

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC HEALTH
BUREAU OF SANITARY ENGINEERING

IN THE MATTER OF THE APPLICATION OF THE
CITY OF LOS ANGELES FOR PERMIT TO CONTINUE
TO FURNISH AND SUPPLY WATER FROM OWENS
RIVER.

Date of Application:

- - - - -

ORDER GRANTING PERMIT

- - - - -

Bureau of Sanitary Engineering
By Ralph Hilscher, Southern Division Engineer
October 15, 1918

[Recreated from barely legible copy]

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May 7th, 1919

Hon. F. T. Woodman, Mayor, and
Members of the City Council,
Los Angeles, California

Gentlemen:

Please be advised that at the regular meeting of the State Board of Health, held on May 3rd, a resolution was regularly and duly adopted, copy of which is enclosed herewith, granting to the City of Los Angeles a permit to continue to furnish and supply to its citizens and others, through its aqueduct system, water from Owens River, its tributaries and other sources.

Permit is being forwarded to you under separate cover.

Very truly yours,

W. H. Kellogg, M.D.,

Secretary.

#36

c/CGG

RE

W.B. Mathews, Attorney,
Wm. Mulholland, Chief Engineer.

WHEREAS, the California State Board of Health has made a thorough investigation of the existing works, system, plant, water supply and all other material circumstances and conditions of the Owens River Water Supply of the City of Los Angeles, County of Los Angeles, State of California, commonly called the Los Angeles Aqueduct, and

WHEREAS, from said investigation the State Board of Health has determined and does now determine as a fact that the water being furnished and supplied by said City of Los Angeles to its citizens and others from the Owens River, its tributaries, and other sources, through said Los Angeles Aqueduct system, is pure, wholesome and potable and does not endanger the lives or health of human beings, and,

WHEREAS, the Director of the Bureau of Sanitary Engineering has heretofore filed with said Board his recommendation in writing that a permit be granted to said City,

BE IT RESOLVED that a permit be granted to said City of Los Angeles to continue to furnish and supply to its citizens and others, through its said aqueduct system, water from Owens River, its tributaries and other sources.

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Report No. 38

to

California State Board of Health

on the

QUESTION OF GRANTING A PERMIT TO THE
CITY OF LOS ANGELES TO SUPPLY WATER
FROM OWENS RIVER.

by

Ralph Hilscher, Southern Division Engineer.

15th October, 1918.

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As a basis for a report by this Bureau on the sanitary quality of Owens River water and on the possibility of the State Board of Health granting to the City of Los Angeles a permit to continue supplying that water inspections and water examinations, covering a period of a year, have been carried on. A trip was made to Owens River Valley in September 1917 at which time inspections were made of Haiwee reservoir and of the river at numerous points from the intake to the headwater. On the same trip Fairmont reservoir was visited. On several occasions in recent months inspections have been made of the San Fernando and Franklin Canyon reservoirs. Chatsworth reservoir was visited on August 26, 1918, and Dry Canyon reservoir on August 29. Thirty-six samples, collected from various points, have been examined in the Bureau laboratories.

GENERAL DESCRIPTION OF SYSTEM.

Accompanying this report is a map which shows the general

location of the main features of this system. By reference to this map and to the following rough outline, a fairly comprehensive idea may be had concerning the origin and mode of delivery of this water.

1. Intake works on Owens River, about 200 miles north of Los Angeles and about 45 miles up stream from the river's outlet into Owens Lake. The drainage area tributary to the river at this point is estimated at 2740 square miles. By far the greatest portion of water reaching this stream flows down from the eastern slopes of the Sierra Nevada mountains and enters the river on the west side. Certain tributaries gather water from large springs. Many of the mountain peaks to the west supply water from melting snow throughout the summer. The eastern side of the watershed consists mainly of arid and barren hills.

2. A line of open aqueduct about 61 miles in length, extending from the intake to the north end of Haiwee reservoir. The northerly portion, comprising about 24 miles, is unlined ditch and the remainder is lined with concrete. This entire stretch of aqueduct is enclosed by a substantial barbed wire fence, as are also all bridge crossings.

