

SOLUTION OF THE HONOLULU WATER
PROBLEM

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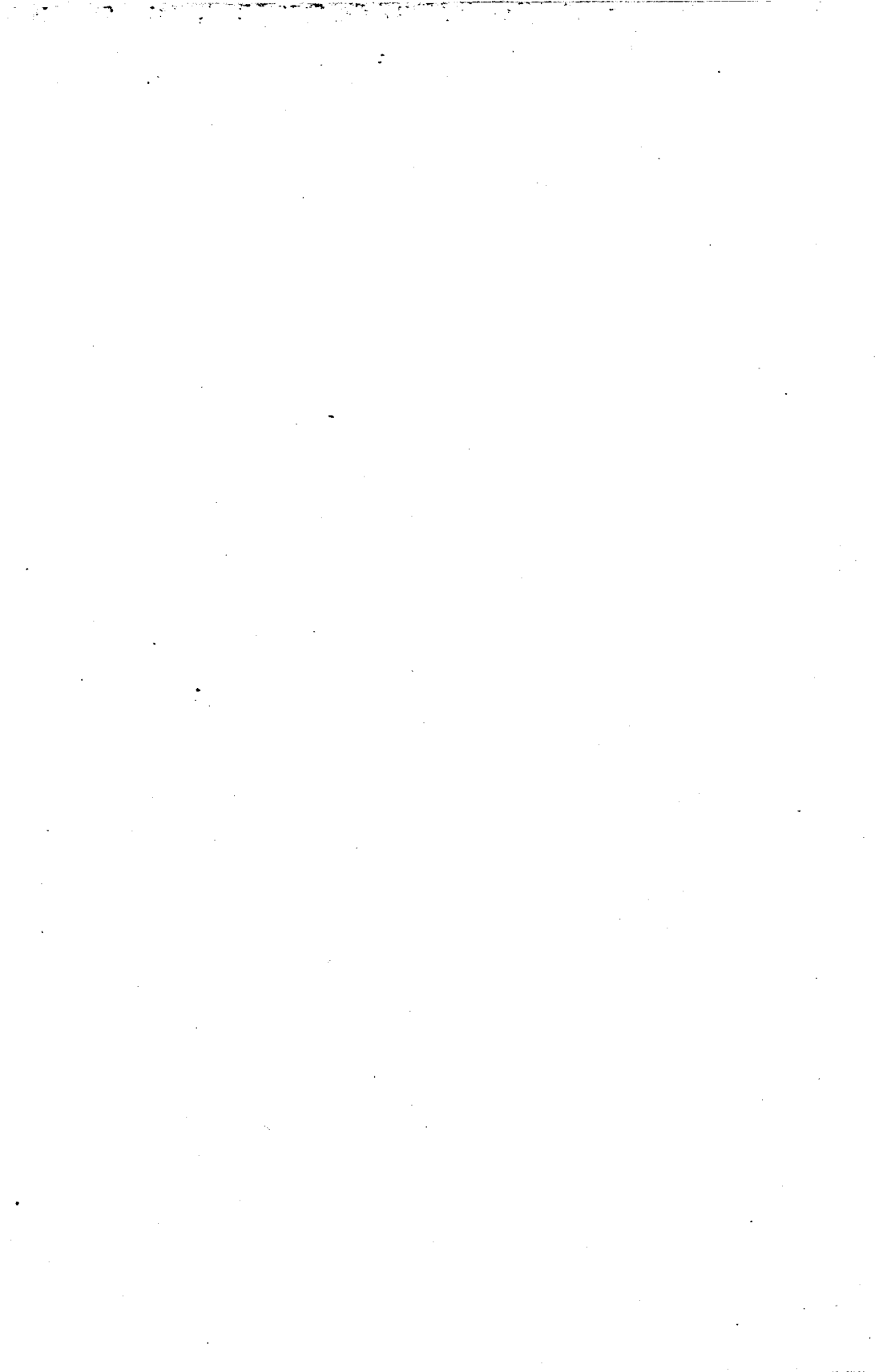
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IN RE
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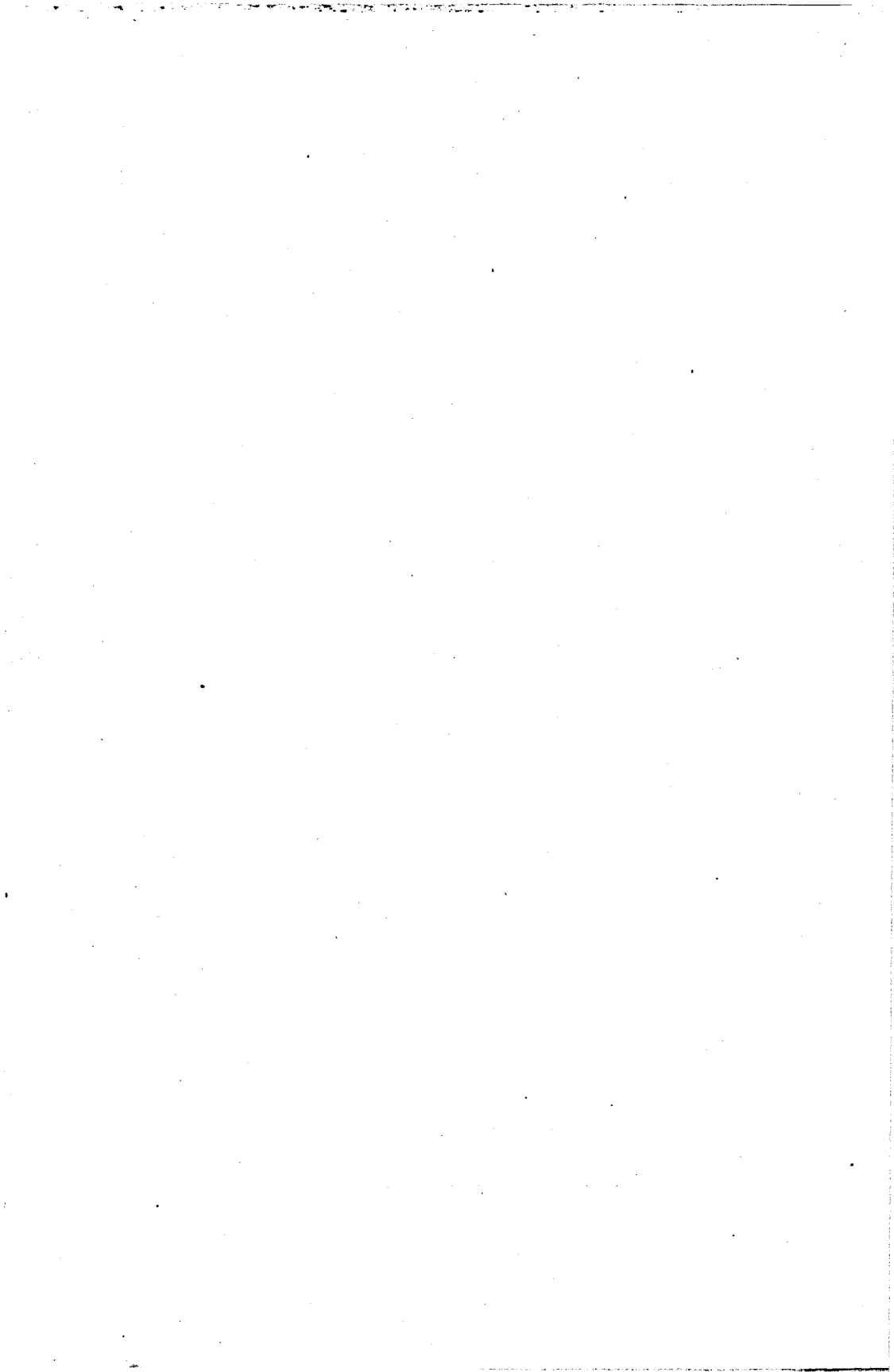
In re Suggestion that the United States
Geological Survey Should Co-operate
with the Territory of Hawaii and the
County of Honolulu in the Solution of
the Honolulu Water Problem ∴ ∴ ∴

