Report on A Pollution Survey of Santa Monica Bay Beaches in 1942

BY

BUREAU OF SANITARY ENGINEERING

TO

CALIFORNIA STATE BOARD OF PUBLIC HEALTH

JUNE 26, 1943

CONTENTS

LETTER OF TRANSMITTAL

Berkeley (4), California,

June 26, 1943

To the State Board of Public Health
Sacramento, California

Gentlemen:

TRANSMITTAL OF "REPORT ON A POLLUTION SURVEY OF SANTA MONICA BAY BEACHES IN 1942."

Pursuant to your instructions of September 15, 1941, that the Bureau of Sanitary Engineering make a sustained study of the pollution by sewage of beaches of Santa Monica Bay to determine if areas existed from which the public should be excluded through quarantine action, a comprehensive investigation was carried on during all of 1942. A trained investigator, experienced in bacteriology, was assigned solely to that task. Based on a review of the year's evidence on April 3, 1943, your board adopted the following Quarantine Order with respect to approximately ten miles of beaches in Santa Monica Bay, lying each side of Hyperion Outfall of the City of Los Angeles:

"QUARANTINE ORDER

"WHEREAS, Laboratory studies and sanitary inspections made by the California State Department of Public Health throughout 1942 have shown that the ocean beach and shore waters of Santa Monica Bay, extending from Fourteenth (14th) Street north of the Hermosa Beach Pier in Hermosa Beach, to Brooks Avenue north of the Venice Pier in Los Angeles, are contaminated and polluted with sewage to a dangerous degree; and

"WHEREAS, This condition constitutes a menace to the health of persons using these beaches; and be it

"*Resolved*, That the California State Board of Public Health, meeting in San Francisco on Saturday, April 3, 1943, does hereby establish a quarantine of the stretch of beach extending from Fourteenth Street north of the Hermosa Beach Pier in Hermosa Beach, to Brooks Avenue north of the Venice Pier in Los Angeles. Quarantine under this Order means the exclusion of the public from the shore waters and the beach in the area described above extending on the beach to the point reached by high tide; and be it further

"*Resolved*, That, pursuant to the above findings of the California State Board of Public Health, a copy of this Resolution be sent to all City and County Health Officers within the area herein described, notifying and advising them of said quarantine and directing that they post signs warning the public that the area is under quarantine and that they enforce the provisions of this Order.

"Said action is taken for the preservation of the public health pursuant to the provisions of the Health and Safety Code of the State of California.

Signed: WILTON L. HALVERSON, M.D.
Executive Officer
State Board of Public Health."

In collaboration with the health departments of the city and of the county, substantial quarantine signs approximately 2 feet by 3 feet have been placed along the beach at approximately 500-foot intervals.

WARNING

BEACH QUARANTINE

THIS BEACH FROM HIGH TIDE LINE SEAWARD, INCLUDING ADJACENT SHORE WATERS, IS POLLUTED WITH SEWAGE AND IS DANGEROUS TO HEALTH. THE PUBLIC IS EXCLUDED FROM THESE AREAS UNDER ORDER OF THE CALIFORNIA STATE BOARD OF PUBLIC HEALTH.

THE AREA UNDER QUARANTINE EXTENDS APPROXIMATELY TEN MILES ALONG THE COAST FROM BROOKS AVENUE NORTH OF THE VENICE PIER IN LOS ANGELES, TO FOURTEENTH STREET, NORTH OF THE HERMOSA BEACH PIER IN HERMOSA BEACH

VIOLATION OF THIS ORDER IS A MISDEMEANOR

APRIL 3, 1943

CALIFORNIA STATE BOARD OF PUBLIC HEALTH

Penalty for Defacing This Sign Is a Misdemeanor Punishable by a Fine of $500.00 or Six (6) Months in Jail

Detailed report of the year-long investigation is now being filed by the Bureau of Sanitary Engineering.

In brief, the important findings of the investigation are:

(1) Early day sewage disposal in Los Angeles 50 years ago was onto sewer farms on the edge of the city. These became obnoxious and in 1894 the city first began to dispose of a part of its sewage to Santa Monica Bay at Hyperion near El Segundo. By 1912 complaints from beach cities south of Hyperion Outfall became intense. Complaints have continued to mount right up to the present time and to take in more territory as far north as Venice. In 1925 the present Fine Screening Plant and 5,000-foot Submarine Outfall were put in full use at Hyperion. This step represents the most recent attempt of the city to meet the beach pollution problem. There have been no further improvements in the last 18 years, and the outfalls have deteriorated and have not adequately been repaired. Population sewering to this outlet in 1920 was close to 500,000. During the investigation in 1942 it was 1,787,000. It is clear that the entire disposal system has long since reached its capacity; that the fine screening method of sewage treatment is wholly inadequate as a preparation for the release of sewage to Santa Monica Bay; and further, the Submarine Outfall leaks so badly along its length that it is estimated that from 20 to 80 per cent of the sewage fails to reach the seaward end. The main influent outfall or trunk sewer, known as the "North Outfall" is cracked to the point of bursting.

(2) An investigation of the historical record reveals one indictment after another of the City of Los Angeles because of procrastination and inadequate planning and financing of sewage disposal suited to the proper assimilation of the drainage in the bay. Plans now on the drafting boards in the office of the city engineer comprise what we regard as the first instance of constructive planning of sewage treatment and Submarine Outfall construction at Hyperion.

(3) Though currents in Santa Monica Bay are fortunately adequate to prevent the formation of sludge banks on the ocean floor, the surface and wind-induced currents are predominantly onshore from the Submarine Outfall. This is particularly true in the recreation months of the summer. Of 54,500 miles of wind movement in 1942, 35,500 miles were beachward. Of this latter movement, 27,000 miles were from the Outfall toward beaches to the north of it. Eight thousand five hundred miles of wind movement were southerly toward Hermosa Beach or directly onshore. In much of the summer of 1942, 80 per cent of the wind movement was toward northerly beaches and in winter it was evenly divided between beaches north and south of Hyperion.

(4) In consequence of inadequate removal of sewage matter by fine screens, which remove but 3 to 8 per cent of the suspended solids and practically none of the grease, numerous forms of sewage debris issuing from Hyperion Outfall land on these shores in a wide, sweeping arc of which Hyperion Outfall is the center. The evidence is conclusive beyond question that 10 miles of beach from Station 5, which is at Fourteenth Street in Hermosa Beach, to Station 14 at Brooks Avenue in Venice are commonly and seriously polluted by sewage organisms, infected sewage grease, feces and other sewage.

Because conditions are as changeable as the wind itself, no one can know when or where beaches are safe within the 10 miles of beach. The frequency of the occurrence of pollution at the various stations established for this study is shown vividly with respect to Hyperion Outfall in Figures 26 and 28 on pages 52 and 54 of this report. To these graphs the reader is especially referred. Taken together with other graphs and evidence in this report they show beyond question that the sewage from Hyperion Outfall is alone responsible for the pollution and that all sewage constituents diminish with distance from the Outfall. Some pollution extends beyond the 10-mile section of beach, but the frequency at which this occurs is low. From such comparisons as can be made with reports and tests in former years, the zone of pollution is extending to additional beaches at an alarming rate.

(5) It is estimated that 40 million people visit the beaches of Santa Monica Bay in a year. Of these, 20 million have frequented the 10 miles of beach now under quarantine. The affected beaches are the nearest to Los Angeles proper. Because neighboring beaches are already congested, it can be estimated that on the item of travel, let alone inconvenience and loss of recreation time, the people of this region will be obliged to drive at least 50 million additional miles per year for seashore recreation or forego this source of health-giving diversion. Here is a direct loss far beyond a million dollars per year on a single item. Any way one looks at it, a thorough-going redemption of the Santa Monica Bay beaches is necessary and will be a profitable undertaking.

(6) Studies of surf water, sand and sewage grease undertaken late in the investigation indicate the frequent presence of members of the typhoid group of organisms, and it is recommended that this phase of the investigation be pursued further.

(7) No special search has been made among exposed persons for cases of actual sewage-borne disease contracted from these beaches. One case of paratyphoid fever described in this report strongly incriminates the surf water and there is no reason to believe that this may be an isolated case. Unlike the explosive epidemics originating from water, milk and foods, cases of sewage-borne disease from polluted surf or beaches are more likely to be scattered geographically, and the source may go unsuspected. The frequency with which pathogens have been isolated from sea and sand in this investigation leads us to the conviction that physicians observing enteric disease among the people of this area should inquire into a possible connection with seashore recreation in the polluted portions of Santa Monica Bay. For such diseases are known to be three times as frequent in proportion to population in this area as they are in other parts of this State.

Respectfully submitted.

C. G. GILLESPIE, Chief,
Bureau of Sanitary Engineering.

CGG:AD

REPORT

SEWAGE DISPOSAL FACILITIES OF CITY OF LOS ANGELES

The system which conveys its sewage through the North Outfall into the Fine Screening Plant at Hyperion and into Santa Monica Bay handles the sewage of an estimated population of 1,787,000 people, living in the city proper and in some 19 other cities or county areas which are under

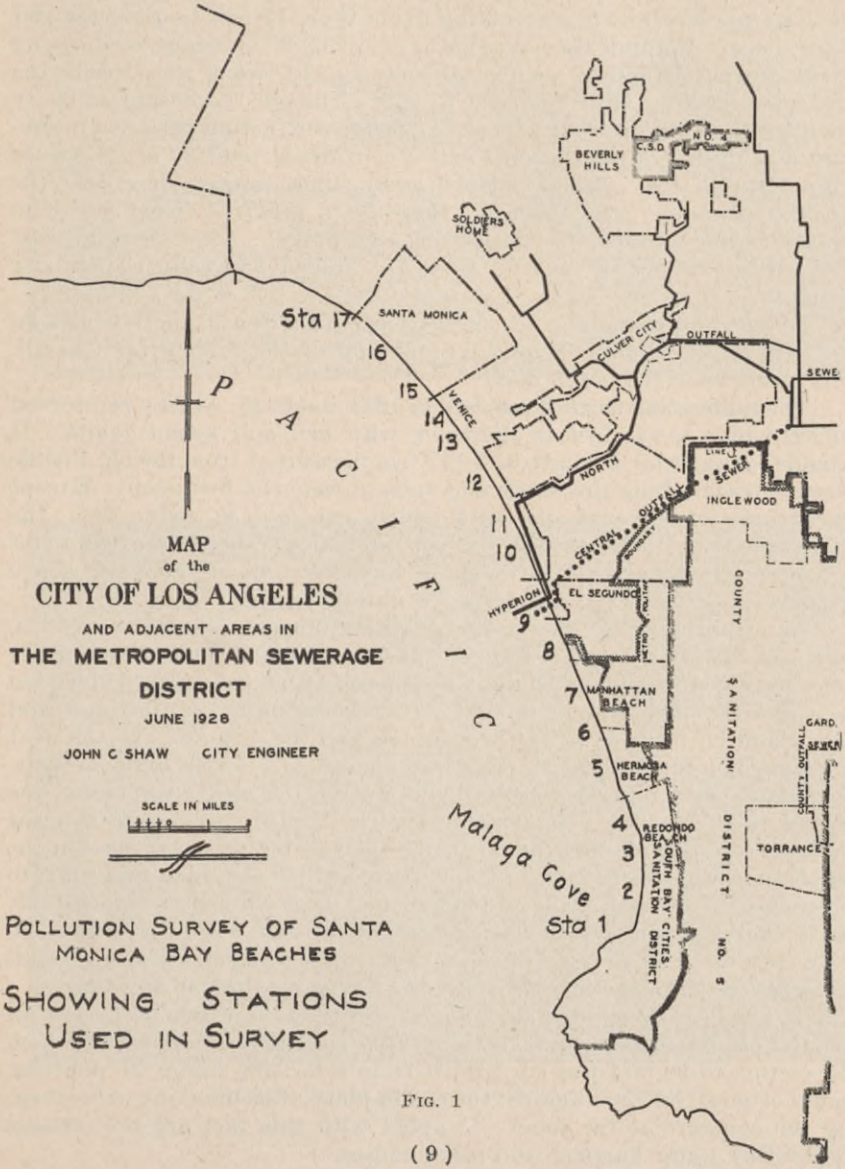

FIG. 1

contract with Los Angeles for their sewage disposal. The lower end of the trunk line system serving these cities, together with the Submarine Outfall into Santa Monica Bay at Hyperion and relation to the beach cities is shown on the map, Fig. 1. The map also shows the location of the stations for sampling surf and observing beach conditions, established for the purpose of this investigation.

The present system was completed and was in full use in 1925. The only changes which have been made since have been the addition of five more fine screens in the main screening plant in 1930 and the construction of a raw sewage by-pass to the beach in 1933.

The fine screens are a revolving drum type, 14 feet in diameter and 12 feet long. Eight of these screens have $\frac{1}{16}$" by 2" openings, comprising 20 per cent of the screen peripheral surface. In two of the screens, the slots have recently been enlarged to $\frac{3}{32}$". Though the design capacity was 30 million gallons daily (m.g.d.), per screen, actual capacity is substantially the same in all screens and is considered to be 20 m.g.d. under average conditions. When clogged, as by slime coatings or grease, the capacity decreases still further. Screenings removed by this system amount to about 10 tons per day as dry screenings. After being pressed and partially dried in a kiln, they are hauled away by a fertilizer company.

In addition to the raw sewage by-pass to the beach, there is also an overflow or relief manhole at the beach end of the Submarine Outfall. This opens upon the beach itself.

The Submarine Outfall was laid in 1924 and 1925. It is a reinforced concrete pipe seven feet in diameter with bell and spigot joints. It extends seaward for a length of 5,147 feet, measured from the old Pacific Electric tracks along this shore and ends in water 54 feet deep. Except for the section through the surf which was laid in coffer dam, the remainder is on the sandy ocean floor, and was lowered from pontoons or barges. Some years ago the outlet was raised about three feet above the ocean floor to escape the menace of sand clogging the pipe.

Immediately after the laying of this Submarine Outfall in 1925, fractures and leaks began to appear at the various joints. Thirty-five leaks were found and underwent repairs the first year, particularly in the terminal 3,000 feet of outfall. It was estimated at the time that only about 25 per cent of the sewage reached the outlet. For the next 10 years the Submarine Outfall was almost constantly under repair. Then new leaks appeared nearer and nearer the shore. Some of the breaks cost $20,000 to $35,000 to repair. Hundreds of thousands of dollars were spent to little or no avail. The high point of success in the repair program was in 1928 and 1929, after which the leaks continued to get worse. The earthquake of 1933 opened up fresh leaks. Since 1935, no further attempt has been made to patch them. Estimates in 1940 were that about 20 per cent of the sewage escaped through leaks. To all appearances the leaks in 1942 and 1943 are worse than at any time.

It has been concluded that the reason these ruptures occur is that the section of concrete pipe, being laid by submarine methods in which the section to be laid was suspended from a floating barge, or pontoon, would often strike hard against the one in place, thus breaking or weakening the concrete at the joint. Coupled with this fact are the stresses induced by water hammer and other causes.

Photographs of the Hyperion Screening Plant, and the screens, are shown in Fig. 2 to 4 inclusive.

FIG. 2. Outside of Main Fine Screening Plant at Hyperion.

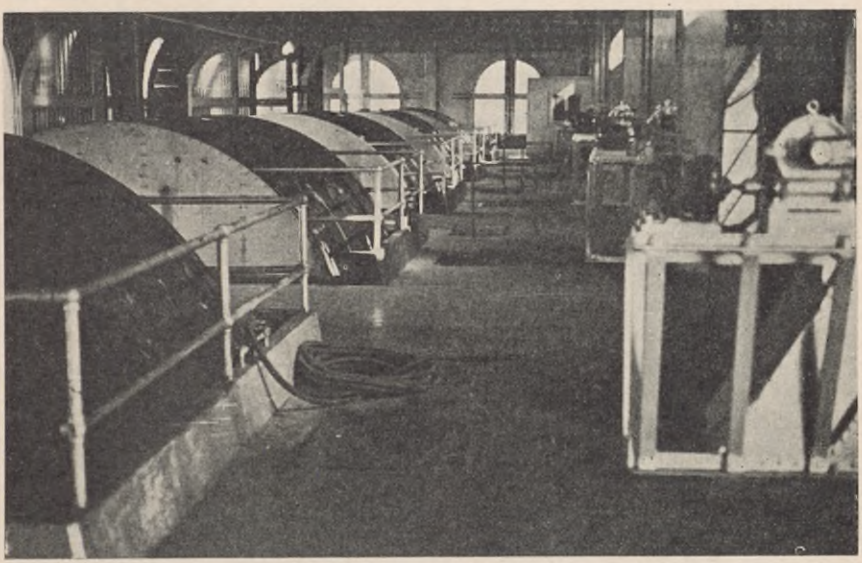

FIG. 3. Inside of Screening Plant at Hyperion.

