As Built, May 12, 1966.

[19] City of Pleasanton, Department of Public Works, "Pumping Station – Wells 5 and 6 Improvements, Well No. 5 Profile," June 9, 1999, Sheet M-4.

Kennedy Engineers

Kennedy Engineers was one of California's pioneering sanitary engineering firms. Founder Clyde C. Kennedy attended UC Berkeley and studied under Charles Gilman Hyde, the field's leading practitioner on the West Coast. Kennedy received a degree in Sanitary Engineering in 1911 and completed a Masters of Science in the School of Public Health the following year. He worked for several years as the city engineer for Berkeley, during which time he served on the joint water commission organized by Oakland, Berkeley, Alameda, and Richmond that later led to the formation of the EBMUD. In 1919, Kennedy opened his own private consulting firm, Kennedy Engineers, with a San Francisco office. The firm developed expertise in water quality investigations (including operating its own laboratory), master planning of sanitary services, facility design, and construction supervision. Kennedy served as consulting engineer for the city of San Francisco and was a member of the board of engineers tasked with solving the East Bay sewage problems. By the end of World War II, Kennedy Engineers had put into operation more than 60 sewage disposal systems in California, including the Sacramento city plant, as well as treatment facilities in Arizona and Nevada. The company designed and built municipal water systems for the cities of Eureka, Paradise, and many other communities.[20]

Clyde Kennedy died in April 1952 at age 71. His two sons, Richard R. and Robert M. Kennedy, took over management of the firm with Richard serving as the company head. Richard Kennedy graduated from Stanford University with a civil engineering degree in the 1930s and immediately joined his father's business, designing the sewage treatment plant at Hoover Dam as his first project. He designed airfields throughout the Western United States during World War II and oversaw the construction of Benicia Arsenal, the largest ammunition handling facility on the West Coast. He did a great deal of international consulting in the post-war decades, designing more than 40 dams in Taiwan and serving as a Bureau of Reclamation consultant for work through Central and South America, as well as in Vietnam and Cambodia. He was a fellow in the American Society of Engineers and served as president of the society's San Francisco section. In 1979, he handed over presidency of the company to his son David D. Kennedy, while remaining chairman of the board of directors. In 1980 he oversaw the merger of Kennedy Engineers with Jenks & Harrison, a company founded by Harry Jenks, another Charles Gilman Hyde student (class of 1917). The Kennedy Jenks company today continues to be an industry leader in environmental engineering services with 34 offices across the country.[21]

By the early 1960s, as the City of Pleasanton was planning the construction of Wells 5 and 6, Kennedy Engineers was already a substantial firm with offices in San Francisco, Los Angeles, Tacoma, and Salt Lake City (**Figure 8**). The company had an established relationship with Alameda County planners, having worked closely with EBMUD for many years. In 1960, the company began preparing a master plan for sewage treatment in the unincorporated areas of Livermore Valley surrounding Pleasanton. That proposal included one of the state's earliest calls for the reclamation of wastewater. The company also served as consultants for the City of Pleasanton on its sewage needs, and prepared master plan proposals for waste and water issues in neighboring Contra Costa County.[22]

Figure 9: 1962 advertisement for Kennedy Engineers.[23]

[20] Kennedy Jenks, "History," accessed March 2023 at https://www.kennedyjenks.com/about-kj/history/; "Commencement at University," *Berkeley Daily Gazette*, May 15, 1912, 8; "City Represented on Water Body," *Oakland Tribune*, December 4, 1918; "Engineer Sees No Difficulty in Sewer Plant," *Santa Rosa Republican*, July 2, 1935, 4; "Sewage System Survey Being Conducted Here," *Portola Reporter*, October 31, 1946, 1; "Water System Designer Dead," *Humboldt Times Standard*, April 29, 1952, 9.

[21] Richard R. Kennedy [obituary]," *San Francisco Examiner*, October 9, 1985, 20; "Hoover Sewage Plant in Operation," *The Reclamation Era*, Vol. 43, No. 3 (August 1957), 79; "People in Business," *Oakland Tribune*, February 15, 1979, 58; Kennedy Jenks "History."

[22] "Livermore Valley Sewer Study Set," *Oakland Tribune*, June 16, 1960, 70; "Sewer Plan for Valley Endorsed," *Oakland Tribune*, May 20, 1966, 26; "Sewage Plan Outlined," *Oakland Tribune*, July 1, 1975, 8; "CC Land Study Ordered," *Concord Transcript*, March 7, 1967, 1.

[23] "Professional Services," *Journal (American Water Works Association)*, Vol. 54, No.11 (November 1962), 266.

Kitchen and Hunt

The architectural firm Kitchen and Hunt achieved national prominence for its work at the 1960 winter Olympic games at Squaw Valley (known today as Palisades Tahoe). In partnership with Corlett and Spackman, the firm drew up master plans and designed major facilities, including the Blyth Memorial Ice Arena that was the centerpiece of the Olympics as the site of the opening and closing ceremonies, as well as the ice hockey and figure staking competitions. (Kennedy Engineers oversaw water and sanitation services for the games.) The ice arena claimed first prize in the nationwide Progressive Architecture design awards for 1959 as the best of more than 300 submitted projects. The firm's other major projects included five Bay Area Rapid Transit (BART) stations (North Berkeley, West Oakland, South Hayward, Union City, and Fremont); the Eastman Kodak distribution center in San Ramon; the Reno-Sparks sewage treatment plant (with Kennedy Engineers); a circular design for the Music Building at California State University, Hayward (now Cal State East Bay); the United Airline building at San Francisco International Airport; library additions at UC Davis; and numerous private residences, including Hunt's home in the Berkeley hills and a Santa Cruz beach residence that appeared on the cover of the March 1951 issue of *Architect and Engineer* (**Figure 9**).[24]

Robert Sieber Kitchen was born in Dayton, Ohio, in 1912. He attended Cornell University and received a Bachelor of Architecture in 1935, followed by a Bachelor of Landscape Architecture in 1936. His work as a student was marked by a pronounced modernism that had not yet come to favor among most of Cornell's faculty, who preferred more traditional Beaux Arts design. Nonetheless, he received the university's Rome Prize for his culminating landscape project and was awarded a two-year fellowship at the American Academy in Rome. He returned from Europe on the cusp of World War II and worked for a time on the General Motors Pavilion at the 1939 New York World's Fair. He relocated to San Francisco in 1939, serving as a draftsman in a local design firm and then as an associate project planner for the Federal Public Housing Agency. After completing U.S. Naval Reserve service during the war, he worked for architect Albert Roller and landscape designer Thomas Church. He formed his partnership with Frank Hunt in 1948 and remained in that position until his retirement. He was named a Fellow of the American Institute of Architects (AIA) in 1964, and later served as president of the Berkeley Civic Arts Commission. Kitchen died in 2007.[25]

Frank Bouldin Hunt was born in Nebraska in 1915 and received a Bachelor of Architecture from UC Berkeley in 1938. He worked in Oakland for William Corlett (later of Corlett and Spackman, the co-designers of the 1960 Olympic games) before serving as a lieutenant in the U.S. Naval Reserve through World War II. Hunt was elected president of the East Bay Chapter of AIA in 1968 and was named a Fellow in 1971. He served as a vice president of Kennedy Jenks Engineers from 1975 through 1986. Hunt died in 1997.[26]

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[24] "Kitchen and Hunt, Architects," Pacific Coast Architecture Database (PCAD), accessed March 2023 at https://pcad.lib.washington.edu/firm/4112/; "Architects Selected for Squaw Valley Job," *Contra Costa Gazette,* June 20, 1956, 12; "Ice Arena Design," *Contra Costa Times,* September 20, 1959, 10; Kodak Dedicates SR Center," *Contra Costa Times,* December 9, 1969, 16B; "California Style, Ocean Side Residence, Del Mar, Santa Cruz," *Architect and Engineer,* Vol. 84, No. 3 (March 1951), cover and 16–19;
[25] "Robert Sieber Kitchen (Architect)," PCAD, accessed March 2023 at https://pcad.lib.washington.edu/person/5543/; "Robert S. Kitchen [obituary]," *The Desert Sun (Palm Springs),* June 15, 2007, B5; Christian Ricardo Nielsen-Pacacios, "Architectural Education at Cornell: 1928–1950, Between Modernism and Beaux-Arts," Masters thesis, Cornell University, 2018, 27–33; The American Institute of Architects (AIA), College of Fellows, *History & Directory,* 2022 Edition, 150.
[26] "Frank Bouldin Hunt (Architect)," PCAD, accessed March 2023 at https://pcad.lib.washington.edu/person/5544/; "Architects Elect New President," *Oakland Tribune,* December 10, 1968, 48; "Honored Architects Ready for Big Day," *San Francisco Examiner,* June 13, 1971, Real Estate-D; AIA, College of Fellows, *History & Directory,* 2022 Edition, 168.

Figure 10: Kitchen and Hunt projects. Upper Row: Eastman Kodiak distribution center, San Ramon / South Hayward BART station model. Middle Row: Music building, Cal State East Bay / Hunt house, Berkeley. Bottom Row: Blyth Memorial Ice Arena, exterior and interior views, Palisades Tahoe.[27]

[27] "Kodak Dedicates SR Center," *Contra Costa Times*, December 9, 1969, 16B; Mel Scott, *American City Planning Since 1890: A History*

Pleasanton Pumping Station and Treatment Plant

Kitchen and Hunt designed the City of Pleasanton Pumping Station with a scale and styling that fit within the aesthetics of the surrounding Tract Ranch subdivision. The building's horizontal massing, low-pitched gable roof with deep overhanging eaves, and attached porte-cochère all blended comfortably with the neighborhood's residential architecture (**Figure 10**). The building also had a touch of Modernistic flair that was particularly evident in the porte-cochère and masonry columns of the south and west elevations. In their other projects, Kitchen and Hunt worked in a variety of Modernist styles including New Formalism, Brutalism, and the Second Bay Tradition style. While the subject building is too architecturally modest to fully embody any particular Modernist substyle, it drew from the Second Bay Tradition and New Formalism.

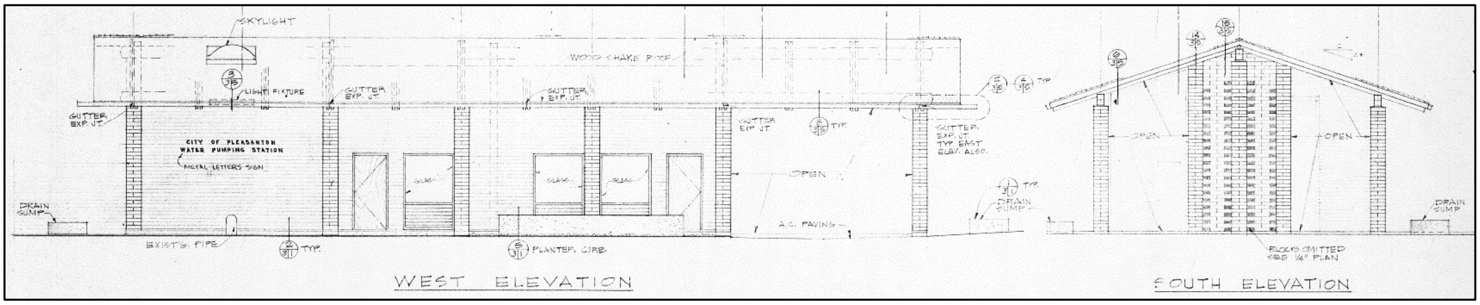

Figure 11: Original construction plans (1967) showing the west and south elevations of the proposed pump station.[28]

The regional Second Bay Tradition was broadly characterized by the use of local building materials; the embrace of a rustic, hand-hewn quality over machine aesthetics; and the employment of unpretentious, vernacular forms. The Bay Area-centered style was often contrasted with Southern California where a more hard-edged, steel-and-glass Internationalism was the predominant interpretation of Modernism. The Second Bay Tradition style was heavily influenced by William Wurster, the head of the UC Berkeley architecture program, who embraced the ideas of modernism and recognized and encouraged the interaction between architecture, landscape architecture, and planning. Architects used the Second Bay Tradition style principally for suburban residences, and it had comparatively little impact in urban areas or commercial building design. It was a style favored by intellectuals and an artistically conscious segment of the upper-middle class who lived in the affluent suburban developments that emerged after World War II. For the subject property, the style was most evident in the building's simple massing, the use of slump bricks, and the original wood shake roof (since replaced with composition shingles). These elements gave the building a rough, vernacular feel that somewhat belied its modern, utilitarian function.[29]

New Formalism was popular for civic and commercial design from the 1950s into the 1970s. In opposition to the ahistoricism of early International Style modernism, New Formalism made conscious use of abstract classical forms, with symmetrical plans and the conspicuous employment of colonnades and full-height pilasters. Wall surfaces were commonly smooth or composed of screens of perforated concrete, masonry, or metal. The Cal State Hayward music building, completed by Kitchen and Hunt in 1965, clearly showed these elements, while the more utilitarian subject pump station gestured towards them with its masonry columns and unadorned wall surfaces.[30]

Commemorating the Fiftieth Anniversary of the American Institute of Planners (Berkely: University of California press, 1971), 605; "California Mid-Century Modern: Education Buildings" RoadsideArchitecture.com, accessed March 2023 at https://www.roadarch.com/modarch/caedu3.html; "4 Houses—A Diversity of Expression," *Arts and Architecture,* Vol. 81, No. 4 (April 1964), 14; Structural Engineers Association of Northern California, "Structures: Blyth Memorial Ice Arena," accessed March 2023 at https://legacy.seaonc.org/structure/blyth-memorial-ice-arena/.

[28] Kennedy Engineers, "Water Pumping Plant, Exterior Elevations" October 9, 1967, sheet A-3.

[29] David Gebhard, "Introduction: The Bay Area Tradition," in Sally Woodbridge, ed., *Bay Area Houses: New Edition* (Salt Lake City: Peregrine Smith Books, 1988), 3-9; Pierluigi Serraino, *NorCalMod: Icons of Northern California Modernism* (San Francisco: Chronicle Books, 2006), 21-25, 69-75.

[30] Planning Resource Associates, Inc., *Mid-Century Modernism Historic Context,* prepared for City of Fresno, September 2008, 78.

Kennedy Engineers planned the treatment building as containing three rooms (**Figure 11).** The building was constructed around the existing wellhead, enclosing it within the large north "pump room." The central "fluoridation room" included a solution tank, pump, and feeder, along with two water softening canisters and a brine tank for recharging the canisters. The south "chlorination room" had trunnion mounts for two one-ton chlorine cylinders, a pump, and a feeder. A hoist rail, hung from the ceiling, ran through the room and across the exterior porte-cochère for exchanging the chlorine cylinders. The water line from Well 5 was routed north through a 12-inch-diameter steel pipe to the treatment plant.

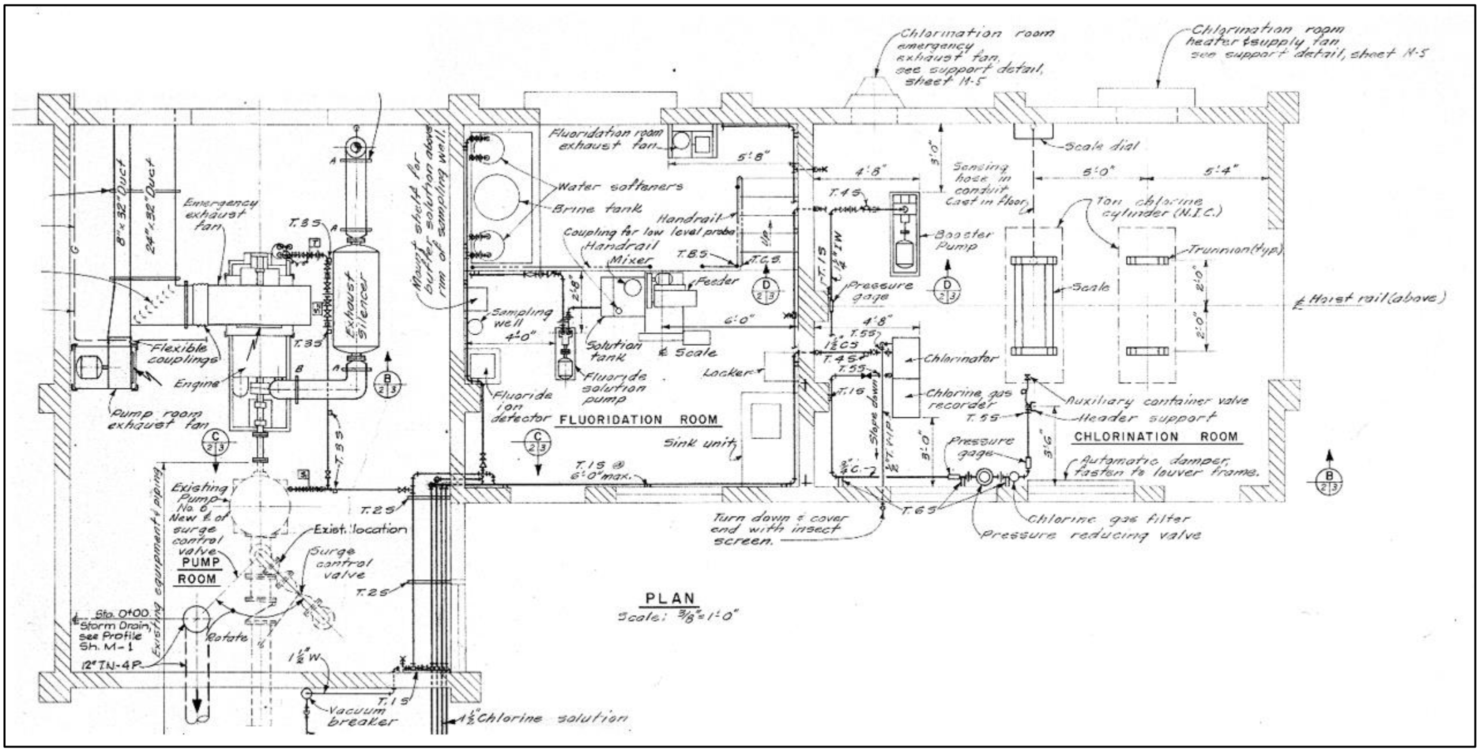

Figure 12: Floor plan showing pumping and treatment equipment.[31]

Chlorination

The permanent, continual chlorination of American drinking water supplies beginning in 1908 was one of the great public health achievements of the twentieth century. Chlorine is a strong oxidizing agent that, when applied in the correct dosage, can quickly kill the microorganisms that cause cholera, dysentery, typhoid fever, and other illnesses, without causing adverse effects in humans. The introduction of chlorination promptly saved tens of thousands of lives that waterborne illnesses would otherwise have claimed. Chlorination also improved the efficiency and palatability of water systems by reducing the mold, algae, and slime that grew in water intakes and distribution systems.[32]

The first experiments in using chlorine compounds to disinfect water occurred in the late nineteenth century. British and German sanitarians in the 1890s used bleaching powder to sterilize watermains and other equipment following outbreaks of typhoid fever and cholera. These short-term efforts succeeded in preventing reoccurrences of the epidemics, but they did not

[31] Kennedy Engineers, "Water Pumping Plant, Mechanical, Plans and Details" October 9, 1967, sheet M-2.
[32] Michael J. McGuire, "Eight Revolutions in the History of US Drinking Water Disinfection," *Journal (American Water Works Association)* Vol. 98, No. 3 (March 2006), 123–149; Wilfred F. Langelier, "Teaching, Research, and Consultation in Water Purification and Sewage Treatment, University of California at Berkeley, 1916–1955," transcript of oral history interview conducted by Malca Chall, April and May, 1970. Regional Oral History Office, Bancroft Library, University of California, Berkeley, 1984,4–6; W. A. Hardenbergh, *Operation of Water-Treatment Plants* (Scranton: International Textbook Company, 1940), 205–207.

attempt to provide continual disinfection of the water supply. In 1905, officials again used chlorine to halt a typhoid epidemic in Lincoln, England, but then as a precautionary measure, they continued a slow feed of chloride solution for a period of years until a new water source became available. This marked the first continual disinfection of a public water system and prompted further experimentation in Europe and America.[33]

The earliest American efforts at continual disinfection occurred in 1908. Wilfred Langelier of the Illinois Water Survey and later professor of chemistry at UC Berkeley participated in the first experiment at the Union Stock Yards of Chicago. The engineers selected the site as only animals would be affected, and the heavily contaminated water supply made an ideal test case. The introduction of a minute quantity of chlorine continually fed into the supply line almost completely sterilized the stockyard water, leaving it in better condition than Chicago's municipal supply. Shortly after, the same engineers applied the technique to the drinking water of Jersey City, with chlorination beginning on September 26, 1908. The city received many complaints about the odor and taste of chlorine, which could not yet be administered with precise control, but the results were so promising that the objections were overruled. In the years immediately following the experiments, sanitary officials constructed many emergency chlorination plants in areas affected by flooding or disease outbreaks.[34]

The introduction of improved chlorine gas feeders around 1913 allowed the process to spread into wide municipal use. Compressing chlorine gas under pressure converted it into a liquid that could be stored and transported in tightly sealed metal containers. A British officer in the Indian Medical Service was the first to use liquified chlorine gas on a small scale in 1903. The US Army experimented with the technology in the Philippines in the early 1910s, and a Niagara Falls plant began using liquid chlorine for temporary treatment in 1912. Philadelphia installed the first permanent liquid chlorine plant in 1913. The Wallace & Tiernan Company of New Jersey designed nearly all the early chlorinators that allowed for the controlled application of dosages, and according to Langelier, many of the first graduates of the UC Berkeley sanitary engineering program found employment with the firm.[35]

All large treatment plants used liquefied chlorine gas as it was the most economical option. However, as the gas is highly toxic, it could be difficult to safely store and an accidental release would endanger employees and nearby communities. Smaller plants therefore sometimes used chlorine in a powdered bleach form. In either case, the chemical was administered through chlorinators of various and evolving designs that connected to the water main with non-corrosive tubing. The chlorine and water mixed within a baffled chlorine contact basin for a specified period of time to produce effective disinfection. Duplicate equipment allowed chlorination to continue in the event of a failure of the primary apparatuses. The chlorine and dosing equipment occupied a dedicated room so that any leaks could be isolated. This room commonly had a separate entrance from the building exterior and no direct connection between it and any other room in the treatment plant or pumping house. Good ventilation facilitated repairs in case of a minor leak. Because liquified chlorine was commonly delivered in large steel cylinders weighing up to a ton, chlorination rooms generally included loading docks built to truck bed height or overhead rails for easy on and off loading.[36]

The Pleasanton facility originally used chlorine gas in one-ton cylinders, but replaced these after 1999 with powdered chlorine tablets and ammonia sulfate. The chlorine room was divided at that time to store the chemicals separately. A solid door replaced the middle window on the west façade to provide access to the new room. The double sliding doors that had opened to the porte-cochère for handling the chlorine cylinders using the overhead hoist rail were removed, and grooved plywood siding was used to fill the bay opening.[37]

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[33] McGuire, "Eight Revolutions," 125–126.
[34] Langelier, "Teaching, Research, and Consultation," 4–6.
[35] McGuire, "Eight Revolutions," 128–129; Hardenbergh, *Operation of Water-Treatment Plants,* 207; Langelier, "Teaching, Research, and Consultation," 6.
[36] Hardenbergh, *Operation of Water-Treatment Plants,* 207; Langelier, "Teaching, Research, and Consultation," 55–56.
[37] Arthur Engineering Inc., "City of Pleasanton, Well Pump 5 and 6 Improvements, June 14, 1999, Sheet E4.

