WATER SUPPLY OF THE CITY AND COUNTY OF HONOLULU

LEE

THE WATER SUPPLY OF THE CITY AND COUNTY OF HONOLULU

by

Bernard C. Lee

THE WATER SUPPLY OF THE CITY AND COUNTY OF HONOLULU

KALAKAUA INTERMEDIATE SCHOOL

by

Bernard C. Lee

B-Lee - May '43 - gift.

Foreword

As public servants, the members and employees of the Board of Water Supply are gratified when teachers, or any other citizens or future citizens, take an interest in the problems of Water Supply; sources, methods of development, improvement of quality, distribution, or uses. Mr. Lee has written a brief introduction to this comprehensive subject, which has been read and approved, and it is hoped that use of such a paper in the schools will lead to a growing interest on the part of students and teachers.

Frederick Ohrt
Manager and Chief Engineer
Board of Water Supply

Gift of Kalakaua Intermediate School 4/6/62

Acknowledgment

The writer wishes to express his appreciation to Mr. Frederick Ohrt, Manager and Chief Engineer, and to Dr. Chester K. Wentworth, Geological Engineer, of the Board of Water Supply for their help in the preparation of this paper. Their contribution makes possible the presentation of this information which is of interest to the teacher, the student, and the layman.

—Bernard C. Lee

Kalakaua Intermediate School
September 20, 1937

THE WATER SUPPLY OF THE CITY AND COUNTY OF HONOLULU

The Board of Water Supply: The water which we use is supplied by the Board of Water Supply. The duties of this Board are many and varied. It controls the sources of water supply to insure us water that is clean, wholesome, and free from disease-producing organisms. It maintains pumping stations and erects reservoirs to supply homes with water at an even pressure and to hold in reserve water for fire fighting purposes. Finally, with the stressing of conservation of water, the water department is continually seeking new sources of water supply to meet the increased needs of this growing city.

The Board of Water Supply was created by the Territorial Legislature in 1929. It consists of seven members, five of whom are appointed by the Mayor with the approval of the Board of Supervisors. The other two members, who are ex-officio, are the Superintendent of Public Works of the Territory of Hawaii and the Chief Engineer of the City and County of Honolulu. The members serve without pay, and the term of office of each is five years.

The affairs of the water department are administered by a manager who is appointed by the Board. The present manager is Mr. Frederick Ohrt, who is also Chief Engineer. Under Mr. Ohrt is a staff of workers, which is divided into four groups: (1) service and office force, (2) engineering department, (3) pumping station force, and (4) maintenance department.

Source of Water: Rainfall is the source of all our water. Water is brought by the North Pacific trade winds which sweep over the Koolau Range. As the moisture laden winds move over the mountains, the change of temperature from warm to cold causes the water vapors to condense and fall as rain. The well-forested mountain sides provide an excellent watershed. The rain water seeps into the

porous soil. By the force of gravity the water percolates deeper into the earth and rests in large natural underground storage basins located directly below this city.

Forests are necessary for a watershed. The cooling effect of trees on the surrounding air causes the moisture in the air to condense and to turn into rain drops. More important are the roots of trees and other vegetation which make the soil porous for the penetration of water. The roots also hold the soil together and prevent its washing away by torrential rains. Thus erosion, which is common in places denuded of forests, is avoided. The roots also reduce the flow of surface run-off water which runs into streams, rivers, and the ocean.

The watershed of Honolulu is a forest reserve that occupies 24 square miles of the higher parts of the Koolau Range. It extends from Kahauiki to Waialae-nui, and it is administered by the Board of Agriculture and Forestry. In this reserve the Board of Water Supply is continually devising ways and means of developing new water resources to meet the increasing demands of the ever growing population of this city.

Pumping Stations: From the large natural underground storage basins water is drawn and piped to consumers throughout the city. Deep wells are sunk into the ground to tap these water sources. Most of the water is drawn by the three main steam pumping stations - (1) Kalihi Pumping Station, (2) Beretania Pumping Station, and (3) Kaimuki Pumping Station.