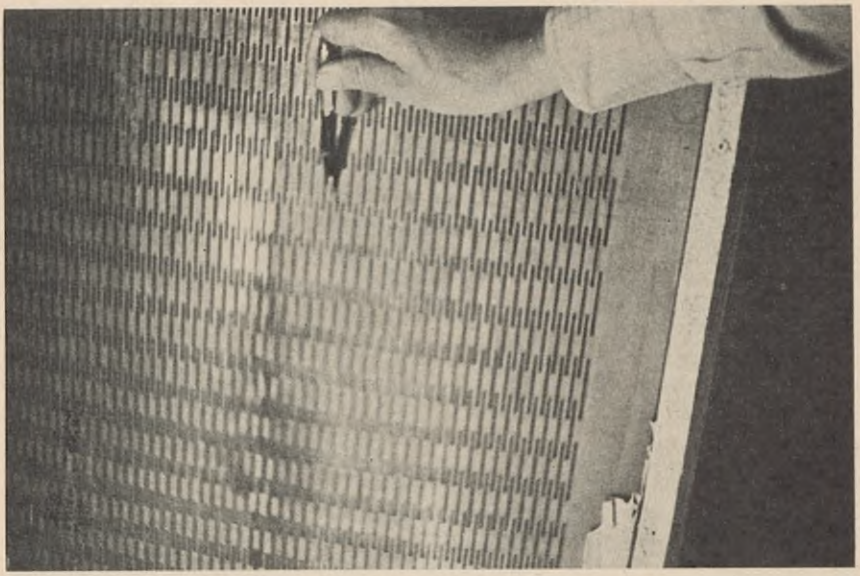

FIG. 4. Close-up of Screen Plates, Slots 1/16" x 2".

There are no other sanitary sewers, other than storm drains, leading to Santa Monica Bay. The nearest neighboring sewer outfall is that delivering the fluid settled sewage of the Los Angeles County Sanitation Districts to the ocean 5,000 feet off White Point, which is in the Palos Verde Hills 16.5 miles south of Hyperion and too far away to enter at all into this investigation. There is some yachting at Santa Monica and there are occasional tankers at Standard Oil Pier at El Segundo. Their toilets contribute a negligible amount of pollution.

CHRONOLOGY OF PRINCIPAL EVENTS IN SEWAGE DISPOSAL OF CITY OF LOS ANGELES INTO SANTA MONICA BAY

The following is compiled from records and files of Bureau of Sanitary Engineering as of May 14, 1943.

1863—Evidence that sanitary sewers existed in Los Angeles.

1873—City commenced construction of public sewers. Population, 7,000.

1883—City, population 15,000, contracted with South Side Irrigation Company for sale of sewage from San Pedro street sewer to irrigate vegetable farms.

1887—First comprehensive plan for sewerage system prepared by Fred Eaton.

1894—City first piped raw sewage about 10 miles to Santa Monica Bay at Hyperion under the Eaton plan. Sewage was discharged through 24-inch cast iron pipe, 600 ft. off-shore.

1895—Population, 70,000. Contract for sewage irrigation with 4 m.g.d. renewed to 1903.

1904—New 30-inch steel pipe outfall was laid, extending 940 ft. from shore.

1908—Central Outfall completed, capacity about 58 m.g.d. when flowing nearly full. Discharged raw sewage in Santa Monica Bay through 34-inch wood stave pipe sewer, laid on trestle 930 feet long, and with discharge submerged. In that year the reports of the city engineer stated that the suspended solids must completely be removed before discharge of effluent into Santa Monica Bay.

1912—Intense complaint began by southerly beach cities of filthy beaches and aerial nuisance.

1915—After years of intolerable fecal nuisance on beaches extending as far as one mile from Hyperion, the State Board of Health demanded that steps be taken to abate the nuisance. City engineer prepared plans for Imhoff tanks.

1916—Bond issue for same defeated. City decided to extend ocean outfall. Temporary permit issued to discharge raw sewage into Santa Monica Bay, 2,000 feet from shore using new Belle View Outfall Trestle 875 feet up the coast (northwest) from the then existing outfall at Hyperion.

1917—State Board of Health directed initiation of legal action to compel abatement of nuisance created by Hyperion Outfall. Bond issue for $1,750,000 for sewer improvements defeated June 5th.

1920—Census was 576,673, and peak dry weather flow about 65 m.g.d.

1921—Special Sewage Disposal Commission reported that sewage nuisance at Hyperion was noticeable along beach one mile in either direction from the outfall, particularly to the south, and stated that bacterial analysis of surf water showed that bathing at Hyperion could be attended with risk if the bathers should swallow some of the water. The commission recommended a new ocean outfall with a capacity of at least 210 m.g.d., and the installation of a fine screening plant. Bond issue for $12,250,000 was overwhelmingly defeated in June. Defeat due principally to objection to sewage disposal near populous beach areas and to idea of water conservation. By autumn, old Central Outfall reached capacity and peak flows began to overflow and flood private premises and lawns of some 10,000 people.

1922—City engineer relieved overflow by diverting certain sewers to Ballona Creek. City asked State Board of Health for permit to screen and chlorinate the overflow and admit it to Ballona Creek. Permit denied February 4th. Culver City, Venice and Playa del Rey filed suits to enjoin discharge of raw or screened sewage into Ballona Creek. Superior court granted injunction and gave city until September 15, 1922, to abate the existing nuisance. In August, a $12,000,000 bond issue was voted 4 to 1 to provide relief sewers, also new North Outfall sewer having capacity of 275 m.g.d.; also two fine screening plants at Hyperion (for old Central Outfall and New North Outfall), having $\frac{1}{8}$-inch slots and working capacity of 148 m.g.d.; also, a new 5,000-foot concrete submarine outfall 7 feet in diameter, into Santa Monica Bay. Outfall capacity 250 m.g.d. at low tide, and 180 m.g.d. at high tide.

1923—After hearing and considerable objection by beach cities, the State Board of Health granted permit for above sewage disposal project at Hyperion, as follows:

"ORDER GRANTING SEWAGE DISPOSAL PERMIT TO LOS ANGELES TO DISPOSE OF SEWAGE EFFLUENT INTO SANTA MONICA BAY (HYPERION) APPLICATION DATED NOVEMBER 22, 1922 ORDER DATED JANUARY 6, 1923

"WHEREAS, The City of Los Angeles has applied for permit to the State Board of Health for permit to dispose of a certain sewage effluent into the Santa Monica Bay, as more particularly set forth in a descriptive statement and general plans therefor, accompanying said application; and

"WHEREAS, It is the desire and intention of the State Board of Health to establish proper standards of cleanliness and safety to health, of all salt water bathing beaches and bodies of salt water affecting the public health and public enjoyment, which are or may become polluted by sewage or sewage effluent; and

"WHEREAS, In pursuance thereof, it is the purpose of the State Board of Health to protect public beaches against the deposit of shore litter due to sewage, to preserve the safety of bathing beaches and bathing waters, and to prevent the creation of odors of putrefaction in the water, or odor at beaches due to sewage pollution; and

"WHEREAS, It is the opinion of this Board the proposed plant of sewage disposal will conform with the desire and intention of the State Board of Health to protect the beaches of Santa Monica Bay against contamination and nuisance; and

"WHEREAS, The proposed plan of sewage treatment is such that it is feasible to construct future and additional treatment tanks of such type as, and when they may be required; and

"WHEREAS, The State Board of Health has the authority to require such future and additional treatment works as and when required; and

"WHEREAS, It is feasible to so conduct the operations of the treatment plant and disposal of screenings, such that there shall be no menace to public health and a minimum of offensive odor nuisance; therefore, be it

"*Resolved*, That Permit be Granted to the City of Los Angeles to dispose of sewage effluent into Santa Monica Bay subject to the following conditions:

"(a) All sewage shall be screened through sewage screens having a maximum width of screen slots of 1/16-inch and all disposed of, at or near Hyperion, through an outfall discharging on the bottom of the Bay, at least 5000 feet from low water shore line, all in accordance with general plans now on file with this Board and in accordance with detailed or working drawings as subsequently approved by said Board. The program of construction of the above works to be such that within eight months all sewage reaching the ocean shall be screened as above provided, disposal to be made through the existing outfall, and within two years all disposal shall be made through the 5000-foot outfall or outfalls above permitted, at which time the existing outfall shall be dismantled.

"(b) Garbage, fecal matter, solid matter or oily sleek, recognizable as of sewage origin from said City, shall not be visible at any of the beaches outside of Hyperion Beach while owned by the City of Los Angeles.

"(c) The quality of water at points, which in the absence of the sewage of Los Angeles, would be safe and suitable for public bathing purposes, shall conform to the bacterial standards for salt water bathing beaches, as may be established or modified from time to time by this Board. This provision shall not apply to Hyperion Beach while owned by the City of Los Angeles.

"(d) There shall be no objectionable odor nuisance in the waters or at beaches used by the public.

"(e) The operations of the sewage treatment works and disposal of screenings shall be conducted so as to prevent a menace to the public health and to minimize offensive odor nuisance.

"(f) It is understood that additional treatment works, changes in outfall or improvements in operation shall be provided when required by the State Board of Health."

By October, 1923, temporary discharge near Culver City was piped to Ballona Creek at Jackson Street in Culver City. On December 3, 1923, the city engineer and the members of the Board of Public Works were adjudged in contempt of court and fined $250 each.

1924—To relieve conditions in Ballona Creek, city piped overflow through temporary outfall into the ocean at Surf Street in Venice. Conditions became intolerable and Venice Beach was quarantined by the State Board of Health that summer. In October, new North Outfall and Hyperion Screening Plant was put in use with five fine screens in main plant. Included also were similar but smaller fine screens on the old Central Outfall and continued use of the Belle View Trestle Outfall.

1925—Hyperion system and new Submarine Outfall in full use about May. Numerous leaks appeared at joints in Submarine Outfall, due to damage and pulverizing of bell and spigot joints because the pipe was laid under rush orders and heavy seas which caused many of the sections to be damaged when laid. In May, 1925, there were 35 such leaks. As rapidly as possible, divers were assembled and joints were repaired, only to be followed by fresh breaks. Hundreds of thousands of dollars were spent on such repairs in the next 10 years, all to no avail. Some breaks cost $20,000 to $35,000 to repair. During this interval, beach conditions were bad but variable, depending on status of repairs and especially on the extent of inshore leaks in shallow water. Least beach pollution occurred in 1928, 1929.

1925 to 1930—Old Central Outfall gradually disintegrated, and bricks continued to fall in and choke down the flow. Finally, in 1930, this outfall was abandoned, also its screening plant, thus leaving only the main plant with a working capacity on a 9-screen basis of 180 m.g.d. The 1930 census was 1,238,000. Dry weather peak flows averaged 160 m.g.d. Sewered population in 1930, 1,400,000. Sewers uptown overloaded and much spouting of sewage on the streets through manholes.

1931—In June, city defeated a $6,000,000 bond issue, most of which was for relief sewers, but $270,000 was for degreasing works at Hyperion.

1933—Raw sewage by-pass was installed around screening plant to the beach because of deficient screen capacity in storms. Same year, city recreational department sought Federal funds to develop an aquatic project at Playa del Rey and other beaches near Hyperion. The department sought approval from the State Board of Public Health to satisfy Federal requirements. Approval was refused but finally granted on condition that submarine outfall be made intact and that degreasing works be constructed. The beaches

were obtained or leased by the city and guard stations were subsequently established but the aquatic development was dropped.

1934—City sought a PWA project for a degreasing plant at Hyperion but nothing came of it.

1935—A huge WPA project was set up to remove the sand dunes at Hyperion in preparation for the construction of treatment works. Removal of the sand was practically completed but no construction ensued.

1939—In November, a Board of Consulting Engineers estimated 1,590,000 people tributary to the Hyperion outfall. The Board reported:

> "the beaches of Santa Monica Bay are among the most accessible recreational resorts available to the people of Los Angeles and vicinity. Therefore, these beaches and shore waters if hygienically safe are of inestimable value. Since the time the first outfall was established at Hyperion many years ago, the adjacent beach and shore waters have been grossly contaminated. The extent of this pollution has been such that significant portions of the beach have been unusable and have been under quarantine by the Department of Public Health."

The board recommended for Hyperion immediate construction of grit and grease removal works, flocculation and sedimentation, disinfection, sludge digestion, and dewatering works, and investigation of the feasibility of repair of the existing submarine outfall. Estimated cost of Hyperion disposal, $8,000,000; and $1,400,000 for repair of North and Central Outfalls.

1940—Average dry weather peak flow for six dry months, 280 m.g.d. Daily average 128 m.g.d. Storm flows reaching Culver City are 20 to 40 m.g.d. per inch of rainfall per day and may amount to 80 to 130 m.g.d. above sanitary flow in more severe storms. Connected population estimated at 1,640,000. Census, 1,504,277. Estimated discharge of grease was 8 to 10 tons per day. Suspended solids, 170 tons. Where North Outfall sewered through Baldwin Hills it had reached such a state of fracture during the last five years that the city began to fear that such surcharging by storm flows beyond its working capacity of about 275 m.g.d. would cause the outfall to burst and flood Venice and other areas. Board of Public Works requested permit from the State Board of Public Health to install a temporary two-year by-pass of 100 m.g.d. capacity to put excess flow into Ballona Creek at Jackson Street in Culver City. Permit was granted September 3, 1940, for a two-year period, and conditioned on financing to allow making the repairs to the North Outfall, estimated to cost $1,000,000. At the same time, the State Board of Public Health suspended the permit of January 6, 1923, for the Hyperion works and disposal because of long-standing violations of its provisions. The board also ordered financing a program for construction, and the preparation within a year of plans for remedial works at Hyperion and thereupon granted temporary permit to continue Hyperion system for that period, conditioned further on excluding public from polluted beaches.

1941—(April). City failed to pass a special annual sewer tax levee of nine cents per hundred dollars to finance repair to North Outfall and improve sewage disposal. No progress on remedial works at Hyperion.

On May 5th, because of no visible assurance that the projected overflow into Ballona Creek would ever be discontinued, if inaugurated, the State Board of Public Health notified the City Council that permit to by-pass overflow to Ballona Creek would be canceled July 1, 1941, unless definite assurance was given that the funds would be at once forthcoming to make the repairs to North Outfall and Hyperion System. This permit was never officially canceled but expired automatically September 3, 1942.

On May 25, 1941, the State Board of Public Health reviewed recent communications from the City Council indicating that the matter of excluding the public from polluted beaches had been referred to the Public Health and Welfare Committee, and the board urged on that committee early establishment of police patrol of polluted beaches. This committee replied that the subject of sewage disposal was before another committee.

September 15, 1941, the State Board of Public Health considered quarantining certain sections of Santa Monica Bay beaches by reason of sewage pollution and directed the Bureau of Sanitary Engineering to make a sustained study of the beaches to obtain data adequate for quarantine purposes. In December, 1941, study got under way.

1942—Beach pollution study continued through 1942.

On March 20, 1942, the State Board of Public Health denied permit to Board of Public Works to construct and use an alternate 100 m.g.d. overflow from the North Outfall into Ballona Creek, this time at the foot of Duquesne Street. Permit had been requested March 11, 1942, for a two-year period to October 1, 1944.

1943—Beach pollution survey continued to about April 1, 1943.

April 3, 1943, State Board of Public Health established quarantine of surf and beach as far back as high tide for the area from Fourteenth Street in Hermosa Beach to Brooks Avenue in the Venice District of Los Angeles, a beach 10 miles long.

At the present time, the city engineer is repairing the North Outfall and has on the drafting board the preparation of plans for substantially the kind of treatment plant recommended by the Board of Consulting Engineers in 1939, but with an increase in capacity to be able to handle all the flow that can be carried by the existing North and Central Outfalls. Treatment plant would include removal of grit, grease, (using a new Vacuator device), settling with or without chemicals, provision for chlorination, digestion of sludge, and flash drying of sludge; also, for a new submarine outfall of length equal to the existing outfall but of better construction. There are also certain plans in mind for redeeming the existing Submarine Outfall by use of interior rubber liners over the joints. This can only be done after the new outfall is in use. The present breaks in the existing Submarine Outfall are, if anything, more serious than at any previous time.

SCHEME OF INVESTIGATION

With Hyperion Outfall as the approximate center, 17 fixed sampling and observation stations were located in a 19-mile length of beach, from Malaga Cove near Palos Verde Hills to Santa Monica Canyon. At each of these stations surf water was sampled nearly every week for bacteriological examination for *Escherichia coli, hereafter referred to as "E. coli" and signifying the coliform group of bacteria.* Sanitary observations were made twice a week at each station. The numerous constituents of sewage: feces, grease, matches, rubber goods and soap, were noted each time. A record was kept also of the various nonsewage debris, such as marine life, harbor and storm debris, garbage, lunch litter, oil and tar, to ascertain what, if any, relation existed to the constituents of sewage found on these beaches. Actually no relation was found to exist between sewage debris and nonsewage debris.

During the 12 months from January 1, 1942, to December 29, 1942, the number of visits to the 17 stations varied from 73 to 77. Forty-one to 45 cultures of the surf water per station were made between February 16, 1942, and December 29, 1942. Contamination of the surf at Hyperion Outfall (Station 9) was so great that, after a few tests, sampling at that station was discontinued.