The Nature of the Problem Defined, and
the Direct Interest of the Federal Govern-
ment Therein Specifically Set Forth ∴ ∴

By Lorrin A. ^{Andrews}Thurston, 1858-



Honolulu, T. H.
The Advertiser, Feb., 1917



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The Honolulu Water Problem

(Copy.)

WASHINGTON, D. C., Dec. 10, 1917.

MR. N. C. GROVER,
Chief Hydraulic Engineer,
United States Geological Survey,
Washington, D. C.

DEAR SIR:

IN RE SUGGESTION THAT THE UNITED STATES GEOLOGICAL SURVEY SHOULD COÖPERATE WITH THE TERRITORY OF HAWAII AND THE COUNTY OF HONOLULU IN THE SOLUTION OF THE HONOLULU WATER PROBLEM.

In a recent conversation upon the above subject, you suggested that it would be of value if the nature of the problem were more clearly defined, and the direct interest of the Federal Government therein specifically set forth.

In compliance with such suggestion, I submit the following, viz:

ANALYSIS OF THE HONOLULU WATER PROBLEM AND OF THE INTEREST OF THE FEDERAL GOVERNMENT THEREIN.

In order to simplify the consideration of the subject, it is subdivided into the following main heads:

- I. *Facts incident to the problem.*
- II. *What the problem is.*
- III. *Special interest of the Federal Government in the solution of the problem.*
- IV. *Coöperation of local governments.*

I.

FACTS INCIDENT TO THE PROBLEM.

(1) *Area and Topography of the Island of Oahu.* The Island of Oahu is forty-six miles long by twenty-five miles wide and contains an area of six hundred square miles. It is divided longitudinally by two ranges of mountains, the "Ko-o-lau" and the "Wai-a-nae."

The Koolau range extends the full length of the Island, in a southeast-northwesterly direction, and rises to an elevation of

from 2500 to 3000 feet. The crest of this range averages from six to ten miles from the sea.

The Waianae range lies parallel to the Koolau, is only half as long, and rises to an elevation of 4000 feet.

The Koolau range is and always will be the sole source of water supply of the City of Honolulu and of the major portion of the Island; but the Waianae range is a factor in the water supply of Schofield Barracks and a limited amount of surface irrigation; and a vital factor in the artesian system of the western portion of the Pearl Harbor Basin and the northerly or "Wai-alu-a" section of the Island.

(2) *Location of Honolulu.* The City of Honolulu is located on the southeast side of the Island of Oahu, along the base of the Koolau mountain, extending eight miles along the shore and back from the shore from four to five miles, into seven deep valleys, which bisect the mountain at right angles, and onto the intervening ridges.

(3) *Variation of Rainfall in Adjacent Localities.* A complicating factor in the Honolulu water problem is the extreme variation in rainfall. For example: Near the city waterfront the average annual rainfall is about 30-40 inches. At Lu-a-ka-ha, five miles inland, the rainfall averages 130-150, and is as high as 185 inches; while at E-wa, on the west side of Pearl Harbor, 12 miles from the city waterfront, the usual rainfall is around 10 to 12 inches. Estimates of water flow from, or requirements in, particular watersheds, require, therefore, intimate knowledge and study of local weather conditions.