These three main pumping stations derive their power from steam which is generated by large crude oil burners. The water mains or pipes of these stations are joined togehter. It is possible for water to be directed from one pumping station to another which needs a greater supply in the event of a fire or any other

emergency. Besides supplying water directly to consumers, these pumping stations also fill the reservoirs located on different levels of the hills in the various parts of the city.

Artesian Wells, Springs, and Tunnels: The water supplied to the city by the Board of Water Supply comes from two sources. Chief of these is the low level or artesian water, which is taken from three groups of artesian wells at the three chief pumping stations - Kalihi, Beretania, and Kaimuki - and from the two new underground pumping stations at Kalihi and Waialae. The other source is the high level water which is developed by a number of springs and tunnels in the various valleys. The artesian wells contribute 90 percent of the total output, while springs and tunnels supply only 10 percent. The three steam pumping stations pumped over 6,320,000,000 gallons of artesian water in 1936. The average draft is 17,300,000 gallons per day for all three stations.

The springs and tunnels supplied the city 2,100,000 gallons of water per day in 1936. The water from this source is not pumped into the mains, but it flows by gravity into the distribution system. Springs and tunnels are found in Kalihi, Nuuanu, Pauoa, Makiki, Manoa, and Palolo valleys.

Distribution Reservoirs: The Board of Water Supply maintains 25 reservoirs and tanks for the storage of artesian water pumped into them by the three steam pumping stations and the nine electric booster pumping stations. From these reservoirs and tanks water flows by gravity into the water pipes which extend to the homes. The erection of reservoirs at different levels of the hillsides is necessary to develop sufficient water pressure. This system eliminates too low pressure which causes water to flow out very slowly from the faucets or too high pressure which causes faucets and flush tanks to leak.

The reservoirs and tanks all store up water for the peak hours. At night, especially during the early morning hours, little water is used. However, the pumping stations continue to pump water, most of which fills these reservoirs. This makes for lower pumping costs and provides a reserve against emergencies, giving an uninterrupted service.

The reservoirs are commonly seen as landmarks on the slopes of the hills such as Diamond Head, Makiki Heights, Punchbowl, Pacific Heights, Wilhelmina Rise, etc.

The Booster Pumping Stations: Eerected on beautifully landscaped grounds, the electric booster pumping stations add to the efficiency of the water system. They make possible the availability of water supply and fire protection service for homes on the upper slopes of the hills. The booster pumps are called such because they literally "boost" or lift water from low to high level.

Three of the nine booster pumping stations include (1) the Pacific Heights Booster Pumping Station, (2) Kalihi-uka Booster Pumping Station, and (3) the Makiki Booster Pumping Station. These are each equipped with two pumps, with a total pumping capacity per station of 600 gallons per minute. The rate is equal to the flow of four fire streams.

Water Mains: The Board of Water Supply operates a network of water mains to furnish water to its consumers. On January 1, 1937 there were 286 miles of water mains. These extend from the pumping stations and reservoirs throughout the city, from sea level to the hillsides, and reach the meters of water users. These mains are either galvanized iron or cast iron pipes. The size of the galvanized iron mains varies from one inch to eight inches in diameter. The cast iron mains range from four inches to 24 inches in diameter.

Hourly Consumption and Peak Hours: The rate of water consumption varies throughout the day, with the peak hours occurring twice daily. The first peak begins in the morning at about 6 o'clock and reaches its greatest height between 7 and 8 o'clock. After the breakfast hours the rate gradually diminishes up to and beyond the noon hour. After 2 to 3 o'clock in the afternoon the rate again increases and advances to its second peak at 5 to 6 o'clock. After the supper hours the flow shows a continuous drop until it reaches its lowest point immediately after midnight.

The average amount of water used by each person in Honolulu in 1936 was 133 gallons per day.