In addition, the sewage screening plant at Hyperion was visited each trip. Operating conditions were noted, such as breakdown of the screens, repairs, by-passing of either raw sewage to the beach or by-passing unscreened sewage through the Submarine Outfall. The overflow of screened sewage directly onto the beach was observed, also the condition of the outfall due to its leaks along its length. The glassy sleek field of sewage and "rafts" of sewage indicative of the spread of the sewage in Santa Monica Bay were sketched at each visit that they were observed.

At the outset, lifeguards at the various stations were interviewed for their observations of behavior of current and wind and to obtain their estimates of the number of beach visitors.

The headings under which the data of each visit were recorded follow: for each of the 17 stations, date and hour of visit, wind direction and velocity, current drift, condition of sea and spray, cleanliness of surf water, surf odor; the different classes of nonsewage debris: marine life, debris of storm origin, shipping debris, garbage, lunch litter, tar and oil; also sewage debris: soap, matches and rubber goods; the equivalent width of the grease band, type of grease, and its freshness; size and freshness of particles of feces, E. coli per c.c. in surf water and beach patronage.

The Santa Monica City guards made special written reports for our department each morning and afternoon. The reports recorded wind direction and velocity, condition of sky, ocean, surf and state of current, and the estimated number of people in bathing suits and in street clothes in the Santa Monica City Beach area. This area extends from about midway between our Stations 14 and 15 to the terminal Station 17.

At the end of each month, the attendance records for bathers and people in street clothes were obtained for all the publicly operated beaches from Redondo to Santa Monica, inclusive.

Wind data, both as to direction and velocity, were obtained from the well-equipped Los Angeles City Weather Station located at Sunset Pier

in Venice. The recordings were later translated into terms of velocity and directions, from which the aggregate mileage of wind travel from each of the eight directions for each day of the year was compiled.

Rainfall data by days and by storms were obtained from continuous rainfall record equipment at the United States Weather Bureau, whose gage is on the roof of the Federal Building in Los Angeles. Beginning February 16, 1942, samples of surf water were collected at each station nearly every week, and until June 9, 1942, samples were cultured by the investigator using the laboratory of the University of California at Los Angeles. After that date the culturing was done by the laboratory of the county health department, located at 808 North Spring Street in Los Angeles. By these arrangements samples were in the laboratory within 1.5 to 7 hours after collection. Being kept on ice, it is reasonably certain that the counts did not change significantly during transit. Every week two to four samples were tested at the bacteriological laboratory of the University of California at Los Angeles, as controls.

Rarely was culturing deferred until next day and in that case samples were put in the ice-box until being cultured.

Special investigations were made to establish the death curve of coliform bacilli in the surf water during various periods of elapsed time between sampling and culturing, both when stored at ice-box temperature and at room temperature.

Special studies were also made of the bacteriologic content of grease collected at random stations, including both freshly deposited grease and grease which had dried on the higher sands. Fresh grease particles were found to be rich in sewage organisms.

A short series of analyses of air for air-borne sewage organisms was made on the Coast Highway opposite Playa del Rey Beach. During strong in-shore winds and heavy seas large numbers of typical sewage organisms were caught on the test plates, exposed at highway level.

Based on some preliminary laboratory investigation in November, 1942, culturing for paratyphoid organisms was started late in the investigation in collaboration with the bacteriological laboratory of the University of California at Los Angeles. The findings are so indicative of the frequent occurrence of paratyphoid organisms in the polluted surf, sands and grease of Santa Monica Bay, that it is advisable to feature this phase of the investigation in future inquiries into the sanitation of these beaches.

CONDITIONS OF SEWAGE PLANT DURING THE INVESTIGATION

The sewage screening plant at Hyperion during all this investigation was kept in as good condition as was possible for this type of plant. The year 1942 was a dry one and sewage by-passing was at a minimum. Average sewage flow in 1942 was approximately 143 m.g.d. and average dry weather maximum flow for six dry months was 194 m.g.d.

Figures derived a few years ago by the city engineer showed that about 170 tons of suspended solids on a dry basis reached the Hyperion plant daily. Of this 170 tons, only about 10 tons were removed by the screening process. At least 160 tons of suspended solids were discharged into the waters of Santa Monica Bay. The tests of the sewage also showed 8 to 10 tons of grease were carried to the Hyperion plant and only a small

part of it is removable by the screening process. Since these figures were obtained, the flow of sewage and population using the sewers have increased, and hence the burden on Santa Monica Bay by the sewage is even higher than these figures indicate.

At this point it may be pertinent to remark that in spite of so much sludge added to Santa Monica Bay, nothing has appeared on the beaches to suggest the formation of sludge banks around the present outfall or elsewhere, such as occurs in the case of outlets into enclosed harbors and bays. During the laying of the present Submarine Outfall in 1924 and 1925, divers working on the inshore end reported a deep sludge deposit and sludge could be seen on the beaches. The deposit was due to disposal of raw sewage through the 2,000-foot Belle View Outfall.

If such a deposit had occurred during this investigation, it would unquestionably also have revealed itself by pellets of black digested sludge in the sea or on the beaches. In the numerous inspections by divers along the whole length of the Submarine Outfall, the divers reported the ocean floor thoroughly clean. They also spoke of currents at times so strong it was difficult for a diver to withstand them.

The only forms of pollution associated with the Hyperion Outfall have been bacterial pollution in suspension and in sand, or in the form of grease; the sewage grease itself; feces; visible sewage-borne material such as matches, rubber goods and soap; the discoloration of the sea water, and sewage-like surf odors. All of these have proven to be confirmatory indices of wide-spread travel of sewage from Hyperion onto the beaches of Santa Monica Bay.

The city maintains a good operating record for each day of the year. Among other things it gives the dates, period and size of by-pass opening every time sewage was by-passed.

A summary of the operating data for 1942 as it relates to by-passing shows the following:

January—By-passed to ocean 25 days for 1.5 to 9.25 hours daily, averaging 4.6 hours per day. By-pass slot opening was 4 feet wide and varied from a 4″ slot to a 14″ slot.

February—By-passed to ocean 4 days for 35 minutes to 2 hours, averaging 1.6 hours. By-pass slot varied from 10″ to 14″.

March—By-passed to ocean 5 times in 2 days averaging 2.6 hours per by-pass. Slot opening 12″ to 4′ 0″. By-passed to beach once for two hours.

April—By-passed to ocean 11 times in 8 days, varying from 1.0 to 8 hours, averaging 4.5 hours each by-passing. Slot opening 6″ to 14″.

May—By-passed to ocean 2 days, 2.0 to 6.4 hours and averaging 4.2 hours each day. Slot opening 5″ and 8″.

October—By-passed to ocean two times in one day, 1.5 hours and 4.25 hours respectively, averaging 2.9 hours. Slot opening 3″ and 8″. Also by-passed to beach 45 minutes on one day.

November—By-passed to beach 12 minutes one day.

There were various causes for by-passing the sewage plant other than flooding the sewers by storm water. The most common cause was screens out of use because of grease clogging or repairs.

The only flow that can now reach the main Hyperion Screening Plant is that from the North Outfall trunk sewer which has a capacity of approximately 275 m.g.d. Any catchment by the tributary sewers above this figure must be released to arroyos and storm drains within the city. Spewing and spouting of manholes during storms is a common sight in much of Los Angeles. Most of such overflow finally reaches Santa Monica Bay at Playa del Rey by way of Ballona Creek.

The average screening plant capacity with eight screens in use would average 160 m.g.d.; with nine screens, 180 m.g.d.; and with all 10 screens, 200 m.g.d. There were, however, a few periods when lard-like grease evidently from meat packing plants came down the sewer and at other times heavy oil appeared. These materials seriously cut down screen capacity. Clogging of the screens with lard was said to be at a minimum during 1942.

The Submarine Outfall capacity is thought to be good for 190 to 260 m.g.d, depending on the height of the tide over the outlet.

Deficient outfall capacity as revealed by spewing of excess effluent at the relief manhole on the Submarine Outfall close to the bluff line was almost a daily occurrence. A small amount of effluent spilled onto the beach nearly every high tide.

The condition of the Submarine Outfall in 1942 as far as one can judge by appearance was worse than in previous years. Leaks prevail all the way from midtide as far out as the eye can see. In October, 1942, a large manhole lid on the Submarine Outfall approximately 1,000 ft. offshore blew off, causing additional leakage. A photo of this leak and of other older leaks is shown in Fig. 5.

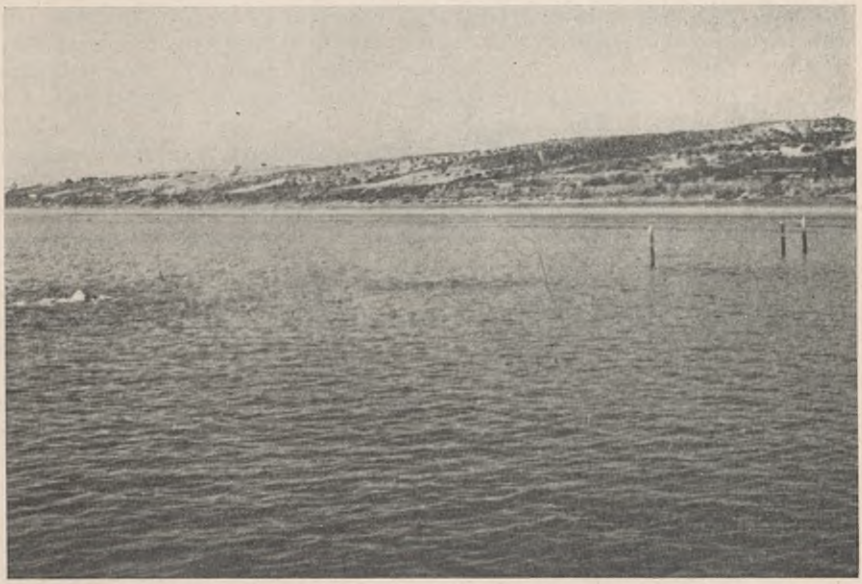

FIG. 5. Leak in Submarine Outfall thought to be due to manhole blowing off in October, 1942, is shown at left of photo. Note other leaks to the right of this one.

DISCUSSION OF CURRENT MOVEMENT IN SANTA MONICA BAY

The bearing of currents on the return of sewage solids and bacteria to shore and their distribution along shore must be manifest to even the casual observer and student of the subject. Current measurements in Santa Monica Bay are practically nonexistent as far as our search has revealed. The nearest approach to a scientific study appears to have been made by the Coast and Geodetic Survey a few years ago. Commander Lukens of the Los Angeles office advises that crews were stationed in Santa Monica Bay and in San Pedro Channel for several months trying to measure and observe surface currents, but they were generally too weak to measure and so variable and unpredictable in strength and direction that the project was abandoned. Divers working on the ocean floor along the Submarine Outfall noted strong currents moving toward the deep San Pedro Channel. As noted previously this fact undoubtedly explains the absence of bottom sludge in Santa Monica Bay.

As we understand Commander Lukens' explanation of currents here, Santa Monica Bay is like a huge bowl whose westerly rim is the land, its bottom is the deep channel lying between land and the chain of channel islands roughly 40 miles offshore, and its opposite rim is the ocean shelf between these islands. Within the large bowl and along its shores, currents behave erratically just as they might in any bowl. In this case the movement is the composite effect of tidal currents, currents induced by wind, and those induced by thermal differences and changes in salinity. The volume of non-saline fresh sewage in one hour represents a 50-foot column over the outlet one-half acre in size. Such a body of fresh water may easily set up local currents on its own account. In this case, the main motion and main currents evidently come from wind action. During the year's observation in the course of this pollution study in 1942, surface tidal or coastal currents were not discernible or at most were vague. For example, during the summer when periods of calm persisted, the sleek field of sewage dispersed in every direction. On the other hand there were three fall months when wind-induced currents up and down the coast should have been about equal. Yet there was a consistent evidence of southerly travel of sewage pollution judged by all constituents, and hence evidence of a southerly tidal current. At other times during these observations it has appeared that the sewage spread more widely up and down the coast than would be expected by mere wind direction or wind-induced currents, thus lending some further proof of some tidal currents strong enough to offset the wind-induced currents. The main behavior of the surface current is nevertheless believed to be related to the behavior of the wind. In the light of this relationship it becomes understandable that the currents in Santa Monica Bay are unpredictable and whimsical just as are the winds themselves. The deposit or return of sewage pollution onto the shores of the bay from Hyperion Outfall is to be explained by the net effect and buffeting action of the various wind movements. Therefore, a particle of sewage may start its wind-blown journey seaward and then be tossed beachward by a succeeding wind. The distribution of visible sewage matter on the shores of Santa Monica Bay can all be explained by this understanding of wind and wind-induced currents.

Light winds under three or four miles per hour (m.p.h.) seem slowly to generate a weak surface movement. At 5 m.p.h or more, the induced current is easily detectable to the eye. According to the United States Geodetic Survey, a wind velocity of 10 m.p.h. will generate a current of 30 ft. per minute; 20 m.p.h., 40 ft. per minute; and by extrapolation it may be concluded that a 5 m.p.h. wind will cause a current of approximately 20 ft. per minute.

The "set" of the current is not, however, in the same direction as the wind. According to the Coast and Geodetic Survey, winds from the southwest set a current more strongly to the north and winds from the northwest set a current still more strongly to the southwest. Currents induced by the west wind show no deviation from wind direction. Thus, it would be expected that winds from the southwest would cause pollution from the Hyperion Outfall to be carried further up the coast toward Santa Monica, while winds from the northwest would carry pollution still further down the coast.

WINDS

There are several ways by which wind influences the behavior of sewage disposed of through Hyperion Outfall. The significance of wind-induced currents which move a great body of bacterially infected water has already been indicated in discussing currents. But likewise, currents are a vehicle for transporting litter of all kinds. Whether the litter is floating or is in semisuspension the wind transports the floating sewage litter and grease just as it will anything floating.

Beneficially, wind of some strength breaks up the sleek fields of sewage and sewage rafts and makes them inconspicuous. But, at the same time, the spume and spray send to the air additional sewage odors and even bacteria, causing what some have termed "germ fog," which the strong winds carry considerable distances.

Wind data for this area are particularly complete by reason of the data collected by the Los Angeles Weather Station at Sunset Pier in Venice. Here, continuous recordings of wind as to velocity and direction are made and the data can be studied in any manner desired.

For the investigation here reported hourly velocities of wind for each direction were first taken off for each day of the year and in turn, daily wind movement by quadrants was compiled and charted on Fig. 6. In turn, wind movement was totaled for each month of the year by quadrants, also in all directions and more particularly for those winds that blew beachward. This summary appears in Table 1.

Similar data had already been computed for 1939 by the city engineer and are included here as Table 2 because it allows comparison between two different years. The year 1942 was a less windy year than 1939 in all months of the year except November. The annual average wind movement in miles per day was 155.4 miles for 1939, compared with 148.2 miles per day for 1942. The summaries show that April and May, 1942, were windy months, whereas the summer months were markedly less windy than in 1939.