(4) *Mountainous Character of the Country.* With the exception of a narrow strip along the shore, slightly above sea level, the country is so mountainous, or on so steep a grade, or so cut up with gulches, that there are but few storage reservoir sites, and those of but limited size.

Storm and surplus water can, therefore, be stored in only limited quantities and the unit cost in most instances is comparatively high.

(5) *Extreme Subdivision of Watershed.* The watershed is divided into small areas by the numerous valleys, requiring either expensive concentration tunnels from one valley to another or numerous separate plants.

600 acres in area and two miles in length by half a mile in width, is the approximate maximum size of the majority of watersheds from which water can be utilized.

(6) *Inaccessibility of Unutilized Water Supply.* All of the unutilized supply on the northerly side of the Island is separated

from the city by high mountains, which must be tunnelled to make the water available. The cheapest such project involves the expenditure of approximately one million dollars.

(7) *Low Level of Artesian System.* Approximately five-sixths of the present supply of the city system is derived from artesian wells, which are located on the level strip of land near the sea.

The artesian water rises to different elevations in different localities. The maximum height above sea level ever reached was 42 feet. The present maximum is 28 to 30 feet, depending upon rainfall. In some places the flowing level is barely above sea level.

(8) *High Elevation Pumping.* A large portion of the city is at a considerable elevation—up to 350 feet. The present growth of the city is toward the higher levels.

Use of artesian water, therefore, involves the cost of high-level pumping, with probable increase of elevation and consequent cost.

(9) *Excessive Call on Artesian Supply.* There is no law controlling the boring of artesian wells, or the use to which the water may be put.

There are over 500 artesian wells on the Island, each of an estimated average flowing capacity of one million gallons of water per day.

Much of this water is entirely wasted by the pipes having rusted through, allowing the water to flow off laterally, underground.

Much artesian water is also used for purposes of inadequate value—for example, for cooling purposes in connection with condensing engines.

This unrestricted boring of wells and use of the water has overtaxed the system, so that the flowing level is steadily falling.

Unless radical protective measures are taken at an early date, the artesian supply will be soon exhausted or, at least, become so inaccessible as to involve lowering the foundations of the pumps (this has already been done in some localities), with ultimate exhaustion, for practical purposes, a certainty.

(10) *Ownership and Use of Surface Water Rights and Existing Artesian Wells.*

(a) *Surface Water.* The city water system owns all of the surface water in one of the seven valleys lying back of Honolulu—Ma-ki-ki; and most of that available for city use in two others—Nu-u-a-nu and Pa-lo-lo. With minor exceptions, all of the remaining surface water on the Island is privately owned.

Most of the privately-owned normal flow water is subdivided

in small quantities among a large number of riparian proprietors, and is used for intensive irrigation of agricultural crops of high value, such as sugar cane, rice, taro, bananas and vegetables.

These facts render purchase or condemnation of this water complicated and expensive and require careful consideration of whether taking for public use will not unduly interfere with the local food supply, as well as commercial enterprises of national importance—the production of sugar, for example.

(b) *Artesian Waters.* The city system owns about a dozen artesian wells, furnishing the supply to four pumping plants. Several others have ceased to flow. All the other 500-odd artesian wells are privately owned, and furnish the great bulk of the water used to irrigate sugar cane, the production of which on the Island of Oahu averages over 130,000 tons of sugar of a present annual value of approximately \$16,000,000.

This water is vital to the sugar and rice industry, and the same considerations are involved as in the case of surface water, in connection with taking it for public use.

(11) *Ownership and Financing the City Water System.* The city water system was built by the local central government, but has been turned over to the Municipality, which is a combined City and County government, with jurisdiction over the entire Island.

There is an outstanding Territorial bonded debt of between one and two million dollars on the system, which has been assumed, and the interest is being paid by the city government.

The net income of the system is somewhat in excess of operating expense and interest; but entirely insufficient to make necessary additions.

Additions to the system will have to be made out of general taxes or by an issue of city bonds. No such issue has yet been made.

(12) *Source of Supply, Extent, Character and Present Consumption of Honolulu Water System.* The present city water supply consists of artesian wells and four pumping plants, located within the limits of the city proper; two storm-water storage reservoirs (Nuuanu reservoirs 3 and 4) and surface water from three of the seven valleys on the immediate watershed of the city.

The quantity of water used per day is approximately 16 million gallons, of which three to four millions is derived from surface water and the balance from artesian wells and high-power pumps.

There are 12 reservoirs. Two of these are for storage of storm water. The others are simply distributing reservoirs.

(13) *Power Derived from Surface Water.* One of the most important facts incident to the Honolulu Water System is that nearly all of the surface water rises at so high an elevation that before it finally enters the pipes for consumption it can be utilized for power. The surface water from Nu-u-a-nu Valley is now treated in this way, supplying nearly enough power to light all the city streets.

(14) *Present Population of the Island of Oahu and City of Honolulu.* The civilian population of the Territory of Hawaii, exclusive of the Army and Navy, is approximately 237,000, of which 107,000 live on the Island of Oahu, and approximately 70,000 in the City of Honolulu.

The Federal Army and Navy organizations in Hawaii are located exclusively on the Island of Oahu. They now number approximately 16,000 in the Army and from 500 to 1000 in the Navy.