3. Haiwee Reservoir with a length of about 7.25 miles, a water surface area of nearly 3.3 square miles and a maximum capacity of approximately 21 billion gallons. This reservoir was formed by building two dams, one at the north and 28 ft. high to high water level, and one at the south end 64 ft. high. It consists virtually of a string of three elongated basins connected by narrow straits. Its natural watershed is small and arid and practically rainless. Almost no water enters the reservoir except from the aqueduct at the north end, and water is withdrawn only at the south end. The rates of inflow and outflow are both under control, comparatively uniform and too low to have any general disturbing effect on the reservoir. The shape of the reservoir, the manner of flow and the

almost total absence of watershed runoff give this basin the maximum of value as an agent for purifying the water by storage.

4. About 135 miles of aqueduct from the south end of Haiwee reservoir to Fairmont reservoir, situated at the north end of Los Angeles county. The first two miles of this consists of open concrete-lined ditch. The remainder consists of concrete-lined and covered aqueduct, concrete-lined tunnels and steel pipe.

5. Fairmont reservoir with a capacity of approximately 2 million gallons and a distance of 0.4 mile from inlet to outlet. Its watershed is small and unoccupied and has been fenced to exclude stock.

6. About 17.6 miles of covered concrete aqueduct, concrete tunnels and steel pipe extending from Fairmont reservoir to Dry Canyon reservoir.

7. Dry Canyon reservoir with a capacity of 430 million gallons and a distance of 0.7 mile from inlet to outlet. This reservoir is at present being fenced to exclude stock. The watershed is small and unoccupied except for a forest ranger's cabin near the upper end of the watershed.

8. About 11.5 miles of covered aqueduct, tunnels and steel pipes from Dry Canyon reservoir to the Cascades at the north end of San Fernando Valley, and then about 1.6 miles of open concrete-lined canal to San Fernando reservoir No. 2. The open canal is tightly fenced with barbed wire, as are also all bridge crossings.

9. San Fernando reservoir No. 2 has a capacity of 7.5 billion gallons and was created by a dam built in the foothills at the north end of San Fernando Valley. The watershed area is 15 square miles, consisting largely of rocky, unoccupied mountain sides. Possibly one third of the watershed is valley land on which are three or four ranch houses and one public highway. Practically all of this valley land is owned by the city

and in the near future much of it will be flooded, as it is planned to build another dam above the present reservoir and thus create San Fernando Reservoir No. 1 with a capacity of about 4.9 billion gallons.

10. Steel pipe line across San Fernando valley and concrete tunnel through the Santa Monica mountains, a total distance of about 12.8 miles from San Fernando Reservoir No. 2 to Upper Franklin Canyon Reservoir.

11. Upper Franklin Reservoir with a capacity of 42 million gallons and a length of 0.25 mile from inlet to outlet. Lower Franklin reservoir is a mile farther down the canyon with a length of 0.63 mile and a capacity of 360 million gallons. Water from the upper reservoir is carried down to the lower reservoir in a steel pipe line, which continues on the bottom of the lower reservoir nearly to the dam at the lower end with a number of outlets for admission of water to this lower reservoir. This inlet arrangement at the lower reservoir was provided to keep the water in motion, reduce algae growths and prevent stagnation which would tend to reduce dissolved oxygen in the water. Franklin Canyon and adjoining hillsides are heavily wooded. A public road leads up the canyon to beyond the upper reservoir. There are two ranch houses in the canyon above the lower reservoir, one of which is above the upper reservoir. On the dam of each reservoir is a caretaker's home.

12. Los Angeles city proper is supplied with Owens River water from Lower Franklin reservoir. The San Fernando valley is supplied with irrigation and domestic water through a pipe distribution system, partly from San Fernando reservoir No. 2 and partly from Chatsworth reservoir. The latter, situated at the west end of the valley, is supplied through a pipe line from the aqueduct just above the inlet to San Fernando reservoir. Chatsworth reservoir is now only partially completed. It is being created by construction of four dams and will flood about 840 acres. Its capacity

will be about 8 billion gallons. The watershed consists of rocky, barren mountain sides and a very small area of valley land. This valley land is practically all owned by the city.