Fluoridation

Pleasanton had begun fluoridating its water supply in 1954 and was among the earliest cities in California to adopt the measure. Grand Rapids, Michigan, installed the world's first municipal fluoridation facility in 1945. Several other Eastern and Midwestern states followed, and the National Institute of Health and U.S. Surgeon General closely studied the pilot programs. Studies soon showed that the rate of tooth decay among children declined by as much as 60 percent in the cities with treated water. By the end of the decade, USPHS, the AMA, the American Dental Association, and the National Research Council all endorsed drinking water fluoridation as safe, effective, and inexpensive. A major public health breakthrough, fluoridation made tooth decay a preventable disease for the first time in history. Fluoridation of the domestic water supply expanded rapidly between 1950 and 1953. San Francisco and Antioch added fluoride to their water supplies in 1952, the first cities in California to do so. Pleasanton installed fluoride treatment equipment at the Arroyo Valle bridge site two years later. A follow-up study five years later found that Pleasanton school children experienced a 34.5-percent decline in cavities as a result of the program.[38]

Despite the public health gains, the fluoridation of public water supplies proved to be the most controversial water treatment issue in the postwar decades. Popular opposition to fluoridation gained traction in 1953. Some 60 cities nationwide reversed themselves over the next decade, halting fluoridation programs that they had earlier begun. In California, 36 communities held referendums on the matter, and in 25 cases voters rejected beginning or continuing fluoridation. Opponents voiced a variety of concerns. Some objected in principle to the idea of forced medication or challenged the addition of any chemical to a natural water supply, echoing earlier complaints about the use of chlorine in water treatment. Others noted that sodium fluoride in large doses functioned as a rat poison and worried about the potential of accidentally providing a toxic dose to humans. In the context of the Cold War, some feared that saboteurs might use fluoridation as cover for introducing harmful substances into the water supply, while figures on the fringe insisted that fluoridation was a communist plot to weaken Americans.[39]

The public opposition to fluoridation apparently had little impact on Pleasanton's decision to continue the practice at the subject treatment plant when it replaced the Arroyo Valle bridge pump station in 1967. Contemporary newspaper coverage recorded no debate or controversy over retaining fluoridation. Nationally, the supporters of fluoridation prevailed in the long run, backed by the unwavering support of public health officials and the clear and measurable dental health improvements in towns that embraced fluoridation. The introduction of fluoridated toothpastes in the early 1970s lessened tensions around the issue and proponents benefited from the greater calm. By 1980, half of the national population consumed water enhanced with fluoride. California, however, lagged behind the national trend. In a much-watched campaign, Los Angeles voters strongly rejected fluoridation in 1974. As late as 1992, less than 16 percent of the state's population received fluoridated water, the fourth lowest percentage in the nation.[40]

Water Softening

Groundwater drawn from certain geological formations by wells could contain high quantities of dissolved minerals including iron, calcium, and magnesium. These dissolved solids make water hard, which detracts from its palatability and interferes with industrial uses by forming scales in boilers and other equipment and requiring greater quantities of soap in laundry applications. Water softening is the process of removing hardening minerals.[41]

Modern water softening is accomplished by the zeolite process that uses ion exchange to replace the soluble calcium and magnesium in water with sodium. Ions are molecules that have acquired a net electrical charge as the result of gaining or losing electrons. As opposite charges attract, positively charged ions, known as cations, will adhere to their negatively charged anion partners. In ion exchange, molecules within solution are swapped with like-charged particles that are adhering to an oppositely charged solid that is immersed in the solution. Ion exchange is a common, natural process that is fundamental to

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38 Melosi, *The Sanitary City,* 303–306; National Institute of Dental and Craniofacial Research, "The Story of Fluoridation;" Ernest Newbrun, "A History of Water Fluoridation in California: Lessons Learned," *Journal (California Dental Association),* Vol. 47, No. 11 (November 2019), 705–711; "Fluorides Reduce Pupil Tooth Decay," *The Daily Review (Hayward),* June 5, 1960, 63.
39 Melosi, *The Sanitary City,* 304–05; Newburn, "A History of Water Fluoridation in California," 706.
40 Melosi, *The Sanitary City,* 305–06; Newburn, "A History of Water Fluoridation in California," 708–711.
41 Mark J. Hammer, *Water and Wastewater Technology,* 2nd ed. (New York: John Wiley and Sons, 1986), 273–282.

soil fertility as the negative charges of clay soil and organic matter attract and hold plant nutrient cations such as potassium, calcium, and magnesium. British soil scientists in the mid-1840s were the first to study the ion exchange process and to recognize that any single cation in the soil could be replaced with any other cation by saturating the soil with water rich in the replacement nutrient.[42]

European chemists began experimenting with ion exchange using zeolites in the 1850s, but without immediately recognizing the material's potential for water softening. The term zeolite refers to a group of natural materials (and today, synthetic products) that combined iron, aluminum, and sodium in a silicate form. Greensand, a marine sandstone, was the most common natural zeolite. When hardwater ran through a bed of zeolite, it exchanged its calcium and magnesium cations for the sodium cations adhering to the zeolite until the sodium was exhausted. Flooding the zeolite with a brine solution then reversed the process, releasing the calcium and magnesium for disposal and replenishing the sodium for another softening cycle. Coating the zeolite with manganese dioxide allowed it to also strip the water of iron. The potential to use zeolities for water softening was recognized by the early twentieth century, and the German scientist Robert Gans patented the process in 1906.[43]

Over the next two decades, small zeolite softeners found their way into many industrial processes as they demineralized water for use in steam boilers, laundry plants, pulp mills, and the like. A zeolite softening unit was essentially a rapid sand filter but with a bed of zeolite replacing the sand quartz and with a special lining to protect against corrosion caused by the brines used in regeneration. Depending on the size of the operation, the units could be either of the gravity-fed basin type or pressurized steel tanks, as was used in Pleasanton. The plant then blended the fully treated water with raw or partially treated water to produce a finished product with a desired level of hardness. The Ohio Valley Water Company constructed the first municipal softening plant below Pittsburgh in 1926. The company added a second plant in 1929, and the area served as a working laboratory for experimenting with the zeolite process on a large scale. The plants entered wide use in the 1930s, appearing in every part of the country. In 1941, the Metropolitan Water District of Southern California constructed its large water softening plant in La Verne using a combination of lime treatment and zeolite filter beds. After a later expansion, the La Verne facility had the distinction of being the largest zeolite softening plant in the world.[44]

It is not known when Pleasanton first began softening its water supply and whether that equipment was in use at the earlier Arroyo Valle bridge site. As tested in the late 1950s, Pleasanton water was only moderately hard, with calcium carbonate concentrations ranging between 81 and 117 parts per million (ppm). The USGS regarded concentrations of 61–120 as moderately hard, 121–200 as hard, and greater than 200 as excessively hard and requiring treatment. At the time, slightly more than a quarter of Pleasanton residence included a personal home water softener to treat the water at the point of consumption. This suggests that the city had not yet begun water softening at the source well, but the practice might have started prior to the new plant being completed in 1967. Newspaper coverage of the facility made no mention of water softening being introduced as a new treatment. It is also unknown how long the treatment continued, though the water softening unit had been removed by 1999. Once the city began receiving wholesale SWP water through Zone 7, that soft supply could be mixed with harder groundwater to produce a palatable supply that would not require additional softening.[45]

<u>Alterations to the Plant</u>

The City of Pleasanton has kept the subject property in operation since its completion. The building was altered in 1999 to subdivide the chlorine room so that powdered chlorine might be used in place of the original chlorine gas (see "Chlorination"

[42] J. T. Campbell and D. E. Davis, "Softening Municipal Water Supplies by Zeolite," *Journal (American Water Works Association),* Vol. 21, No. 8 (August 1929), 1035–1053.

[43] Hardenbergh, *Operation of Water-Treatment Plants,* 232–240; J. T. Campbell and D. E. Davis, "Softening Municipal Water Supplies by Zeolite," *Journal (American Water Works Association),* Vol. 21, No. 8 (August 1929), 1035–1053.

[44] D. E. Davis, "Observations on Zeolites in Water Softening and Demanganization," *Journal (American Water Works Association),* Vol. 29, No. 10 (October 1937), 1515–1525; Campbell and Davis, "Softening Municipal Water Supplies by Zeolite," 1035–1053; James M. Montgomery and William W. Aultman, "Water-Softening and Filtration Plant of the Metropolitan Water District of Southern California," *Journal (American Water Works Association),* Vol. 32, No. 1 (January 1940), 1–24.

[45] USGS and DWR, *Alameda Creek Watershed Above Niles,* F-18 and K-3–K-5; Arthur Engineering Inc., "City of Pleasanton, Well Pump 5 and 6 Improvements," June 14, 1999, Sheet E4.

discussion above). The city also added well control piping around the same time to allow for closer management. The Well 6 piping was added south of the building and the Well 5 piping within the underground vault. The original wood shake roofing was replaced at an unknown date by composition shingles, and the lettering identifying the building was lost.

Evaluation

The subject City of Pleasanton Water Pumping Station, including the treatment building and Wells 5 and 6, is not eligible, either in whole or for any separate elements, for inclusion in the NRHP or CRHR as it does not possess historic significance.

The subject property lacks important associations with significant events or trends, and it is not eligible under NRHP Criterion A or CRHR Criterion 1. The City of Pleasanton bore the two wells and constructed the building in the 1960s to expand and modernize the city's existing municipal water supply. The city had a long history of water development, dating back to 1890 when the first wells were developed along Main Street. Pleasanton installed a distribution system in 1897 and developed artesian wells and storage reservoirs east of the town in today's McKinley Park. Around 1905, the city added a pumping plant north of the Arroyo Valle bridge on Main Street. This served as the city's principal pumping plant and treatment facility for six decades until the subject property replaced it in 1967. The new plant continued to fulfill the same role as the earlier facility and did not introduce any new services or fundamentally change the nature of the Pleasanton municipal water system. The subject property also provided only a portion of the community's water supply, as city officials had entered agreements to buy wholesale water from Zone 7 and the Pleasanton County Water District. The subject property treated the groundwater pumped by its two wells with chlorination, fluoridation, and water softening. All of these processes were well established and widely adopted prior to the subject property being constructed. While Pleasanton was an early adopter of fluoridation in California, that treatment began in 1954 at the Arroyo Valle facility. Thus, the property merely continued existing pumping and treatment activities at a new location rather than introducing any historically important new activities, and it therefore lacks significance under this criterion.

The subject property lacks clear association with any individual important to history and is not significant under NRHP Criterion B and CRHR Criterion 2. The property is municipally owned and is closely associated with the City of Pleasanton, but not with any particular city leader, community advocate, or public works employee. Contemporary newspaper coverage treated the plant's construction as a routine function of municipal government and identified no specific individuals as playing a major role in proposing the plant or backing the bond campaign to finance its construction. City staff in the public works department have operated the plant since its completion, but no individual has had a long or meaningful individual association with the facility.

The subject property lacks significance under NRHP Criterion C or CRHR Criterion 3 as it is not an important example of its type, period, or method of construction; nor is it a work of high artistic value or an important example of the work of a master architect or engineer. As a work of water systems engineering, the plant employed technology and treatment methods common to its era and the property is typical of small-scale, municipal groundwater systems installed in the 1960s to accommodate suburban growth. The plant's design garnered no attention from trade publications, government agencies, or university researchers who would have noted the introduction of novel practices. The two wells with perforated steel casings and submersible pumps also made use of ubiquitous technology and lacked individual importance. As a work of Modernist architecture, the treatment building makes modest use of Second Bay Tradition and New Formalism design elements, but it is not a fully realized or important example of either Modernist subtype. The small municipal building filled an essentially utilitarian role and it did not warrant great architectural ambition. Indeed, it was largely designed to blend inoffensively with its suburban residential neighborhood. Kennedy Engineers and Kitchen and Hunt might conceivably qualify as master engineers and architects, respectively. Kennedy Engineers was important for its pioneering work in municipal drinking water and wastewater systems engineering, and Kitchen and Hunt completed important architectural works, most notably for the 1960 Olympic games. However, the subject property, which was small in scale and minimalist in design, is not an important example of the work of either firm, both of which had developed a portfolio of higher-profile, award-winning works well prior to designing the Pleasanton treatment plant. The subject property is not an important work for understanding the design tendencies or trajectories for either firm.

Finally, the property is not significant under NRHP Criterion D or CRHR Criterion 4 as it has not yielded, and is not likely to yield, data important to the understanding of history. The materials and construction and engineering techniques employed on this property were common in their time and are well documented in a wide body of written sources.

Photographs (continued):

Photograph 2: Well 5 vault; facing north by northwest, October 13, 2022.

Photograph 3: An August 2018 Google Streetview image shows the treatment building and porte-cochère; facing east. Foliage on the front tree prevented an unobstructed full view of the building at the time of recordation in 2022**.**

Photograph 4: View of the porte-cochère and south building side, showing exposed roof beams and sheathing; facing northeast, October 13, 2022.

Photograph 5: Partial wall and columns supporting the porte-cochère roof; facing north, October 13, 2022.

Photograph 6: Rear east side showing irregularly spaced pilasters; facing southwest, October 13, 2022.

Photograph 7: West side fenestration; facing north, October 13, 2022.

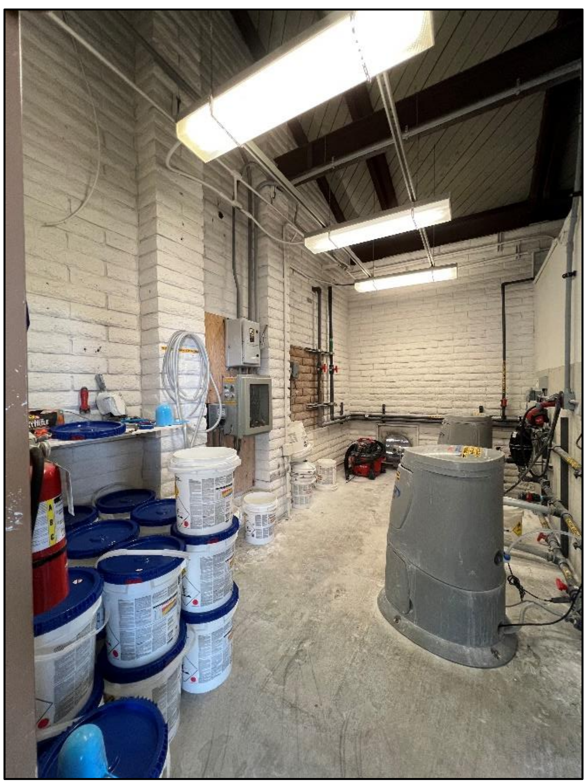

Photograph 8 and 9: Views of porte-cochère interior, showing hoist rail and the infilled bay opening; facing north (left) and south (right), October 13, 2022.

Photograph 10: Pump room with Well 6 wellhead, motor, and generator; facing northeast, October 13, 2022.

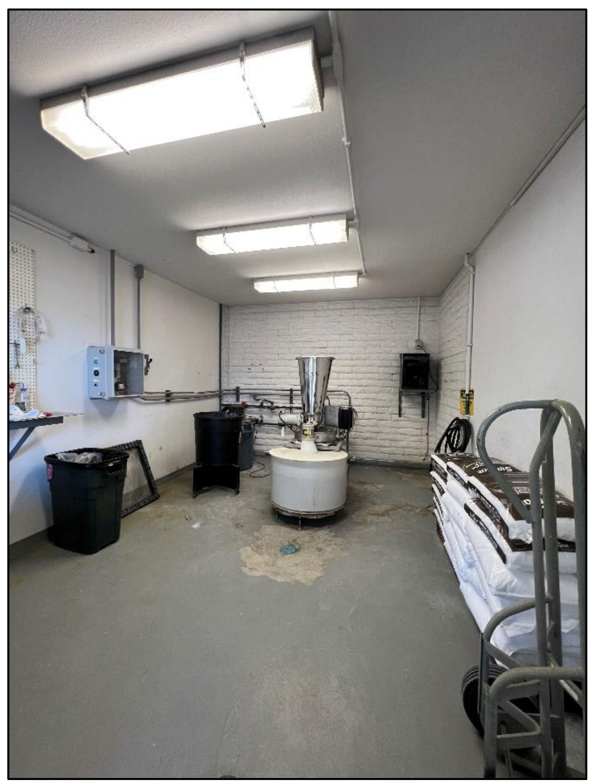
***Resource Name or #** (Assigned by recorder) City of Pleasanton Water Pumping Station

***Recorded by** D Hickman & D. Baza *Date October 13, 2022 ☒ Continuation ☐ Update

Photograph 11: Fluoridation room showing storage tank and dosing unit in front of loading dock; facing southeast, October 13, 2022.



Photograph 12: Chlorine tablet unit in subdivided room; facing east, October 13, 2022.



Photograph 13: Ammonium sulfate unit with installed wall at left and new drop ceiling; facing east, October 13, 2022.

Photograph 14: Landscaping at rear of building; facing southwest, October 13, 2022.

Photograph 15: Well control piping installed around 1999 south of building; facing north, October 13, 2022.

Page 28 **of** 28 ***Resource Name or #** (Assigned by recorder) City of Pleasanton Water Pumping Station

***Map Name:** USGS National Map ***Scale:** 1:24,000 ***Date of Map:** 2019

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary # ______
HRI # ______
Trinomial ______
NRHP Status Code 6Z

Other Listings ______
Review Code ______ Reviewer ______ Date ______

 ***Resource Name or #** (Assigned by recorder): Yountville Wastewater Reclamation Facility

P1. Other Identifier: Yountville Wastewater Reclamation Facility

***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County**: Napa

and (P2b and P2c or P2d. Attach a Location Map as necessary.)

***b. USGS 7.5′ Quad**: Yountville, CA **Date**: 2021 **T**:6N; **R**:5W; **Sec**: 3; Mount Diablo Meridian

c. Address: 7501 Solano Avenue City: Yountville Zip: 94599

d. UTM: (give more than one for large and/or linear resources) Zone: 10S; 555789 mE/ 4279737 mN

e. Other Locational Data: (e.g., parcel #, directions to resource, elevation, etc., as appropriate)

Assessor Parcel Number (APN): 34-140-13

***P3a. Description:** (Describe resource and its major elements. Include design, materials, condition, alterations, size, setting, and boundaries)

This form serves to record and evaluate the Yountville Wastewater Reclamation Facility and an associated pumping station, both in the Town of Yountville, Napa County. The wastewater reclamation facility is located off Solano Avenue immediately east of the grounds of the Veterans Home of California, and the pumping station is on Land Lane near the southeast corner of the town boundaries (see **Location Map**). The reclamation facility consists of a control building, treatment structures and equipment, and a set of effluent storage and sludge drying ponds that were constructed at various points between 1940 and 2018 as the plant evolved to meet changing treatment standards and needs (**Photograph 1** and **Sketch Map**) (See Continuation Sheet.)

***P3b. Resource Attributes:** (List attributes and codes) HP9—Public Utility Building; HP11—Engineering Structure

***P4. Resources Present:** ☒ Building ☒ Structure ☐ Object ☒ Site ☐ District ☐ Element of District ☐ Other (Isolates, etc.)

P5b. Description of Photo: (View, date, accession#) **Photograph 1.** Yountville Wastewater Reclamation Facility showing control building (left) and tricking filter (center); facing southeast; September 15, 2022.

***P6. Date Constructed/Age and Sources:**
☒ Historic ☐ Prehistoric ☐ Both
Est. 1940 (*Napa Valley Register*)

***P7. Owner and Address:**
Yountville Public Works
6550 Yount Street
Yountville, CA 94599

***P8. Recorded by:** (Name, affiliation, address)
David Hickman & Danielle Baza
JRP Historical Consulting, LLC
2850 Spafford Street
Davis, CA 95618

***P9. Date Recorded**: September 15, 2022

***P10. Survey Type:** (Describe)
Intensive

***P11. Report Citation:** (Cite survey report and other sources, or enter "none.") None

***Attachments:** ☐ None ☒ Location Map ☒ Sketch Map ☒ Continuation Sheet ☒ Building, Structure, and Object Record ☐ Archaeological Record ☐ District Record ☐ Linear Feature Record ☐ Milling Station Record ☐ Rock Art Record ☐ Artifact Record ☐ Photograph Record ☐Other (list) ______

***NRHP Status Code**: 6Z

***Resource Name or #** (Assigned by recorder): Yountville Wastewater Reclamation Facility

B1. Historic Name: Veterans Home Sewage Treatment Plant; Yountville Sanitary District Sewage Treatment Plant
B2. Common Name: Yountville Wastewater Reclamation Facility; Pumping Station
B3. Original Use: Sewage Treatment B4. Present Use: Sewage Treatment
***B5. Architectural Style**: Spanish Revival
***B6. Construction History**: (Construction date, alteration, and date of alterations) See continuation sheet.
***B7. Moved?** ☒ **No** ☐ **Yes** ☐ **Unknown** **Date:** ___ **Original Location:** ___
***B8. Related Features:** ___
B9. Architect: Harry S Jenkins (1940); Kennedy Engineers (1979) b. Builder: Fred J. Early (1940); Unknown (1979)
***B10. Significance: Theme**: N/A **Area**: N/A
Period of Significance: N/A **Property Type**: N/A **Applicable Criteria**: N/A
(Discuss importance in terms of historical or architectural context as defined by theme, period, and geographic scope. Also address integrity.)

The Yountville Wastewater Reclamation Facility and associated pumping station do not meet the criteria for listing in the National Register of Historic Places (NRHP) or the California Register of Historical Resources (CRHR), and they are not historical resources for the purposes of California Environmental Quality Act (CEQA). These resources have been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code. (See Continuation Sheet.)