The approximate population of the Island of Oahu is, then:

Civilians	107,000
Army	16,000
Navy	1,000

Total population of Oahu..... 124,000

(15) *Rate of Increase of Population.* The population is steadily increasing, as shown by the following census of the civilian inhabitants of the Island of Oahu, viz:

Increase of Population, Island of Oahu.

1890	31,194
1896	40,205
1900	58,504
1910	81,993
1917	107,000

The rate of increase of the city proper is similar, viz:

1890	22,907
1896	29,926
1900	39,300
1910	52,183
1917	70,000

The figures prior to 1917 are actual census count. For 1917 they are the official estimate.

The announced plan of the War Department is to increase the Army establishment in Hawaii to approximately 25,000 men; while the Navy Department, as soon as the Pearl Harbor Naval Station is completed, which will be within a year or so, will be increased to not less than 2500, with a much higher maximum as the fleet comes and goes.

From these figures it will be seen the civilian population of Oahu increased from 1896 to 1900, at the rate of 4574 per annum; from 1900 to 1910, at the rate of 2348 per annum; and from 1910 to 1917, at the rate of 3572 per annum; or at an average rate for the 21 years 1895-1917 of 3180 per annum.

If this rate of increase continues, and I know of no reason why it should not, in 1925, eight years hence, the population of Oahu will be:

Present civilian population	107,000	
Eight years' increase, at 3180 per annum.....	25,440	
Estimated civilian population of Oahu in 1925.....	132,440	
Estimated Federal military population of Oahu in 1925:		
Army	25,000	
Navy	2,500	27,500
		<hr/>
Total estimated population of Oahu in 1925		159,940

At the same rate of increase, in twenty (20) years, i. e., in 1937, the population of Oahu will be, in round numbers, 200,000; and in fifty (50) years, i. e., in 1967, it will be, in round numbers, 300,000.

(16) *Present Consumption of Water.*

(a) *City System.* The present consumption of water supplied by the City System is from 16,000,000 to 19,000,000 gallons per day. This is largely used for irrigation of lawns, gardens and trees. During a great part of the year most vegetation will not grow in the city without irrigation.

(b) *From Private Sources.* The consumption of water on the Island of Oahu, from sources other than the city system, is not less than 250,000,000 gallons per day, chiefly used for irrigating sugar cane, rice and taro. These three crops are *entirely* dependent on irrigation.

II.

WHAT THE PROBLEM IS.

Fundamentally, the Honolulu Water Problem is to ascertain how the water resources of the Island of Oahu, Territory of

Hawaii, can best and most economically be developed and conserved, so as to furnish the City of Honolulu with an adequate water supply without depriving agricultural and industrial enterprises of water necessary for irrigation and manufacture.

The problem involves many subordinate questions and complications, each requiring investigation, study and determination, before the main decision can be made.

The following is an analysis of these subordinate problems, an enumeration of the arguments for and against each source of water, and suggestions incident thereto, viz:

(1) *The Honolulu Water Problem Involves the Watershed of the Island of Oahu as a Whole.* The primary object sought is an adequate supply of pure water for the City of Honolulu; but a condition precedent to a complete solution of the problem is, that the water resources and requirements of the entire Island of Oahu, and of all interests located thereon, shall be simultaneously considered.

The reasons for this are:

First, that the total area of the Island is so small, and the present and prospective demands for water so great, that, unless every possible water source is utilized, there will not be water enough to go around.

Second, while the supply of water to the city is of primary importance, the necessity for irrigation in the production of the local food supply; for national supply of sugar, and local manufactures and utilities, cannot be ignored.

The balancing of these opposing demands will require, in a number of localities, exhaustive investigation and the exercise of great discretion.

(2) *Sources of Supply.* There are four separate and independent sources of supply to be considered. While the study and utilization of the water from different sources will necessarily overlap, still each source presents problems of its own and requires separate study and treatment.

The four sources referred to are as follows, viz:

- (a) Artesian Water.
- (b) Surface Streams.
- (c) Storage of Storm Waters.
- (d) Tunnels into the Mountains.

Factors and Problems Incident to Sources of Water. The following is a brief enumeration of the factors and problems incident to the several water sources, and suggestions incident thereto, viz:

1. ARTESIAN WATER. The largest and most easily available

source of water for the City of Honolulu, and the Island of Oahu as a whole, is artesian water. The following is an enumeration of advantages and difficulties incident to this source, and suggestions in connection therewith.

A. Advantages Incident to Use of Artesian Water.

(a) *It is close at hand*, available within the city limits at any point within a half mile to a mile of the sea, at depths of approximately 600 to 1000 feet;

(b) *It is pure*, requiring no filtering;

(c) *Its first cost is low*. A 12-inch well yielding one to two million gallons per day costs \$6000 to \$10,000; while the area of land required is so small as to reduce the cost of that item to a minimum. A "battery" of wells—6 to 10—can be located within a few feet of each other without materially diminishing the flow of each.

B. Difficulties and Disadvantages Incident to Use of Artesian Water Supply.

(a) *The artesian supply, as a whole, is overtaxed* and the flowing level steadily falling. This fact is established by a long series of observations and records, and is exhaustively treated in a report on artesian wells by a Territorial Commission, made this year.

(b) *The law regulating artesian wells is meager and inadequate*. It does not cover underground lateral flow when the pipe rusts off. The loss through this cause is heavy.

Legislation is necessary to control the boring of new wells; to stop waste; to limit the uses to which the water can be put; to secure the closing, reduction in flow or condemnation of enough existing private wells to bring the flow within the capacity of the available supply and prevent the total exhaustion of this source.