SANITARY ASPECTS OF SUPPLY AT SOURCE.

It is the consensus of opinion among sanitarians that human water-borne diseases have their origin only in human beings. In other words, the lower animals are not susceptible to the human water-borne diseases such, for instance, as Typhoid Fever, Dysentery, and Asiatic Cholera. The intestinal discharges of persons afflicted with water-borne diseases contain the germs of their particular diseases and the Hygienic protection of a water supply involves solely the prevention of access to the water of human fecal matter. From an aesthetic standpoint it is, of course, also desirable to exclude fecal matter of lower animals, but this is not always feasible, nor from a health standpoint is it necessary. This is the practical conclusion supported by the history of all disease cases known to have resulted from water infection. Theory, in a manner, supports the proposition that certain diseases typical of lower animals may be transmitted to humans through the medium of a water supply. A common case in point is Anthrax, a disease most commonly found in cattle. But, so far as known, there has never been a single well-authenticated case of water-borne human anthrax. This point is made here for the reason that certain persons opposed to the Los Angeles aqueduct project have contended that the health of the water users was endangered by anthrax-infected cattle in Owens Valley. Even though anthrax be admitted to be a water-borne disease, the same influence of long storage in reservoirs, which protects the water users against possible human contamination in Owens Valley, would protect them also against cattle contamination.

The watershed of Owens River above the intake, with an area of about 2740 square miles, has residing on it approximately 4000 people, an average of

less than 1.5 per sq. mile, which is far less than the population density on many drainage areas of surface water supplies of recognized good quality.

G. G. Hyde had, for instance, computed the average population on 77 Massachusetts watersheds as 132 per sq. mile. There are no unusual or particularly difficult problems of watershed sanitation in Owens Valley and tributary mountain sides. The enormity of such problems is practically proportional to the density of population and, if on more thickly settled watersheds the pollution can be satisfactorily controlled, as is done in many cases, the safeguarding of Los Angeles against dangers of contamination on the Owens River watershed is entirely feasible by the exercise of watchfulness and the proper use of purifying agents now provided.

The population above the Owens River intake is grouped, in a general way, in three districts, namely: Big Pine, Bishop and Round Valley. Big Pine, with a population of about 300 and the center of a small agricultural district, is situated about 25 miles up stream from the intake. Bishop, the only incorporated city in the entire Owens River country, has about 1500 people and is the center of another agricultural district. It is about 35 miles above the intake. Round Valley, about 45 miles from the intake, is little more than a sparsely settled farming section devoted principally to stock raising. Outside of these three districts the country drained by Owens River consists almost entirely of desert, mountain, and forested areas.

The city of Bishop has a sewerage system which is used by about two-thirds of the population. The sewage is passed through a septic tank and is disposed of, during the greater part of the year, by irrigation of 80 acres of city-owned land, and also privately-owned land nearby. At times a portion of the sewage effluent escapes toward the southeast to a slough along which it may pass, reaching either Owens River or Big Pine Canal. If it enters Big Pine Canal, as is usually the case, it eventually disappears entirely by seepage and does not reach the river.

Aside from those using the Bishop sewers, the people on Owens River watershed are dependent almost entirely upon privies for toilet conveniences. Of these privies, estimated to be about 750 in number above the intake, it is said that inspection a few years ago showed but one discharging its contents into any stream and that at least 95 per cent of them were at substantial distances from watercourses. Even these unusually good conditions have been improved upon through efforts of Los Angeles public-service and health authorities.

While it cannot be said that Owens River is entirely free from human contamination, it appears that the contamination is slight. There is little reason to believe that the contamination will increase with time, as sanitary remedial measures undoubtedly can keep pace with the relatively slow development of the Owens River Valley.

SANITARY ASPECTS OF AQUEDUCT SYSTEM.