A perusal of Tables 1 and 2 shows what is generally suspected, that the main winds on this coast are: (1) from the southwest, which even at its weakest in winter averaged 25 to 50 miles travel per day in 1942 and in summer 90 to 100 miles; (2) from the northeast, especially in

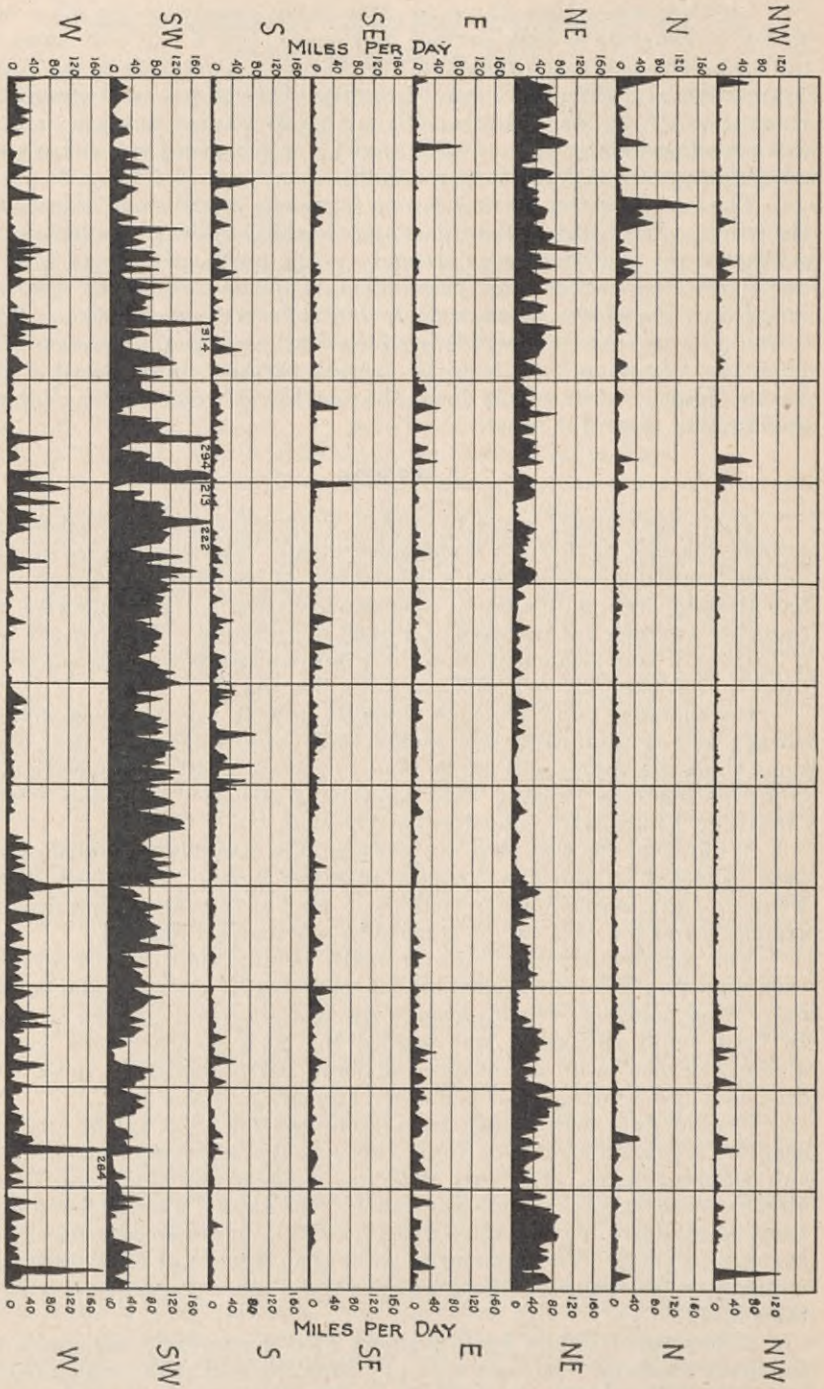

FIG. 6. Daily Wind Travel in 1942 From Directions Shown. Based on Hourly Wind Records of Los Angeles City Weather Station.

winter and late fall, averaging for 1942, 25 to 67 miles travel per day, compared to an average of only 7 to 10 miles per day in summer months; (3) the west wind is normally third in magnitude, but for 1942 it was especially weak in summer, averaging only 4 to 5 miles travel per day in June and July, compared to 44 miles the summer of 1939. Beach conditions, bad as they were in 1942, would be still more serious in another year of stronger on-shore summer wind.

Wind movement from the south, southwest, west and northwest is toward some beach. Of a total annual wind movement of 54,500 miles in 1942, 35,500 miles were beachward. Twenty-seven thousand miles were beachward from the Hyperion Outfall toward Santa Monica, and 8,500 miles of wind movement were directly on-shore or else toward southerly beaches.

TABLE 1. AVERAGE MILES OF WIND MOVEMENT PER DAY FROM DIRECTIONS SHOWN BY MONTHS FOR YEAR 1942

From Hourly Wind Records of Los Angeles City Weather Station at Sunset Pier

	WIND FROM								Total in miles in all directions	Beachward movement	
	NW.	N.	NE.	E.	SE.	S.	SW.	W.		Toward northerly beaches	Toward Hyperion and southerly beaches
January	4.7	13.2	54.2	7.7	2.5	5.1	23.3	19.8	130.5	28.4	24.5
February	7.9	2.9	49.7	4.2	5.6	15.4	43.0	17.1	145.8	58.4	25.0
March	1.6	5.4	44.0	5.3	4.3	8.5	70.9	18.5	158.5	79.4	20.1
April	6.7	7.1	28.2	11.8	6.5	11.6	89.3	14.0	175.2	100.9	20.7
May	1.3	2.7	26.2	7.1	5.8	7.7	98.0	28.4	177.2	105.7	29.7
June	0.2	2.3	9.7	7.2	9.2	10.3	99.9	3.9	142.7	110.2	4.1
July	1.6	1.0	8.3	5.7	7.0	20.8	92.8	5.3	142.5	113.6	6.9
August	1.1	0.4	7.4	6.9	5.8	5.9	96.0	14.7	138.2	104.9	15.8
September	1.5	1.4	23.6	5.3	5.9	1.7	67.4	26.8	133.6	69.1	28.3
October	7.1	1.6	29.4	12.9	10.5	7.0	45.4	27.6	141.5	52.4	34.7
November	4.6	4.7	67.5	14.2	5.0	4.9	29.8	31.2	161.9	34.7	35.8
December	9.2	3.8	55.0	10.3	2.8	1.9	24.4	23.8	131.2	26.3	33.0

Winds toward beaches are: South and southwest toward Hyperion Beach and beaches north of it; west and northwest winds toward beaches south of Hyperion.

TABLE 2. AVERAGE MILES OF WIND MOVEMENT PER DAY FROM DIRECTIONS SHOWN BY MONTHS FOR YEAR 1939 FOR COMPARISON WITH SIMILAR STATISTICS FOR 1942

From Hourly Wind Records of Los Angeles City Weather Station at Sunset Pier

	WIND FROM								Total all directions
	NW.	N.	NE.	E.	SE.	S.	SW.	W.	
January	6.6	19.5	48.8	17.4	7.8	6.7	10.0	36.9	153.7
February	10.7	44.5	39.8	8.0	1.2	4.0	26.5	44.5	179.2
March	2.3	5.0	28.0	7.7	12.6	5.2	55.0	49.6	165.4
April	1.8	2.1	20.5	9.4	6.6	3.0	73.6	37.8	154.8
May	3.3	1.7	13.9	5.4	3.6	3.2	81.0	54.5	166.6
June	2.2	1.8	16.4	3.6	3.8	5.4	84.0	44.0	161.2
July	1.6	1.4	8.7	6.6	4.3	3.1	87.0	43.5	156.2
August	2.4	1.1	11.8	7.9	6.6	5.4	88.0	26.2	149.4
September	4.3	5.2	23.4	12.5	8.2	4.9	52.2	35.5	146.2
October	5.3	6.7	51.5	11.5	1.7	2.9	36.5	39.0	155.1
November	2.0	3.9	68.5	9.1	4.4	3.4	18.5	19.5	129.3
December	5.9	11.8	64.0	8.2	3.8	3.1	25.3	27.3	148.5

The percentage of wind movement from Hyperion Outfall toward these respective beaches is shown in Table 3. In winter the wind movement toward beaches from Hyperion Outfall averaged fairly even for all parts of Santa Monica Bay, but in summer 80 per cent of the wind movement was toward northerly beaches. In October, November and December, on-shore winds to the north and to the south beaches averaged about the same. Winds from the northeast increased in these months. This latter wind carried pollution southerly. When on-shore winds followed, as was frequently the case, Station 5 in Hermosa Beach experienced its worst pollution. Station 6 also received its worst pollution in these fall months.

Of course, overall air movement due to winds does not tell the complete story. Other traits also affect the transporting power of wind. For example, there is the shifting around of wind from hour to hour and, in consequence, a buffeting action on floating particles. There is a saying hereabouts that in daytime wind is from the sea and at night from the land, and that the wind "boxes the compass." To portray the vacillation of the wind for any length of time would require pages of data. It may be sufficient therefore to illustrate the point from the actual wind record of a couple of typical days, hour by hour, presented in Table 4. The weak though fairly persistent night breeze from the northeast was followed by a gradual shift to the light southwest breeze in the afternoon. In summer, the night breezes were still more erratic and feeble, whereas the southwest wind was strong and persistent. Other days would show extreme variations from these patterns.

TABLE 3. PERCENTAGE OF TOTAL WIND MOVEMENT WHICH WAS BEACHWARD FROM HYPERION OUTFALL IN 1942

As Derived From Table 1

	Toward Northerly Beaches	*Toward Hyperion Beach and Southerly Beaches*
January	21.9%	18.8%
February	40.0	17.4
March	50.3	12.7
April	59.7	11.8
May	59.7	16.8
June	77.2	2.8
July	79.8	4.8
August	76.0	11.4
September	51.6	21.2
October	37.1	24.6
November	23.1	22.1
December	20.0	25.1

TABLE 4. SHOWING HOURLY WIND VELOCITY AND DIRECTION FOR TYPICAL DAYS TO ILLUSTRATE THAT WIND "BOXES THE COMPASS"

From Hourly Wind Records of Los Angeles City Weather Bureau

	A winter day								A summer day							
	NW.	N.	NE.	E.	SE.	S.	SW.	W.	NW.	N.	NE.	E.	SE.	S.	SW.	W.
1 A.M.	-----	-----	4	-----	-----	-----	-----	-----	2	-----	-----	-----	-----	-----	-----	-----
2	-----	-----	5	-----	-----	-----	-----	-----	-----	-----	-----	2	-----	-----	-----	-----
3	-----	-----	-----	5	-----	-----	-----	-----	-----	-----	-----	-----	3	-----	-----	-----
4	-----	-----	6	-----	-----	-----	-----	-----	-----	-----	-----	-----	2	-----	-----	-----
5	-----	-----	5	-----	-----	-----	-----	-----	1	-----	-----	-----	-----	-----	-----	-----
6	-----	-----	3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2
7	-----	4	-----	-----	-----	-----	-----	-----	-----	1	-----	-----	-----	-----	-----	-----
8	-----	-----	4	-----	-----	-----	-----	-----	-----	-----	2	-----	-----	-----	-----	-----
9	-----	4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	4	-----
10	-----	-----	4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	5
11	-----	-----	-----	-----	3	-----	-----	-----	-----	-----	-----	-----	-----	-----	5	-----
12 Noon	-----	-----	-----	-----	-----	5	-----	-----	-----	-----	-----	-----	-----	-----	8	-----
1 P.M.	-----	-----	-----	-----	-----	-----	7	-----	-----	-----	-----	-----	-----	-----	9	-----
2	-----	-----	-----	-----	-----	-----	8	-----	-----	-----	-----	-----	-----	-----	10	-----
3	-----	-----	-----	-----	-----	-----	9	-----	-----	-----	-----	-----	-----	-----	12	-----
4	-----	-----	-----	-----	-----	-----	8	-----	-----	-----	-----	-----	-----	-----	13	-----
5	-----	-----	-----	-----	-----	-----	11	-----	-----	-----	-----	-----	-----	-----	14	-----
6	-----	-----	-----	-----	-----	-----	9	-----	-----	-----	-----	-----	-----	-----	15	-----
7	-----	-----	-----	-----	-----	-----	-----	12	-----	-----	-----	-----	-----	-----	13	-----
8	-----	-----	-----	-----	-----	-----	-----	8	-----	-----	-----	-----	-----	-----	11	-----
9	-----	-----	2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	9	-----
10	-----	-----	3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	6	-----
11	-----	-----	4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	5	-----	-----
12 Midnight	-----	-----	4	-----	-----	-----	-----	-----	-----	-----	-----	-----	5	-----	-----	-----

Moreover, feeble winds induce little movement at sea of floating particles. The reverse is true of the strong breezes or winds. The net effect on beaches is the result of many hours of previous wind, and simplification of prediction or of explanation of beach pollution by winds is a refinement not yet possible to us. The erratic winds and currents likewise leave the beach visitor wholly unable to predict when the beach will be either clean or dangerous. The only way to redeem these beaches is to remove the suspended solids and grease before discharge to the ocean.

SLEEK FIELDS

Sewage sleek fields are areas of glassy sea around sewer outfalls. They are due to oil and grease. They were commonly observed and associated with Hyperion Outfall. The sleek fields were sketched as noted 74 times during the year. It is to be realized that sleek fields change rapidly with winds and currents. Observed beach deposits give a better index of the effects of fields of sewage.

Table 5, and also Fig. 7, portray the seeming behavior and variation of sleek fields as seen in these visits to Hyperion Outfall. The observations were usually in late forenoon.

In the 74 inspections for sleek fields, actual "rafts" of sewage were observed nine times. These rafts are compact masses of the coarse material, grease pellets and colored water issuing from the sewer outfall, which under conditions of calm sea frequently concentrate in narrow bands or small islands. Sometimes these rafts traveled a long way before breaking up. They have been seen as far north as Station 14 and as far south as Station 5, a spread of approximately 10 miles.

TABLE 5. SHOWING FREQUENCY OF OBSERVED DIRECTION OF TRAVEL OF SLEEK FIELDS FROM HYPERION OUTFALL DURING 74 OBSERVATIONS IN 1942

	Down Coast (Southerly)	*Head-on*	*Up Coast (Northerly)*
January	3 times	3 times	1 time
February	2	4	1
March	4	1	4
April	2	2	2
May	3	2	2
June	0	4	2
July	1	2	2
August	2	2	1
September	4	3	0
October	2	2	0
November	3	0	1
December	1	4	1
Total	27	29	18

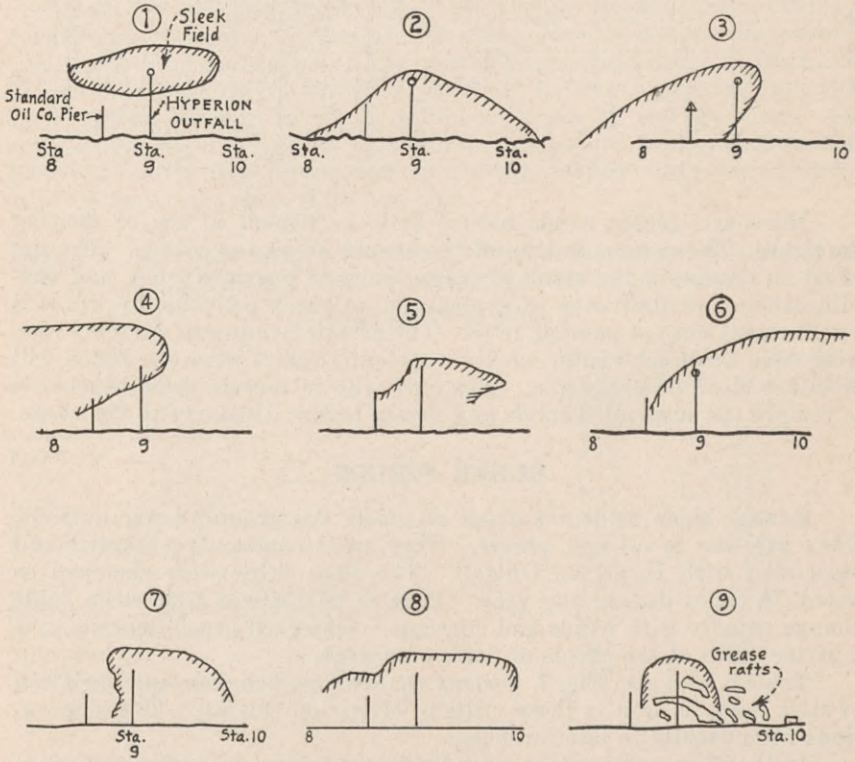

FIG. 7. Sketches Showing Characteristic Sewage "Sleek" Fields from Hyperion Outfall.

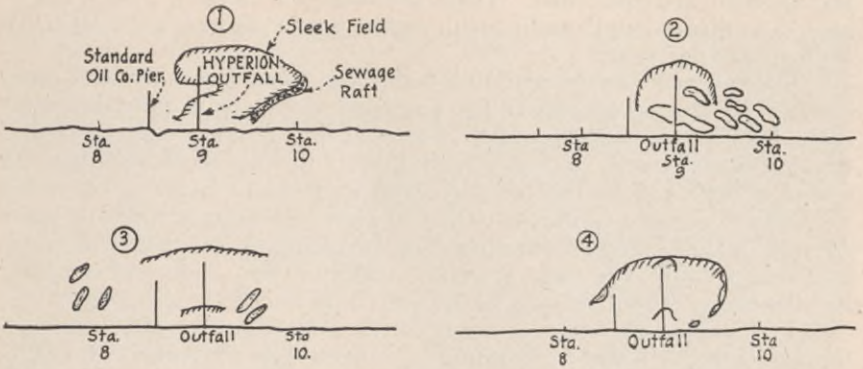

FIG. 8. Characteristic Sewage "Rafts" from Hyperion Outfall.

RAINFALL

Rainfall records for 1942 at Los Angeles City Weather Station at United States Weather Bureau at Federal Building, Los Angeles are as follows:

	Inches		*Inches*
January 1	.22	April 20	.01
January 21	.09	April 21	.21
January 22	.28	April 28	.05
January 25	Trace	August 9	.19
February 14	.04	August 10	.04
February 21	.98	August 31	Trace
February 22	.01	October 11	.02
February 27	.02	October 12	Trace
March 11	.23	October 28	.56
March 12	Trace	November 3	.04
March 14	1.03	November 15	.04
March 24	Trace	November 18	.10
April 3	.29	November 19	.06
April 4	.20	December 5	Trace
April 5	.30	December 17	.01
April 6	Trace	December 23	.19
April 9	.02	December 24	.52
April 10	.38	December 25	.29
April 11	.28		
April 12	Trace	Total, 1942	7.40
April 14	.40		
April 17	.30	Normal	15.23

Traces of rain on May 1, 7, 26; June 6, 10, 12, 25; September 18. The normal rainfall is 15.23 inches. Therefore, 1942 was decidedly a dry year and by-passing of sewage was no doubt reduced in consequence.