With the exception of limited legislation and some decisions in the West, principally in California, there are few if any precedents covering these conditions. It will be pioneer work.

(c) *The utilization of artesian water requires expensive pumping*. The maximum flowing well level is about 28 feet above sea level. Pumping is already required up to 350 feet, and the city is steadily extending up the foothills. Even the low levels must be supplied by pumps to secure pressure.

High-duty pumps are expensive and the cost of operation high. The average cost to the city of pumping water in Honolulu, prior to war prices for fuel, was over \$30 per million gallons.

It is suggested that if development of surface, storm or tunnel water sources are simultaneously undertaken, incidental power can be derived therefrom sufficient to operate all the pumps required in connection with artesian water.

This subject is referred to in more detail under the title "Surface Streams," hereinafter contained.

2. SURFACE STREAMS.

A. Advantages Incident to Use of Surface Streams.

(a) *The sources are at a high level, so that the water flows by gravity to the city system, reducing operation cost to a minimum.*

(b) *Much of this water can be utilized to produce power before it enters the city system for consumption.* Part of the water from one valley, Nu-u-a-nu, now supplies power which produces a large portion of the street lights of the city.

Reliable estimates show that other sources of surface, storm, and tunnel water can be made to furnish incidental power of a money value equal to that of the water itself, without in any way impairing the quality of the water for consumption.

(c) *A large part of the surface water is now used for flood irrigation within the city limits, tending to breed mosquitoes and increasing the danger from mosquito and water-borne diseases.*

Diverting this water to the city system would greatly diminish this menace.

This is an important point to consider, for cholera has already been once spread in Honolulu through the medium of surface streams; and, the yellow fever mosquito being already domiciled in Honolulu, there is danger of introduction of this disease from Central or South America, in connection with the development of commerce through the Panama Canal.

(d) *The aggregate amount of the surface water, on the immediate watershed of the city, is so large that it cannot be ignored as a source of city supply.* The rapid increase of population and the demands for agricultural irrigation will certainly require the economic use of all possible sources of water supply on the Island.

No complete record of available surface water has been compiled; but it is a conservative estimate that from the watersheds normally contributory to the city, not less than 12 to 15 million gallons per day can be made available, plus, say, 10 million gallons not now utilized, from the northerly slope of the Island, which can be brought through the mountain by tunnels.

Other surface waters are now being used for irrigation by private owners, to the estimated amount of not less than 50 million gallons per day.

B. Disadvantages Incident to Use of Surface Streams.

(a) *Much of this water will have to be filtered.* On the southerly watershed of the Ko-o-lau mountains most of the water is surface drainage, subject to defilement by the mud of freshets, from decaying vegetation and the trespass of man and beast.

Filtration plants are expensive to build and to operate, and even with care there remains an element of danger in the use of water once infected.

It is suggested that the unit cost of filtering will be no greater, and the danger of infection far less, than is the case in connection with the supply of many mainland cities which derive their water from rivers into which there has been emptied the sewage of cities located up-stream.

On the northerly watershed most of the surface water comes from springs located in the mountains, above inhabited territory. This water is of great purity and can be piped direct to the city without need of filtering.

(b) *The surface water of the Honolulu watershed is subdivided among many owners, rendering its acquirement complicated and insecure.*

The point is well taken, and, with few exceptions, no private purchases of water rights should be made.

It is suggested, however, that a safe, and the only safe way to secure good title to these waters, at a fair price, is to proceed by condemnation suit against all of the water and water-right owners of each valley, the water of which is desired; thus securing judicial determination of the identity of each owner, the amount of water owned by him and the sum which must be paid to secure the same. Upon these facts being ascertained, the government can purchase individually, from the several owners so ascertained, whatever water is then needed, to the amount of the appropriation then available.

.. (c) *The available surface water is intensively used for irrigation and its acquisition will therefore be expensive.*

The point is well taken, for what it is worth.

It is also a fact that all the water rights under consideration are an appurtenant to specific pieces of land, and are not owned independently of land.

It is suggested that, to minimize the cost of acquiring water rights, whenever practicable, condemnation proceedings be brought against the lands to which the water is appurtenant, including the water right, instead of against the water right alone; as experience has shown that separate valuations of land and

water produce an aggregate valuation much higher than the valuation of the land with an incident water right.

If the course suggested is followed, the government is in a position to utilize the water right and retain the land for any public purpose, or sell the land and devote the proceeds to reducing the cost of the project.

In fact, it is probable that the drying up of rice and taro patches, now flood irrigated, and the furnishing of water to such land for domestic use, through the city water system, would so increase the value of such land for building sites, as to enable its sale for that purpose for enough to pay the bulk of the cost of condemnation, beside enabling the opening up and improvement of large areas of undeveloped land.

3. STORAGE OF STORM WATERS.

A. Advantages of Storage of Storm Water.

(a) *Little use is now made of this water. It will therefore be an addition to the available supply, and minimize the damage caused by freshets.*

There are only two storm-water reservoirs on the Island owned by the city; also two privately owned. All of the storm water not conserved by these reservoirs, amounting to billions of gallons per annum, rushes in freshets, sometimes destructive, to the sea, injuring arable land and depositing mud in the harbor which involves frequent and expensive dredging.

(b) *The ownership of Storm Water is confined to a few.*

In marked distinction from the normal flow waters, which are owned by many persons, the storm waters of Oahu are owned by but few; the ownership in each valley being limited to from one to five or six. There is no difficulty in locating title, and, so far as this point is concerned, there will, in most cases, be no necessity for condemnation proceedings.