The aqueduct system, as heretofore outlined, includes about 240 miles of conduit and seven impounding reservoirs. The greater part of the conduit consists of concrete-lined and covered ditch or flume, concrete-lined tunnels and steel pipe. About 62 miles is open ditch, partly lined and partly unlined. The open ditch is all tightly fenced with barbed wire and all bridge crossings are similarly inclosed. The water appears to be amply protected against contamination along the line of these conduits. The entire length is patrolled every day by city employees, each patrolman having a length of about 12 miles to inspect.

The watersheds of the various reservoirs appear to present very little that is objectionable from a sanitary standpoint. These watersheds are all small and are comparatively easy to control, particularly Haiwee, Fairmount and Dry Canyon, which are so far removed from centers of population as to make visitors rare.

At Haiwee a caretaker is stationed at each end of the lake. It is planned eventually to fence the lake to keep out stock. So far as human contamination is concerned the danger is negligible.

Fairmont reservoir has been fenced and a caretaker is stationed there permanently. The watershed is unoccupied and remote from general travel.

Dry Canyon reservoir is now being fenced. The watershed is accessible only over a city-owned road. The only dwelling on it is that of a forest ranger. A caretaker lives at the dam.

San Fernando Reservoir No. 2 drains about 15 sq. miles of adjoining territory and the city employs two men to patrol this area. One spends his time principally around the lower end of the lake, while the other patrols an area of perhaps three or four square miles of tributary valley land around the upper end. The greater part of the watershed consists of unoccupied mountains to the north. The valley land is nearly all owned by the city and will eventually be flooded by San Fernando Reservoir No. 1. In the meantime it is being leased for farming purposes and on it are three or four houses. These premises do not appear to be sources of likely danger to the water in the reservoir. The patrolmen should be able to prevent effectually all dangerous contamination. At this reservoir, however, was observed the only seriously objectionable condition seen at any of the reservoirs. This is the practice of permitting numerous people to fish from the banks around the upper end. Some of these people are said to wade out into the water and doubtless do when not prevented. Trespass by the public on lands immediately surrounding any of the reservoirs should be prohibited as far as possible.

The watershed of Franklin Canyon reservoir is accessible along a public road passing up the canyon along one side of each reservoir. This road terminates at the upper end of the canyon. Either reservoir is almost entirely visible from its dam and at each dam is built the dwelling of a caretaker

and patrolman. There are two other dwellings in the canyon, one above the upper reservoir about 1/4 mile and one about the same distance above the lower reservoir. These premises appear to be well kept and are so situated as to present little, if any, danger to the water supply. There is perhaps a small amount of picnicking in the canyon, but good picnic spots are not easily found, as the bottom of the canyon is very narrow and heavily grown over with brush, except where cleared and graded for the roadway.

Chatsworth reservoir, when completed, will flood nearly the entire watershed except precipitous rocky hills to the west. Around the upper end, between the reservoir and the hills, will be a considerable acreage of very attractive valley land grown over with live-oaks, where special precautions will probably be necessary to prevent picnicking but this, as well as all other nearby land surrounding the reservoir, is owned by the city and trespass can be effectually prevented by proper patrol. Two dwellings are built on the watershed, both on city-owned land; one of these must be removed, as the land on which it stands will be flooded, the other is back probably 1/4 mile from the lake and, if not demolished, can be maintained in a manner to prevent no serious menace.

On the whole the storage and conveyance of water from Owens River to the consumers in Los Angeles is attended with extremely little danger of objectionable contamination. The important thing in operation from a sanitary standpoint is to maintain vigilant patrol around the various reservoirs, to keep clean the few dwelling sites on the watersheds, and to prevent undesirable trespassing, fishing, boating, bathing, etc.

THE ACCUMULOT SYSTEM AS A PURIFYING AGENT.