B11. Additional Resource Attributes: (List attributes and codes) ___

***B12. References**: "Veterans Home Sewage Plant Is In Operation," *Sacramento Bee*, July 22, 1940, 6; State Department of Public Health, Bureau of Sanitary Engineering, "A Report of Sanitary Survey: Yountville Sanitation District," September 7, 1954; "A Modern Sewage Plant," *Napa Valley Register*, July 10, 1979, 1; See also footnotes.

B13. Remarks:

***B14. Evaluator**: David Hickman
***Date of Evaluation**: May 2023

(This space reserved for official comments.)

(Sketch Map with north arrow required.)

See Continuation Sheet.

P3a. Description (continued):

The control building, constructed in 1979, is composed of two units with offices and laboratory spaces occupying the northern two-thirds of the building, and a chemical storage unit at the south end with a roof line raised four feet above the office wing (**Photographs 2-4**). The building has a generally rectangular footprint, 36-feet-8-inches by 48-feet-8-inches, with a projecting bay at the rear northeast corner of the office wing. The concrete block construction has a smooth stucco finish. Both units have low-pitch gable roofs clad with Spanish tile and showing exposed rafters under the moderate eaves. The office wing has a primary entrance on the west façade, with adjacent double hollow metal louvered doors accessing a maintenance room, and two rear personnel entrances. The chemical storage wing has dual hollow-metal, hinged bay doors on the west façade and personnel doors on the south and east sides. All personnel doors are hollow metal with four-light upper glazing. A monorail crane support beam extends through the top of the chemical storage bay doors. Fenestration consists of six- or eight-light, aluminum-frame, casement windows. Numerous metal louvers ventilate the storage areas, and a particularly large 8-foot-by-8-foot vent is located at the north end of the west façade. The office wing interior includes a control console that allows staff to monitor and direct plant operations (**Photograph 5**).

Wastewater enters the reclamation facility through an aerated grit chamber with trash rack screens (**Photograph 6**). The concrete chamber is set below grade and has a metal grill covering. A modern shed with grooved plywood siding adjacent to the grit chamber shelters equipment used to aerate the incoming waste stream to aid waste removal. An auger removes debris for disposal (**Photograph 7**). A comminutor, also known as a grinder, is located behind the grit chamber and shreds large incoming materials (**Photograph 8**). Adjacent to the comminutor is a moder dissolved air floatation system under a shed shelter; both were installed around 2018 (**Photograph 9**).

Wastewater then passes to the clarifier tanks (also known as settling or sedimentation tanks) (**Photographs 10** and **11**). Two sets of tanks flank the sludge digestor building, with the primary clarifier to the south and intermediate clarifier to the north. The clarifier tanks and sludge digestor were constructed as a single integrated concrete structure and they share walls. The clarifier tanks are set below grade, with a total depth of 12 feet. Each tank is approximately 15 feet wide and 62 feet long. Two concrete slab bridges with metal handrails span each tank. Mechanical skimmers rake the surface and bottom of the tanks to collect grease and sludge. Centrifugal pumps are located at the tank ends.

Two octagonal trickling filters are located alongside the clarifier tanks, with the primary filter to the south and secondary filter to the north (**Photographs 12** and **13**). The concrete structures are 50 feet in diameter and approximately six-feet-nine-inches deep. An ornamental band, formed from three parallel recessed channels, circles the upper wall of the filters, and regularly spaced ventilator ports are near the wall bottoms. The wall surfaces show the imprint of the boards used in forming the concrete. Four distributor arms rotate around a central hub and spray wastewater onto a plastic media (**Photograph 14**).

The activated sludge tanks are a modern addition to the plant, constructed in 1992 (**Photographs 15** and **16).** The concrete structure is divided into three square chambers and is set below grade. Aerating pipes at the bottom of each chamber release a continual stream of oxygen to the churning wastewater. A mechanical blower is located at the north end of the tanks and a plastic storage tank is at the south end.

The final clarifiers, east of the activated sludge tanks, were completed in 1979. Each of the two chambers is approximately 15 feet wide by 80 feet long. The clarifiers are recessed below ground and are surrounded by metal pipe railings. Mechanical skimmers remove grease and sludge from the tanks (**Photograph 17**). Effluent from the final clarifiers passes to the adjacent fuzzy filter (**Photograph 18**). The vertical pressure tank was installed in 1998 and contains plastic media that provides a final filtering of the wastewater. The effluent is then disinfected in the chlorine contact basin (**Photograph 19**). This raised concrete structure was constructed in 2010. Baffles divide the basin into five long, interconnected channels through which the water flows while chlorine is injected by automated dosage equipment.

The final treated and disinfected effluent is piped to the effluent storage and flow equalization ponds located south of the control buildings (**Photographs 20** and **21**). The unlined ponds have capacities of 2.7 and 3.8 million gallons. Electrical and mechanical equipment for pumping are located on the banks of the ponds.

Sludge that is collected from the clarifiers is treated in the central sludge digestor that lies between the clarifiers (**Photographs 22** and **23**). The digestor has a total height of 25 feet with approximately half of that located below grade. It includes two sealed digestion chambers and two control rooms at its east end. The digestion chambers have metal walls and gas collectors on the roof. The control rooms are of concrete construction with a stucco finish. The easternmost control room has a shed roof clad in corrugated metal. The control rooms have wood and metal personnel doors and aluminum-frame sliding windows. The interiors have unfinished concrete walls, ceilings, and floors (**Photograph 24**).

The digested sludge is pumped to two sludge drying ponds located south of the effluent storage ponds. These unlined basins were completed in 1989 (**Photograph 25**).

The pumping station is located on the grounds of the original Town of Yountville wastewater treatment plant, approximately three-quarters of a mile east of the reclamation facility. The original facility once included a multi-clarifier, trickling filter, sludge digestor, and sludge drying beds, but all that remains of the earlier plant is the shell of the trickling filter (**Photograph 26**). The concrete structure has a diameter of 36 feet and a depth of four feet. The central hub and inlet pipe is still in place and has a metal plate identifying the manufacturer as the Pacific Flush-Tank Company of Chicago and New York (**Photograph 27**). The control room and pump station located towards the southwest corner of the property are the only parts of the plant that currently operate as part of the town's wastewater recycling system. These were constructed in 1979 in the same fashion as the control building at the main treatment plant. The control room has dimensions of approximately 24 feet by 28 feet. It sits on a raised concrete foundation that forms a full-width porch on the south façade, a loading dock on the east side, and merges with the pump station to the north (**Photographs 28** and **29**). The low-pitch hip roof has Spanish tiles and exposed rafters. Five square wood posts support the porch roof extension and metal tube handrails wrap around the porch, loading dock, and pumping station. The windows, doors, and louvered vents are of the same design as the treatment plant control building. The pump station has two deep concrete shafts and a metal crane.

B6. Construction History (continued):

Treatment Plant	
Contact Basin	Constructed pre-1915; converted to trickling filter ca 1935; converted to sludge drying basin in 1979; demolished and removed in 1989
Trickling Filters	Constructed 1940; filter media and distributor arms replaced 1979
Sludge Digestor and Control Room	Constructed 1940; control room addition built 1948-1965; concrete digestor chambers replaced with metal chambers at unknown date; sludge pumps replaced 1989
Grit Chamber	Constructed 1979
Final Clarifier	Constructed 1979
Control Building	Constructed 1979
Effluent Storage Ponds	Constructed 1979
Sludge Ponds	Constructed 1989
Activated Sludge Tanks	Constructed 1992
Fuzzy Filter	Installed 1998
Chlorine Contact Basin	Constructed 2010
Dissolved Air Flotation System and Shed	Installed circa 2018

Pumping Station	
Multi-Clarifier	Constructed 1956; demolished and removed after 1979
Sludge Digestor	Constructed 1956; demolished and removed after 1979
Sludge Drying Beds	Constructed 1956; demolished and removed after 1979
Pump House	Constructed 1956; demolished and removed after 1979
Trickling Filters	Constructed 1956; abandoned in 1979 and media and distributor arms removed
Control Room and Pump Station	Constructed 1979

B10. Significance (continued):

The Yountville Wastewater Reclamation Facility today treats the wastewater of both the Town of Yountville and the Veterans Home of California. Prior to 1979, the two entities maintained separate treatment facilities. The Veterans Home constructed a plant in 1940 that forms the core of the modern reclamation facility, while the Town of Yountville completed its own plant in 1956 at the site of the current pumping station. The federal Environmental Protection Agency (EPA) required the two facilities to merge in the late 1970s as the most practical way for both plants to meet higher treatment standards. The Town of Yountville assumed ownership of the former Veterans Home plant and expanded and modernized the facilities. At the same time, the town abandoned its former treatment plant and constructed the pumping station at the site to convey the town's wastewater to the new joint facility. The facility has continued to evolve over the subsequent decades to meet increased demand and tighter regulatory requirements. Today it contains a mixture of treatment equipment that was constructed between 1940 to near the present.

<u>Historic Context</u>

<u>Veterans Home of California</u>

The facility that became the Veterans Home of California was established in Yountville in 1882 by the Veterans Home Association, a private organization composed of Grand Army of the Republic and Mexican War Association members. The organization purchased 910 acres in Napa County and constructed dormitories, a dining hall, and a hospital. The facility opened in April 1884, accepting honorably discharged veterans who previously had been relegated to almshouses, county hospitals, or the state asylums. In 1900, the State of California took over ownership and operation of the facility, at which point it became known as the Veterans Home of California. The complex then consisted of 55 buildings housing 800 residents.[1]

The State Board of Health inspected the facility's sewage system in May 1916. The treatment facilities at the time consisted of a septic tank preceded by "a large, so-called equalizing tank," which served to regulate the rate of inflow and retention time for the septic tank. Effluent from the septic tank discharged to the home's vegetable garden and an adjoining alfalfa field, where it was used for irrigation. The report noted that the plant had earlier made use of "contact beds of unique design," but that these had since fallen into disuse.[2] An English engineer developed the contact bed technology in the early 1890s, and it was first used in California beginning in 1910. A contact bed was a water-tight basin, some four to eight feet deep, filled with small pea-to-walnut-sized particles of gravel or brick. Operators intermittently filled and drained the basin, and the bacteria that formed on the filler material served to partially digest the waste. Contact beds were a relatively short-lived technology in California as the more efficient trickling filters replaced them beginning in 1915. Only four contact basins are known to have been constructed in the state, and only one of these remained in operation in 1930. Chester Gillespie, the long-serving head of the State Bureau of Sanitary Engineering, recalled the Yountville contact bed when recounting early sewage projects in the state for a 1970 oral history interview. Gillespie chuckled at the memory, describing the contact bed as a real "humdinger," and explained that "there weren't any engineers out here before the Bureau was

[1] Mead & Hunt, Inc., "Veterans Home of California Historic District," DPR-523 form, February 18, 2014, revised January 19, 2016, 4.
[2] State Board of Health, *Twenty-Fourth Biennial Report for the Fiscal Years from July 1, 1914, to June 30, 1916* (Sacramento: State Printing Office, 1916), 126; Veterans Home of California, *Annual Report of Board of Directors and Officers, Fiscal Year ending June 30, 1912* (Sacramento: State Printing Office, 1912), 8–15, 27.

formed that really knew the science of design of these plants."[3] In the 1930s, the contact bed basin was repurposed as a trickling filter, but this did not prove entirely satisfactory, and the basin was again converted into a sludge drying bed around 1979 before being eventually removed in 1989. **Figure 1** shows the location and arrangement of the early-twentieth-century treatment facilities relative to the plant constructed in 1940, which today comprises the core of the Yountville Wastewater Reclamation Facility. None of the early twentieth-century features are extant.[4]

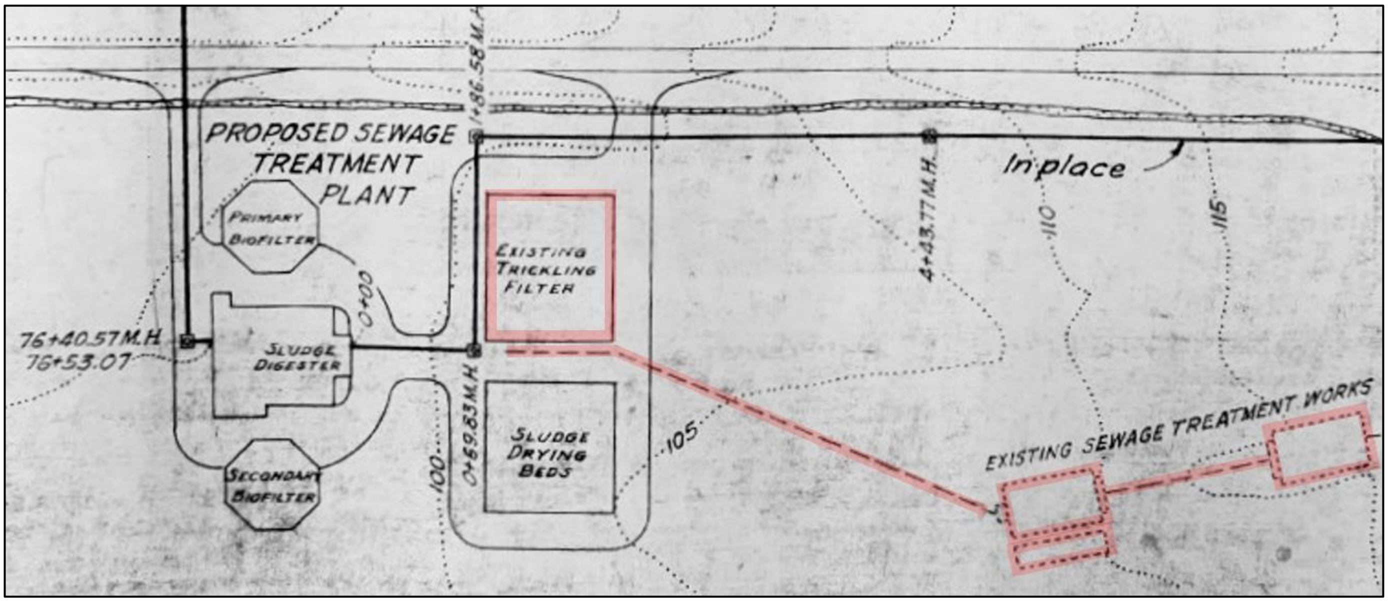


Figure 1: Plans for the 1940 proposed sewage treatment plant show the earlier treatment works (highlighted in red) that included the equalizing tank and septic tank at right and the original contact bed that had been converted to a trickling filter.[5]

The Napa River was a notoriously polluted waterway in the early twentieth century. The era's sanitation laws focused almost exclusively on communicable disease and paid little attention to environmental pollution. The valley towns of Calistoga, St. Helena, Yountville, and Napa all drew their water supplies from wells or mountain springs, and used the Napa River only as a dumping site for their waste. This practice limited serious waterborne disease outbreaks, but made an open sewer of the river. Both St. Helena and the Veterans Home made attempts to confine their sewage effluent to agricultural fields, but during the rainy season, the waste overflowed into drainage ditches that ran alongside the main highway and ultimately drained to the river. The other towns and Napa State Hospital at the south end of the valley simply discharged raw sewage into ditches draining directly to the river. Water quality testing near Yountville in 1923 showed organic contamination levels 500 to 5,000 times greater than was considered safe for drinking water by even the lax standards of the era. When water levels fell in the late summer, the Napa River became so polluted that any contact was unsafe, and health officials posted signs warning against wading or swimming.[6]

The modern sewage system at the Veterans Home became operational in 1940. State officials began planning upgrades to the facilities in the summer of 1938 in response to repeated complaints about odors along the highway. The legislature

[3] Chester Gillespie, "Origin and Early Years of the Bureau of Sanitary Engineering," transcript of oral history interview conducted by Malca Chall, 1970, Regional Oral History Office, Bancroft Library, University of California, Berkeley, 1984, 11.
[4] Charles Gilman Hyde, "Pencil Manuscript, A Chronology of Sewerage and Sewage Treatment and Disposal in the United States and Abroad," Box 17, Charles Gilman Hyde papers, WRCA 046, WRCA UC Riverside, 2; Gillespie, "The Sewage Situation in California," *Sewage Works Journal,* Vol. 1, No. 4 (1929), 461; W. A. Hardenbergh, *Operation of Water-Treatment Plants* (Scranton: International Textbook Company, 1940), 169-172; "Yountville Treatment Plant History," provided by Town of Yountville Public Works Department.
[5] Division of Architecture, "Sewer Lines & Appurtenance, Veterans Home, Yountville, Calif., Plans and Profiles," June 16, 1941, Sheet M-2.
[6] "Pollution of River," *The St. Helena Star,* August 10, 1923, 7; C. G. Gillespie, "Twenty Years of Sanitary Engineering," *Weekly Bulletin (California State Department of Public Health),* Vol. 15, No. 1 (February 1, 1936), 2.

appropriated $135,000 for the project in early 1939, plans were completed over the summer, and construction commenced in November. Officials intended the upgrades as part of a valley-wide sewage improvement effort, but voters in the city of Napa declined to support a 1938 bond issue needed to construct a treatment plant in the city. The state-owned facilities in the valley—the Veterans Home and Napa State Hospital—thus took the lead in implementing advanced sewage treatment and improving environmental conditions in the Napa River.[7]

Harry N. Jenks

The Division of Architecture in the State Department of Public Works held ultimate responsibility for the sewage plant design, but as was common on such projects, the division turned to a private consultant who specialized in such matters to select a treatment method and prepare plans. Harry N. Jenks, a leading sanitary engineer, received the contract. Jenks was born in Missouri in 1893, but spent much of his childhood in Mexico and South America as the son of a mining engineer. He attended the University of California, Berkeley, and studied under Charles Gilman Hyde, the preeminent sanitary engineer on the West Coast. He completed his master's thesis in 1916 on the sewage system at the Sonoma State Home (later the Sonoma Developmental Center). He began his career as a health officer in Burma, before joining the Sanitary Board of Chicago. Jenks returned to California in 1924 to take a position as superintendent of the Sacramento Municipal Filtration Plant and concurrently served on the California State Board of Health. He later worked as a professor of civil and sanitary engineering at Iowa State University and the University of North Carolina. He entered private practice in 1937, establishing a consulting engineering firm with an office in Palo Alto. His consulting career spanned 28 years, during which he participated in the planning and construction of a great many sewage systems in northern California, and he was credited with developing several widely used processes. His son John later took over the consulting business. In 1980, John Jenks arranged a merger with Kennedy Engineers to form the firm Kennedy Jenks, which remains an industry leader in the environmental engineering field.[8]

Jenks' most commercially successful innovation was the so-called Biofiltration System, a variation on the trickling filter. Jenks began developing the system in 1927 at Iowa State College, using dairy and slaughterhouse waste for the preliminary tests. He continued to refine the process through his subsequent job postings, experimenting with domestic sewage in Sacramento in 1931-32 and textile waste at the University of North Carolina in 1933. He installed the first pilot-project-scaled biofiltration tanks in the communities of Santa Ana and Salinas in 1934-35, and simultaneously conducted experimental two-stage work at Palo Alto. The first commercial installation took place in 1936 at San Mateo, and the first large-scale plant went into operation the same year at Camarillo State Hospital. With the technology successfully demonstrated, Jenks sold the rights to the Biofiltration System in 1936 to the Dorr Company and Link-Belt Company, two major manufacturers of sanitary engineering equipment. The proceeds of the sale allowed Jenks to establish himself as an independent consultant. Over the next half decade, the manufacturing companies installed 60 full-scale plants across the nation, with 23 of them in California (**Figure 2**). The system was popular for institutional use and units were installed at three California state hospitals, the Sonoma State Home, and Monterey County Hospital, in addition to the Veterans Home. During World War II, the biofiltration plants were widely used on military installations.[9]

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[7] "Officials Will Discuss Veterans Home Sewage," *Sacramento Bee,* August 12, 1938, 5; "$135,000 Vets' Home Sewage Plant Bill Signed," *Napa Journal,* May 27, 1939, 1; "Support Pledged in Napa Sewage Disposal Drive," *Napa Valley Register,* March 24, 1937, 1; "$225,000 Sewer Bond Issue Fails to Receive Necessary Two-Thirds Ballot," *Napa Journal,* September 30, 1938, 1

[8] "Services Tomorrow for Harry N. Jenks," *Redwood City Tribune,* February 3, 1965, 14; Harry N. Jenks, "A Report on Sewage Purification at the Sonoma State home, Eldridge, California," Master's thesis, UC Berkeley, 1916; "Along the Line," *Building and Engineer News,* September 18, 1926, 3; "Alumni Notes," *California Engineer,* Vol 11, No. 6 (February 1924), 16; Kennedy Jenks, "History," accessed May 2023 at https://www.kennedyjenks.com/about-kj/history/.

[9] Frank Bachmann, "High Capacity Filtration: The Biofiltration System," *Sewage Works Journal,* Vol. 13, No. 5 (September 1941), 895–904.