(c) *Being of no present economic value, the cost of acquiring storm water rights should be low.*

No storm water is now conserved on the Honolulu watershed, except by the city, and no private enterprise of the kind is likely.

Not only is no use made of the water, but the reservoir sites are, as a rule, at localities where the land values are nominal or low. Practically the sole cost of storm water will consist of the expense of construction of plant, and partial filtering, as other operating outlay will be nominal.

(d) *The sources are at a high elevation and power can be developed therefrom, before it enters consumption.*

All of the practicable storm-water storage reservoir sites are

at elevations ranging from 500 to 1000 feet above sea level. Even though some water is reserved for consumption at high levels, a considerable portion can be utilized below elevations of from 100 to 250 feet, giving the benefit of all power produced in the drop from the source to the point of final distribution.

B. Disadvantages Incident to Storage of Storm Water.

(a) The water will be muddy and require filtering.

When the rains are heavy, this will be temporarily so; but for considerable periods, after the first rush of water is over, filtering will probably be unnecessary.

It is generally acknowledged, however, that surface waters not piped direct from springs to the city system, should be filtered most of the time. Consequently, filters will be required in any event. The necessary filtering of storm water can therefore be done through the plant provided for surface water, or additional units thereof.

Even with the added cost of filtering, storm water will probably be much cheaper than pumped water, irrespective of the value of the power incidentally obtained therefrom.

(b) The available storage sites are few and inferior, and the unit cost high.

This is the only serious obstacle to storm-water storage.

The valleys, in which the reservoirs must be placed, are short and grades, as a rule, steep.

The recent report of the City Water Commission of Honolulu specifies several sites, however, which can be economically developed, and others will doubtless be found.

It is not suggested, moreover, that all possible storage be undertaken at present.

It will be one of the chief duties of the proposed investigating body, to ascertain the relative economy and value of the several sources of available water, and of the several localities under each source which should first be undertaken. It may be that comparison of the respective costs and economic results will indicate that other sources should first be utilized; and it is certain that some storm water projects will take precedence of others; while some may be found to be economically impracticable except as a last resort.

In any event, the general necessity of utilizing all possible sources of water, and the specific advantages of making use of storm water, justify the fullest investigation and consideration of this source.

4. TUNNELS INTO THE MOUNTAINS.

A few words of explanation are necessary to elucidate this unusual source of water.

By reason of the peculiar geological formation of the Koolau Mountains, subterranean water in large quantities is impounded between nearly perpendicular dikes of rock impervious to water, which extend longitudinally and parallel to each other, along the axis of the mountain. This water can be made available by lateral tunnelling at elevations at least as high as 700 feet. One such tunnel, known as "Wai-a-ho-le" tunnel, some 12 miles from the city, constructed by a private company, yielded as high as 35 million gallons per day for several months, and now yields continuously approximately seven million gallons per day.

This peculiar formation appears to continue throughout a considerable portion of the length of the Island, and there is good reason to believe that tunnels at the heads of other valleys back of the city will tap these underground reservoirs and secure large amounts of water.

The advisability of such tunnelling is discussed, as follows, viz:

A. Advantages Incident to Tunnelling for Water.

- (a) *The water is pure, requiring no filtration.*
- (b) *The source is at a high level, and the water will flow to the city by gravity, obviating pumping expense.*
- (c) *No visible use is now made of this water, consequently the cost of acquiring the right to utilize the same should be low.*
- (d) *The source is at a high level, making it available for incidental power production.*
- (e) *This is a new source of water, adding to the available supply.*

The above points (c) and (e) are disputed. See discussion below, under points B. (b) and

B. Disadvantages and Obstacles Incident to Tunnelling for Water.

- (a) *Tunnelling is expensive. The presence of water at any given point is uncertain and expenditures may be a total loss.*

It is admitted that no mining venture is sure of success; but there are so many evidences, plainly visible, that the conditions demonstrated to exist at Waiahole continue for some miles in a southerly direction, that the risk of failure does not appear great.

It will be one of the most important duties of the investigating commission to make a geological and water survey and study of the locality in question, and decide whether tunnelling is advisable, and if so, at what points.

(b) *The water which will be tapped by these tunnels is the source of the artesian supply. Diverting it at the source will cause the artesian wells to fail.*

It is suggested that there is no certainty that this water is the source of the artesian supply, although there is strong evidence that it may be connected therewith.

Admitting, however, for the purposes of the argument, that this source is connected in a general way, as claimed, it is submitted that it does not follow that diversion in the mountains will dry up the Honolulu wells located along the coast.

For example:

First, there are many parallel dikes, each confining a separate body of water. This fact was demonstrated at Waiahole, where, upon the penetration of each successive dike, the water gushed forth under pressure as high as 60 pounds to the square inch. One or more of these bodies of water may be connected with the artesian system and the others not.

Second, the tunnels will be miles away from the wells, with no probable direct connection. At Waiahole the tunnel has affected a spring directly below and a few hundred feet away; but springs a few hundred yards distant, on the same general level, are not affected at all.

Third, while the artesian system is divided into a few fairly well-defined basins, within those basins water permeates the entire substratum, in all directions. The proposed tunnels will be located only at the heads of certain of the valleys which bisect the mountain; probably several miles apart and from 6 to 20 miles distant from the wells.

The probability is remote that such tapping would have any tangible effect on wells at that distance.

Fourth, water, probably from this source, is now escaping through numerous springs approximately at, and even below, sea level, where it is wasted. Other large amounts escape on the northerly side of the Island, where the great bulk of it is wasted. To intercept this *wasted water* by tunnelling will not interfere with the artesian wells.