The efficiency of a storage reservoir as a water purifier depends upon the minimum time that any portion of the water remains in that reservoir. The organisms of water-borne diseases, when placed in the unfavorable

environment of a reservoir, where they are exposed to the influence of sedimentation, sunlight, unaccustomed temperatures, osmosis and unsuitable food supply, rarely survive for more than two weeks and can, with practical certainty, be depended upon to die out within a month. If a reservoir can be depended upon to retain every portion of a stream of water for a period of at least thirty days, it may be conservatively classed among the most efficient of purifiers.

The six reservoirs of the aqueduct system located in Los Angeles County (not including Haiwee) may be depended upon to a limited extent as removers of objectionable bacteria. Some of these reservoirs are too small compared to the rates of inflow and outflow, and in others the inlets are too near the outlets, to eliminate possible short currents and to insure long storage for all the water. However, their beneficial effect is by no means negligible. Water supplied to Los Angeles city proper must, in addition to Haiwee reservoir, pass through Fairmont, Dry Canyon, San Fernando and Franklin Canyon reservoirs, which have a combined capacity of over 10 billion gallons, approximately 37 times the maximum daily flow through the system. This apparent retention of 37 days is not fully realized, due to the above mentioned conditions as well as the fact that the reservoirs at times are only partially full, but it probably is reasonable to assume that they afford at least two weeks retention. Besides, as already explained, the opportunities for contamination along the aqueduct and reservoirs is practically negligible and purification facilities for such contamination are not a vital necessity.

Haiwee reservoir is the unit in which greatest dependence is placed for removal of any objectionable bacteria that may enter Owens River and its tributaries, and this basin is remarkably well formed and situated for the purpose. It was created by building a dam at each end of a gorge, thus making a lake over seven miles long with an average width of about half a mile.

It consists actually of three elongated basins connected by narrow straits. The maximum depth is about 64 feet and the average depth is estimated as 30 feet. The banks are generally steep and rocky and areas of shallow water are small. The aqueduct from Owens Valley empties into this reservoir at one end and all water drawn off is taken from the opposite end. The small land area tributary to the reservoir is practically rainless and may be considered as entirely without significance, so far as disturbance or dangerous contamination of the reservoir is concerned. In a basin such as this, which is shaped more or less as a deep channel about fifteen times as long as its average width in which the flow is entirely from one end to the other, and in which the inflow and outflow are absolutely under control, there is little left to be desired insofar as uniformity of storage is concerned. It is doubtful if any other large reservoir exists in which the ideal conditions for water purification by storage are so nearly approached.

The capacity of Haiwee reservoir, when full, is approximately 21 billion gallons. Water cannot pass through it at a higher rate than the maximum capacity of the outlet, which is 272 million gallons per day. If it is assumed that the reservoir may be only half full when this maximum draft occurs, the reservoir will provide 38 days storage. As a matter of fact, it will be many years before the maximum capacity of the system will be even approached and the storage period consequently for a long time will be much greater than above indicated. Elaborate studies, extending over a long series of years, have demonstrated that the minimum flow in Owens River and tributaries, together with ground water which can and is to be developed in Owens Valley, will be ample to maintain Haiwee reservoir at least half full under all conditions of consumption.

SANITARY PRECAUTIONS TAKEN BY THE WATER DEPARTMENT.

The maintenance of guards or patrolmen at all of the reservoirs and along the various conduits to enforce proper sanitation, as well as to

locate and report any other undesirable conditions, had already been mentioned. The reservoir patrolmen are on duty at all times. The entire length of the aqueduct is inspected everyday by a number of men, each of whom has a length of about twelve miles to cover.

Sanitary control is placed mainly under the supervision of the department's bacteriologist, Dr. Carl Wilson, who in person visits the reservoirs in the immediate vicinity of Los Angeles two or three times a week. He takes a trip to Owens Valley and Haiwee reservoir on an average of once a month. Dr. Wilson has been deputized by the State Board of Health.

Every department employee, who in any way comes in contact with the water, is required to meet certain health requirements. Before such a man is engaged a careful inquiry is made into his past to determine whether he has ever had typhoid and, if it appears advisable, a blood test is made. By this means the employment of typhoid carriers is avoided. This is an unusual precaution, but unquestionably a good one in view of the necessity of employing so many persons to operate this very extensive system.