Biofiltration Plant Installations*

Arranged Chronologically According to Type — Single, Two and Three-Stage

SINGLE-STAGE

No.	Location	Year Built	Design Flow M.G.D.	No. Bio-Filters	Bio-Filter Size Dia. Ft.	Bio-Filter Size Depth Ft.	Max. Filter Design Dos. Rate M.G.A.D.
1	Camarillo State Hosp., Cal.	1936	1.0	1	85	3	38.8
2	Modesto, Cal.	1937	3.0	1	90	3	61.2
3	Placerville, Cal.	1938	1.0	1	60	3	77.0
4	Dayton, Wash.	1938	0.76	1	100	3	20.0
5	Walla Walla, Wash., State School	1938	0.05	1	20	3	41.7
6	Stockton State Hosp. Farm, Cal.	1939	0.5	1	45	4	42.2
7	Sonoma State Home, Cal.	1939	1.0	1	100	6½	24.0
8	Loveland, Colo.	1939	0.8	1	60	4	47.8
9	Mendocino State Hosp., Cal.	1940	1.0	1	85	3	18.2
10	Seminole, Okla.	1940	0.75	1	58	3	36.0
11	Leavenworth, Wash.	1940	0.2	1	41	3	20.0
12	Walla Walla, Wash., Camp	1940	0.3	1	20	4	40.0
13	Wellman, Iowa	1940	0.2	1	36	7	21.0
14	Ceres, Cal.	1940	0.3	1	45	3	24.0
15	San Juan, Cal.	1940	0.1	1	40	3	10.0
16	Fort Bragg, N. C.	1940	4.55	2	134	3	45.0
17	Oakdale, Iowa	1940	0.3	1	34	3½	13.8
18	Marine Rifle Range, San Diego, Cal.	1940	0.35	1	55	3	26.0
19	Centralia, Mo.	1940	0.3	1	35	3	41.0
20	Camp Edwards, Mass.	1940	3.0	2	100	3	29.2
21	Federal Correction Inst., Sandstone, Minn.	1940	0.18	1	36	6	7.7
22	Dyersville, Iowa	1940	0.25	1	75	9	4.1
23	Nevada, Iowa	1940	0.29	1	75	8	5.7
24	North Girard, Pa.	1940	0.48	1	32	6	35.2
25	Scranton, Iowa	1940	0.26	1	26	7	21.2
26	Crownsville State Hosp., Maryland	1940	0.52	1	50	5	32.2
27	Camp Elliott, Cal.	1941	0.70	1	75	3	27.6
28	Camp Polk, La.	1941	2.1	1	103	3	38.4
29	Hill Field, Utah	1941	0.15	1	50	3	19.7
30	Wendover Bomb. Range, Utah	1941	0.17	1	25	3	18.9
	TWO-STAGE						
1	San Mateo, Cal.	1936	0.07	2	15	3	53.0
2	Healdsburg, Cal.	1937	0.4	2	36	3	85.7
3	Petaluma, Cal.	1938	1.0	2	75	3	30.0
4	Turlock, Cal.	1938	2.0	2	90	3	55.2
5	Covina, Cal.	1939	0.5	2	60	3	20.0
6	Santa Paula, Cal.	1939	1.0	2	80	3	35.1
7	Lakeport, Cal.	1939	0.25	2	36	3	46.0
8	Monterey County Hosp., Cal.	1939	0.05	2	20	3	25.0
9	Yountville Veterans Home, Cal.	1940	0.5	2	50	3	48.0
10	Auburn Cal.	1940	1.0	2	60	3	40.0
11	Liberty, N. Y.	1940	1.0	2	80	3	28.5
12	Chesterfield Co., Va.	1940	0.8	2	45	3	48.0
13	Prineville, Ore.	1940	0.15	2	30	3	17.7
14	Camp Haan, Cal.	1940	1.05	2	80	3	30.0
15	Plainview, Minn.	1940	0.33	2	54	3	43.4
16	Goldendale, Wash.	1940	0.75	2	36	3	49.4
17	Camp Livingston, La.	1940	2.0	3	67	3	54.0
18	Camp Stewart, Ga.	1940	2.0	2	73	3	63.7
19	Camp Wallace, Texas	1941	1.05	2	45	3	102.0
20	Camp Warren, Wyo.	1941	0.525	2	50	3	38.3
21	Camp Roberts, Cal.	1941	2.1	2	90	3	52.2
22	Camp Wolters, Texas	1941	1.26	2	69	3	55.2
23	Fort Sill, Okla.	1941	3.0	2	85	3	21.0
24	Naval Air Station, Seattle, Wash.	1941	0.35	2	36	3½	48.9
25	San Diego Housing, San Diego, Cal.	1941	1.20	2	80	3	34.0
	THREE-STAGE						
1	San Leandro, Cal.	1939	0.06	3	15	3	42.7

* To April 15, 1941.

Figure 2: Biofiltration plants installed between 1936 and 1941. The Veterans Home was the ninth two-stage plant installed.[10]

[10] Bachmann, "High Capacity Filtration," 897.

The Biofiltration System was essentially a trickling filter with a high continual rate of input and a partial recirculation of the filter effluent back through the clarifying and filtration process (**Figure 3**). By rapidly and repeatedly running wastewater through the filter and clarifier tanks, the system sought to mimic aspects of the more efficient activated sludge process, but with the simplicity of a trickling filter. In a trickling filter, the microorganisms responsible for digesting organic waste lived in a thin biofilm that accumulated on the surfaces of particles that filled the concrete basins. Rotating arms with spray nozzles released wastewater at a steady rate so that much of the suspended material in the waste stream adhered to the filter particles and was digested. In the activated sludge process, the microorganisms did not live upon filter materials but were suspended within the wastewater stream. Aeration by mechanical blowers or paddle agitators stimulated the microorganisms to rapid growth. The activated sludge process allowed for speedy and thorough digestion of waste but required careful control to maintain microbial populations at optimal levels. A trickling filter required less care as the microbial populations were more stable when growing on particle surfaces. The Biofiltration System combined the two approaches. The microorganisms lived on the filter particles, allowing for easy management, but some share of them washed off as wastewater passed rapidly through the tanks. This allowed digestion to continue as the effluent recirculated to the clarifier, while the repeated passes through the filter kept the wastewater well aerated. The systems could use a single recirculating filter or combine two or three filters for more thorough processing. The Yountville plant used primary and secondary filters and clarifiers for a two-stage process.[11]

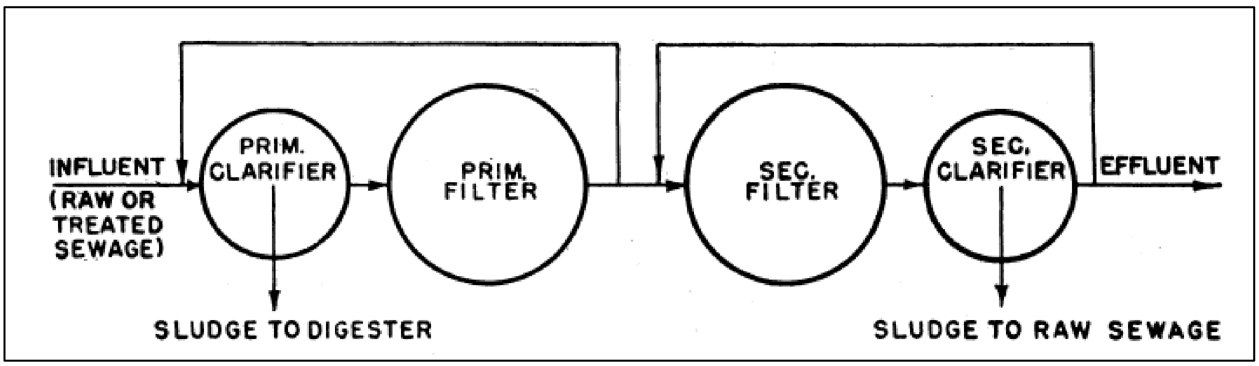

Figure 3: Schematic of the two-stage biofiltration process as used at Yountville.[12]

The Dorr Company advertised the two-stage biofiltration plant as "the full equivalent of the activated sludge process," but the company struggled to produce consistent results. After five years of production, the company admitted that the actual cleaning levels varied widely between plants and that "much still remains to be learned relative to the underlying principles."[13] The chief selling point of the system was its relative economy and simplicity in comparison to activated sludge plants. This largely accounts for its appeal at smaller institutions, where it could be a challenge to hire and retain experienced operators. From the manufacturing companies' perspective, the real advantage of the Biofiltration System may have been its patent status. The 20-year patents on original trickling filter equipment were starting to expire in the mid-1930s and Jenks' modifications to the process were sufficient to generate new patents. The Dorr and Link-Belt companies could then advertise themselves as the exclusive providers of proprietary technology (**Figure 4**). The term "Biofiltration System" was never widely used outside of the companies' promotional materials, and it eventually fell completely from favor. Devices of this type are now referred to simply as trickling filters, recognizing the essential continuity in technology and process between the older filters and Jenks' modification.[14]

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[11] Bachmann, "High Capacity Filtration," 895–904.
[12] Bachmann, "High Capacity Filtration," 899.
[13] Bachmann, "High Capacity Filtration," 896, 899, and 904.
[14] On the importance of patents in the development and marketing of treatment technology, see the discussion response of UC Berkeley professor Harold Farnsworth Gray in A. J. Fischer, "Current Developments and Trends in Sewage Treatment," *California Sewage Works Journal*, Vol. 13, No. 1 (July 1941), 54–55.

SEWAGE WORKS JOURNAL

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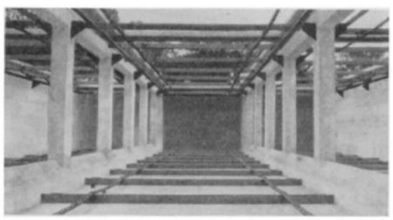
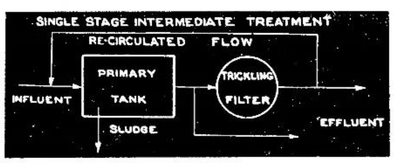
BIOFILTRATION SEWAGE TREATMENT SYSTEM

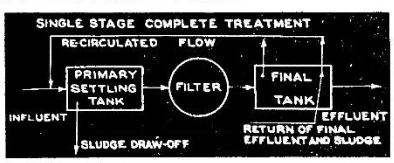
● Much of the effectiveness of this system depends on the reactions between the filter effluent and the raw or partly treated sewage in the settling tanks.
Rectangular tanks equipped with Link-Belt STRAIGHTLINE Collectors have proved ideal for this process; giving excellent results wherever used. The California plants listed on this page employ the Biofiltration system, with STRAIGHTLINE Collectors.

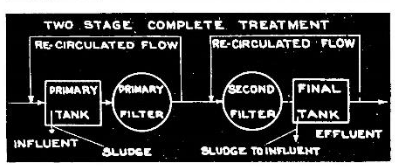


Camarillo, Calif.

This is a complete Biofiltration plant. The two primary tanks, each of which is 10′ 0″ wide x 10′ 0″ water depth x 54′ 0″ long, are equipped with STRAIGHTLINE Collectors. The secondary tank is also equipped with two STRAIGHTLINE Collectors, each 18′ 0″ wide x 10′ 0″ water depth x 54′ 0″ long.







San Mateo, Calif.

The large city plant for the treatment of the entire volume of sewage is of the separate sludge digestion type. A small volume of treated sewage from the settling tank flows to a small Biofiltration plant which was installed for the purpose of purifying a sufficient amount of sewage for use in irrigation and as wash water around the plant. The two settling tanks, each of which are 6′ 0″ wide and 3′ 0″ water depth x 15′ 0″ long, are equipped with Link-Belt STRAIGHTLINE Collectors.

Placerville, Calif.

This is a complete Biofiltration plant, equipped with two STRAIGHTLINE sludge collectors for the final settling tank. Each is 16′ 0″ wide x 12′ 0″ water depth x 58′ 0″ long.

Turlock, Calif.

This complete Biofiltration plant employs one STRAIGHTLINE sludge collector for the primary tank—18′ 0″ wide x 12′ 0″ water depth x 68′ 0″ long—and two STRAIGHTLINE longitudinal sludge collectors and one cross collector for the final tank—37′ 0″ wide x 12′ 0″ water depth x 68′ 0″ long.

Lakeport, Calif.

A complete Biofiltration plant with one STRAIGHTLINE Collector for the primary tank—10′ 0″ wide x 8′ 0″ water depth x 32′ 4″ long, and one STRAIGHTLINE Collector for the final tank—10′ 6″ wide x 8′ 0″ water depth x 32′ 4″ long.

San Leandro, Calif.

While this is not a complete Biofiltration plant, it does use a small biofilter unit for the same purpose as at San Mateo, previously described. It employs three STRAIGHTLINE Collectors for the final tank, each measuring 7′ 0″ wide x 4′ 0″ water depth x 20′ 0″ long.

Yountville, Calif.

This plant, which will be of the Biofiltration type, employs one STRAIGHTLINE sludge collector for the primary tank—15′ 0″ wide x 10′ 0″ water depth x 62′ 0″ long, and one STRAIGHTLINE Collector for the secondary tank—15′ 0″ wide x 10′ 0″ water depth x 62′ 0″ long.

LINK-BELT COMPANY PHILADELPHIA CHICAGO LOS ANGELES 7932–A

LINK-BELT

SCREENS • COLLECTORS • AERATORS • GRIT CHAMBERS • DIFFUSERS

Figure 4: A 1940 advertisement presented Link-Belt clarifier tank equipment as an integral part of the Biofiltration System. The Yountville plant was offered as an example.[15]

[15] Front Matter, *Sewage Works Journal*, Vol. 12, No. 2 (March 1940), 8.

Jenks' plans for the Veterans Home plant called for two octagonal biofiltration tanks flanking a central sludge digestor with clarifying tanks (also called settling tanks) on both sides (see **Figure 1** above). The biofiltration tanks had 50-foot diameters and were approximately six-feet-nine-inches deep. The primary tank and clarifier were south of the sludge digestor and the secondary equipment on the north side. The sludge digestor had two tanks and a control room at the east end, above an underground chlorine contact chamber. The sludge digestor and clarifying tanks were constructed as an integrated concrete structure, with shared walls between the clarifying and sludge digesting tanks. The sludge tanks had a total height of 25 feet, with about half of that below grade (**Figure 5**). The existing trickling filter (former contact bed) was abandoned and a sludge drying bed was constructed adjacent to it. The disinfected effluent discharged by pipeline into the Napa River.[16]

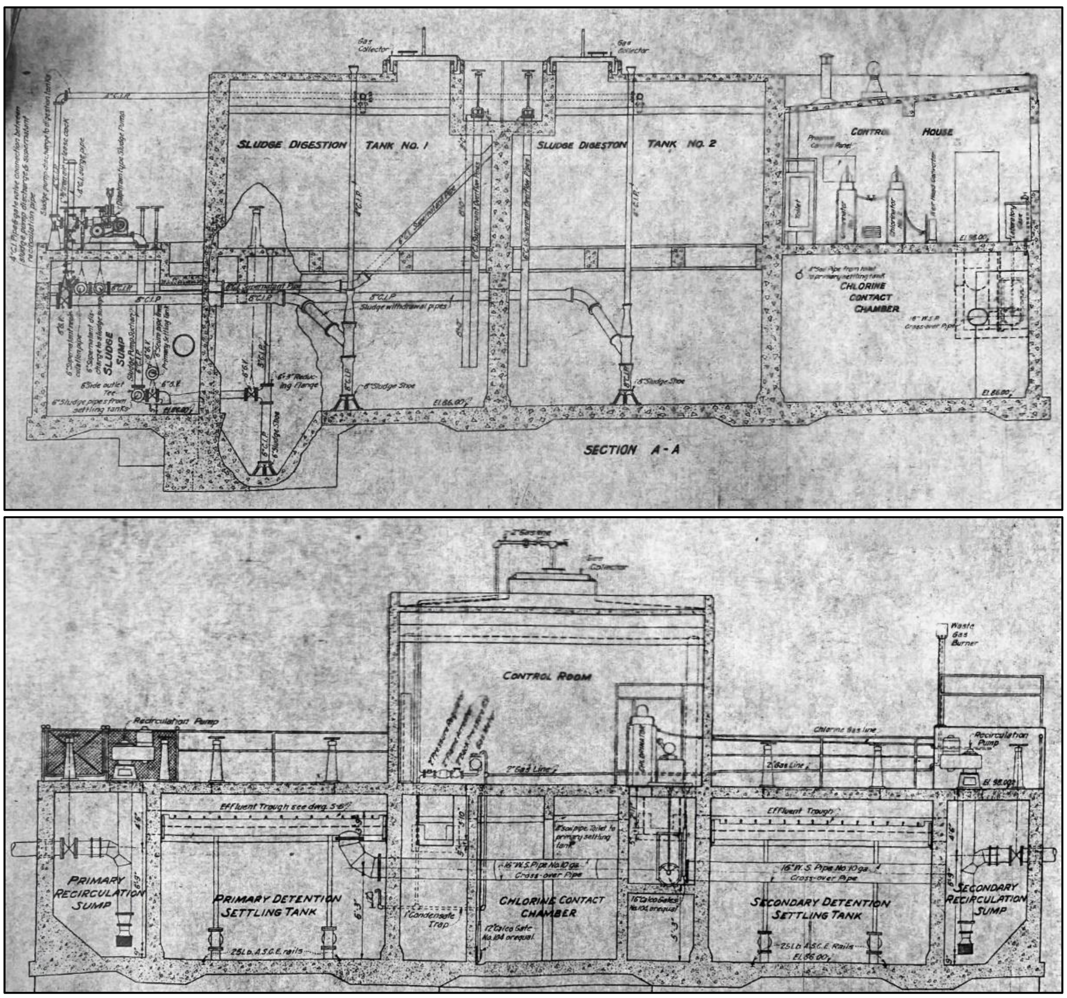


Figure 5: Cross-sectional views along the length (top) and width (bottom) of the sludge digestor show an integrated concrete structure combining two digestion and two clarifying tanks (labeled detention settling tanks in diagram). The control room is at the east end of the structure (right in upper diagram), above the chlorine contract chamber.[17]

The construction contract for the plant was awarded to Fred J. Early, Jr., a general contractor based in the San Francisco Bay Area. Jenks and Early had previously worked together on the Sonoma State Home sewage system and would again collaborate in constructing the City of Napa sewage plant in 1949. Construction of the plant itself cost approximately $83,000 out of the

[16] "Construction Work Started on New Vets' Home Sewage Disposal Plant," *Napa Journal*, November 15, 1939, 8; Division of Architecture, "Sewage Treatment Plant, Veterans Home, Yountville, Calif.," September 25, 1939, Sheets M-2, M-3, and S-6.
[17] Division of Architecture, "Sewage Treatment Plant, Veterans Home, Yountville, Calif.," September 25, 1939, Sheet M-3.

$135,000 that had been appropriated for all upgrades to the Veterans Home sewage and waters systems. The facility became operational in July 1940. Only limited alterations were made to the plant in the first decades after its construction. At some point between 1948 and 1965, an addition was constructed for the control room, adding laboratory and office space. This modestly lengthened the sludge digestion structure (**Figure 6**).[18]

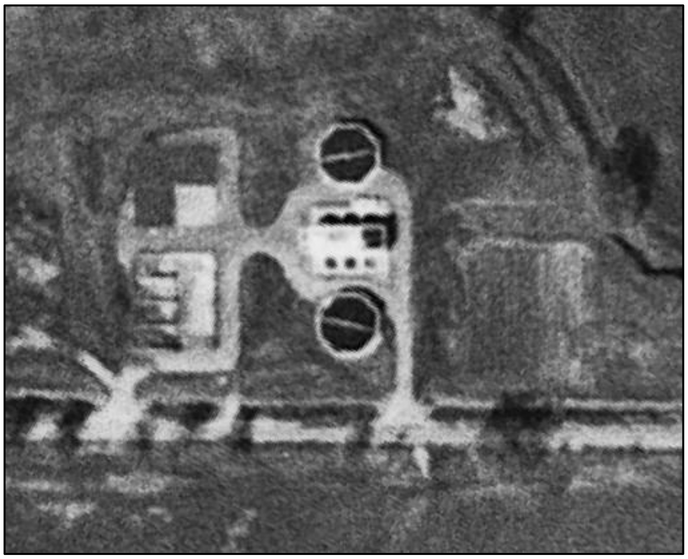


Figure 6: A 1948 aerial photograph (left) shows the treatment plant several years after completion. The sludge drying beds are on the left with the biofiltration system (trickling filters) and sludge digestor structure at right. Note that the filters have two spraying arms versus the four now used. A 1965 photograph (right) shows that an addition had been constructed on the control room, visible at the right side of the sludge digestor.[19]

Yountville

Meanwhile, the unincorporated Town of Yountville, which was a short distance from the Veterans Home, continued disposing of its sewage through more rudimentary methods, including privies and septic tanks without leach fields. Nearly a quarter of the town's population relied upon wells as their only source of domestic water, so the inadequate sewage systems posed a public health threat in addition to having adverse environmental and recreational impacts. In 1946, the county retained Harry Jenks to prepare preliminary sewage plans for the town, and the community organized the Yountville Sanitation District in 1949. Jenks updated his plans in 1950 and proposed an activated sludge plant. However, the town lacked available resources to finance the project and construction was not undertaken. The State Department of Public Health brought increasing pressure over the following years to find a solution to the sewage problems.[20]

In 1954, the Napa County Board of Supervisors provided initial funding for the sewer project and secured a state loan of $210,000. The Yountville voters passed a bond issue of $240,000 nearly unanimously in early 1955 and construction commenced later that year. The new system included sewage mains and laterals of vitrified clay pipe to collect waste

[18] Construction Work Started on New Vets' Home Sewage Disposal Plant," *Napa Journal*, November 15, 1939, 8; Contracts Award," *Engineering News-Record*, 123: 1 (1939). 147, 448; "Sewage Disposal Plant Cuts River Pollution," *Napa Journal*, October 23, 1949, 19; "Veterans Home Sewage Plant Is In Operation," *Sacramento Bee*, July 22, 1940, 6.

[19] U.S. Geological Survey (USGS), Flight AR1EF, Frame 2-53, 1:28,400, February 29, 1948; Cartwright Aerial Surveys, Flight CAS-65-130, Frame 63-47, 1:12,000, May 1, 1965.

[20] State Department of Public Health, Bureau of Sanitary Engineering, "A Report of Sanitary Survey: Yountville Sanitation District," September 7, 1954, Water Resources Center Archives, University of California, Riverside; "Sewage System for Yountville Discussed," *St. Helena Star*, March 15, 1946, 10; "Legal Notices," *Napa Journal*, January 21, 1949, 11; "Supervisors Proceedings," *Napa Journal*, June 25, 1950, 10; State Department of Public Health, Bureau of Sanitary Engineering, H.B. Hommon and A. W. Reinhardt, memorandum, August 15, 1944,.

throughout the town limits and a treatment plant near the southeast corner of Yountville, at the current pumping station location. The treatment plant was scaled down from Jenks' earlier proposals and included a pump house, multi-clarifier, trickling filter, chlorine mixing box, a sludge digester, and sludge drying beds (**Figure 7**). The trickling filter had a diameter of 36 feet and a depth of four feet. The multi-clarifier combined primary and secondary clarifying chambers in a single concrete structure. The primary clarifier occupied the center of the structure and had a diameter of 22 feet. The secondary clarifier consisted of a ring, 2.75-feet wide, that surrounded the primary chamber. Wastewater flowed from the pump house to the center of the primary clarifying chamber, and then to the trickling filter, before returning to the outer secondary chamber in the multi-clarifier. The effluent was disinfected in the chlorine mixing box and then piped to an outfall pipe used in common with the Veterans Home for discharge to the Napa River. Sludge collected from the multi-clarifier was digested in an unheated tank with a diameter of 22 feet and a height of 16 feet. The digested sludge dried on sand beds before local farmers collected it to use as fertilizer. Of these components, only the concrete shell of the tricking filter is extant today.[21]

The Yountville plant met the town's immediate wastewater treatment needs, but it was not designed to accommodate substantial population growth. The plant's designed capacity of 125,000 gallons per day was small in comparison to the half-million-gallon-per-day capacity of the Veterans Home facilities. Yountville's population had remained steady for decades, but the development of mobile homes parks and a boutique retail complex in a repurposed historic winery drove rapid population growth during the 1960s, which rendered the plant insufficient by the early 1970s. The town (incorporated in 1965) hired the engineering consulting firm Heid & Heid to prepare options for upgrading and expanding the treatment plant.[22]

Yountville attempted to carry out the recommendation, but the project never came to fruition. When the town applied for federal funding, the EPA blocked approval of any grant unless the town agreed to a building a joint plant with the Veterans Home. That requirement reflected pressure from the Regional Water Quality Control Board, which had ordered both agencies to improve the effectiveness of their wastewater treatment systems. Moreover, because Yountville's expansion had brought the Veterans Home into its town limits, there were logistical reasons for them to combine their treatment systems. The resulting plan was for the town to take over the existing Veterans Home plant and rebuild it to provide greater capacity and meet updated treatment standards. Both entities agreed to the proposal, but the process became embroiled in disputes over the price to be paid for the 35-year-old Veterans Home treatment plant and the division of operational costs. The town ultimately assumed title to 6.88 acres of land and agreed to construct a $3.5 million plant. The operation was the largest municipal project Yountville had ever undertaken, even as the town was only directly responsible for around 12.5 percent of the cost, with state and federal funds covering the remainder.[23]

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[21] "County Board Aids Yountville Sewer Project," *Napa Valley Register*, December 2, 1953, 1; "Cost of Yountville Sanitation System Estimated At $222,000," *Napa Valley Register*, June 15, 1954, 1; "Yountville Sewer Loan Approved," *St. Helena Star*, August 26, 1954, 2; "$240,000 Yountville Sewer Bonds Pass As 186 Out of 192 Vote," *Napa Valley Register*, March 30, 1955, 1. Heid & Heid Consulting Engineers, "A Study Regarding Yountville Wastewater Management Plan," January 1973, Part III, 1-3.