Moreover, it is suggested that one test tunnel would demonstrate whether it affected the wells. The result would then be considered in connection with the decision as to whether additional tunnels should be constructed.

Finally, if the direct connection between the water in question and certain artesian wells be established, and the latter be dried up or diminished in consequence of the tunnel, it is submitted that whether the water should be utilized through the medium of a tunnel or a well is purely an economic one, calling for a compar-

ison of relative costs and advantages of utilizing the water by one method or the other.

On the one hand, the tunnel is certain of getting the water; it will flow by gravity to the city system, at nominal expense; it will produce power before entering consumption.

On the other hand, the water may not flow to the well. If it does, the water will have to be pumped from the well to the city system, thereby consuming power at high cost instead of producing it at a good margin of profit.

III.

SPECIAL INTEREST OF THE FEDERAL GOVERNMENT IN THE SOLUTION OF THE PROBLEM.

The Federal Government, beside its general interest in the development of American resources throughout the country, is specifically and specially interested in the solution of the Honolulu Water Problem for the following three reasons, viz:

(1) *Value of Hawaii as a Strategic Military Post.* The primary value of the Hawaiian Islands to the United States Government is due to its strategic position from a military standpoint. This appeared throughout the Congressional debates and Presidential messages incident to the annexation of Hawaii. It was the basic reason for annexation.

It is elementary that for use as a Military Station, an ample supply of water is essential.

(2) *Value of the Island of Oahu as a Sugar Producer.*

Irrespective of the local or commercial importance of the industry, present war conditions have demonstrated the national value of a domestic sugar supply.

The Island of Oahu is one of the largest producers of sugar per acre of any in the world. It annually produces approximately 130,000 tons, of the approximate value of \$16,000,000.

This sugar production is absolutely dependent upon irrigation, the water being chiefly derived from artesian water and high-duty pumps. An increased water supply can considerably increase the present sugar output.

(3) *Honolulu the Nerve Center of Hawaii.*

From a military standpoint, the Island of Oahu is the controlling military factor of Hawaii, and Honolulu is the nerve center of the Island and the group.

The Army and Navy establishments are exclusively located on the Island of Oahu, and all of the Federal Civil Departments are centered there.

(4) *Schedule of Federal Interests in Hawaii Dependent on Honolulu Water Supply.* The following schedule of Federal interests—Military, Naval and Civil, which are directly dependent upon the Honolulu water supply—all but three of them upon the present inadequate city plant—demonstrates the vital interest of the United States Government in a proper solution of the Honolulu Water Problem.

(a) *Schofield Barracks*, located twenty-two miles from the city. It has a water supply independent of the present city system; but this water can be diverted to Pearl Harbor and Honolulu, and its utilization to the best effect is an essential part of the problem under consideration.

(b) *Pearl Harbor Naval Station*, seven miles from Honolulu, is not supplied by the city system; but its source of supply is artesian wells in the City of Honolulu from which the water is pumped. There is no surface water at the Station, and the artesian water at that point is too salt for use.

(c) *Fort Kamehameha*, at the entrance to Pearl Harbor. The conditions and source of water supply are the same as at Pearl Harbor Naval Station.

The following, all located within the city limits, derive their water from the city system, viz:

- (d) *Fort Shafter.*
- (e) *Fort Armstrong*, at the entrance to Honolulu Harbor.
- (f) *Fort De Russy*, at Waikiki Beach.
- (g) *Fort Ruger*, back of Diamond Head.
- (h) *The Batteries and Fortifications of Diamond Head Crater.*
- (i) *The Fortifications on Black Point*, beyond Diamond Head.
- (j) *The Naval Station and Docks at Honolulu Harbor.*
- (k) *The Quartermaster's Department and Warehouses at Honolulu.*
- (l) *Army Headquarters at Honolulu.*
- (m) *The Federal Customs House and Bonded Warehouses.*
- (n) *The Federal Quarantine Station.*
- (o) *The Federal Immigration Station.*
- (p) *The Federal Post Office, Courts, District Attorney's and Internal Revenue Offices.*
- (q) *The Army Base Hospital.*

IV.

COÖPERATION OF LOCAL GOVERNMENTS.

I understand that, other things being equal, the policy of the Geological Survey Department is to coöperate with those local

governments and organizations which show a disposition to help themselves.

The self-helpful disposition of the Hawaiian community is preëminent, as evidenced by the following facts, viz:

(1) *The Territory and the City of Honolulu* have already expended, in the development of the Honolulu Water System, in the neighborhood of \$2,000,000.

(2) *The Territorial Government* at the 1915 Session of the Legislature provided for a Commission to investigate and report upon the status of the artesian water system of Honolulu. Such commission was duly appointed, with Mr. G. K. Larrison of the United States Geological Survey as chairman. This Commission has made a comprehensive report, which is in print.

(3) *The Government of the City and County of Honolulu*, in 1916, appointed a Commission to investigate and report upon the status of the Honolulu Water Supply, with recommendations for developing, improving and enlarging the same.

This Commission has compiled all available reports, statistics, articles, maps and other information relating to the subject, whether in print or manuscript. These have been bound, indexed and deposited in the Government Archives Building, in Honolulu.

This Commission also made field surveys and estimates of quantities of water available and cost of concentrating and storing storm waters; of tunnelling through the Koolau Mountains to secure surface water from the northerly slope, and, incidentally, water from the tunnel; and to a considerable extent investigated the amount of available surface water on the Honolulu watershed and methods of securing and utilizing the same.