Since 1914 the department has maintained a well-equipped water laboratory of which Dr. Wilson has charge. Determinations of bacteria and algae in the supply are regularly made. Bacterial samples are collected at Franklin reservoir three times a week and at San Fernando twice a week. Tap samples at the laboratory, consisting of a mixture of aqueduct and Los Angeles river gallery water, are examined daily.

A careful study of algae growths in the reservoirs is under way at all times and treatment with copper sulphate is applied whenever necessary. San Fernando, Chatsworth and Franklin Canyon reservoirs are the only ones which it has been considered necessary to so treat. The basins receive from one to three general treatments each season, the dose ranging from about one to one and a half parts per million, based on the volume of water represented by

the maximum depth at which objectionable organisms are found. The size of dose depends upon the kind and number of organisms to be destroyed. In addition to general treatments occasional partial or marginal treatments are applied. The cascade at the north end of San Fernando valley, where the water plunges down a mountain side in open aqueduct, produces very thorough aeration, which is considered highly effective in removing tastes or odors due to any growths of algae in the reservoirs above. Occasionally it is necessary to introduce copper sulphate at the top of the cascade to keep down certain growths in the channel below. This practically amounts also to treatment of San Fernando reservoir, as water at the cascade reaches this reservoir within a few minutes.

Dr. Wilson is endeavoring to determine the permissible maximum number of various organisms as a guide for future copper treatment. He has fixed for the present an arbitrary limit of 200 diatoms per c.c. The plan is to place the limit low at first and then gradually increase it, if possible. This research work should in time be of great value to the department, but as reliable data can be obtained only by repeated trial on the reservoirs themselves the desired information will probably be acquired only after several year's observation.

LABORATORY DETERMINATIONS.

During the past year samples have been collected at intervals from various points and examined in the laboratories of this Bureau. The sampling points were as follows:

Inlet to Dry Canyon reservoir - - - - -	1	sample
Outlet from Dry Canyon - - - - -	1	"
Inlet to San Fernando reservoir - - - - -	3	"
San Fernando reservoir at dam - - - - -	2	"
Inlet to Upper Franklin reservoir - - - - -	6	"
Lower Franklin reservoir at dam - - - - -	6	"
Tap, 517 N. St. Andrews Place, Los Angeles - - -	18	"

Total - - - - - 37 Samples.

Following is a summary of the results of these examinations:

Number showing no B. Coli in 20 c.c. - - - - -	16
" " B. Coli only in 20 c.c. - - - - -	5
" " " " " " 10 c.c. - - - - -	6
" " " " " " in less than 10 c.c. - - - - -	10
Total - - - - -	37

Of each sample two portions each of 10 c.c., 1.0 c.c. and 0.1 c.c. were examined for B. Coli, thus making a total of 74 examinations for each sized portion.

Proved positive

Of the 10 c.c. portions - - - - -	37, or 50 %
" " 1.0 c.c. " - - - - -	13, or 17.6%
" " 0.1 c.c. " - - - - -	5, or 6.7%

Considering all of the samples as a single composite and computing the number of B. Coli by the theory of probabilities from McCrady's tables, a result of 9 B. Coli per 100 c.c. is arrived at.

The total number of bacterial grown on agar averaged 450 per c.c. for the 37 samples. The maximum was 6000 and the minimum 6. Over three fourths of the samples had less than 200 bacterial per c.c.

The results of analyses from all sampling points were similar, or at least there was not sufficient difference to indicate any changes in quality of water attributable to particular influences. The results do not indicate serious contamination. There is probably more or less access to the water along the aqueduct by wild animals and a little by domestic animals, which is not of hygienic significance. The few findings of B. Coli in the samples may as readily be attributed to these as to human contamination. The source of greatest possible human contamination along the aqueduct is probably the water department employees who, as stated, are accepted only after an inquiry has been made into the possibility of their being sources of infection and these considered dangerous have been eliminated.