[22] San Francisco Bay Regional Water Pollution Control Board, "Napa River Drainage Basin, Napa County, Long-Range Plan and Policy for Water Pollution Control," March 1964, 16, 22; Heid & Heid Consulting Engineers, "Yountville Wastewater Management Plan," (January 1973), 2-5.

[23] Jeff Mapes, "Yountville Sewage Treatment Plant Purely Frustrating," *Napa Valley Register*, November 11, 1976, 21; State Water Resources Control Board, Water Quality Control Engineer, Donald Lee, letter to M.M. Mansfield, Veterans Homes of California, Department of Veterans Affairs, October 27, 1975; Department of Veterans Affairs, Veterans Homes of California, M.M. Mansfield, letter to Donald Lee, Water Quality Control Engineer, State Water Resources Control Board, November 5, 1975; Department of Veterans Affairs, Veterans Homes of California, Virginia Mae Days, letter to Yountville City Council, October 17, 1975; State Water Resources Control Board, Division of Water Quality Control, letter to, Yountville City Council M. Mansfield, State Veterans Home, September 11, 1975; "Yountville Sewer Plant Eyed," *Napa Valley Register*, December 8, 1976, 8.

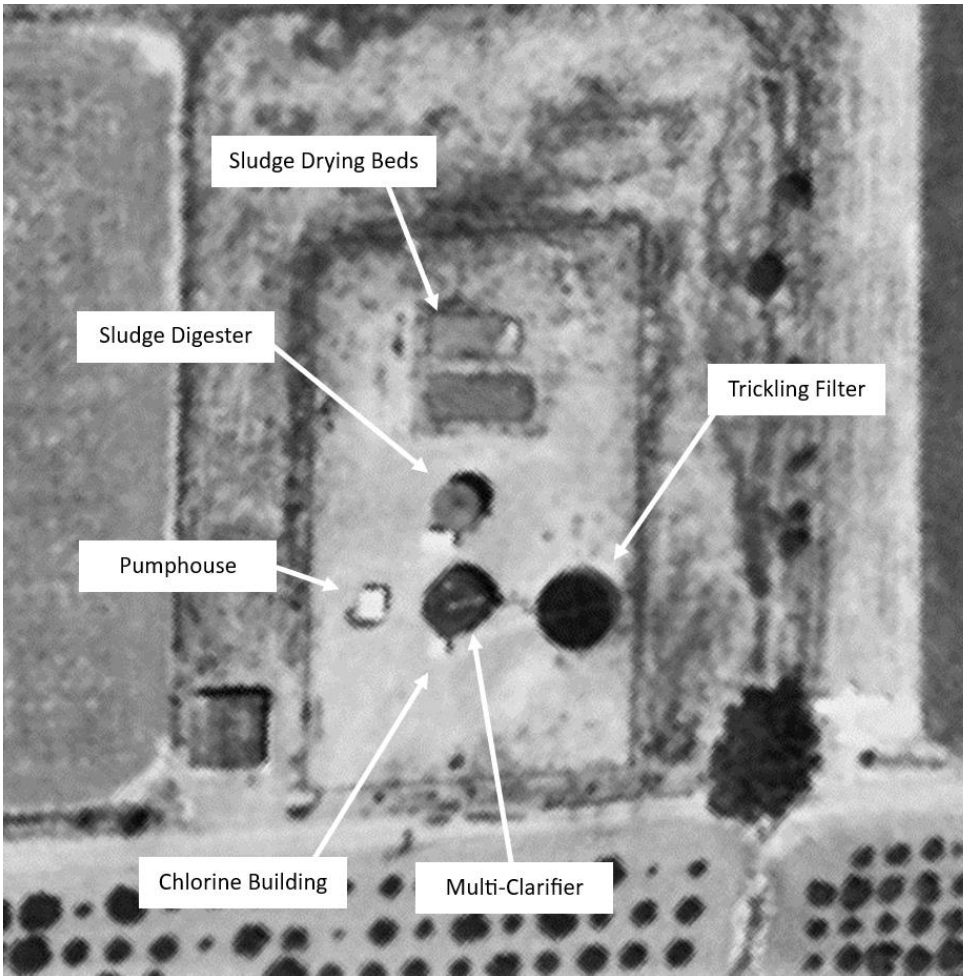

Figure 7: An annotated 1965 aerial photograph shows the Yountville Sanitary District treatment plant.[24]

The Veterans Home – Yountville Joint Wastewater Treatment Facility

Kennedy Engineers, one of California's pioneering sanitary engineering firms, designed the joint treatment plant. Irving Shultz, an engineer in the State Office of Architecture and Construction, provided state oversight on the project. Kennedy Engineer founder Clyde C. Kennedy attended UC Berkeley several years ahead of Jenks and also studied under Charles Gilman Hyde. Kennedy received a degree in Sanitary Engineering in 1911 and completed a Masters of Science in the School of Public Health the following year. He worked for several years as the city engineer for Berkeley before opening his own consulting firm in 1919 with a San Francisco office. Kennedy Engineers developed expertise in water quality investigations (including operating its own laboratory), master planning of sanitary services, facility design, and construction supervision. Kennedy served as consulting engineer for the city of San Francisco and was a member of the board of engineers tasked with solving the East Bay sewage problems. By the end of World War II, the firm had put into operation more than 60 sewage disposal systems in California, including the Sacramento city plant, as well as treatment facilities in Arizona and Nevada. The company designed and built municipal water systems for the cities of Eureka, Paradise, and many other California communities.[25]

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[24] Cartwright Aerial Surveys, Flight CAS-65-130, Frame 63-47, 1:12,000, May 1, 1965, annotated by JRP.

[25] Kennedy Jenks, "History," accessed March 2023 at https://www.kennedyjenks.com/about-kj/history/; "Commencement at University," *Berkeley Daily Gazette,* May 15, 1912, 8; "City Represented on Water Body," *Oakland Tribune,* December 4, 1918; "Engineer Sees No Difficulty in Sewer Plant," *Santa Rosa Republican,* July 2, 1935, 4; "Sewage System Survey Being Conducted Here," *Portola Reporter,* October 31, 1946, 1; "Water System Designer Dead," *Humboldt Times Standard,* April 29, 1952, 9.

Clyde Kennedy died in April 1952 at age 71. His two sons, Richard R. and Robert M. Kennedy, took over management of the firm with Richard serving as the company head. Richard Kennedy graduated from Stanford University with a civil engineering degree in the 1930s and immediately joined his father's business, designing the sewage treatment plant at Hoover Dam as his first project. He designed airfields throughout the Western United States during World War II and oversaw the construction of Benicia Arsenal, the largest ammunition handling facility on the West Coast. He did a great deal of international consulting in the post-war decades, designing more than 40 dams in Taiwan and serving as a Bureau of Reclamation consultant for work through Central and South America, as well as in Vietnam and Cambodia. He was a fellow in the American Society of Engineers and served as president of the society's San Francisco section. In 1979, he handed over presidency of the company to his son David D. Kennedy, while remaining chairman of the board of directors. In 1980 he approved the merger with Jenks & Harrison, creating the Kennedy Jenks company that exists today.[26]

The Kennedy Engineer plans called for additions and modifications to the existing Veterans Home and Town of Yountville treatment facilities to merge, modernize, and expand their operations. At the old town plant, the company constructed a new pump station with a comminutor (a sewage grinder for reducing solids), trash rack, three pump units, and a flow meter. Wastewater collected throughout the town flowed to the pumping station where it was forced up a slight gradient to the new treatment facility. The remainder of the old treatment plant equipment at the site—trickling filter, multi-clarifier, sludge digester, and drying beds—was abandoned. With the exception of the trickling filter shell, all of it has since been demolished and removed from the site.[27]

The new joint treatment facility modified the existing Veterans Home plant by constructing a new grit chamber, final clarifying tanks, tertiary pressure filters, effluent storage ponds, and a control building. The existing trickling filters (the so-called Biofiltration System) were modernized by replacing the rock filter particles with plastic packing media and by upgrading the sprayers to four-arm models over the original two-arm devices. The sludge digestor control room was modernized, and a gas-fired heat exchanger was added to the digestion tanks. The original contact bed, which had been transformed into a trickling filter but had not been used since 1940, was again modified to become a sludge drying bed. The new control building included laboratory and storage space as well as a sophisticated electronic control console that allowed the plant's three staff members to monitor and regulate the plant operations (**Figure 8**). The control building and the pump station at the old town plant were both designed in the Spanish Revival style with red tile roofs, stucco walls, and minimal ornamentation.[28]

The new plant was completed in the summer of 1979 and had a reported treatment capacity of 4.5 million gallons per day, leaving substantial room for future growth as Yountville and the Veterans Home together produced an average 500,000 gallons of wastewater per day in dry months and one million gallons per day in wet months. The plant pumped most of the treated effluent four miles to the Chimney Rock golf course east of Yountville, while the Veterans Home continued to use a smaller amount of the recycled wastewater to irrigate hay fields. The effluent storage ponds could hold approximately eight million gallons, allowing the plant operators to regulate the delivery of recycled wastewater to meet the needs of irrigators. The plant no longer discharged directly to the Napa River except in the wettest times of the year, and then it still needed to meet stringent state requirements.[29]

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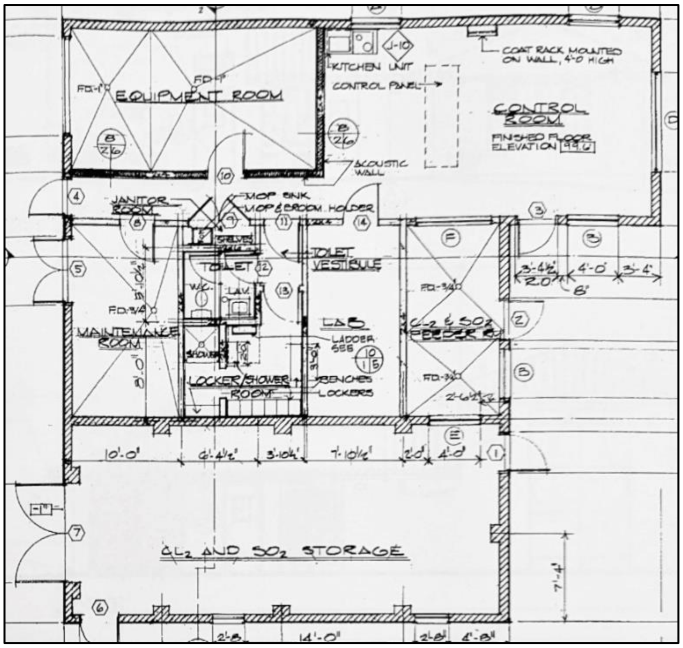
[26] Richard R. Kennedy [obituary]," *San Francisco Examiner,* October 9, 1985, 20; "Hoover Sewage Plant in Operation," *The Reclamation Era,* Vol. 43, No. 3 (August 1957), 79; "People in Business," *Oakland Tribune,* February 15, 1979, 58; Kennedy Jenks "History."

[27] Kennedy Engineers, "City of Yountville Wastewater Facility Improvements, Pump Station – Site Plan," June 1, 1977, Sheet No. C-5.

[28] Kennedy Engineers, "Yountville – Veterans Home Joint Wastewater Treatment Facilities, Site Plan & General Arrangement," June 1, 1977, Sheet No. C-1.

[29] "A Modern Sewage Plant," *Napa Valley Register,* July 10, 1979, 1.



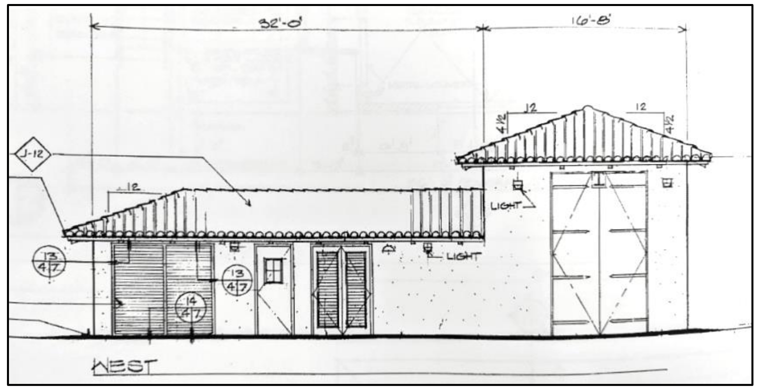


Figure 8: The floorplan and west façade elevation for the control room.[30]

The Yountville Wastewater Reclamation Facility has continued to evolve over the four decades since the joint plant was completed. In 1989, the town removed the sludge drying beds, including the old contact bed, to construct a shop area for the public works department. The current sludge drying beds south of the effluent storage ponds were completed at that time and new sludge pumps were installed. In 1992, the facility substantially upgraded its treatment abilities by adding activated sludge tanks, allowing it to purify the recycled wastewater to higher standards. In 1998, a new fuzzy filter, consisting of a vertical pressure tank filled with polymer fiber balls, replaced the 1977 pressure filters. In 2010, the plant added the current chlorine contact basin, ending the need to use the basin beneath the sludge digestor control room.[31]

Evaluation

The Yountville Wastewater Recycling Facility and associated pump station are not eligible, either in whole or for any separate elements, for inclusion in the NRHP or CRHR as they do not possess historic significance.

The subject properties lack important associations with significant events or trends, and they are not eligible under NRHP Criterion A or CRHR Criterion 1. The Veterans Home of California constructed the trickling filters and sludge digestor at the current plant in 1940 as they modernized and expanded their existing sewage treatment facilities. That 1940 plant provided the first secondary treatment of sewage in the Napa Valley and was a meaningful step towards cleaning up the badly polluted Napa River. However, planning for a larger valley-wide sewage improvement program had been in the works prior to the plant's construction and it was merely the first of the facilities to be completed. As a state-owned institution, it benefitted from the legislature's ability to appropriate the needed funds without requiring that voters approve a bond measure as municipalities did. The completion of the Veterans Home plant allowed the larger plan to progress, but it was not responsible for inspiring the effort, which depended more on pressure applied by state regulators. The town of Yountville completed its first treatment plant at the location of today's pumping station in 1956. Almost nothing of that plant survives and it lacks importance as it was a late and small part of the sewage improvement efforts made in the Napa Valley.

[30] Kennedy Engineers, "Yountville – Veterans Home Joint Wastewater Treatment Facilities, Treatment Plant Control Building," June 1, 1977, Sheet Nos. A-1 and A-2.
[31] "Yountville Treatment Plant History;" Historical aerial photographs, 1968, 1982, 1993, 2010, and 2012, accessed May 2023 at www.Historicaerials.com.

The joint Yountville-Veterans Home wastewater recycling facility was constructed in 1979 by expanding the 1940 Veterans Home plant and transforming the town plant into just a pumping station. Federal regulators compelled the town to accept this cooperative arrangement as the most practical way of meeting higher treatment standards. The arrangement did not fundamentally change the nature of sewage collection and treatment in Yountville or the Veterans Home, but merely allowed it to continue on a larger scale. Such cooperative agreements were common when small municipalities or institutions could not meet rising standards with their own resources. Thus, neither the current treatment facility nor pumping station introduced any historically important new activities, and thus they lack significance under this criterion.

The subject properties lack clear association with any individual important to history and they are not significant under NRHP Criterion B and CRHR Criterion 2. The properties are publicly owned and are closely associated with the Veterans Home of California and the Town of Yountville, but not with any particular political or institutional leader, community advocate, or public works employee. Contemporary newspaper coverage treated the plants' construction as routine functions of municipal government and identified no specific individuals as playing a major role in proposing the plants or backing the bond campaign to finance construction of the town plant. Veterans Home and Yountville staff members have operated the plants since their completion, but no individual has had a long or meaningful individual association with the subject properties.

The subject properties lack significance under NRHP Criterion C or CRHR Criterion 3 as they are not important examples of their type, period, or method of construction; nor are they works of high artistic value or important examples of the work of a master architect or engineer. Taken as a whole, the Yountville Wastewater Reclamation Facilities contains a mixture of equipment from 1940 to near the present and it does not represent any one particular era or method of treatment. Its mixture of variously aged equipment is common at small municipal plants that continue to evolve to meet changing treatment standards and expanding capacities, and the Yountville plant lacks importance within that context. Additionally, none of the individual pieces of equipment at the treatment plant or pumping station have historic importance under this criterion. The trickling filters and clarifiers at the treatment plant were installed as part of a Biofiltration System, a modification of existing practices developed by Harry Jenks. The subject equipment was the seventeenth such system installed in the United States and came four years after the first large-scale system was completed. It is thus not an important example of its type. The other historic-aged or near-historic-aged equipment at the plant—sludge digestor, final clarifier, grit chamber, effluent storage ponds, and control house—are all standard pieces of equipment at wastewater treatment facilities and show no indication of unique design. The control buildings at both the treatment plant and pump station are in a Spanish Revival style, but are not strong examples of the type as they lack such common features as arched entries or windows, flush eave lines, and decorative vents.[32] The small municipal buildings filled an essentially utilitarian role and did not warrant great architectural ambition. Harry Jenks and Kennedy Engineers might conceivably qualify as master engineers as both did pioneering work in municipal drinking water and wastewater systems engineering. However, the subject properties, which are small in scale and involved few major design challenges, are not important examples of the work of either firm, both of which had developed a portfolio of higher-profile works well prior to designing the Yountville treatment plant. The subject property is not an important work for understanding the design tendencies or trajectories for either firm.

Finally, the property is not significant under NRHP Criterion D or CRHR Criterion 4 as it has not yielded, and is not likely to yield, data important to the understanding of history. The materials and construction and engineering techniques employed on this property were common in their time and are well documented in a wide body of written sources.

[32] Virginia Savage McAlester, *A Field Guide to American Houses: The Definitive Guide to Identifying and Understanding America's Domestic Architecture* (New York: Alfred A. Knopf, 2015), 520-534.

Photographs (continued):

Photograph 2: Control Building, northwest corner, camera facing east, September 15, 2022.

Photograph 3: Control building, southwest corner, camera facing north, September 15, 2022.

Photograph 4: Control building, south and rear east side, camera facing northwest, September 15, 2022.

Photograph 5: Control console in office wing of control building, camera facing west, September 15, 2022.

Photograph 6: Grit chamber with shed for aeration equipment, camera facing east; September 15, 2022.

Photograph 7: Auger used grit chamber debris disposal, camera facing southwest; September 15, 2022.

Photograph 8: Comminutor, camera facing east; September 15, 2022.

Photograph 9: Dissolved air flotation system, camera facing southeast, September 15, 2022.

Photograph 10: Clarifier tanks in front of sludge digester, camera facing northeast, September 15, 2022.

Photograph 11: View from above clarifier tanks, camera facing west, September 15, 2022.

***Resource Name or #** (Assigned by recorder): Yountville Wastewater Reclamation Facility

***Recorded by**: D. Hickman & D. Baza *__Date__: September 15, 2022 ☒ Continuation ☐ Update

Photograph 12: Trickling filter, camera facing south, September 15, 2022.

Photograph 13: Trickling filter, camera facing north, September 15, 2022.

Photograph 14: Trickling filter distributor arms and plastic media, camera facing east, September 15. 2022.

Photograph 15: Activated sludge tanks with final clarifier behind, camera facing northeast, September 15, 2022.

Photograph 16: Activated sludge tank, camera facing southeast, September 15, 2022.

Photograph 17: Final clarifying tanks, camera facing north, September 15, 2022.

Photograph 18: Fuzzy filter, camera facing northwest, September 15, 2022.

Photograph 19: Chlorine contact basin, camera facing southwest, September 15, 2022.

Photograph 20: Effluent storage pond, camera facing east, September 15, 2022.

Photograph 21: Flow equalization pond, camera facing northwest, September 15, 2022.

Photograph 22: Rear of sludge digestor, camera facing east, September 15, 2022.

Photograph 23: Control rooms at east end of sludge digestor, camera facing northwest, September 15, 2022.

Photograph 24: Digestion control room interior, September 15, 2022.

Photograph 25: Sludge drying beds, camera facing north, September 15, 2022.

Photograph 26: Trickling filter shell at pump station; camera facing east, September 15, 2022.

Photograph 27: Central hub and inlet pipe for tricking filter, showing Pacific Flush-Tank Company brand; camera facing east, September 15, 2022.

Photograph 28: Pumping station control building, camera facing north, September 15, 2022.