The Commission also investigated the necessity for filtering surface water; location for filter plant and estimates of cost of same.

The report of this Commission, including maps, plans and photographs, has been printed.

(4) *The Honolulu Chamber of Commerce*, after a meeting to consider the subject, has appointed a Special Committee to forward the project of securing an expert study of the Honolulu Water Problem, with a view to securing the coöperation, in so doing, of the Federal, Territorial and County Governments. This Committee is now in active existence.

Financial Status of Project.

I am unable to state whether the Territorial or County Governments have available funds to devote to the project; but know that they are favorably inclined thereto.

Suggested Procedure.

I suggest that if your Department will formulate a proposition suggesting lines of procedure and what your Department is willing to do; and what, in consideration thereof, you desire the local governments to do, it will receive prompt consideration at Honolulu.

I think it probable that communicating through the Honolulu Chamber of Commerce Committee, at least in the preliminary stages, will secure the promptest action.

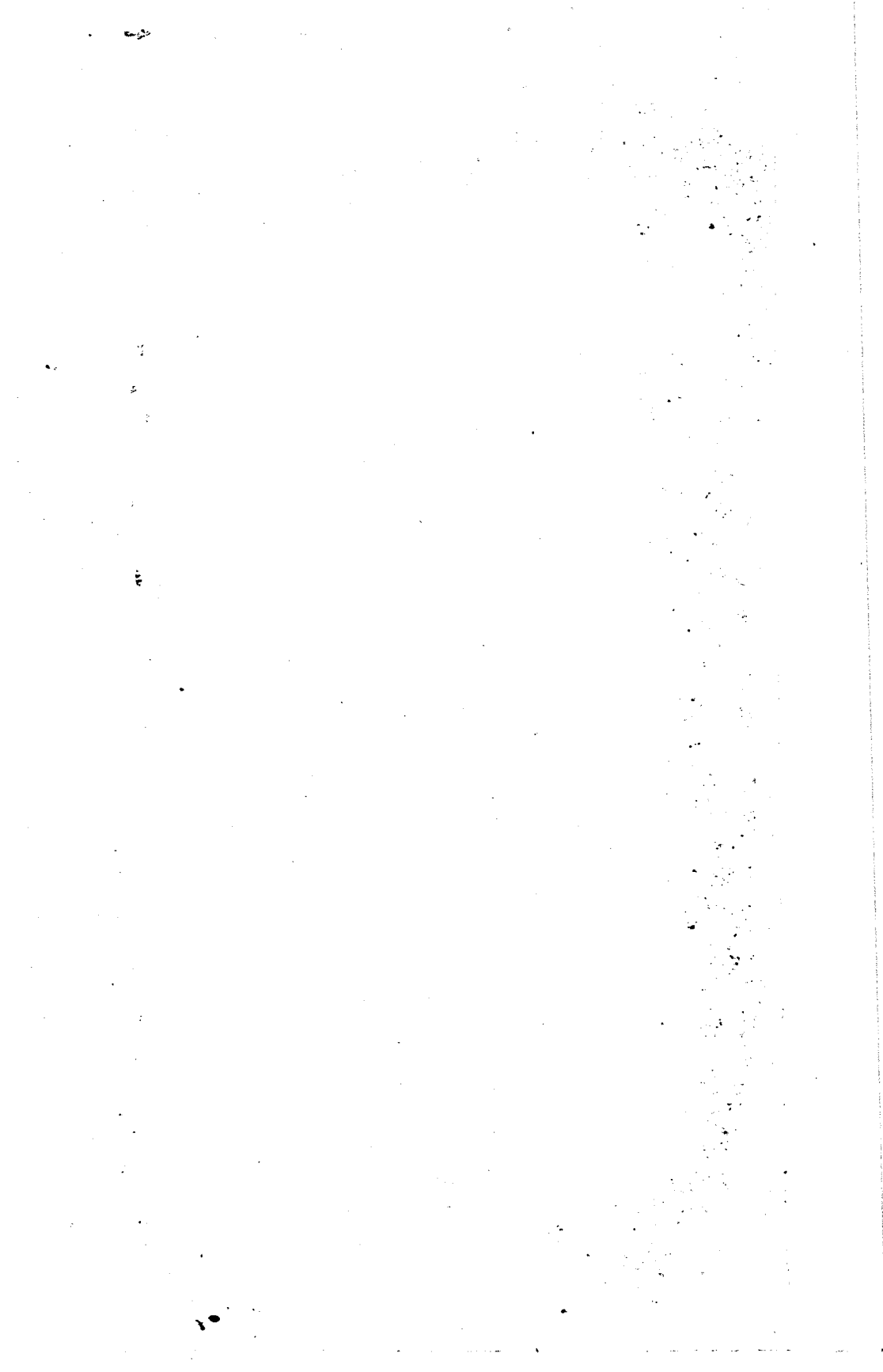
I would say that I have no official, financial or professional interest or connection with the subject matter, other than as a citizen of Honolulu, and am seeking none. The information which I have upon the subject is due to a lengthy residence at the Islands and the fact that in the days of the Monarchy I was connected with the Water Department of Honolulu, and was also a member of the County Commission which recently reported.

I would say that there is an epidemic of typhoid fever now prevailing at Schofield Barracks, fortunately with few fatalities, directly traceable to the drinking water. Some years ago the same disease, from the same cause, ran its course in the City of Honolulu, causing many deaths.

I will gladly render any assistance in my power to forward this project, which I consider a most vital one to all concerned.

Respectfully submitted,

LORRIN A. THURSTON.



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