The routine procedure followed in the laboratory of the city water

department includes plating on agar to determine total bacterial and the determination of E. Coli by the technique prescribed by the standard methods of the American Public Health Association. In determining E. Coli five 10 c.c. portions of each sample are incubated. Generally about six samples of aqueduct water from Franklin, San Fernando and Chatsworth reservoirs are examined each week.

Dr. Wilson reports that the average total bacterial count on these has been about 90. Immediately following copper sulphate treatment he finds the bacterial counts run very high, due, no doubt, to the decaying of microorganisms killed by the treatment. He reports that E. Coli determinations show on an average about one positive tube out of five. Such results as these would indicate a satisfactory water, as they would come within the United States Treasury standard which is generally considered rather severe.

While it has always been argued that Haiwee reservoir was a very efficient water purifier due to the long and uniform storage that it affords, no careful bacterial study had ever been made to prove this contention until the present month. This study was made by Dr. Wilson and following is his report in full:

October 17th, 1918.

William Mulholland, C. E.,
Chief Engineer,
Department of Public Service,
Los Angeles, California.

Dear Sir:

In accordance with the request of the State Board of Health, and under approval of yourself, the writer undertook a special bacteriological study of Haiwee reservoir, the object being to demonstrate, if possible, the natural purification processes which take place in waters stored there. A field laboratory was set up at Cartago, the point nearest to the reservoir where electric current for the operation of the incubators could be obtained. Samples were taken at five different stations in the lake on each of five consecutive days, from October 8th to 12th, both inclusive, with results as shown on the sheet attached hereto.

In connection with these results it is interesting to note that for a week prior to October 8th there had been heavy rains in the mountains, and the creeks and river feeding the aqueduct were swollen with flood run-off following extremely low water. The influent stream was very muddy and the effect was plainly visible in the turbid water which extended down the north basin of the reservoir almost to the McLeod cut. On October 8th there was a high wind blowing from the north, kicking up good-sized waves and whitecaps on all three basins, while on October 12th a strong wind from the south caused squally rough water. On the other three days the lake was calm, while on the 9th, there was absolutely no wind, and the surface of the water was a perfect mirror. Taking everything into consideration, the conditions were about as unfavorable for a bacterial showing as are likely to occur; a flood wash bringing in the scourings of the creek beds after a summer of low water, accompanied by winds blowing from the inlet towards the outlet. Yet in spite of this, with an average bacterial count at the inlet of 1450 per cubic centimeter for the five days, the average count at the outlet was only 125 per cubic centimeter. Colon bacillus was positive in all but one of the one cubic centimeter tubes at the inlet, while at the outlet it was found in but two of the twenty-five ten cubic centimeter tubes which were inoculated.

The technique followed was that prescribed by the Standard Methods of the American Public Health Association, edition of 1917, except that for the purpose of this investigation the production gas in the standard lactose broth has been taken as sufficient proof of the presence of the colon bacillus, and no confirmation of the diagnosis has been attempted, owing to the limitations imposed by the field laboratory. However, this simply means that we have placed the worst possible interpretation upon our findings, and if any error has been made it merely causes the water to appear worse than it really is.

Yours faithfully,

(Signed) Carl Wilson,
Bacteriologist.

HAIWEE RESERVOIR BACTERIAL RESULTS

Total Count on Agar.

Station*	Oct. 8	Oct. 9	Oct. 10	Oct. 11	Oct. 12
1	2000	1200	1500	1200	1300
2	1000	1200	1000	900	1500
3	300	530	425	500	380
4	300	100	180	115	230
5	185	70	82	80	200

Colen Bacillus, Number of Positive Tubes.

Station*	Oct. 8		Oct. 9		Oct. 10		Oct. 11		Oct. 12	
	10 cc	1 cc	10 cc	1 cc	10 cc	1 cc	10 cc	1 cc	10 cc	1 cc
1	5	1	5	1	5	1	5	1	5	0
2	5	0	5	0	5	1	4	0	5	0
3	3	0	1	1	5	0	2	0	2	0
4	1	0	0	0	1	0	0	0	1	0
5	1	0	0	0	0	0	0	0	1	0

- *Station 1 was in the influent stream at the north dam.
- Station 2 was at the lower end of the north basin.
- Station 3 was at the center of the middle basin.
- Station 4 was at the north end of the south basin, off the Meadows.
- Station 5 was at the effluent tower at the lower end of the south basin.