Service Zones: The pumping stations furnish water to homes built on the different elevations of the city, some at or near sea level, and others located high on the hillsides. To maintain an almost even water pressure in the homes of any elevation, the water department has established three "service zones" - (1) Low Service Zone, (2) High Service Zone, and (3) Mountain Service Zone.

The Low Service Zone has an elevation range from sea level to 100 feet above sea level. The water for this zone is supplied by the main pumping stations and the reservoirs built on the hillsides 180 feet above sea level. All reservoirs for this zone are built on nearly the same level because they are connected with one another by pipes. When a reservoir in one part of the city is drained by excessive use of water for fire fighting or other purposes, it is quickly refilled by water coming from another reservoir in another part of the city. The reservoirs of this zone are supplied with water by the three main pumping stations.

The High Service Zone is immediately above the Low Service Zone. Its reservoirs are built at an elevation of 405 feet to serve homes located between the

100 and 300 foot level. They are also connected with one another by pipes, and they derive their water supply from the main pumping stations.

The Mountain Service Zone extends from 300 feet to the top of the hills, the highest level being 1035 feet. Reservoirs are constructed at different levels. High hills have more reservoirs than low hills, the number being determined by the water pressure. Water from these reservoirs is supplied by mountain springs and tunnels and by electric booster pumps from the High Service Zone reservoirs.

It is interesting to note that 70 per cent of Honolulu water users reside in the Low Service Zone, 20 per cent in the High Service Zone, and 10 per cent in the Mountain Service Zone.

Underground Water Development: The Board of Water Supply is constantly watchful of the future water needs. The ever-growing population is demanding more water. Within the last year the water department has constructed two new underground water development projects: (1) Kalihi Underground Pumping Station, and (2) Waialae Underground Pumping Station. The first is located on the north side of Kalihi Valley just above School Street. The second is located at 16th and Claudine Avenues. These stations are important new types of development which reach the underground water just above sea level instead of in deep artesian wells. The water comes from the Moanalua and Waialae artesian areas, respectively.

Filtration Plant and Surface Water: The local water supply does not come from surface water reservoirs, like those in Nuuanu Valley. Such surface water will never enter the water system, unless in an emergency such as a drought. For such an emergency the Board of Water Supply has already requested and has received permission to issue bonds for money to build a 10 million gallon filtration plant. The plant will be built only when there is need for it and only with the

permission of the governor of the Territory of Hawaii

Nuuanu Aerator: Water from springs and tunnels in Nuuanu Valley is piped into the new Nuuanu aerator. This aerator removes much of the carbon dioxide content of the water and improves its quality.

Water Meters: Water furnished to consumers is measured by meters. Since 1932 the city has been 100 percent metered and at the beginning of 1937 there were 19,572 "services" or meters.

Water Rates: Water is charged for on a sliding scale. First block, Domestic Rate - the first 25,000 gallons of water per month or any part thereof, is 18 cents per 1000 gallons. Second block, Intermediate Rate - in excess of 25,000 gallons and under 250,000 gallons per month, is 14 cents per 1000 gallons. Third block, Industrial Rate - in excess of 250,000 gallons per month, is 10 cents per 1000 gallons. The distribution of water users is as follows: 16,100 users in the first block pay an average monthly bill of $2.40; 3,600 users in the second block pay an average monthly bill of $11.00; and 250 users in the third block pay an average monthly bill of $75.00.

Shipping Water Rates: All shipping vessels are charged 50 cents per 1000 gallons of water. This rate applies to foreign, coastwise, government, inter-island, and fishing vessels.

Quality of Water: The local water supply is clean, wholesome, and free from disease-producing organisms. Water experts have reported that the quality is exceptional among tropical water supplies. The water contains very small amounts of dissolved mineral matter, largely sodium bicarbonate (baking soda). Local water is "soft" as contrasted with the "hard" water found in many other places of the world.