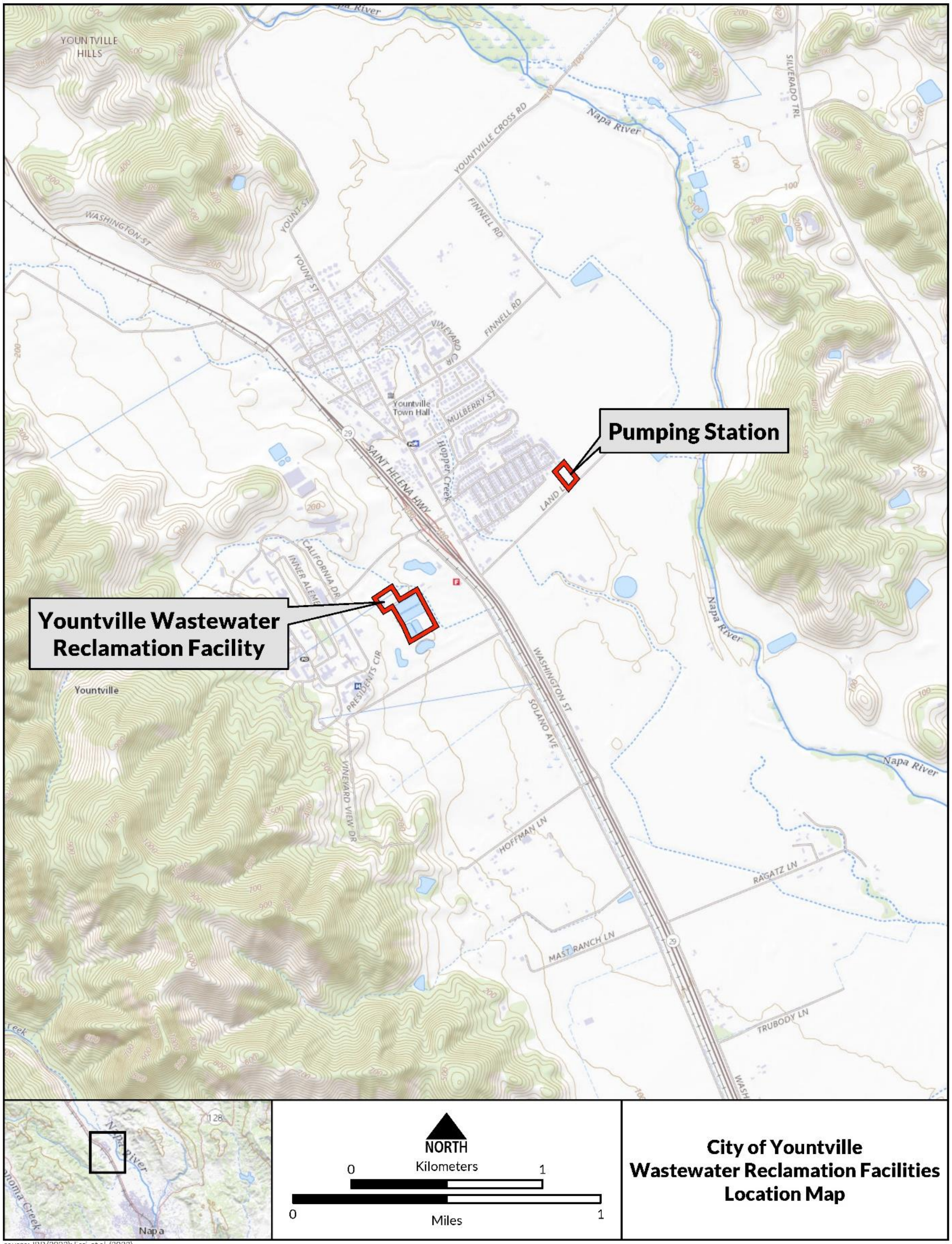
Photograph 29: East side of control building with pump station to right, camera facing west, September 15, 2022.

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
LOCATION MAP

Primary # ______________
HRI # ______________
Trinomial ______________

Page 32 **of** 33 ***Resource Name or #** (Assigned by recorder) Yountville Wastewater Reclamation Facility

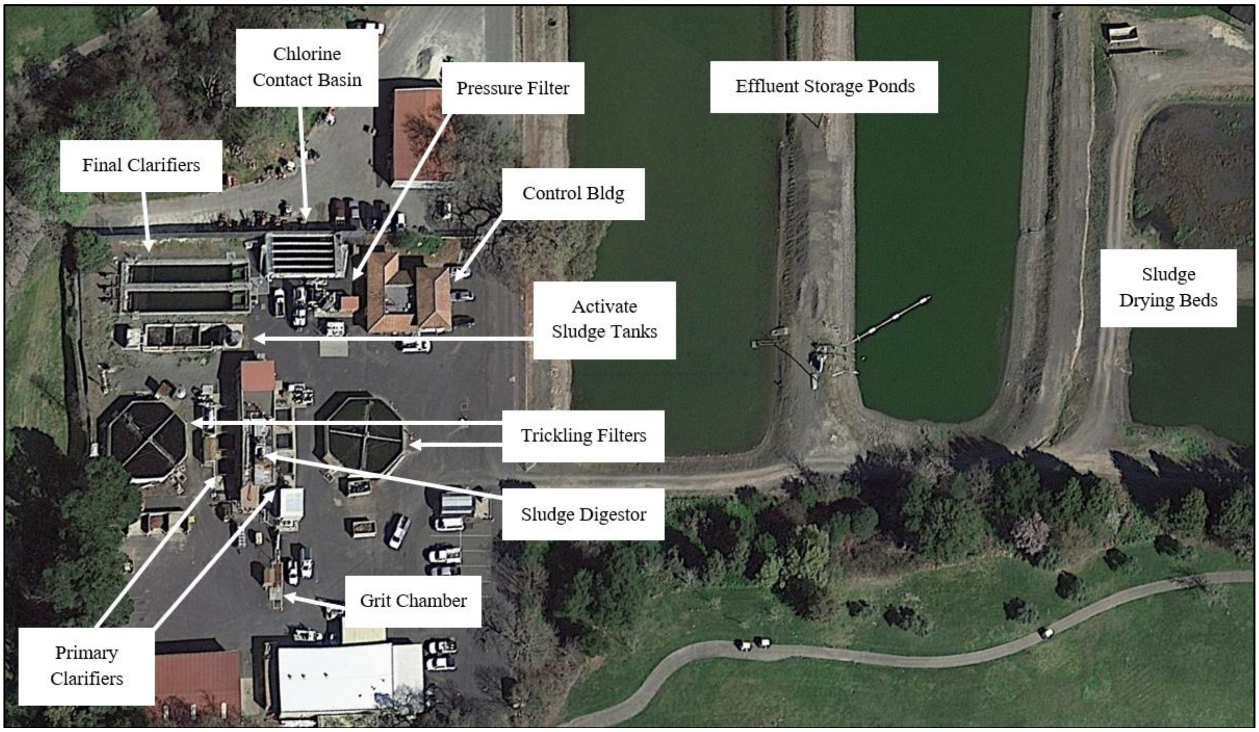
***Map Name:** USGS National Map ***Scale:** 1:24,000 ***Date of Map:** 2019



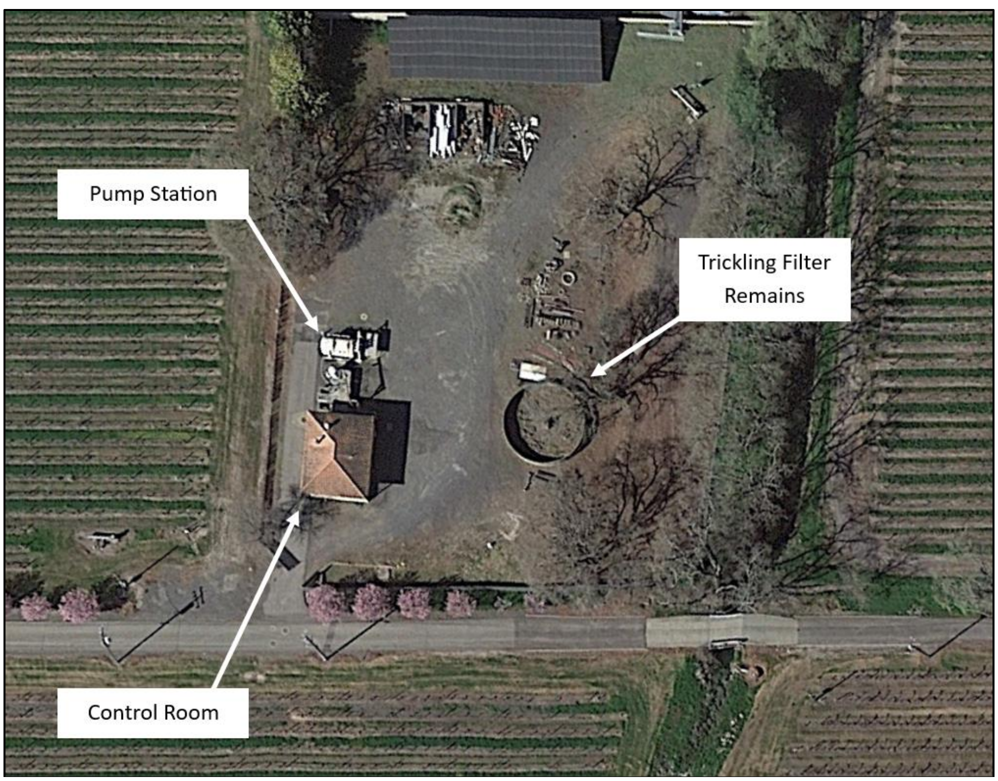
source: JRP (2023); Esri, et al. (2023).

***Resource Name or #** (Assigned by recorder) Yountville Wastewater Reclamation Facility

Sketch Maps:



Yountville Wastewater Reclamation Facility



Pumping Station

On November 22, 2022, AECOM archaeologists Karin G. Beck and Mark Hale conducted a site visit with Mokelumne Hill Sanitary District (MHSD) President Phil McCartney and State Water Resources Control Board (Water Board) archaeologist, Braden Elliott, for the purpose of gaining additional information to support Julia Costello's November 2021 National Register of Historic Places (NRHP) and California Register of Historical Resources (CRHR) evaluation of P-05-003525 (site). The site is being used as one of the case studies in the historic context and research design for drinking and wastewater facilities the Water Board contracted AECOM (and others) to prepare.

Costello's (2021) evaluation of the 1947 MHSD Treatment Plant found the facility was not eligible for listing to either r the NRHP nor CRHR. AECOM's field efforts do not change this evaluation. This update reports on additional features identified during the 2022 field visit and expands on the Criterion D discussion.

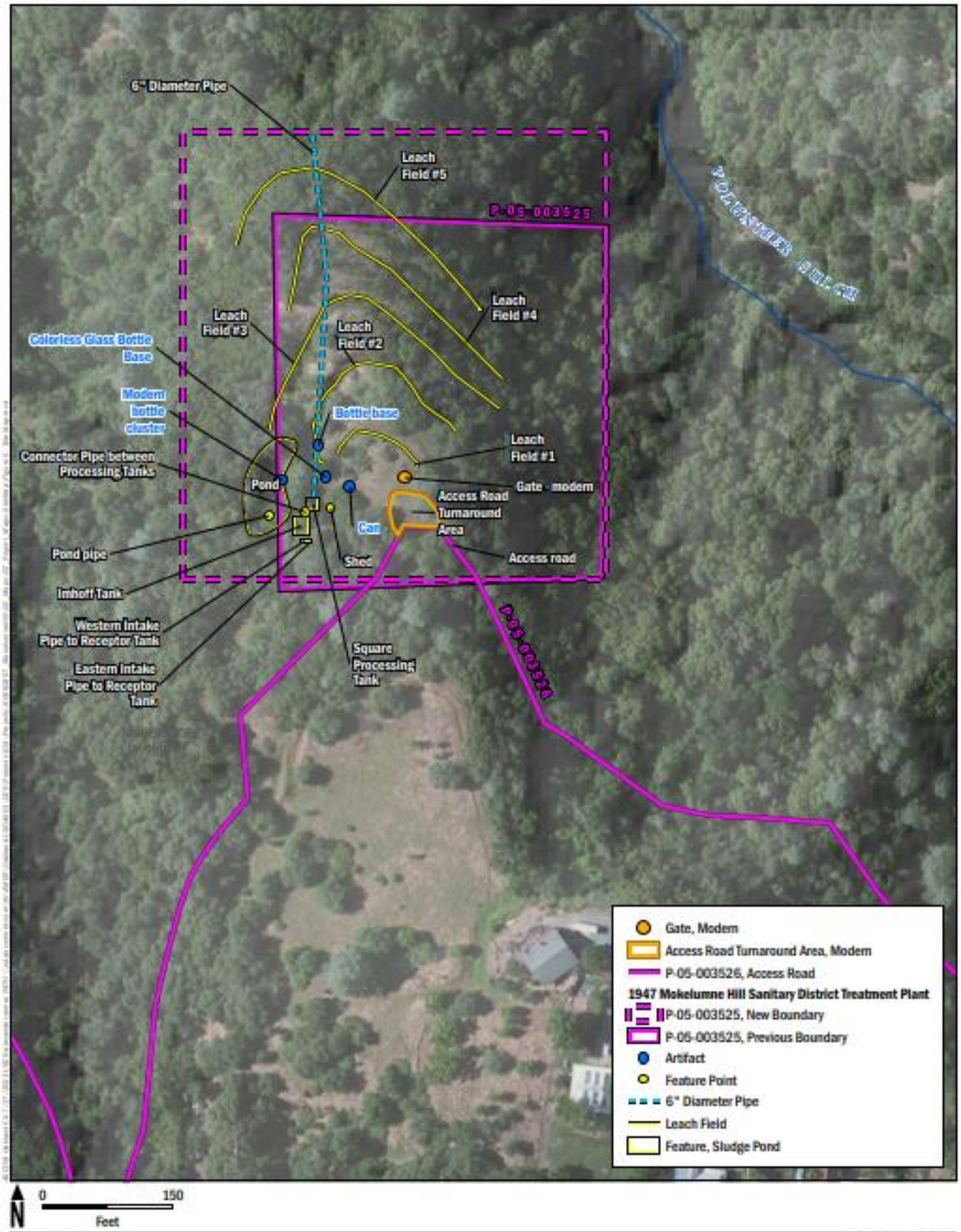
P3a. Description

As recorded by Costello (2021), the 1947 MHSD Treatment Plant consisted of a concrete receptor tank, two concrete processing tanks (one, larger two-chambered primary tank with manholes [which appears to be an Imhoff Tank], and one smaller square secondary tank), a corrugated metal electrical shed, a pond, and a series of five (corrected from Costello's recorded four) excavated leach fields or trenches (corrected from Costello's spray fields) situated on the downslope of the hillside that ends in a steep ravine with a release valve pointed north towards Volunteer Gulch (see **Photograph 1; Site Map**).

Photograph 1. Overview of treatment plant: 1) receptor tank, 2) primary processing tank, 3) square, secondary processing tank, 4) electrical shed, 5) southern end of leach field #2, 6) pond. View north.

CONTINUATION SHEET

Property Name: 1947 Mokelumne Hill Sanitary District Treatment Plant (UPDATE)



AECOM

FIGURE X
Site Map

CONTINUATION SHEET

State Tells Mokelumne Hill to Expand Sanitary System

MOKELUMNE HILL — An ultimatum has been issued to the Mokelumne Hill Sanitary District by state sanitation authorities to immediately expand and improve the present sanitary facilities in the Mokelumne Hill District.

The State Bureau of Sanitation, and the Central Valley Regional Water Quality Control Board, in making constant water pollution tests, report a health hazard has been created as the result of overloading the facility.

Designed 20 years ago to serve about 150 residents within the townsite, the Mokelumne Hill sanitry system is presently serving about 350 people, commissioners said.

State authorities warned the district commissioners to move immediately to expand the present system to accommodate present users and possible future growth of the townsite.

The firm of Haight & Weatherby has been employed by district commissioners to prepare a preliminary feasibility study to determine costs for rebuilding portions of the existing system, and additional collection lines with treatment facilities to serve the entire community until about 1990.

The original sewer bonds for the district will be paid off in one more year.

The district has prepared and will file an application with the Farmers Home Administration to assist in possible low interest financing of the expansion, commissioners said. This application will ask for a grant in the amount of $93,700, and a loan in the amount of $93,800. The district will hold an election for the voters to approve a low interest loan.

The commissioners stated they are moving with all possible speed to meet community requirements and the demands of the state agencies.

Plate 1. Article from *Stockton Evening and Sunday Record* (June 17, 1969)

The MHSD was founded in 1947 and operation of the gravity-fed treatment plant began the same year. It appears that the shed was constructed later to aid an already struggling system (see discussion below).

The MHSD Treatment Plant was overloaded for the population of Mokelumne Hill, only designed to "serve about 150 residents" but was already serving about 350 people by 1969 (**Plate 1**). The State sanitation authorities issued an ultimatum to the MHSD to immediately expand and improve the treatment plant, and by 1973 the 1947 MHSD Treatment Plant had been abandoned and replaced by a new facility constructed to the west (**Plate 1**).

Vitrified sewer pipe carried sewage in two mains from different parts of town: sewage from the eastern part of town collected at East Center Street and gravity-fed north to the MHSD Treatment Plant through a main intake pipeline located below the Access Road (P-05-003526) leading to the site (**Photograph 2**). Sewage from west of Main Street drained northward and was collected on West Center Street (east of the Protestant Cemetery at 8514 Center Street) and descended by gravity feed to the MHSD Treatment Plant (**Photograph 3**).

Photograph 2. Access Road (P-05-003526), view south.

Photograph 3. Access cover to western intake main located at 8514 Center Street, east of the Protestant Cemetery.

Once at the MHSD Treatment Plant, sewage drained into the concrete, board-formed Receptor Tank, which measures 10 feet long (east-west) by 29 inches wide (north-south) by five feet tall (**Photograph 4**). The western intake pipe entered the tank from the south (**Photographs 5 and 6**), while the eastern intake pipe entered the tank from the east (**Photograph 7**). Sewage filled the Receptor Tank, which has the remains of "L" shaped metal bars that likely functioned to prevent larger non-sewage items from clogging the system. The heavy fraction settled and exited from the bottom of this tank to the larger, three-chambered Processing Tank via a 12-inch diameter corrugated metal pipe from its west face (**Photographs 1 and 8**). Light fraction entered the processing tank when the liquid level reached a separate 12-inch diameter corrugated metal pipe from the Receptor Tank's upper north face (**Photographs 8 and 9**).

After leaving the Receptor Tank, sewage entered the Primary Processing Tank (which appears to be an Imhoff Tank) via the above mentioned pipes on its south face. The processing tank is comprised of two separate chambers: an open, upper chamber flanked by narrow, closed chambers on its west (downhill) and east (uphill) sides that is connected to the lower chamber (**Photographs 1 and 10**).

The lower chamber is accessed via manholes at the southern corners of the tank. The Processing Tank measures 15 feet wide (east-west) by 25 feet long (north-south) by approximately 20 feet tall. Heavy fraction entered the upper chamber where solids settle and slide down the sides which are chamfered towards the center near the bottom of the tank to contain sludge, while the wastewater can move through the tank. The length is split in the center by a large baffle that reaches from the top to about midway into the tank (**Photograph 10**). The baffle acts to reduce the mixing of the upper scum layer with the wastewater as it moves through the tank. Extending from the baffle, north to the wall is a metal trough measuring approximately 12 inches wide by four inches deep and spans the northern half of the open upper chamber approximately three feet from the top (**Photograph 10**). The trough enters the northern interior wall of the Processing Tank where it exits the tank via a 12-inch diameter corrugated metal pipe that connects to the west wall of the eight-foot-square Secondary Processing Tank (**Photographs 11 and 12**), thereby moving the effluent to the next phase of processing. There are also two, 2-1/2-inch diameter galvanized pipes, one in each northern corner of the open chamber, extending approximately three feet into the tank and wrapping over the top, and into, the closed chambers (**Photograph 10**). The pipes move wastewater from the top of the closed chamber to mix with the wastewater in the open upper chamber, then out to the Secondary Processing Tank, when the liquid level reaches capacity in the closed chamber.

Photograph 4. Receptor Tank with western intake pipe in (right) foreground (red arrow), view north-northwest. Source: Costello 2021.

Photograph 5. Western intake pipe entrance to Receptor Tank.

Photograph 6. Inside the Receptor Tank with entry hole from western intake pipe and corrugated pipe for eastern intake pipe.

Photograph 7. Eastern intake pipe at entrance to Receptor Tank.

Photograph 8. Pipe connecting the Receptor Tank (A) and the Primary Processing Tank (B); heavy fraction pipe in foreground (C), light fraction pipe in background (D). View east.

Photograph 9. Light fraction connector pipe between the Receptor Tank (left) and the Primary Processing Tank (right). View west.

CONTINUATION SHEET

Photograph 10. Primary Processing Tank, with upper open chamber flanked by the closed lower chamber. Upper chamber has a baffle in the center and a trough extending to the wall and outlet to a Secondary Processing Tank. View northwest.

Photograph 11. Connector pipe between the Primary and Secondary Processing Tanks. View east.

Photograph 12. Secondary Processing Tank with 6-inch diameter effluent outlet pipe exiting from north wall; Primary Processing Tank in background. View southwest.

The interior of the Secondary Processing Tank has what appears to be a pump at the bottom of the tank. A metal cylinder approximately 12 inches in diameter with "PACIFIC.." embossed on the top and a 2-1/2- or three-inch diameter pipe coming out of its side near its top then elbowing towards the ground (**Photograph 13**). Other pipe fragments and several "O" ring-like pieces litter the bottom of the tank along with foliage and a modern wooden pallet. In this tank, the effluent would be pumped via a six-inch diameter cast iron Distribution Pipe (embossed with "W175/ G [in triangle]/48) north to five (corrected from Costello's four) leach fields. At the northern end of the Distribution Pipe, downslope from the last leach field (Leach Field #5), there is a shut-off valve with a hand wheel.

Photograph 13. Interior of Secondary Processing Tank with 12-inch diameter inlet pipe from Primary Processing Tank in west wall; pump at base of tank, along with modern pallet. View southwest.

An electrical shed measuring six square feet is located upslope and east of the Secondary Processing Tank (**Photographs 1, 14, and 15; Site Map**). It is constructed of a wood frame with 2- by 4-inch studs, clad in sheets of corrugated aluminum with an earthen floor, and supported with wood mudsills on a concrete pier foundation (corrected from Costello 2021). It has a shed roof that is also clad in corrugated aluminum.

Photograph 14. Electrical shed, west and south elevations. View northeast.

Photograph 15. Electrical shed, north elevation.