BEACH USE AND CROWDS

From Malaga Cove on up the coast through Los Angeles County is an endless sandy beach that is a most popular source of seashore recreation for much of southern California. In the 20-mile stretch covered by this investigation there are 14 major beaches so far as ownership and

management are concerned. These are listed on Table 6. They aggregate 15.5 miles in length and provide recreation for upwards of 40,000,000 visitor-days per year.

Use of beaches for recreation is year-long. Some use is made of every beach every day of the year. The hugeness of crowds is quite definitely related to warm weather and to week-end and holiday travel. Warm weather in mid-week is almost certain to start throngs of people planning a week-end visit to the beaches and at such times all beaches are crowded to the limit. Photos in Fig. 9, 10 and 11 give only a meager idea of beach crowds. Table 7 shows certain weather data more or less related to recreational activity. The visitors swim, lounge on the sands and eat their lunches there. Children play in the wet sands where waves lap the shore.

Following completion of the Coast Boulevard, about 1933, connecting Playa del Rey and El Segundo, the heretofore little-used Hyperion beaches also began to draw increasing crowds which overflowed from the more heavily patronized beaches north and south. These beaches between Ballona Creek and Hyperion, about three miles in length, are among the closest to Los Angeles proper, and afford easy automobile parking.

TABLE 6. SHOWING PUBLIC AND MAJOR PRIVATE RECREATION FRONTAGES ON SANTA MONICA BAY COVERED BY INVESTIGATION 1942

Beach and owner	Jurisdiction	Beach frontage	Station
(a) Torrance City	Los Angeles County	4,500 ft.	2
(b) Clifton Beach (County)	Los Angeles County	4,000 ft.	Bet. 2 & 3
(c) Redondo (County)	Los Angeles County	3,500 ft.	3
(d) Private-P. E. Ry.		1,500 ft.	
(e) Redondo City	Los Angeles County	4,000 ft.	4
(f) Hermosa City	Los Angeles County	11,000 ft.	5 and 6
(g) Manhattan City (City, etc.)	Los Angeles County	4,000 ft.	6 and 7
(h) Manhattan (State Park Dept.)	State	4,750 ft.	7
(i) El Porto (County)	Los Angeles County	2,800 ft.	8
(j) Playa del Rey (Los Angeles City)	Los Angeles City	7,700 ft.	10
(k) West Port Beach Club, etc. Private (closed)	Los Angeles City	4,700 ft.	11
(l) Venice (Los Angeles City, etc.)	Los Angeles City	15,400 ft.	12, 13, 14
(m) Santa Monica City	Santa Monica City	13,000 ft.	15, 16
(n) Santa Monica State	State	1,100 ft.	17

Barring quarantine, they could be as heavily patronized as any. In 1933, the Los Angeles City Recreation Department made plans for an elaborate aquatic park development here, but had to abandon the plans, largely because of the pollution aspect. However, the recreation department did construct stairways down to the beach and established lifeguards, and the beach has become very popular.

Each of these beaches gets more or less lifeguard service by city, county or State, depending on jurisdiction. In most of them guards are maintained only through the summer months. Lifeguards are kept on all year at city and State beaches in Santa Monica, also at the headquarters at Sunset Pier in Venice, and at Hermosa Beach Pier.

Most of the beaches are also given some kind of beach cleaning. The common practice is simply to rake up the large debris by hand rakes. Hermosa Beach has a novel tractor rake which is used from spring until fall, sometimes as often as four or five times a week. It removes some of the debris and the remainder is harrowed into the sand by the machine—and to outward appearances, the beaches so raked appear physically clean after the operation.

FIG. 9. An ordinary Sunday beach crowd in summer. Playa del Rey Beach, south of West Port Beach Club near Station 10.

FIG. 10. A beach crowd just south of Venice Pier (in distance) same day as Photograph No. 6. Near Station 13.

FIG. 11. Santa Monica State Beach, showing Santa Monica Canyon Creek traversing the beach, also a mid-week crowd in warm weather. At Station 17.

TABLE 7. SUMMARY OF WEATHER, WIND, AND OF BEACH PATRONAGE—1942

1942	Beach patronage (thousands)		Temperature, 1:00 p.m.				Days sky clear 10:00 a.m.	Rained		Wind travel—average miles per day					Days wind velocity was:	
			Air			Ocean				Total all directions	Toward beaches				Above 10 m.p.h.	5-10 m.p.h.
											Northerly		Hyperion and southerly			
	Bathers	Spectators	Average	Max.	Min.			Days	Inches		Miles	Per cent	Miles	Per cent		
Jan.	85	575	63	90	52	54	12	3	0.59	130.5	28.4	21.9	24.5	18.8	5	21
Feb.	122	674	65	77	46	54	7	4	1.05	145.8	58.4	40.0	25.0	17.4	14	14
Mar.	518	696	68	81	45	55	15	2	1.26	158.5	79.4	50.3	20.1	12.7	18	13
April	426	1,105	70	82	61	62	6	11	2.44	175.2	100.9	59.7	20.7	11.8	18	12
May	5,736	5,905	69	83	62	59	16	0	0	177.2	105.7	59.7	29.7	16.8	20	10
June	1,147	1,647	74	78	68	62	3	0	0	142.7	110.2	77.2	4.1	2.8	17	13
July	4,217	4,294	75	80	67	64	5	0	0	142.5	113.6	79.8	6.9	4.8	19	12
Aug.	3,365	3,247	73	83	66	64	2	2	0.23	138.2	104.9	76.0	15.8	11.4	13	17
Sept.	1,336	1,603	75	80	70	62	3	0	0	133.6	69.1	51.6	28.3	21.2	14	16
Oct.	518	693	73	87	52	63	7	2	0.58	141.5	52.4	37.1	34.7	24.6	9	21
Nov.	507	903	70	85	60	58	17	4	0.24	161.9	34.7	23.1	35.8	22.1	7	22
Dec.	125	373	67	86	54	52	17	4	1.01	131.2	26.3	20.0	33.0	25.1	5	25

TABLE 8. SHOWING NUMBER OF BEACH VISITORS IN THOUSANDS TO BEACHES IN 1942

B—In Bathing Suits; S—In Street Clothes

1942	Redondo County Beach		Redondo City Beach		Hermosa City Beach		Manhattan City Beach		Manhattan State Beach		El Porto County Beach		Los Angeles City Beach		Santa Monica City Beach		Santa Monica State Beach		Total	
	B	S	B	S	B	S	B	S	B	S	B	S	B	S	B	S	B	S	B	S
Total Monthly Visitors in thousands																				
January	1	13	1	21	15	138	2	14	1	9	1	8	2	151	56	162	6	59	85	575
February	1	16	5	20	24	183	5	14	1	11	3	20	1	126	74	223	8	61	122	674
March	6	30	3	36	80	217	15	41	9	31	7	29	4	171	349	245	35	96	508	896
April	9	25	14	35	239	533	15	39	15	31	8	25	88	339	------	------	38	77	426	1,104
May	19	52	14	48	504	1,027	18	35	98	153	39	64	1,468	2,850	3,489	75	87	1,601	5,736	5,905
June	24	52	22	35	399	905	25	37	20	37	31	57	128	241	367	117	131	166	1,147	1,647
July	62	98	85	123	1,130	2,532	102	153	87	163	143	245	279	476	2,135	182	194	322	4,217	4,294
August	51	96	53	77	984	1,813	80	114	41	92	140	275	275	416	1,639	173	102	191	3,365	3,247
September	31	54	16	34	414	773	52	68	47	106	29	63	146	252	534	117	67	136	1,336	1,603
October	8	20	6	23	228	334	17	41	------	------	16	33	96	163	147	79	------	------	518	693
November	7	22	6	13	231	452	15	46	------	------	12	32	65	174	171	164	------	------	507	903
December	4	11	3	11	19	50	6	24	------	------	10	35	29	122	54	120	------	------	125	373
Totals	223	489	228	476	4,267	8,957	352	626	319	633	439	886	2,581	5,481	9,015	1,657	668	2,709	18,092	21,914
Visitors in Thousands for Maximum Day																				
January	0.1	1.2	0.3	4.3	1.3	11.0	0.3	2.0	0.2	0.9	0.2	1.5	0.3	14.0	8.0	17.0	2.0	8.0	12.7	59.9
February	0.3	2.0	2.0	3.0	6.0	15.0	0.5	1.0	0.3	2.0	1.0	4.0	2.0	13.0	26.0	22.0	2.0	9.0	40.1	71.0
March	2.0	7.0	1.0	7.0	15.0	22.0	5.0	8.0	4.0	6.0	2.0	3.0	1.0	20.0	100.0	20.0	8.0	15.0	138.0	108.0
April	2.0	5.0	5.0	8.0	70.0	100.0	5.0	9.0	6.0	11.0	1.2	3.0	12.0	22.0	------	------	9.0	12.0	110.2	170.0
May	4.0	8.0	4.0	10.0	100.0	135.0	5.0	8.0	12.0	21.0	8.0	16.0	14.0	23.0	80.0	20.0	11.0	21.0	238.0	262.0
June	5.0	7.0	7.0	7.0	77.0	132.0	9.0	10.0	3.0	6.0	8.0	14.0	16.0	33.0	43.0	14.0	18.0	27.0	186.0	250.0
July	8.0	20.0	7.0	12.0	175.0	250.0	11.0	15.0	9.0	15.0	11.0	21.0	30.0	60.0	280.0	14.0	28.0	40.0	559.0	447.0
August	7.0	15.0	8.0	8.0	122.0	189.0	15.0	20.0	5.0	10.0	12.0	24.0	25.0	52.0	325.0	16.0	21.0	35.0	540.0	369.0
September	5.0	5.0	3.0	5.0	95.0	150.0	13.0	16.0	6.0	12.0	6.0	13.0	12.0	40.0	105.0	14.0	12.0	24.0	257.0	279.0
October	2.0	4.0	2.0	4.0	85.0	100.0	5.0	9.0	------	------	4.0	4.0	9.0	16.0	38.0	15.0	------	------	145.0	152.0
November	1.0	3.0	1.0	2.0	65.0	115.0	5.0	14.0	------	------	3.0	4.0	4.0	11.0	70.0	36.0	------	------	149.0	185.0
December	0.4	1.2	0.4	2.0	4.0	6.0	1.0	3.0	------	0.3	3.0	9.0	3.0	7.0	10.0	30.0	------	------	21.8	58.5
Totals	36.8	78.4	40.7	72.3	815.3	1,225.0	74.8	115.0	45.5	84.2	59.4	116.5	128.3	311.0	1,085.0	218.0	111.0	191.0	2,396.8	2,411.4

Beaches south from the Standard Oil Tank Farm, including Redondo Beach and also the beaches from Playa del Rey north have always been popular. They are easily accessible; they are broad and their sand is fine-grained. There are recreation piers, concessions, and, in recent years, lifeguard protection, all of which attracts recreation-minded crowds.

The guards at all beaches attempt to make a count each day which enables them to estimate the crowds using their particular beach. The figures herein have been obtained from these lifeguard records, and appear in monthly summary form in Table 8. It is to be noted that in 1942 there was an estimated total of 40,000,000 beach visitors in the section covered by this investigation. Of the number, 18,000,000 were in bathing suits, and 22,000,000 in street clothes. Within the 10 miles of quarantined area alone, it is estimated that in 1942 there were about 20,000,000 visitors, or half of the total. Of these, over 6,000,000 were in bathing suits.

Even in the grossly polluted section between Playa del Rey and Hyperion, the guards estimated 5,000,000 total visitors for the year. For a single heavy day in July, 1942, the poll showed 1,000,000 for all the beaches listed, and 470,000 occupied the beaches now under quarantine. Nearly 40 per cent of the people were bathers. On the Fourth of July, 1941, it was estimated that 90,000 people used the grossly polluted Playa del Rey Beach alone. On warm week ends, 40,000 to 50,000 people used it per day and on warm weekdays, 8,000 to 15,000 per day.

A study of average density of use of these beaches, considering the frontage of each, shows the following for the maximum day for July, 1942, which was the heaviest day for visitors to the beaches:

	Visitors per 100 ft. frontage
Redondo County Beach	234
Redondo City Beach	320
Hermosa City Beach	3,800
Manhattan City Beach	650
Manhattan State Beach	500
El Porto County Beach	450
Los Angeles City Beach (El Segundo to Santa Monica)	276
Santa Monica City Beach	2,260
Santa Monica State Beach	6,200

It is to be concluded that large numbers of people are menaced by this beach pollution. As a corollary even larger numbers would be well served by a clean-up of the polluted conditions. The heavy use of Hermosa Beach, part of which lies in the quarantined area, points to the capacity of the Santa Monica Bay beaches to serve the south. To redeem beaches so valuable as these and provide an economical recreation for millions of people surely justifies considerable investment in keeping the surf and beaches clean and safe. Furthermore, until the sewage hazard is removed, the people inclined to use the more polluted beaches need to be forewarned or even protected in their choice of recreation.

Contrary to indications in the earlier analyses of surf water by the city engineer that filth from beach crowds caused high E. coli counts, this investigation in 1942 reveals no pollution effects of consequence by the crowds in any particular, except possibly heavier deposits of non-sewage lunch debris.

RESULTS OF SAMPLING OF SURF AND OF OBSERVATIONS

The section each side of Hyperion Outfall selected for the sanitary survey was laid out to encompass all the area that had previously been reputed as receiving sewage in any noticeable amount. This systematic study ended on the south at Malaga Cove below Palos Verde Hills and on the north at Santa Monica Canyon Creek in Santa Monica, thus covering a distance of approximately 19 miles. As mentioned previously, the 19 miles was divided into 17 stations, Station 9 being the Hyperion Outfall itself, with 8 stations each side of the outfall.

Stations were spaced 0.7 to 1.55 miles apart, but the separation of stations was modified by such considerations as convenience or access to the beach, popularity of their use and avoidance of piers, creeks or abnormal conditions that might introduce a form of pollution that would be confused with that due to the Hyperion Outfall. The choice of stations has proven to be fortunate, except possibly two of the most northerly ones, Stations 15 and 17 in Santa Monica, where creeks or storm sewers were difficult to escape. The position of stations with respect to city boundaries is shown on the map, Fig. 1, page 9. The stations are described in more detail later on in the report, together with a word summary of the behavior of each station as regards its cleanliness or pollution throughout the investigation.

Under the present heading, the purpose is to consider the mass of evidence as related to Santa Monica Bay as a whole. Three general classes of material go to make the estimate of the extent and degree of pollution of Santa Monica Bay and fix its origin. These are: First, the sewage organisms of which E. coli is the recognized best index; second, sewage litter, debris, discolored water and malodors which are outstandingly of sewer origin; and third, the non-sewage debris.

Sewage debris includes rubber goods, matches, soap and especially sewage grease which the aggregate households of the city send down the kitchen drains in large quantity. Nonsewage debris means the litter one sees on most shores—kelp and seaweed, harbor and shipping debris such as boxes, crates, sticks and timbers from waterfront work, garbage-like material, lunch refuse and papers, oil and tar. Many of these latter items have points of origin of their own and the pattern of their dispersal helps to understand the spread of constituents emerging from Hyperion Outfall.

E. coli in Surf Water. The samples of surf water for this investigation were collected by the investigator of the Bureau of Sanitary Engineering at the several stations, usually once a week from February 16, 1942, through the year. The samples were taken regularly on Tuesday and only occasionally on a Monday. Thus they do not overlap the periods of week-end crowds. Routine sampling began February 16, 1942. Forty-four series were thereafter obtained or a total of 750 samples.

Samples were taken irrespective of tide, wind, crowds or other conditions. Therefore they most nearly represent the average of all conditions that occur during daylight hours for the forepart of the week.

Samples were collected using a 20-foot bamboo pole from the end of which a sterile sample bottle of about 120 c.c. capacity was dangled from

a short loop. Samples were taken from an incoming wave by reaching as far out as the pole permitted. When sampling in polluted water, the loop cord was wiped fairly dry and sterilized by an alcohol antiseptic after each use.

During the early part of the investigation, until June 6th, there was more or less parallel culturing in the bacteriological laboratory of the University of California in Los Angeles and in the County Laboratory under Dr. R. V. Stone. Thereafter the remaining samples were analyzed in Dr. Stone's laboratory.

Standard Methods for the Examination of Water and Sewage as issued by the American Public Health Association were followed throughout. Dilutions routinely were two 1 c.c. portions, two 0.1 c.c. and two 0.01 c.c. Inoculation was into lactose broth for 24 to 48 hours. All presumptive coliform bacilli were confirmed on Eosin Methylene Blue agar (E. M. B.) and doubtful colonies were put through the completed test using lactose broth, E. M. B. agar, and Gram's Stain. Results were computed as the most probable number by the Hoskin's Index. Results were charted both by stations and by months for study purposes.