Fire Protection: The Board of Water Supply maintains a system of fire hydrants for public fire protection service. The fire hydrants are installed or replaced wherever and whenever necessary. They are regularly painted, inspected, and tested to insure perfect working order when needed. On January 1, 1937 there were 1,864 fire hydrants in this city.

The Board of Water Supply also provides water for automatic fire sprinkler systems in some large buildings of this city. In the sprinkler systems pipes are laid on or suspended from the ceilings. The sprinklers are cocked with lead which melts when heated by the fire and permits the discharge of water. Automatic fire sprinklers may be found in such buildings as the Advertiser Publishing Company, Princess Theatre, Hawaiian Pineapple Company, etc.

The water department makes no charge for water piped from fire hydrants and for automatic fire sprinklers. The cost of providing this public fire protection service amounts to approximately $150,000 annually.

Profile of Water Layers: If this city and its mountain watershed were a large cake cut into halves, a side view would show the types of water found at different levels. Fresh rain water that has seeped into the ground, mostly in the rainy mountainous area, trickles downward through the pervious rock for hundreds of feet to reach sea level. This high level water follows so many small and unknown paths that it can only be used as a water source where the water is perched or held up locally by tight layers of rock and forms springs or is reached in mountain tunnels. In the porous lava rocks, with their large cracks, lava tubes and other openings, the trickling water accumulates near sea level in a continuous body of underground water which slowly moves toward the ocean. Under the city of Honolulu this water is held under pressure by tight, clay-like rocks

that form the coastal plain. This is artesian water which, in the central part of the city, is under sufficient pressure to flow from the tops of the 600 foot deep artesian wells at the Beretania Pumping Station. Because the fresh water is lighter than the salt water of the ocean it is held up about 30 feet above sea level in the Beretania area and extends downward about 1200 feet below sea level.

The three pumping stations draw their water from the fresh artesian water layer. The artesian wells of the Kalihi Pumping Station are sunk to a depth of 412 feet below sea level; Beretania Pumping Station 579 feet; and the Kaimuki Pumping Station 247 feet.

Below the fresh artesian water layer is a "zone of diffusion" in which fresh and salty ocean water mix. Immediately below this zone is the salty ocean water layer. This layer arrangement exists as such because fresh water, being lighter than salt water, remains on the top.

Conserve Water: The people of Honolulu are continually reminded to "conserve water." Such a precaution is necessary because the artesian water supply is not inexhaustible and is replenished only as fast as rain falls on the mountains. If water is used in excess and wastefully, the height of the artesian water layer may soon be reduced, as happened so strikingly in 1926. Further pumping may cause salty ocean water to be drawn up.

All the fresh water available in Hawaii comes from rainfall; there is no other source. Because of the concentration of this water in the low level and artesian water body, this has been the main source of supply. The amount available on the average has been computed as 35 to 42 million gallons daily. In dry seasons the amount is less and in just such seasons there tends to be more water used. In 1926 the city came unpleasantly close to overdrawing the supply

and continuance of the dry weather would have been disastrous.

To go far outside of the Honolulu area for water will involve great expense and involve the difficult question of water rights. In order to obviate such action and to insure an adequate supply of water for the growing city, the Board of Water Supply has constantly emphasized both conservation and the search for new supplies. Conservation means elimination of waste in homes from regular fixtures, of loss through leaks, of waste from artesian wells that in the past have been allowed to flow continuously, elimination of underground losses from leaking well casings, and other unproductive losses. In its search for new supplies the Board of Water Supply seeks to locate water bodies which have not yet been tapped, new points of development of known water bodies more conveniently located to the points of use and points for development of high level water so as to reduce pumping costs. Even the search for new supplies can be regarded as a form of Conservation, since it all means efficient and prudent use of the fundamentally limited water from rainfall.

Bernard C. Lee
Kalakaua Intermediate School
Honolulu, Hawaii

THE WATER SUPPLY OF THE CITY AND COUNTY OF HONOLULU

KALAKAUA INTERMEDIATE SCHOOL

by

Bernard C. Lee