The results of Dr. Wilson's study show surprising uniformity.

Summarizing them in another way we obtain the following:

	Average Total Bacteria for 5 days	Average No. B. Coli per 100 c.c. for 5 days, computed by McCready's tables.
Station 1: Inlet to reservoir	1440	35
Station 2: 2 miles from inlet	1120	25
Station 3: 3-1/2 " " "	430	9.4
Station 4: 5 " " "	185	1.2
Station 5: 7 " " "	122	0.8

While the water entering the reservoir at this time was of inferior sanitary quality, that at the last two sampling stations, at least, was entirely satisfactory. The results of these examinations afford very convincing proof that Haiwee reservoir is a highly efficient purifying agent.

TYPHOID FEVER IN LOS ANGELES

In discussing the sanitary aspects of the Owens River water supply it is of interest to consider the prevalence of typhoid fever in Los Angeles, in view of the fact that this is the most important water-borne disease to guard against. The following table contains the typhoid death rate for the past twenty-three years:

<u>Year ending</u> <u>June</u>	<u>Typhoid deaths</u> <u>per 100,000</u> <u>population</u>	<u>Year ending</u> <u>June</u>	<u>Typhoid deaths</u> <u>per 100,000</u> <u>population</u>
1895	48	1906	22
96	37	07	23
97	25	08	21
98	43	09	20
99	40	1910	13
1900	46	11	14
01	32	12	12
02	43	13	11
03	44	14	11
04	40	15	6.6
05	30	16	2.8
		17	2.9

The general tendency has been a gradual decrease in typhoid throughout this period and for the past several years the rate has been remarkably low. Owens river water was first delivered to Los Angeles in the year 1913 and has been used in increasing quantity ever since. The typhoid record obviously does not reflect any deleterious effect from the introduction of this supply.

SUMMARY AND RECOMMENDATIONS

The Los Angeles Aqueduct supply is derived from Owens River and tributaries, fed by springs and mountain streams draining the eastern slopes of the Sierra Nevada mountains. The watershed has residing on it an average

population of less than 1.5 per square mile. The stream probably is slightly contaminated above the intake, but the likelihood of human contamination of a dangerous character is small compared with many other streams used for domestic supply. There is a very remote possibility of sewage from Bishop in an aged and relatively harmless condition reaching the river in flood season.

The water, after being taken into the aqueduct system, is subject to possibility of further dangerous contamination so small as to be negligible.

The consumers of this water have a very efficient safe-guard against contamination in the form of purification by long storage in reservoirs between Owens Valley and Los Angeles. Haiwee reservoir, in particular, is of great value in this respect. It provides storage of several months at the present rate of consumption and, even with consumption at the ultimate maximum capacity of the system, actual storage of all water for at least a month will be provided.

From the standpoint of design and construction and general surroundings the system appears to present no seriously objectionable sanitary features. In other words, the successful elimination of any possible danger has been made entirely feasible. The success of such elimination depends entirely upon the care and watchfulness exercised in the operation of the system.

Proper operation from a sanitary standpoint will include conscientious patrol of the watersheds of all reservoirs and of all open conduits to prevent access of human beings or human offal to the water. It will eliminate, as far as possible, all trespass by human beings on lands immediately surrounding the reservoirs and will forbid all use of the reservoirs for fishing, bathing and boating.

It is recommended that, upon receipt of application from the City of Los Angeles, a permit be granted by the State Board of Health to continue operation of its aqueduct system, supplying water from Owens River and

tributaries, with the provision that the system be operated with due care to prevent contamination, as above outlined.

Respectfully submitted,

(Signed) Ralph Hilscher

Southern Division Engineer.

Approved:

Director.