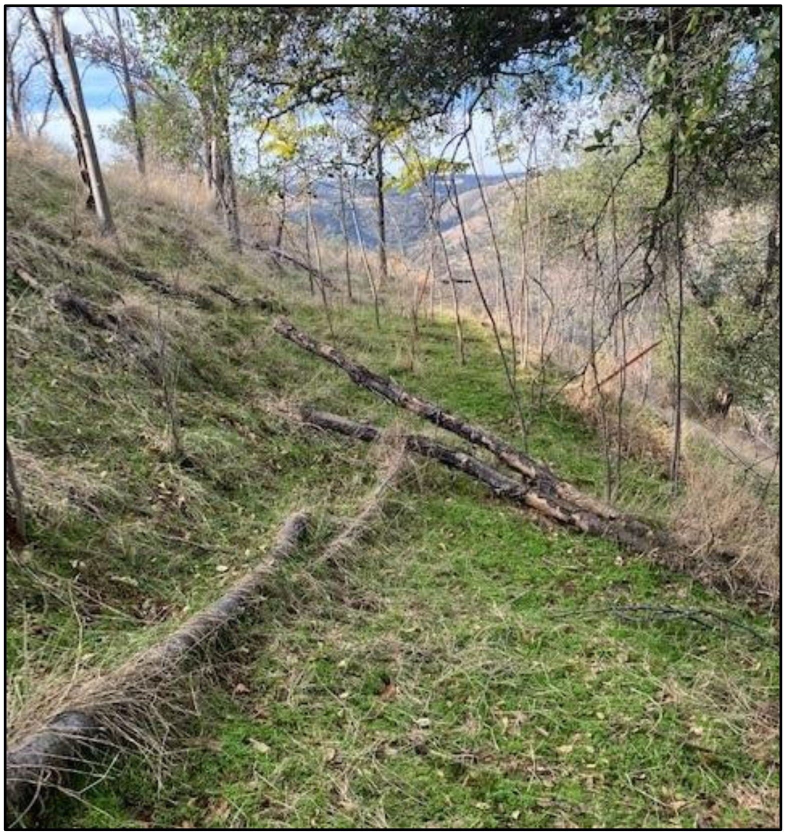
Inside the shed are electrical boxes on the west wall from the Square D Company in Los Angeles, one safety switch, a reset box, and another (perhaps power) box (**Photograph 16**). Along the south wall, not *in situ*, is a tank, possibly a pressure tank used to pump effluent out of the Secondary Processing Tank to the Leach Fields 1 through 5 (**Photograph 17**). The date “4-5-52” was painted on a roof rafter, presumably the date of the shed’s construction.

Photograph 16. Electrical shed interior west wall.

Photograph 17. Electrical shed interior with tank.

A series of five (corrected from Costello's four) leach fields, or trenches, were excavated along the contour of the hillside terraced between approximately 1400 and 1200 feet elevation towards Volunteer Gulch, which is east of the site trending northwest (**Photograph 1**). The gulch meets up with another drainage approximately a quarter-mile north-northwest of Leach Field #5 before flowing to the Mokelumne River. Effluent was piped via the six-inch diameter Distribution Pipe to each leach fields' supply pipe (3-1/4-inch diameter cast iron), where it was filled, not sprayed (there are no remnants of sprinkler heads, just open pipes) into the trenches to be absorbed into the ground prior to reaching Volunteer Gulch. Leach fields ranged from approximately 125 to 500 feet long (corrected from Costello's 600 to 1,000 feet long) and are roughly 20 feet wide or less (**Photographs 18 and 19**). The degree of overgrown vegetation and whether the pipes are buried varies between leach fields. It is likely that Costello missed the leach field (Leach Field #5) furthest downslope due to the supply pipe being mostly buried by soils and vegetation.

Photograph 18. Leach Field #2 with supply line pipe and distribution heads. View northeast



Photograph 19. Leach Field #5 with overgrown supply pipe looking similar to the nearby fallen trees. View northwest.

Photograph 20. Example of pipe attached to supply line pipe that filled the leach fields.

Sludge from the Primary Processing Tank exited into a pond by way of a partially buried pipe, immediately west of the tank (**Photographs 1, 21; Site Map**). The pipe spans the pond near its southern end and has a large oval diffuser attached to the middle of the line, with what appears to be a reducer coupling on the ground (not *in situ*) that acted to reduce the force of the flow of effluent into the pond (**Photograph 22**). The pond is approximately 100 feet long (north-south) by 45 feet wide (east-west) by about six feet deep (**Photograph 23**). The sludge would exit from the lower chamber of the Primary Processing Tank Costello identifies the pond is for "overflow effluent" but could not identify how the effluent reached the spray fields. AECOM identified two, 12-inch diameter, corrugated metal pipes in an earthen berm at the pond's northern limits that allowed overflow effluent to drain into the terraced Leach Field #3 (**Photograph 24**).

Photograph 21. Overflow Effluent Pipe (A) west of Primary Processing Tank (B). View southeast.

CONTINUATION SHEET

Photograph 22. Overflow pipe diffuser with reducer on ground. View south.

CONTINUATION SHEET

Photograph 23. Pond. View northwest.

Photograph 24. Corrugated pipe exiting the northern Pond berm into Leach Field #3. View southwest.

State of California - The Resources Agency
DEPARTMENT OF PARKS AND RECREATION

Primary# P-05-003525
HRI #
Trinomial

CONTINUATION SHEET

Property Name: 1947 Mokelumne Hill Sanitary District Treatment Plant (UPDATE)

Several undiagnostic and late twentieth century artifacts were identified at the MHSD Treatment Plant, most of which can be attributed to post-1980 use of the site for alcohol consumption (**Photographs 25 through 30**). The majority of these artifacts were found within the Pond near the Primary Processing Tank; however, a coffee can and two, colorless bottle bases were identified north of the Shed (**Photographs 1, 25, and 26; Site Map**). A single five-inch tall pail was identified near the end of the Distribution Pipe (**Photograph 30; Site Map**).

Photograph 25. Coffee can.

Photograph 26. Colorless glass bottle base.

Photograph 27. King Cobra bottle.

Photograph 28. Glass candle by General Wax Candle Company

Photograph 29. “///GENERAL WAX CO/ and [symbol]/VICTORIAN/5”

Photograph 30. Small, galvanized pail, missing the handle.

Evaluation

The 1947 MHSD Treatment Plant does not appear to meet the criteria for listing in the NRHP or the CRHR. It is not a historic property under Section 106 of the National Historic Preservation Act nor is it an historical resource for the purposes of the California Environmental Quality Act (CEQA). This resource has been evaluated in accordance with Section 106 of the National Historic Preservation Act of 1966 (as amended) (54 U.S.C. 306108) and its implementing regulations (36 CFR Part 800), and Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code.

Historic Context (adapted from Costello and Marvin 2022)
The Mokelumne Hill Sanitary District (MHSD) was formed out of necessity in response to the need for a more modern system. Prior to the formation of the Sanitary District, sewage disposal for Mokelumne Hill was treated in individual septic tanks:

> The trickling sewage draining down the various streets from overloaded and filled-up ceptic [*sic* septic] tanks is hardly anything to brag about. A number of old-fashioned bay-yard plumbing systems still prevail and no amount of arguing can make anyone really believe they are an asset to the town or to good health; let alone convenience and comfort [*Calaveras Weekly* 29 August 1947].

The MHSD was formed as a special district under the Sanitary District Act of 1923, and it owns and operates (to this day) the wastewater collection, treatment, and disposal facilities serving the community of Mokelumne Hill. The MHSD Board, which consisted in 1947 of Peter Mornonzoni, John Gardella, Alexander Lombardi, Myron Greve, and F.J. Solinksy, Jr., sent a letter to the Calaveras County Board of Supervisors requesting that:

> The Board pass and adopt a resolution assigning to the said Mokelumne Hill Sanitary District the sum of $21,912 out of the monies allocated to Calaveras County under Chapter 20, Statues of 1946 (First Extra Session) to be used in connection with the construction of a sewer system in said district [Board of Supervisors Book W:311, *Calaveras Prospect* 19 July 1947].

The action was approved and on August 2, 1947, the MHSD went about scheduling a vote on a bonded indebtedness of $25,000 "for the purpose of raising monies for the acquisition, and construction of sewers, drains, sewage collection, outfall, treatment works and sanitary disposal" (*Calaveras Weekly* 29 August 1947). Bonds were to be 25 in number, of $1,000 each, bearing interest at a rate not to exceed five per cent per annum, payable semi-annually. The vote was scheduled to be held Tuesday, 2 September 1947 (*Calaveras Weekly* 29 August 1947). The sewer bond proposition was passed with a vote of 112 to 2, and was noted as "very gratifying indeed," with construction work to begin "before too many days" (*Calaveras Weekly* 5 September 1947).

The MHSD Treatment Plant was constructed in 1947 on just over 2.6 acres of land acquired for this purpose in the Northeast Quarter of Section 12, Township 5 North, Range 11 East, Mount Diablo Base and Meridian. It is located on a hillside that slopes north towards the Mokelumne River over a half-mile below. This area is on the northern outskirts of town, situated between the Protestant Cemetery on the west and Volunteer Gulch and the St. Thomas Aquinas Cemetery on the east (**Site Map**). The location was accessed by a road (P-05-003526) overlying the eastern collection pipe from Center Street.

The 1947 MHSD Treatment Plant relied on gravity feed lines to collect sewage from town. Main Street occupied the community's central high ridge and drained northward from Main Street. It was then collected at 8514 West Center Street and piped to the treatment plant. Sewage from the eastern portion of town was collected at East Center Street and brought north through the main pipeline along the access road.

After the system was constructed, official easements were obtained for locations where the new sewer line crossed private property. These were all filed between June 30 and July 11, 1949, by Myron Greve, Secretary of the Sanitary Board, and all conveyed the rights to "lay, install, use, operate, maintain and replace" the buried sewer lines. The easements also stipulated that "the sewer pipe shall be buried at least three feet below the surface of said ground and properly covered by refill." None of the easements were accompanied by maps or precise descriptions of locations (Calaveras County Deeds v. d.).

No information was obtained to identify the architect or builder of the 1947 treatment plant. The MHSD Treatment plant was designed to serve a population of 150 residents (*Stockton Evening and Sunday Record* 17 June 1969). There is a date of "4-5-52" on a rafter within the Electrical Shed that is believed to be a construction date. It is possible that the original design did not function as desired, so an electrified system consisting of a pressure tank and sump pump was installed to assist in moving effluent from the processing tanks to the leach fields. By 1969, the treatment plant was overloaded by about 200 residents and the Sanitary District was forced by State authorities to upgrade and expand their system immediately (*Stockton Evening and Sunday Record* 17 June 1969). In 1973, the original plant was abandoned and a new Class I treatment plant, with a design capacity of 0.15 million gallons per day, was constructed at the northwest edge of town.

<u>Evaluation</u>
The MHSD Treatment Plant is not eligible for inclusion in the NRHP or CRHR as it does not possess historic significance.

The MHSD Treatment Plant lacks important associations with significant events or trends, and it is not eligible under NRHP Criterion A or CRHR Criterion 1. The MHSD was formed in 1946 out of necessity to construct a modern system that would ensure the City of Mokelumne Hill's water quality would not be compromised due to individual septic tanks regularly overflowing. The construction of the treatment plant in 1947 expanded the community's sanitary system to accommodate about 150 residents, but within 20 years the population had risen to nearly 350 residents and was once again needing replacement. The expansion and operation of the 1947 MHSD Treatment Plant did not contribute any importance to the community's history.

The MHSD Treatment Plant lacks clear association with any individual important in history and is not significant under NRHP Criterion B or CRHR Criterion 2. The property is owned by MHSD and is not associated with any city leader or public works employee. Newspaper accounts do not specify any government official that championed the plants construction. MHSD staff operated the plant since its completion, but no individual has had a long or meaningful association with the facility.

The MHSD Treatment Plant lacks significance under NRHP Criterion C and CRHR Criterion 3 as it is not an important example of its type, period, or method of construction; nor is it a work of high artistic value or an important example of the work of a master architect or engineer. The plant is of a very rudimentary design, employing an Imhoff Tank which became popular in 1912. This design offered some advantages over septic tanks but were fairly quickly superseded by more sophisticated secondary treatment methods. The MHSD Treatment Plant is a typical example of a common resource type of its era, not the work of a master, nor does it represent any advancements in engineering design or construction.

The MHSD Treatment Plant lacks significance under NRHP Criterion D and CRHR Criterion 4 as it has not yielded, and is not likely to yield, information important to the understanding of history. It does not appear to have any likelihood of yielding important information regarding historic construction materials or technologies. The plant was built at a time when the work force employed to construct the facility was likely local and not housed in a labor camp nearby. The Works Progress Administration (WPA) projects ended in 1943, so no information can be gained in regard to the people who constructed the facility. Likewise, there is little remnant construction debris due to its post-World War II build date when materials were scarce and were needed elsewhere when construction was complete. Furthermore, the operation of the plant was generally passive, with only the occasional need to muck out sludge from the bottom of the Processing Tank into the pond (or haul away). Any material cultural left behind during the brief times of activity, would not provide more information about the operation of the facility. The material cultural that was identified on site post-dates the operation of the treatment plant. Anything to be learned about the 1947 MHSD Treatment Plant would be found in archival sources including as-builts and original design plans. An attempt was made by MHSD President Phil McCartney to retrieve any of those documents through the MHSD and the architectural firm hired to design the 1973 treatment plant, but to no avail.

PRIMARY RECORD

Primary#
HRI#
Trinomial
NRHP Status Code 6Z
Other Listings
Review Code Reviewer Date

 ***Resource Name or #:** Mill Creek Filtration Plant

P1. Other Identifier:
***P2. Location:** ☐ **Not for Publication** ☒ **Unrestricted** ***a. County:** San Bernardino
***b. USGS 7.5' Quad** Yucaipa **T** 1S; **R** 2W; **¼ of ¼ of Sec** 15 and 22**; B.M.** San Bernardino
c. Address n/a **City** Mentone **Zip** 92359
d. UTM: Zone 11S; 492943 m E/ 3770727 m N
e. Other Locational Data: The abandoned Mill Creek Filtration Plant is situated between Mill Creek to the south and Newport Avenue to the north and has a general east to west orientation. The westernmost boundary of the Plant is located approximately 0.25-mile southwest of the intersection of Newport Avenue and Fish Hatchery Road, accessible along a dirt road. The easternmost boundary is located approximately 500 feet west of the Southern California Edison Hydroelectric facility on Newport Avenue.

***P3a. Description:** The abandoned Mill Creek Filtration Plant was a surface water treatment plant that treated water from Mill Creek for human consumption built circa 1926 and likely operated until circa 1968 when the Henry L. Tate Water Treatment Plant went online and replaced it. The plant was originally owned by the City of Redlands. Based on a 1955 Redlands Sanitary Survey report (Howard 1955), the plant consisted of a coagulation basin, an aeration basin, a regulation tank, a filter plant, Clear Well No. 1 and No. 2, and several supporting weirs, channels, and segments of 20-inch diameter metal pipe. At the time of the recording, the remnants of each feature mapped and discussed in the 1955 report were documented, as were several other features that appeared associated with the treatment plant based on location, design, and use of construction materials (**Photographs 1-13**) (Table 1). Some of the additionally documented features may be associated with other water management operations in the area, including irrigation for orchards. (SEE CONTINUATION SHEET)

***P3b. Resource Attributes:** AH2 – Foundations/structure pads; AH6 – Water Conveyance System
***P4. Resources Present:** ☒Structure ☒Site

P5a. Photo or Drawing

P5b. Description of Photo:
Photograph 1. Overview of Filter Plant (Feature 5) from Surge Tank (Feature 8), camera facing west, December 8, 2022

***P6. Date Constructed/Age and Source:** ☒Historic ☐Prehistoric ☐Both
(Built circa 1926, Howard 1955:2)

***P7. Owner and Address:**
San Bernardino County Flood Control District
825 East Third Street, Room 108
San Bernardino, CA 92415-0835

***P8. Recorded by:** Allison Hill and Leah Moradi, AECOM
401 West A Street, Suite 1200
San Diego, CA 92101

***P9. Date Recorded:** December 8 and 13, 2022

***P10. Survey Type:** Intensive

***P11. Report Citation**: JRP Historical Consulting, LLC and AECOM, 2023, *Drinking Water and Wastewater Treatment Facilities in California: Historic Context Development and Evaluation Procedures*. Prepared for State Water Resources Control Board and Department of General Services.

***Attachments:** ☒Location Map ☒Continuation Sheet ☒Building, Structure, and Object Record ☒Archaeological Record

BUILDING, STRUCTURE, AND OBJECT RECORD

***NRHP Status Code:** 6Z
***Resource Name or #** Mill Creek Filtration Plant

B1. Historic Name: Mill Creek Filtration Plant
B2. Common Name:
B3. Original Use: Water Treatment
B4. Present Use: Abandoned circa 1968; demolished
***B5. Architectural Style:** Utilitarian
***B6. Construction History:** Constructed circa 1926; alterations made in 1938 (see Feature 14; as well as Historic Context for details)
***B7. Moved? ☒ No**
***B8. Related Features:** N/A

B9a. Architect: Unknown b. Builder: Unknown
***B10. Significance: Theme** n/a **Area** n/a
Period of Significance n/a **Property Type** n/a **Applicable Criteria** n/a

The Mill Creek Filtration Plant does not appear to meet the criteria for listing in the National Register of Historic Places (NRHP) or the California Register of Historical Resources (CRHR), nor does it appear to be an historical resource for purposes of the California Environmental Quality Act (CEQA). Likewise, it does not meet the City of Redlands Historic Resource Criteria. The Mill Creek Filtration Plant does not retain integrity to its original construction and does not meet any of the significance criteria necessary for eligibility for listing in either the NRHP or CRHR or Local Register. The property has been evaluated in accordance with Section 15064.5(a)(2)-(3) of the CEQA Guidelines, using the criteria outlined in Section 5024.1 of the California Public Resources Code. SEE CONTINUATION SHEET

B11. Additional Resource Attributes: (List attributes and codes)

***B12. References:** SEE CONTINUATION SHEET

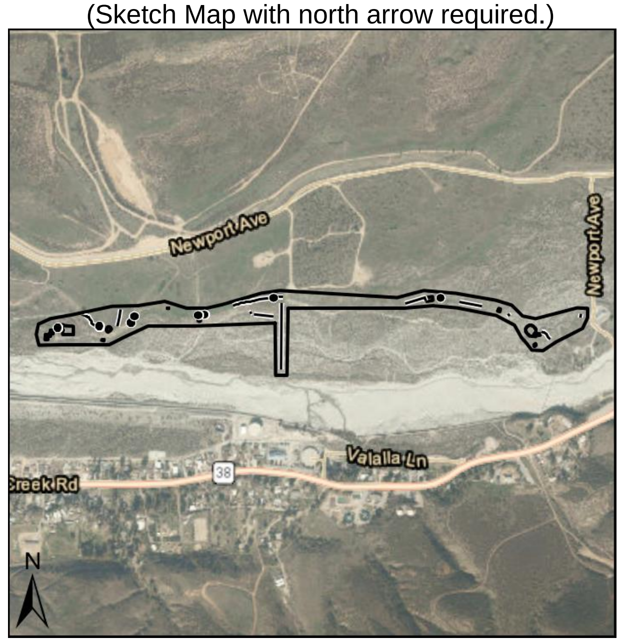
B13. Remarks:

***B14. Evaluator:** Karin G. Beck

***Date of Evaluation:** April 2023

(This space reserved for official comments.)

(Sketch Map with north arrow required.)



***A1. Dimensions: a. Length:** 1,290 m (E-W) × **b. Width:** 180 m (N-S)
Method of Measurement: ☒ Other: GIS
Method of Determination: ☒ Features

Reliability of Determination: ☒ Medium Explain: Some recorded features match a 1955 map of the facility (Howard 1955), although additional features were observed during recordation which may or may not be associated with the treatment plant.

Limitations: ☒ Site limits incompletely defined ☒ Disturbances ☒ Vegetation

A2. Depth: ☒ Unknown
***A3. Human Remains**: ☒ Absent

***A4. Features:** (SEE CONTINUATION SHEET)

***A5. Cultural Constituents**: Observed artifacts include 12 crushed sanitary cans, 1 aerosol can, 1 large pan, 1 hole-in-top can, 2 sanitary can lids, 1 metal bucket, 4 large cans, 1 piece of braided wire, 2 mattress springs, 1 colorless jar, 1 amber bottle, and 31 pieces of assorted scrap metal.

***A6. Were Specimens Collected?** ☒ No
***A7. Site Condition**: ☒ Poor: Features were severely damaged after flooding in 1938 (Howard 1955). Additional disturbances appear to have taken place after the plant fell out of use circa 1968, including the demolition of the filtration plant.