In judging the potential danger or freedom from danger, 10 E. coli per c.c. is used as a limiting standard for assured safety for recreational use of the surf water. This so-called "standard" was arbitrarily set by this bureau many years ago, in judging the performance of salt water outfalls along the California coast.

Considerations arguing for this particular figure as a limiting standard for safety are the following: First, the limit is about 500 times the pollution allowed by the United States Public Health Service in drinking waters, which is a standard that has been universally accepted by water and health experts for many years. Comparing relative ingestion of drinking water and possible ingestion of salt water in the course of bathing, of say 2 or 3 c.c. per swim, the two figures harmonize reasonably. Second, there was no well defined epidemiology to indicate that water within the standard had caused ill health. Therefore it reasonably protected recreationists. Third, there was the fact that many natural streams and bodies of salt water soon reach that level of E. coli but reach lower levels much more slowly. Therefore the standard, even though arbitrary, should not operate in any important degree as confiscatory of recreation rights. Fourth, any less severe standard as applied to disposal of raw or screened sewage in salt water would often show "approved" areas to lie within visible sleek fields of sewage and hence judgment would probably appear to a layman as lacking in common sense and decency.

Later, other states took up the subject of standards for recreation waters. New York City Health Department set its limiting standard for its salt water recreation at 30 E. coli per c.c. The State Department of Health in Connecticut bases judgment on one E. coli per c.c. under average conditions and allows 10 per c.c. as a maximum. A well recognized committee of the American Public Health Association and the Conference of State Sanitary Engineers, based on a correlation of E. coli findings and Sanitary Surveys, classes outdoor bathing waters containing over 10 E. coli per c.c. as "Class D" and unacceptable for recreation uses. In another field it is of interest to note that the standard allowed for safe

oyster growing beds in salt water is E. coli 0.5 per c.c. Since the tolerable contamination in Class D recreation waters is 20 times that allowed in waters over oyster beds, it should be evident that the standard set for recreation waters is not a severe one and on all counts is fair indeed.

Because of occasional freak or anomalous results that are inevitable in the testing of water, sewage or other substances for E. coli, an excess above the standard 20 per cent of the time is arbitrarily allowed by us before deciding the length of beach that violates the standard. In this connection it may be noted that the Public Health Service allows deviation in excess of its drinking water standard on 5 per cent of the samples.

It should be manifest that the mass of the evidence needs to be examined as a whole or by shorter periods to form judgment rather than to depend on only a few samples or observations.

The results of the surf sampling have therefore been compiled for all the stations, month by month and the 12 sheets are here shown as Fig. 12 to 23, inclusive, to show the occurrence and amount of coliform bacilli and of grease deposits. Where the charts or text indicate "E. coli" the coliform group is implied, as defined in Standard Methods of American Public Health Association.

Turning these pages one can not but be struck by the tendency of fields of pollution to switch back and forth with the Hyperion Outfall as the fulcrum. For the months of April, May, June, and July the field of E. coli contamination in the surf centered northerly near Station 12 or 13 in Venice and on frequent occasions its limitations in excess of 10 E. coli per c.c. extended from Station 7 or 8 to Station 14 or even 15. For the winter and fall months, pollution centered on Station 9 or 10 and frequently extended from Station 5 or 6 to Station 12 or 13.

Sewage Grease. Sewage grease is not at all like oil or tar. In a sewage plant grease may be seen separating out as a gray metallic scum. In the case of the sewage disposal at Los Angeles, the material passes readily through the screens with only slight extraction along with the small amount of screenings removed and it issues from the submarine outfall or from leaks along it. It is estimated that fully 8 to 10 tons a day of grease were discharged through this outfall. The grease readily congeals in the cold ocean water into gray, pebble or shell-like specks or in some instances into a froth. In any form grease is easily recognized by eye and by the greasy feel. In congealing, grease encases not only sewage organisms, which continue to live in it, but tends to form around small particles of feces. When particles are opened, the yellow fecal center can often be observed. Since grease floats readily on the surface of the bay, it is easily wind-blown and it is one of the most sensitive indices of travel of sewage pollution, in this instance. It may also be an index of danger to health because each particle, especially if still fresh, contains not only sewage organisms but may contain feces and pathogens. On the bodies of bathers, sewage grease is revolting and difficult to remove. Some people resort to a "gasoline bath" after a stay on the beach.

There is no recognized yardstick by which to measure the grease on beaches such as these. We resorted to an equivalent grease band or sheet of grease. Grease is usually left deposited in wave rows of varying

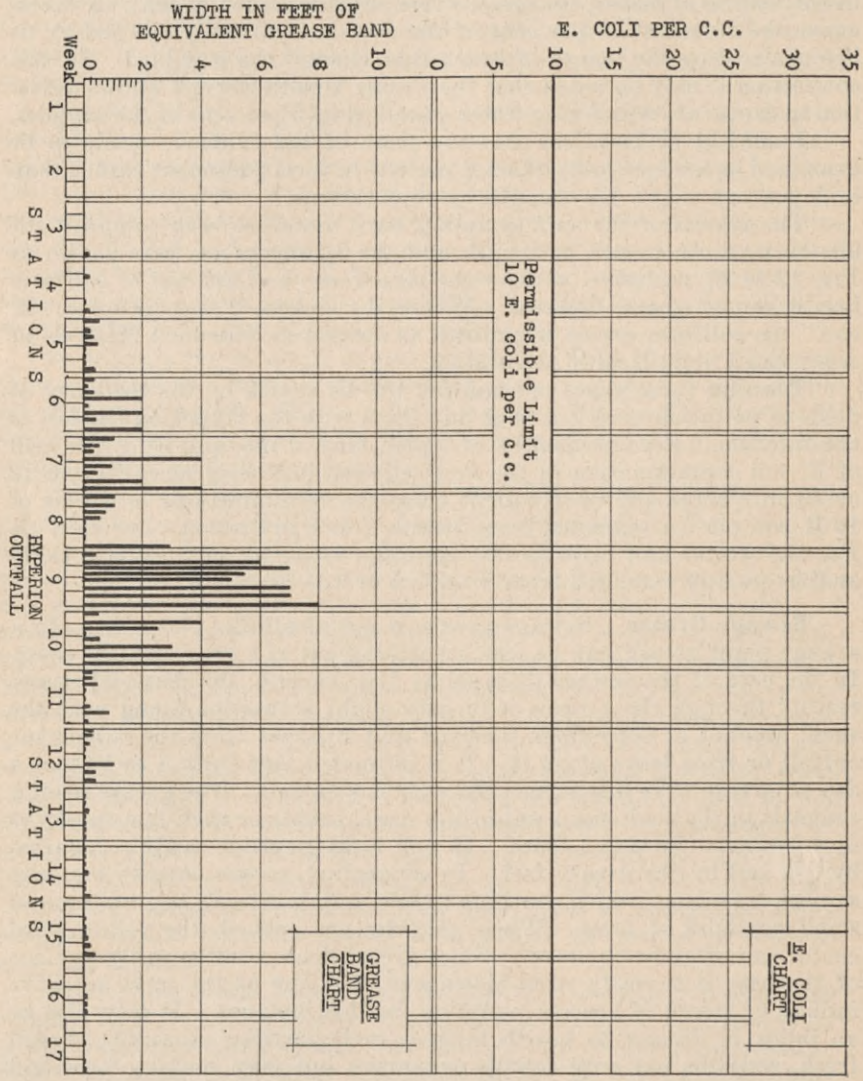

FIG. 12. E. Coli and Grease Band by Stations for JANUARY 1942.

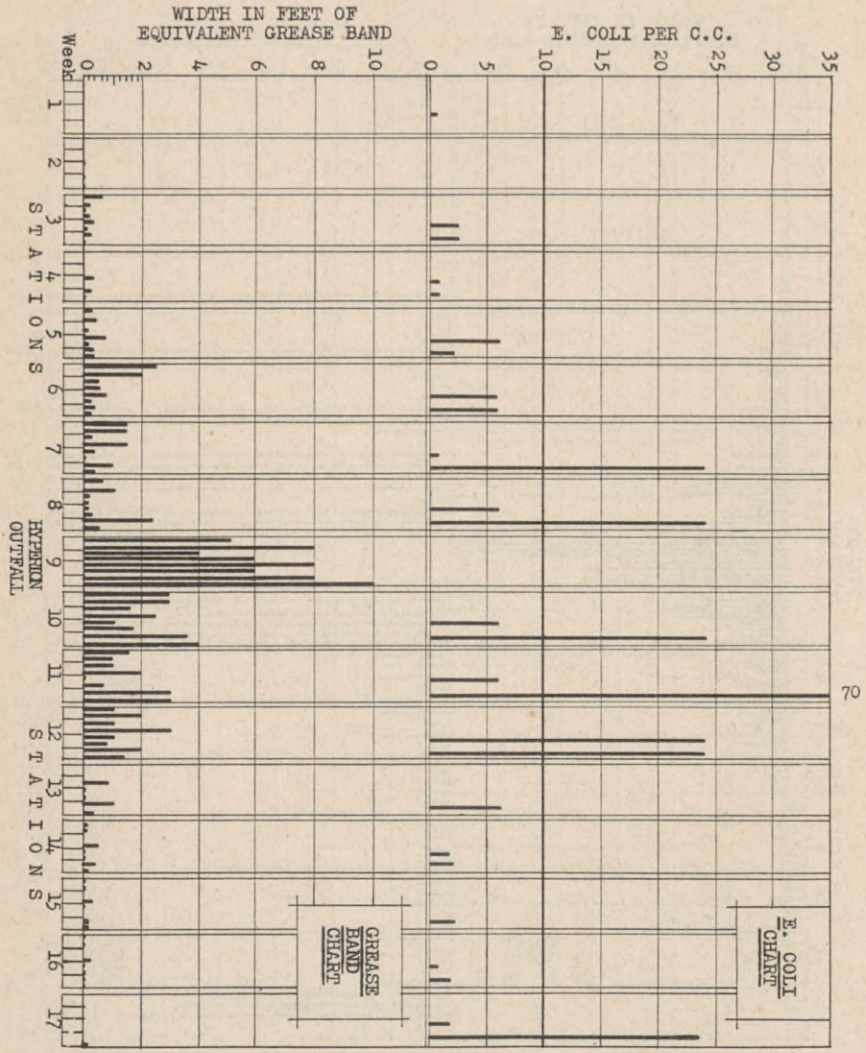

FIG. 13. E. coli and Grease Band by Stations for FEBRUARY 1942.

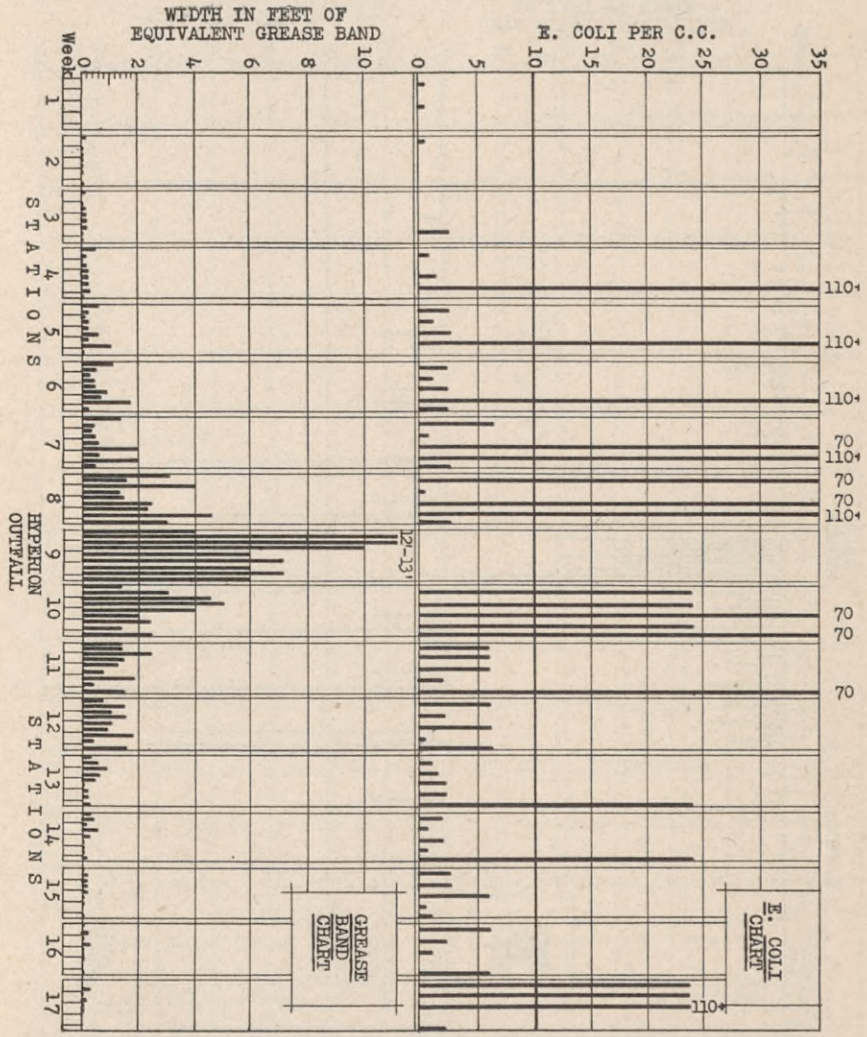

FIG. 14. E. coli and Grease Band by Stations for MARCH 1942.

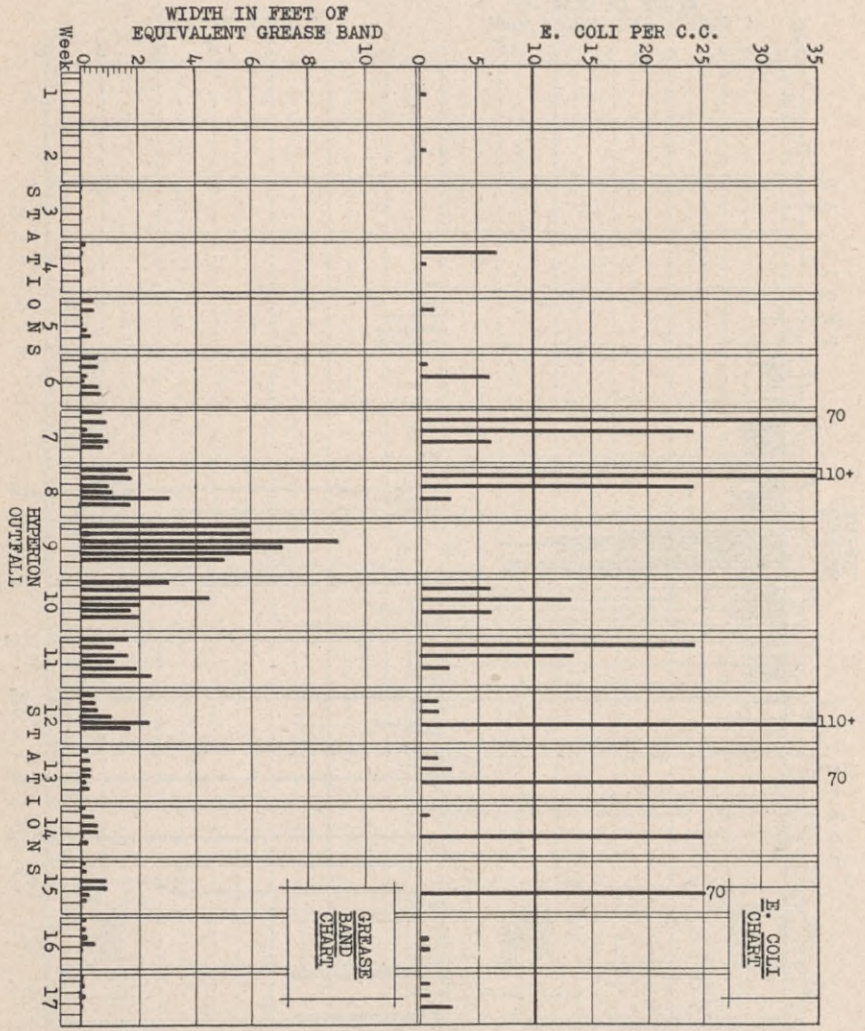

FIG. 15. E. coli and Grease Band by Stations for APRIL 1942.

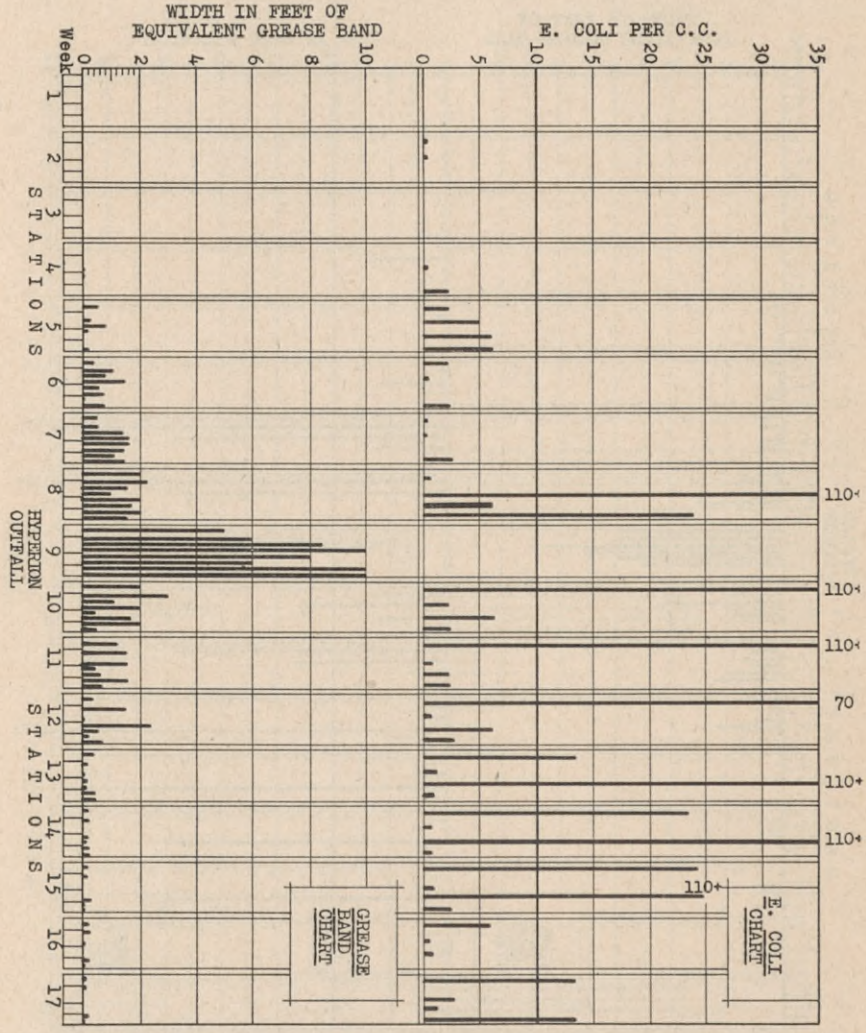

FIG. 16. E. coli and Grease Band by Stations for MAY 1942.

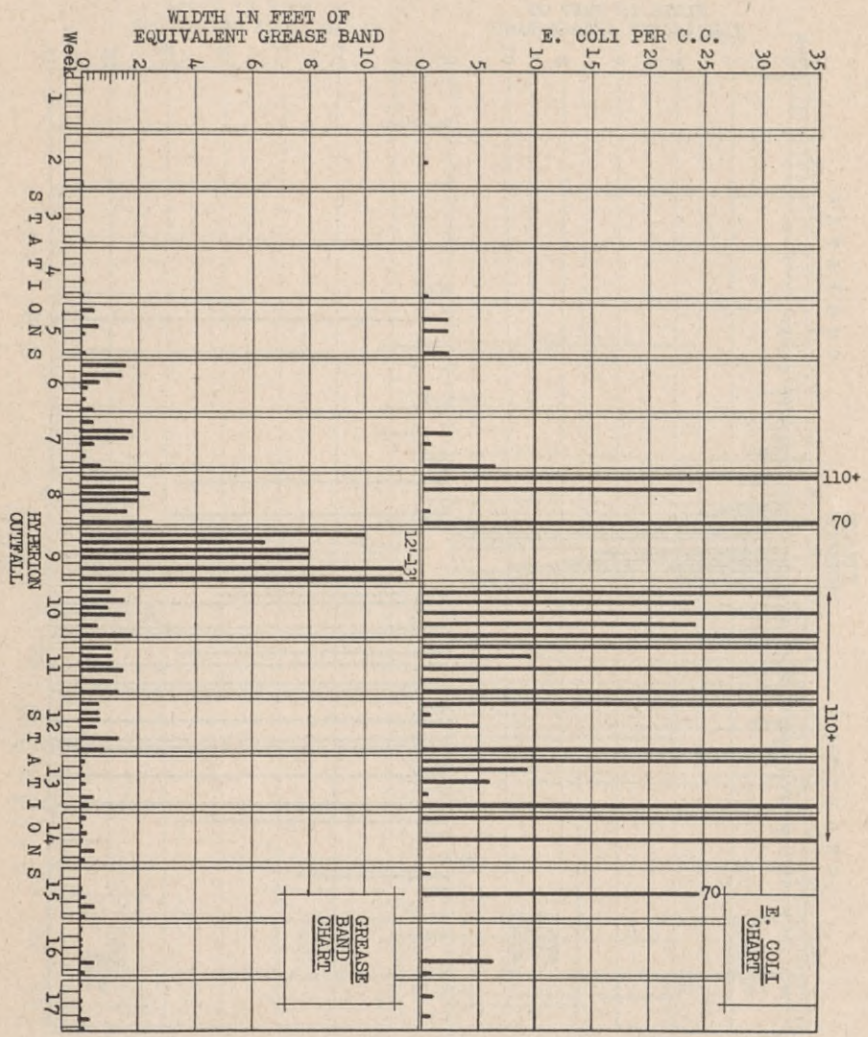

FIG. 17. E. coli and Grease Band by Stations for JUNE 1942.

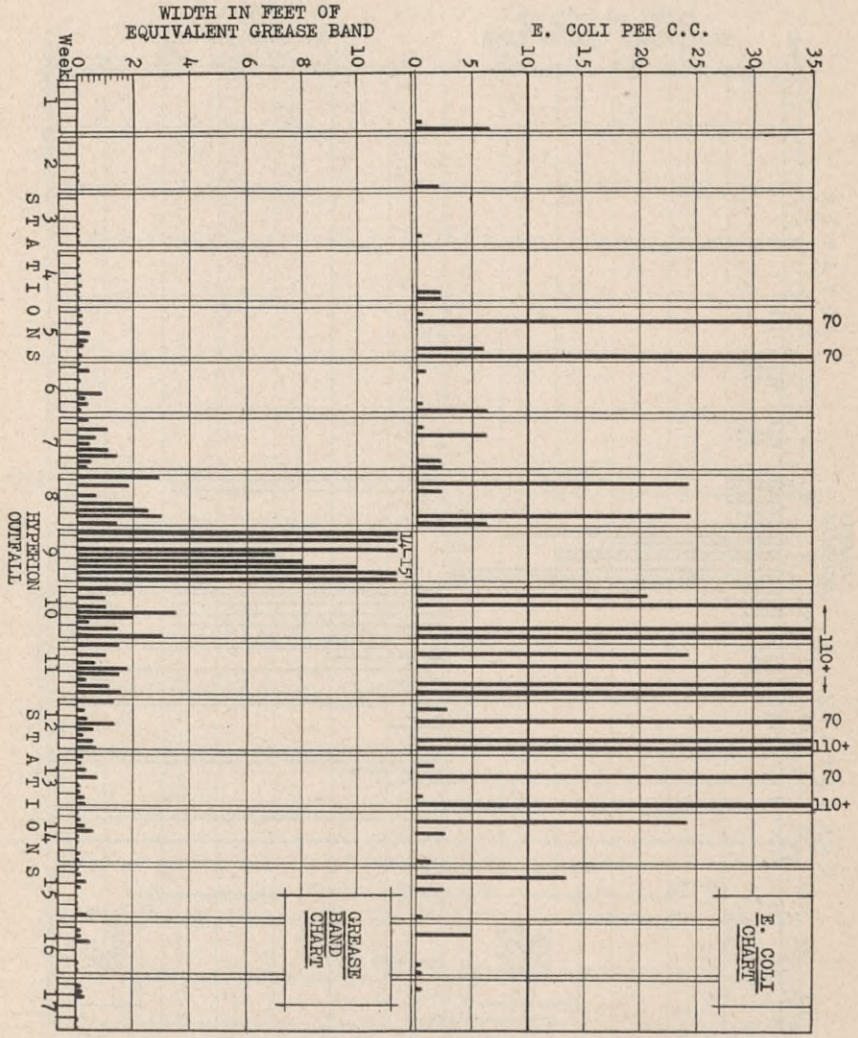

FIG. 18. E. coli and Grease Band by Stations for JULY 1942.

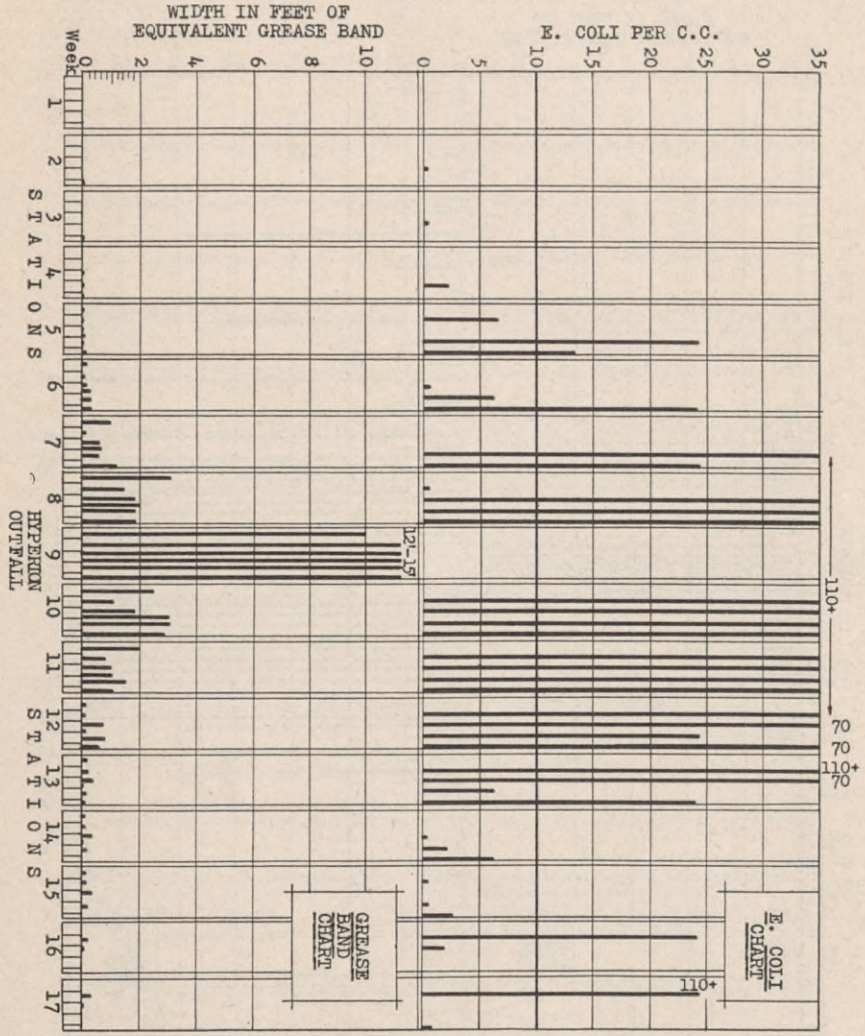

FIG. 19. E. coli and Grease Band by Stations for AUGUST 1942.

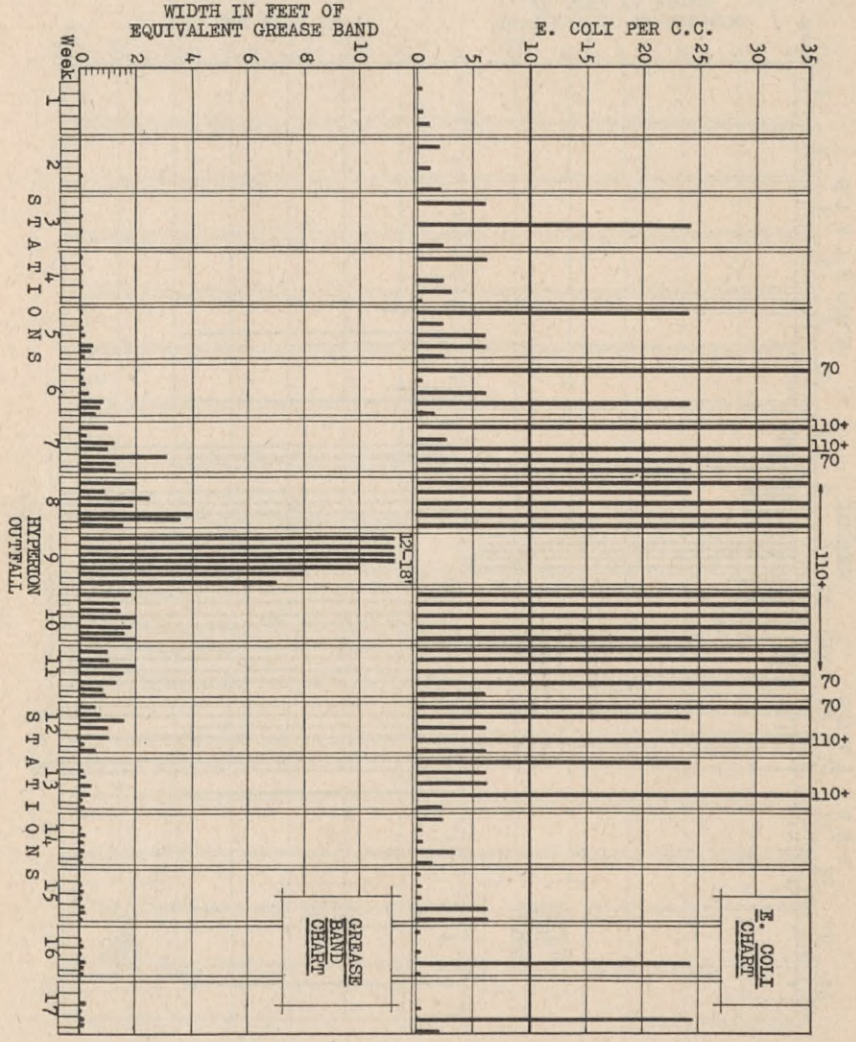

FIG. 20. E. coli and Grease Band by Stations for SEPTEMBER 1942.

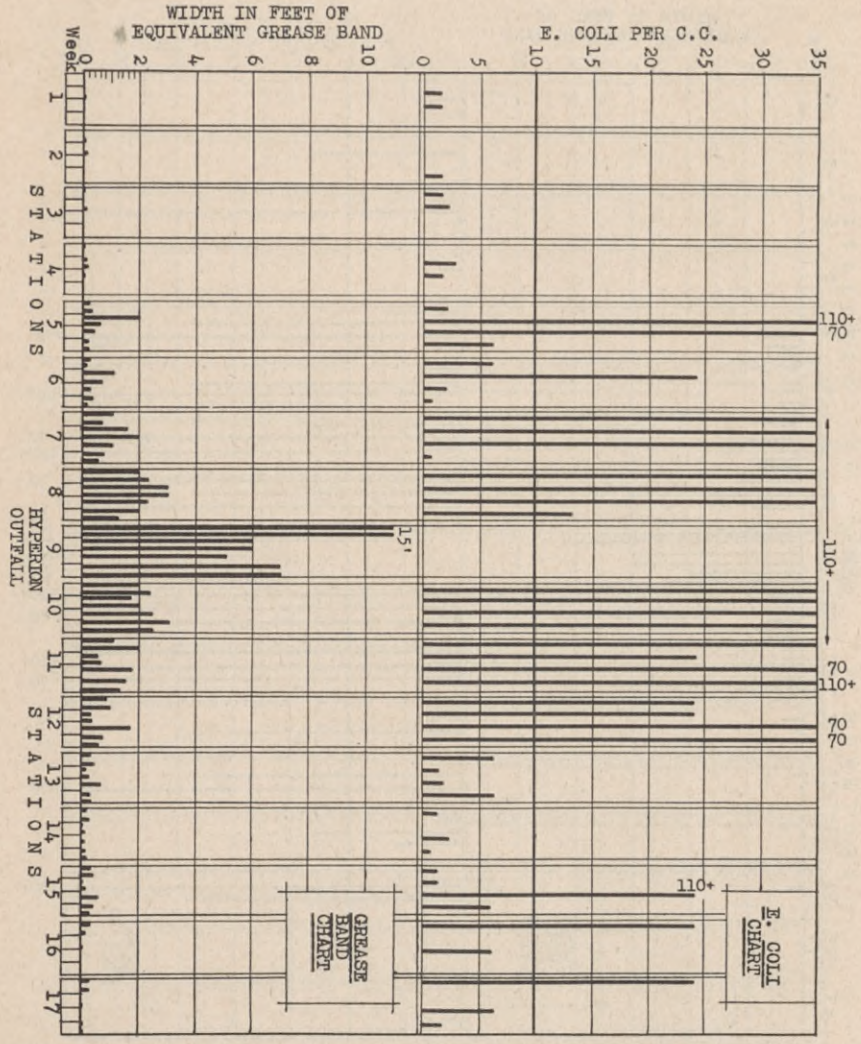

FIG. 21. E. coli and Grease Band by Stations for OCTOBER 1942.