***A8. Nearest Water**: Situated approximately 131 feet (40 meters) north of Mill Creek
***A9. Elevation**: Approximately 2,200-2,600 feet above mean sea level
A10. Environmental Setting: Resource is located in the Mill Creek wash

A11. Historical Information: (SEE CONTINUATION SHEET)

***A12. Age**: ☒ 1914-1945 ☒ Post 1945; Built circa 1926 and went out of use circa 1968.

A13. Interpretations (Discuss data potential, function[s], ethnic affiliation, and other interpretations):

A14. Remarks:

A15. References: (SEE CONTINUATION SHEET)

A16. Photographs (List subjects, direction of view, and accession numbers or attach a Photograph Record.):

Original Media/Negatives Kept at:
***A17. Form Prepared by**: Allison Hill and Leah Moradi, AECOM **Date**: 1/4/2023
Affiliation and Address: AECOM, 401 West A Street, Suite 1200, San Diego, CA 92101

***A4. Features:** (Continued)

Table 1. Recorded Features of the Mill Creek Filtration Plant

Feature Number	Name	Description	Included in 1955 Report	Photograph
1	Weir box	Poured concrete in wood frame with 3 sectioned off areas	Yes	10
2	Clear Well No. 1	Open irregular rectangular structure predominantly of wood framed poured concrete with a couple walls made from cinder block	Yes	9
3	Concrete pipe segment	Small circular concrete fragment placed on soil - disturbed context	No	-
4	Cinderblock topped structure (Possible Clear Well No. 2)	Adjacent to Feature (F) 1 - tall rectangular structure that is mostly wood frame poured concrete topped with cinder block	Yes	8
5	Filter plant	Remnants of filter plant in varying degrees of destruction. Entire foundation filled with soil and gravel	Yes	1, 6, 7
6	Concrete pipe alignment	Partially buried concrete pipe that extends out of the west wall of the Filter Plant (F5) and heads west to just north of F2. Likely concrete cased 20-inch pipe from Howard (1955) report.	Yes	-
7	Rectangular vault	Vault comprised of local cobble and mortar with metal lid. Southwest of Surge Tank (F8) below bluff	No	-
8	Surge tank	Wood frame poured concrete structure. Large circle with rectangular section on south side	Yes	5
9	Concrete pipe along bluff	May not be related to treatment plant – 14-inch drain concrete pipe located along midsection of bluff, partially buried	No	-
10	Abandoned road segment	Eroded dirt road just below top of bluff that follows edge of bluff ending at tank (F8) slope	No	-
11	Concrete stump	Poured concrete stump where road ends below Surge Tank (F8)	No	-
12	Possible concrete footings	May not be related to treatment plant - a line of concrete footings along top of bluff to east of Surge Tank (F8)	No	-
13	Concrete and cobble square vault	Irregular rectangular vault of poured concrete and local river cobble with 4 metal rods sticking out of top	No	-
14	Concrete and cobble rectangular vault	Located approximately where EL 1 and 2 are mapped on 1955 map. Could be weir box or meter well. “1938” date etched into NW top of wall	No	11, 12
15	Metal well/vault	Circular metal vault with welded on lid, adjacent to F14	No	-

16	Footing and foundation rubble	A concentration of poured concrete slab rubble, two 5 course cobble and concrete trapezoidal footings, and one concrete and cobble slab rubble in slightly raised dirt pile	No	-
17	Concrete and cobble slab	Square slab of rough poured concrete and cobble on a low mound of soil	No	-
18	Metal pipe with concrete lining	Welded metal pipe with concrete lining which is broken. Exposed part of pipe is cobble lined. Appears to go E/W and heads into N bluff of wash near aqueduct	No	13
19	Cobble retaining wall	Partially eroded loose stacked cobble wall	No	-
20	Bear Valley High Line Aqueduct	Irrigation canal constructed circa 1892	No	-
21	Concrete vault	Rectangular concrete vault with sheet metal lid	No	-
22	Detention basin and aerator	Large, low rectangular tank made from concrete poured in wood form. Two interior walls: one at west end is cinder block with drain in center, one at east end is curved and stepped down with drain at south end	Yes	4
23	Cobble-walled channel	A single thick cobble wall about 90 inches west of basin (F22) on ground surface with a concrete pipe in center	Yes	-
24	Concrete vault	A poured concrete vault with granitic boulders placed where metal pipe was located vertically	No	-
25	Rock wall lined channel	A segment of a long linear dirt channel with stacked rock lined walls on N and S sides. Appears to connect F22 to F26	No	-
26	Concrete foundation	Low rectangular concrete foundation with small rectangular vault at south end	No	-
27	Concrete vault	Small rectangular concrete vault just SE of F26. Filled with local cobbles	No	-
28	Concrete pipes	Two concrete pipe segments on slope between F27 and F29	No	-
29	Coagulation basin	Large wood frame poured concrete basin with circular shape. Located partially in Mill Creek. Appears filled with dirt	Yes	3
30	Demolished cobble, brick and, concrete structure	Possibly in situ. At least 4 brick manufacturers. Photos taken of stamps.	No	-
31	Weir box	Wood frame poured concrete with cinder block interior walls. Has places with threaded metal bolts on SE side. Has rim of concrete on top where a top may have been	Yes	2

32	Small rock lined channel	Single course boulder and cobbles lined up making narrow curving channel	No	-
33	Concrete retaining wall	Concrete wall with cobble base and a 24-inch metal pipe coming out to north	No	-

***P3a. Description (continued):**

The following description of the treatment plant is taken from the 1955 Sanitation Survey Report (Howard 1955), with edits made for clarity.

The Mill Creek Filtration Plant is situated on the Mill Creek Wash, where the surface slope facilitates the flow of water through the entire plant. The coagulation and sedimentation basin **(Feature 29)**, aeration basin **(Feature 22)**, and the treatment plant **(Feature 5)** are located below the flood level of the Mill Creek Wash and suffered considerable damage as a result of the 1938 Mill Creek flood. Water from the diversion flows through a 20-inch steel pipeline to a wood covered concrete weir box about 500 feet downstream from the Southern California Edison (SCE) Hydroelectric Plant No. 1. An automatic recording device is housed in the weir box **(Feature 31)**. Water from the weir flows through a concrete channel running into the coagulation and sedimentation basin **(Feature 29)**. The coagulation-sedimentation basin is of a spiral flow type, 70 feet in diameter, 10 feet deep at the outer edge and 14 feet deep at the center. The chlorinator and coagulant feeder are located in a corrugated metal head house adjacent to the basin. The chlorinator room has walls and a ceiling of plaster boards. The flocculated water flows through a 20-inch steel pipe for approximately 1,000 feet to the aeration basin **(Feature 22)** which is 25 feet long, three feet deep at the inlet end, and four feet deep at the outlet end. The basin is reinforced concrete construction and is uncovered. A curved baffle at the inlet end of the basin tends to direct the water into a circular motion as it flows through the basin. At the outlet end of the basin, water flows over a weir into an open collecting channel parallel with, and extending the entire length of, the deep end of the basin. From here water flows through an underground pipe to the flow regulation tank which is 35 feet in diameter and 25 feet deep **(Feature 8)**. It is reinforced concrete construction, uncovered, and located on the north bank of Mill Creek about 300 feet upstream from the filter plant. The inlet is near the top on the east side and the outlet is flush with the bottom south side of the tank. Filters are housed in a corrugated sheet metal building which has a concrete floor **(Feature 5)**. Clear Well No. 1 **(Feature 2)** is of reinforced concrete construction and is approximately 5 feet deep, 20 feet wide, and 26 feet long. The sides are from two to eight feet above ground level. Clear Well No. 2 (likely **Feature 4**) is of similar construction to clear Well No. 1 and is 11 feet by 20 feet in plan and approximately six feet deep. It receives through a weir (likely **Feature 1**) from Clear Well No. 1 (Howard 1955).

Today, only remnants of these features are visible on the landscape that was the Mill Creek Filtration Plant, and then only with the help of archival documents and maps is the proper layout recognized. The facility stretches approximately one mile along the northern bank of the Mill Creek wash.

***Resource Name or #** Mill Creek Filtration Plant

Recorded by: A. Hill and L. Moradi ***Date:** January 2023 ☒ Continuation ☐ Update

[REPLACE WITH Sketch map of Filter Plant (Feature 5).]

***B10. Significance (continued):**

Historic Context

The following historic context includes sections excerpted from the City of Redlands: Citywide Historic Context Statement by Architectural Resources Group (2017), with edits made for clarity.

The earliest development in the Redlands area was related to the establishment of surface water control features, starting with multiple ditches joining the existing 1819 Mill Creek Zanja to form a nascent water control network. The 1819 Mill Creek Zanja served as the primary source of drinking water and irrigation for the valley's early nineteenth century residents, concentrated in the area of the Asistencia/ Mission District. People living along the Zanja shared water rights and coordinated water diversion on an ad hoc basis (with levels of conflict dependent on the dryness of the season). The Mormon colonists that occupied the area in the 1850s constructed a second ditch to bring water from the Santa Ana River, though it proved unusable due to a water rights dispute. In 1867-1868, Berry Roberts moved from the north side of the river to the south side and brought his existing water rights with him, acquiring the Mormon Tenney Ditch and expanding and partially re-routing it. The Berry Roberts Ditch proved an important infrastructure feature for the early community of Lugonia, and growing numbers of new residents through the 1870s meant growing needs for water control systems.

In 1874, early Lugonians led by Colonel William Tolles began construction of the South Fork Ditch running from the Santa Ana River to Lugonia; they ran out of money after the first half mile. The ditch was completed in 1877, when Dr. J.D.B. Stillman provided funding in return for a designated diversion to his new vineyard. The Sunnyside Ditch joined the Berry Roberts Ditch near Orange Street. Later and more commonly known as the Sunnyside Ditch, the South Fork Ditch was originally a simple dirt structure, but in 1878 was lined with cemented boulders; this appears to have been the first improvement of a ditch in the area. Both the Berry Roberts and Sunnyside Ditches, as well as the Zanja, gained multiple offshoots to individual land holdings as more settlers arrived. This created a need for a more organized system of allocation, leading local users to consolidate into the Lugonia Water Company.

Local conventional wisdom held that the land south of the Zanja was unirrigable by gravity flow, but after a survey, Lugonia residents E.G. Judson and Frank E. Brown realized that prevailing slopes would in fact allow it. With visions of a vast agricultural region centered on their new townsite in mind, they immediately began to explore avenues for controlling and directing water from the Santa Ana River. In 1881, the partners bought 50 shares of the Sunnyside Ditch from Lugonia resident E.A. Ball. With assistance from San Bernardino banker Louis Jacobs, they established the Redlands Water Company and continued expansion of their nascent water control network by developing a spring in Morton Canyon, excavating tunnels into the Santa Ana River wash, and hiring Native American laborers to construct their Judson and Brown Ditch. This 5.5-mile long ditch, now listed in the NRHP, extended all the way from the river to Reservoir Canyon (now Redlands' Ford Park) at the eastern edge of town. Unlike the earlier ditches, it was the first meant exclusively for irrigation. It was rock lined in some places and cemented in others and was covered with wood to prevent evaporation.

Judson and Brown intensified their development of the Redlands water network in 1885, when construction of their Bear Valley Dam (designed by Brown) was completed. This mortared stone dam was sited high in the San Bernardino Mountains and created the massive Bear Valley Lake Reservoir by impounding Bear Creek specifically to irrigate Redlands. Water from the dam filled the Judson and Brown Ditch and all of its offshoots, as well as the pipeline network that soon followed. Redlands began to boom once its source of water was assured. In 1886, Judson and Brown's new Bear Valley Company entered an agreement with the Lugonia Water Company to take over the Sunnyside Ditch in exchange for delivery of water whenever the lake had a sufficient amount stored; it improved and expanded the Sunnyside Ditch into the Bear Valley Canal.

By 1890, Redlands had a robust water control system, with private ditches (like one labeled as "Hewitt's private ditch" on an 1890 city map) coexisting with the larger arteries of the Zanja, Sunnyside/South Fork, and Bear Valley networks, plus furrows, flumes, canals, and other water control-related features. The city also had at least two municipal reservoirs for drinking water: Redlands Reservoir in what became known as Reservoir Canyon (now Ford Park), and the Domestic

Water Company's reservoir at the Zanja near Dearborn Street, established around 1888.

In 1891, Redlands was forced to recognize its need for a more substantial runoff control system to augment its irrigation and drinking water system. A major flood caused by a summertime thunderstorm filled gullies to capacity, caused new gullies, caused the Zanja to overflow, and left a thick layer of mud behind. It damaged many streets, buildings, young orange groves, streetcar lines, and other features. The flood inspired voters to approve a bond issue to fund construction of an expansive new storm water control system. Frank E. Brown volunteered his survey time and joined with City Engineer E.A. Tuttle and civil engineer Walter C. Butler to design a stormwater system using ditches, culverts, and bridges at street crossings to control all future runoff. They proposed a fan-shaped system with named ditches extending from the area of Brookside Avenue, reaching as far as San Mateo Street to the west and Central Avenue to the east. Mortared stone was the primary construction material, with concrete for ancillary features and steel for some of the bridges. The ditches were mostly open and uncovered in their original state, but most have been at least partially closed over. They have served the city well for decades; some were extended and improved by the Works Progress Administration (WPA) during the Great Depression.

By the turn of the twentieth century, Redlands' water control network was well established and quite extensive. The city and the water company spearheaded additional improvements to the system, including the construction of a new concrete dam at Bear Valley in 1912 to replace the original 1885 dam; this led to the submersion of the old dam. Also, in 1912, Redlands's residents approved a bond issue which gave the city ownership of the drinking water supply; Redlands bought and took over the Domestic Water Company and bought other facilities from the Redlands Water Company, establishing a municipal system and expanding it with 40 miles of new pipe, 80 new fire hydrants in the commercial core, and 200 more throughout the city.

Redlands experienced a rapid population growth from 1920 to 1926, nearly doubling its population from 9,877 to 18,438 (*San Bernardino Daily Sun* February 21, 1926). This increase was likely due to its expanding citrus industry—by the late 1930s, Redlands was the center of the largest navel orange producing region in the world, surrounded by 15,000 acres of citrus groves—as well as the city's connectedness to the fast-growing city of Los Angeles and its new port at San Pedro via railway. Until 1936, Redlands was the eastern terminus of the "Big Red Car" system, an interurban connection between Los Angeles and San Bernardino completed by the Pacific Electric Railway (PE). By July 1936, PE abandoned its service to Redlands, while its parent company Southern Pacific, maintained its freight connection to the Sunkist packing plant until the 1970s.

The increase in population prompted city officials to add to its existing wells by collecting additional surface water from Mill Creek. A $525,000 bond was issued by Redlands in 1926 for the purpose of buying rights to 45 precent of Mill Creek's water in order to acquire a water supply at a high level to avoid pumping costs. Following the approval of voters, the City approached the owners of Mill Creek water below Redlands with two alternatives (Howard 1955). The City of Redlands took out its allotment of Mill Creek water, which formerly flowed through the Mill Creek Zanja, just below the discharge from the SCEs Powerhouse No. 1 and the fish hatchery, one-quarter of a mile above the Zanja intake. However, this water needed to be treated. An article in the *San Bernardino Daily Sun* (May 3, 1953) described the process through the subject facility:

> "This is done by pre-chlorination and the addition of aluminum sulphate or ferric chloride. The purpose of these two chemicals is to purify the water and to coagulate the sediment….[then the water is sent] through a sedimentation tank where most of the dirt and silt are dropped to the bottom of the tank. The water is then aerated for removal of the chlorine and then is run through the filters. The filtration plant consists of 10, 8-foot by 20-foot sand filters. The maximum rate of flow through the filters is two gallons per square foot per minute. After passing through the filters, the water is fed directly into the distribution system, [which consists of multiple reservoirs, booster pumps, and miles of pipe]."

This system gave the Redlands city water department a very economical and satisfactory auxiliary water supply. The Mill Creek surface water is much softer than the deep well-water from the pumped wells of the City of Redlands, and thus the mixture improved the total supply.

A flooding event in 1938 caused damages to the Mill Creek Filtration Plant (Howard 1955). On March 2, 1938, Southern California was subjected to flooding due to heavy rains, and San Bernardino County suffered the worst damage it had in 80 years. The Mill Creek Filtration Plant experienced significant damage to its filter plant: 180 feet of outlet pipe carried away by the flood (at a cost of $270 in materials to replace), taking the City's Bear Valley High Line water conveyance connection out of operation; a similar length of steel intake pipe was demolished (at a cost of $287 in materials to replace); the loss of 624 feet of concrete pipe (at a cost of $900 in materials to replace); as well as seven feet of sand buried in the coagulation tanks (*San Bernardino Daily Sun* March 8, 1938). A 40-man WPA work crew was enlisted to construct a temporary road to the filtration plant in order to make repairs to the facility (*San Bernardino Daily Sun* March 8, 1938).

Further alterations to the Mill Creek Filtration Plant occurred later that year in July 1938 when a new 30-inch pipeline was laid to avoid the Rainbow Angling Club fish hatchery upstream of the facility (*San Bernardino Daily Sun* July 21, 1938). The completion of the much-anticipated pipeline (buried 12 feet underground) bypassed the fish hatchery, thereby ensuring the municipal domestic water supply from Mill Creek was void of contamination from the hatchery. The pipeline "takes 600 inches of water from the tailrace of the Southern California Edison Co., powerhouse No. 1 and carries it to the city's coagulating plant. Thence it travels through the filtration plant and enters the municipal lines" (*San Bernardino Daily Sun* July 21, 1938).

<u>Evaluation</u>
The Mill Creek Filtration Plant is not eligible for inclusion in the NRHP or CRHR as it does not possess historic significance.

The Mill Creek Filtration Plant is associated with early twentieth century water infrastructure development in San Bernardino County. The treatment plant was established circa 1926 following the acquisition of 45 percent of the water rights to Mill Creek by the City of Redlands. Repairs were made to the facility following a 1938 flooding event along Mill Creek. The facility went out of use following the establishment of the Henry Tate Water Treatment Plant in 1968. While associated with the municipal development of water infrastructure, the Mill Creek Filtration Plant was not essential for the development of Redlands, as the City's population nearly doubled its size from 1920 to 1926 on well water and water from the Mill Creek Zanja before the facility was constructed. The construction of the plant was simply built in response to that population boom as water demand increased. Mill Creek water was supplemental to well water in supplying the City of Redlands. In addition, the filtration process was not unique but followed a similar design that was utilized in other locations during this era. Therefore, the Mill Creek Filtration Plant does not contribute to any significant importance in the community's history and is not eligible under NRHP Criterion A or CRHR Criterion 1.

The Mill Creek Filtration Plant lacks clear association with any individual important in history and is not significant under NRHP Criterion B or CRHR Criterion 2. Historic research did not identify any specific important individuals associated with the design, construction, or maintenance of the facility. As with water conveyance systems in California, water treatment facilities will rarely be found eligible for their association with significant people (JRP and Caltrans 2000). Important people that may be associated with the water treatment features would most likely have been involved with the design and construction of these features, such as a master engineer, which would be more appropriately evaluated under Criterion C/3. There may be instances, however, when a water treatment facility would be eligible under Criterion B/2, notably when the person's association with the facility is very strong and no properties more closely associated with that person remain or exemplify that person's work. This does not appear to be the case with the Mill Creek Filtration Plant.

The Mill Creek Filtration Plant lacks significance under NRHP Criterion C and CRHR Criterion 3 as it is not an important example of its type, period, or method of construction. The facility does not appear to have any unique or distinctive characteristics, but rather was constructed in a simple manner that was typical of its era. It is not the work of a master engineer or important sanitation design or construction company, nor does it represent any advancements in engineering design or construction.

Mill Creek Filtration Plant lacks significance under NRHP Criterion D and CRHR Criterion 4 as it is not a source (or likely source) of information important to the understanding of history. It does not appear to have any likelihood of yielding important information about historic construction materials or technologies. The facility was built at a time when the work force employed to construct the facility was likely local and not housed in a labor camp. Although, WPA labor was used during the 1938 flood repairs at Mill Creek Filtration Plant, newspaper accounts of that time suggest the laborers were camped in higher elevations where there was more need for more men to repair damaged infrastructure, so it is unlikely that there would be remnant deposits from labor camps at the facility. Any material culture left behind during the operation of the facility would have been minimal, and would not provide more information about the operation of the facility. The material cultural that was identified in the recordation of this resource, likewise, does not provide information about those that worked at the facility or how it operated. Anything to be learned about the Mill Creek Filtration Plant would be found in archival sources including as-builts, original design plans, and company documentation about the workers. Therefore, the Mill Creek Filtration Plant does not appear eligible under NRHP Criterion D or CRHR Criterion 4.

In conclusion, the Mill Creek Filtration Plant does not appear to be eligible for listing in the NRHP or the CRHR, as an individual resource or as a contributor to a larger resource, if it is ever determined such a resource may exist. Likewise, the Mill Creek Filtration Plant does not meet any of the City of Redlands Historic Resource Criteria (listed below):

A. It has significant character, interest, or value as part of the development, heritage or cultural characteristics of the city of Redlands, state of California, or the United States;

B. It is the site of a significant historic event;

C. It is strongly identified with a person or persons who significantly contributed to the culture, history or development of the city;

D. It is one of the few remaining examples in the city possessing distinguishing characteristics of an architectural type or specimen;

E. It is a notable work of an architect or master builder whose individual work has significantly influenced the development of the city;

F. It embodies elements of architectural design, detail, materials, or craftsmanship that represents a significant architectural innovation;

G. It has a unique location or singular physical characteristics representing an established and familiar visual feature of a neighborhood, community, or the city;

H. It has unique design or detailing;

I. It is a particularly good example of a period or style;

J. It contributes to the historical or scenic heritage or historical or scenic properties of the city (to include, but not be limited to, landscaping, light standards, trees, curbings, and signs);

K. It is located within a historic and scenic or urban conservation district, being a geographically definable area possessing a concentration of historic or scenic properties which contribute to each other and are unified aesthetically by plan or physical development.

***B12. References (continued):**

Architectural Resources Group, 2017. City of Redlands: Citywide Historic Context Statement.

Howard, J.B., 1955. Redlands Sanitary Survey; Water Supply Owned by the City of Relends Bureau of Sanitary Engineering. Sate Department of Public Health.

San Bernardino Daily Sun, February 21, 1926. “Redlands Has Good Streets: Paved Thoroughfares Only Is Rule; Water Supply is Home-owned.” Available: https://cdnc.ucr.edu/. Accessed: March 2023.

San Bernardino Daily Sun, March 8, 1938. “Redlands May Move Water Filter Plant From Mill Creek: Shifting City Filter Plant is Considered; Stopping Future Flood Menaces Needed, Says Clapp; Plans Left with Committee.” Available: https://cdnc.ucr.edu/. Accessed: March 2023.

San Bernardino Daily Sun, July 21, 1938. “Old Sore Spot is Healed for Future Years: Cry of Water Pollution Dies as Redlands Officials Dedicate Fishless Water Route.” Available: https://cdnc.ucr.edu/. Accessed: March 2023.

San Bernardino Daily Sun, May 3, 1953. “City’s 18 Wells, Mill Creek Surface Water Supply System.” Available: https://cdnc.ucr.edu/. Accessed: March 2023.

***Resource Name or #** Mill Creek Filtration Plant

Recorded by: A. Hill and L. Moradi ***Date:** January 2023 ☒ Continuation ☐ Update

P5a. Photographs (continued):

Photograph 2. Weir box (Feature 31), camera facing southwest (12/13/2022).

Photograph 3. Coagulation basin (Feature 29), camera facing east (12/13/2022).

Photograph 4. Detention basin and aerator (Feature 22), camera facing south (12/13/2022).

Photograph 5. Surge tank (Feature 8), camera facing west (12/8/2022).

Photograph 6. Filter plant (Feature 5), camera facing southeast (12/8/2022).

CONTINUATION SHEET

Primary # ______________
HRI # ______________
Trinomial ______________
NRHP Status Code 6Z

***Resource Name or #** Mill Creek Filtration Plant
Recorded by: A. Hill and L. Moradi ***Date:** January 2023 ☒ Continuation ☐ Update

Photograph 7. Filter plant (Feature 5), camera facing south (12/8/2022).

Photograph 8. Cinderblock-topped structure (Feature 4), camera facing west (12/8/2022).

Photograph 9. Clear Well No. 1 (Feature 2), camera facing north (12/8/2022).

Photograph 10. Weir box (Feature 1), camera facing north (12/8/2022).

Photograph 11. Concrete and cobble rectangular vault (Feature 14), camera facing northeast (12/13/2022).

Photograph 12. "1938" marking on Feature 14, camera facing west (12/13/2022).

Photograph 13. Metal pipeline with concrete lining (Feature 18), camera facing northeast (12/13/2022).