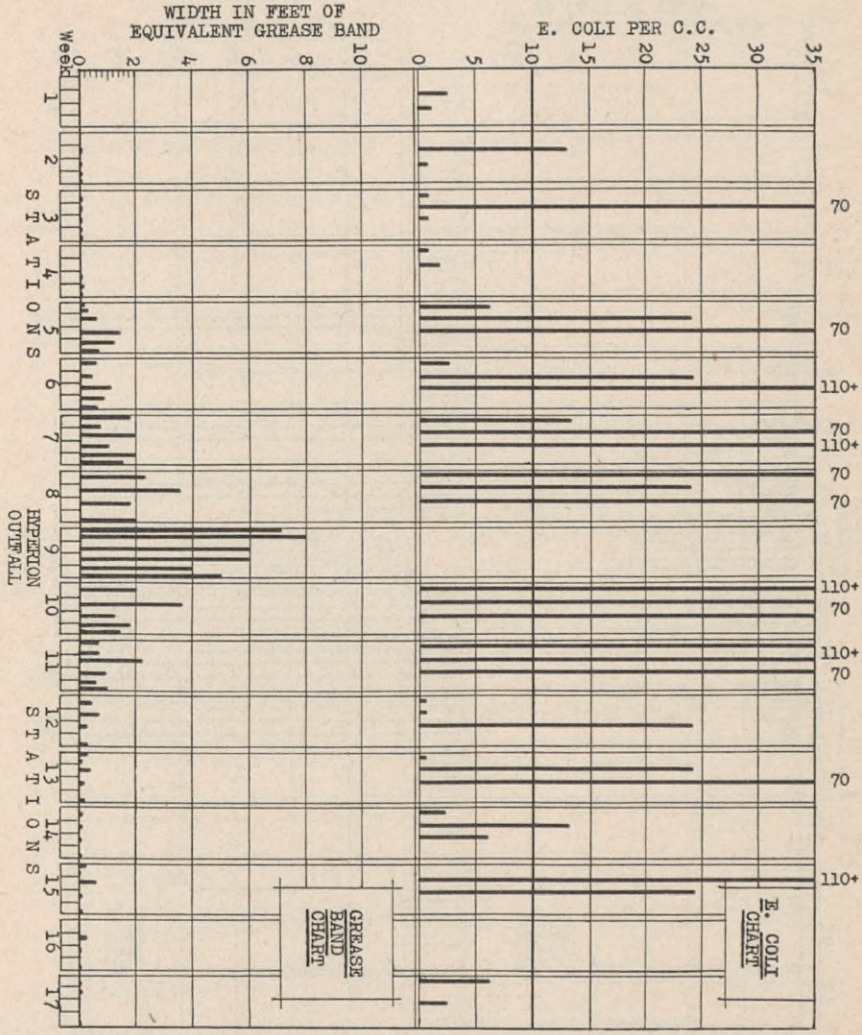

FIG. 22. E. coli and Grease Band by Stations for NOVEMBER 1942.

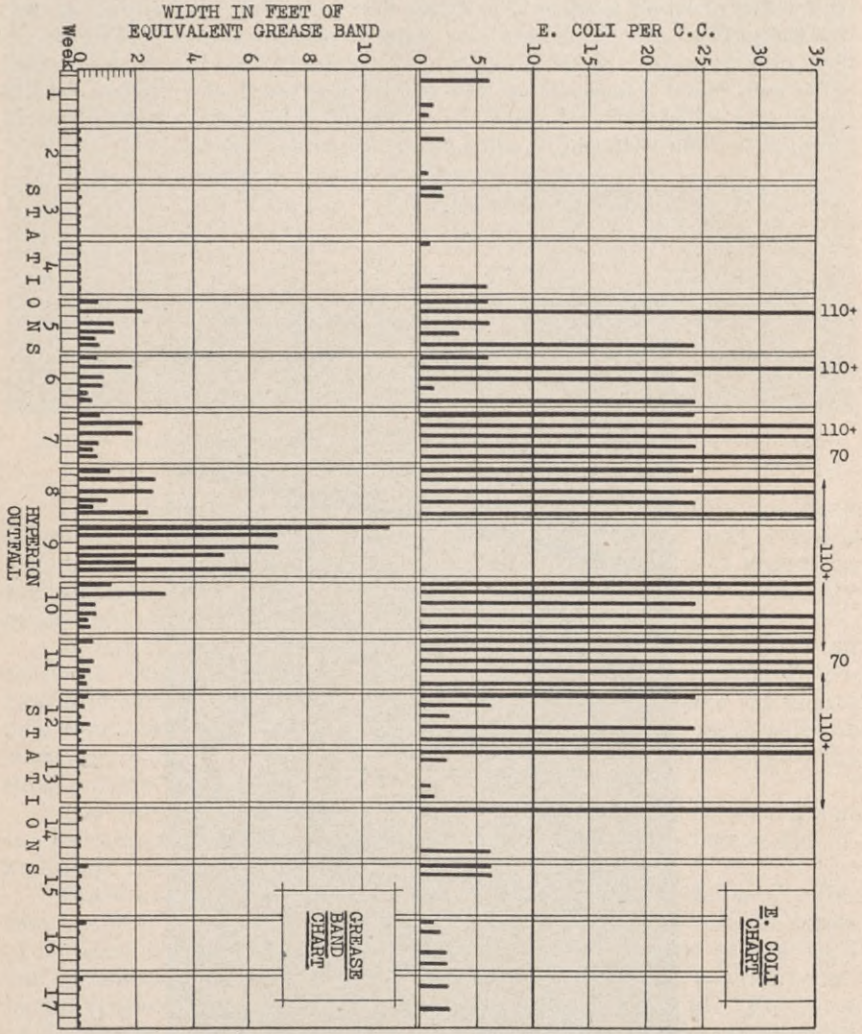

FIG. 23. E. coli and Grease Band by Stations for DECEMBER 1942.

thickness and width by the receding waves. Fig. 24 shows a heavy deposit of almost frothy grease on El Segundo Beach and in the upper half of the picture may be seen the more common and a lighter wave row of it. The photograph in Fig. 25 near Manhattan Beach also shows typical grease bands and in them a little child at play. For the purpose of a numerical expression each wave row was visualized or estimated as the width it would assume if brushed thin into a band of approximately the thickness of the grease grains. These average about $\frac{1}{8}''$ thickness and will vary from, say, $\frac{1}{16}''$ at the distant stations to $\frac{1}{8}''$ to $\frac{1}{4}''$ near the Outfall. This equivalent grease band was recorded at each observation and its frequency of occurrence appears on the monthly charts, Figs. 12 to 23, inclusive, along with the E. coli content of the surf water.

FIG. 24. On El Segundo Beach showing particularly heavy grease deposit and in the upper corner lighter wave row of grease.

FIG. 25. Near Manhattan Beach, showing typical grease wave rows with child playing in the grease.

It is to be noted that though there are some fluctuations in the width of grease bands at a given station from one visit to the next, there is a much more definite pattern to the curve of distribution of grease up and down the coast than is the case with the E. coli values. Distinctly grease deposits "peak" at Hyperion and fall away each side of it.

In fact it needs to be pointed out that all the substances that one can associate with a sewer are found here to point directly back to the Hyperion Submarine Outfall, and when charted the graphs have the aspect of a mountain peak whose apex is the Hyperion Outfall. Each side the constituents fall off in a declining slope. These grease curves follow the same pattern perfectly.

The peak of grease band pollution remained at Station 9 throughout the investigation and the deposits showed a tendency to flatten out up and down the coast seasonally.

But the shifts do not necessarily correspond with the shifts of pollution by E. coli. Quite uniformly throughout the year, grease in excess of so conspicuous a grease band as 3 inches wide occurred at Station 5 and occasionally at Station 4. In the northerly direction, the limit commonly reached Station 14 and varied from Stations 12 to 16. For three of the winter months, the center of gravity of the grease deposits seemed to swing southerly. For the spring and summer months the shift tended northerly.

The frequency with which E. coli was 10 per c.c. or higher and also the frequency with which grease bands of different widths occurred throughout the whole period of the investigation, is shown in graph form on Fig. 26. It is to be noted that if one accepts the proposition that when 20 per cent of the time E. coli is 10 per c.c. or higher, the beach is not safe for healthful recreation, then the width of grease bands that

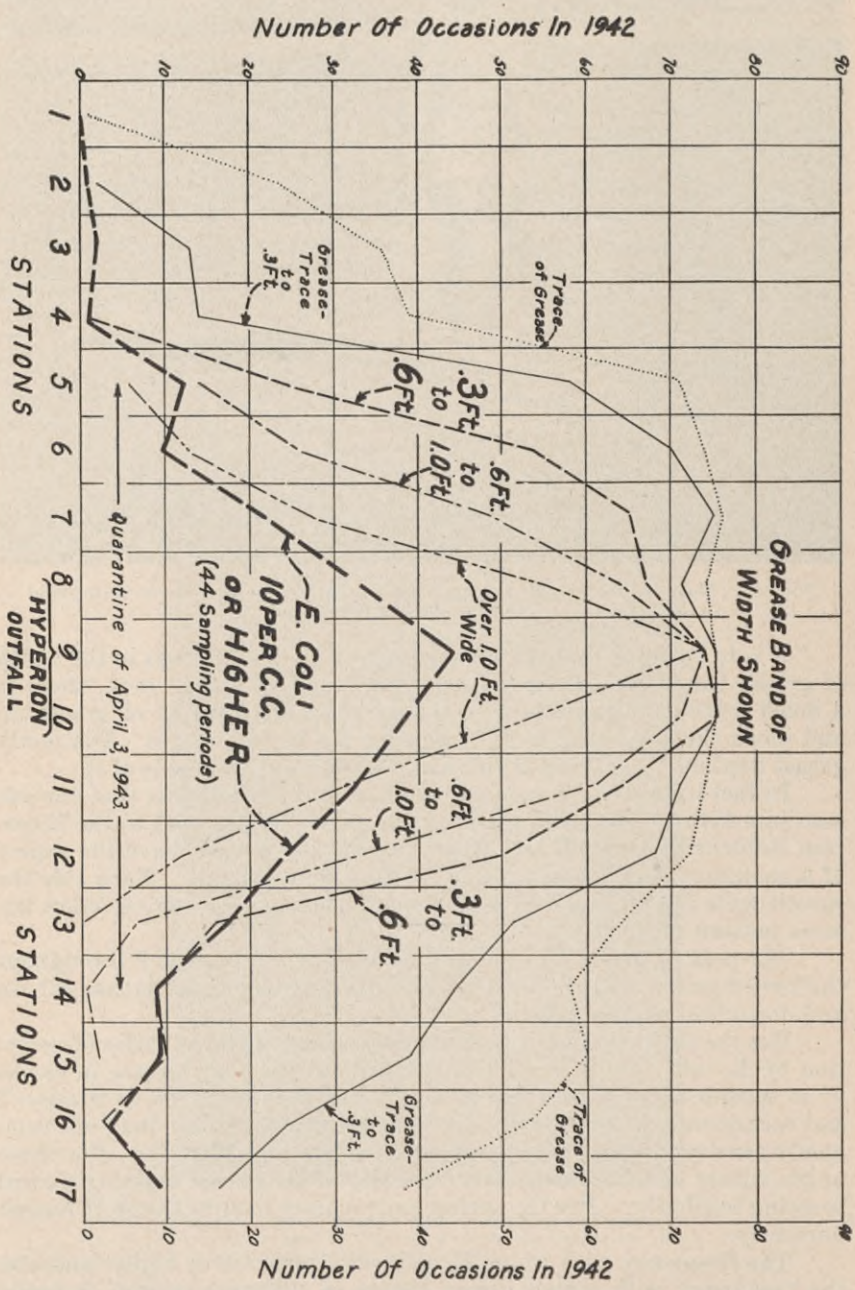

FIG. 26. Comparison of Grease Band and E. coli in Surf Water 10 per c. c. or Higher. Based on Approximately 75 Observations for Grease and 44 Samplings of Surf Water for E. coli at Each Station.

most nearly corresponds with that standard is one approximately 6 inches wide. Such a deposit of grease is readily recognized. In fact, grease equal to a 3-inch band is easily noticeable.

Other Sewage Debris. Various other forms of sewage issue from the submarine outfall at Hyperion. These include matches and feces and various other constituents such as pieces of soap, rubber goods, and bad smells of sewage in the water and discolored water. The debris is pictured in Fig. 27.

FIG. 27. Showing matches, feces and pellets of grease and bits of soap on beach.

The frequency of occurrence of various miscellaneous forms of sewage debris are also shown graphically by stations on Fig. 28. The study of both Fig. 26 and 28 points unmistakably to the Hyperion Outfall as the seat of all that is suggestive of sewage on the Santa Monica Bay beaches, and all the constituents ultimately declined to negligible amounts on receding from the Outfall, and within fairly narrow limits of agreement.

Probably because the screens were in good condition in 1942 and there was a minimum of bypassing that year, the distribution of feces fell inside the spread of grease. Rubber goods quite closely simulated the critical grease band in distribution. Matches and traces of light grease traveled the farthest and circumscribed the polluted zone. It might be thought that matches came from local sources but the fact that the frequency of occurrence follows the same law of diminution as one leaves the Outfall, must prove that the Outfall is the predominant source rather than the beach recreationists themselves.

The loss of cleanliness of the water also appears to have been a good index of sewage pollution. Surf water began losing its cleanliness at Station 3 and did not show frequent indications of complete recovery

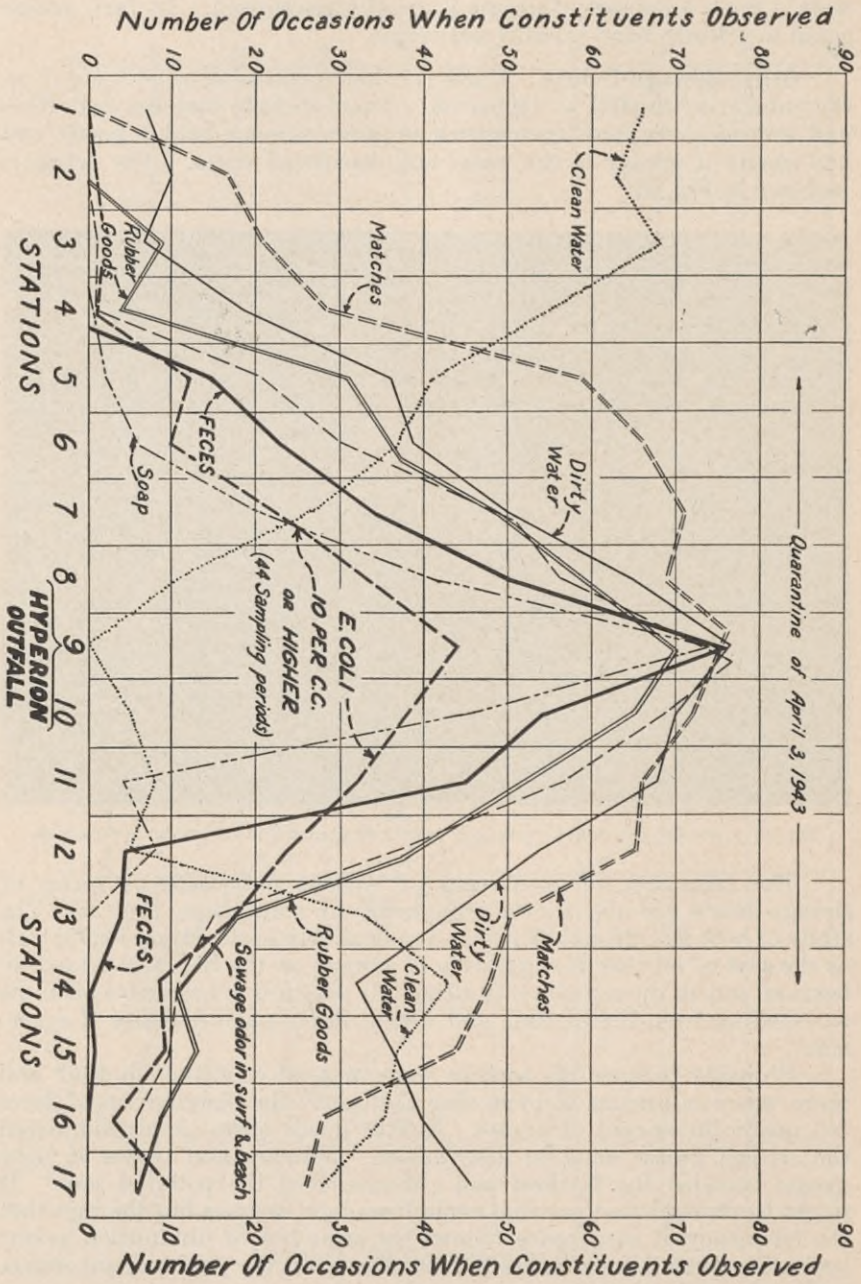

FIG. 28. Comparison of Incidence of Various Forms of Sewage Debris.

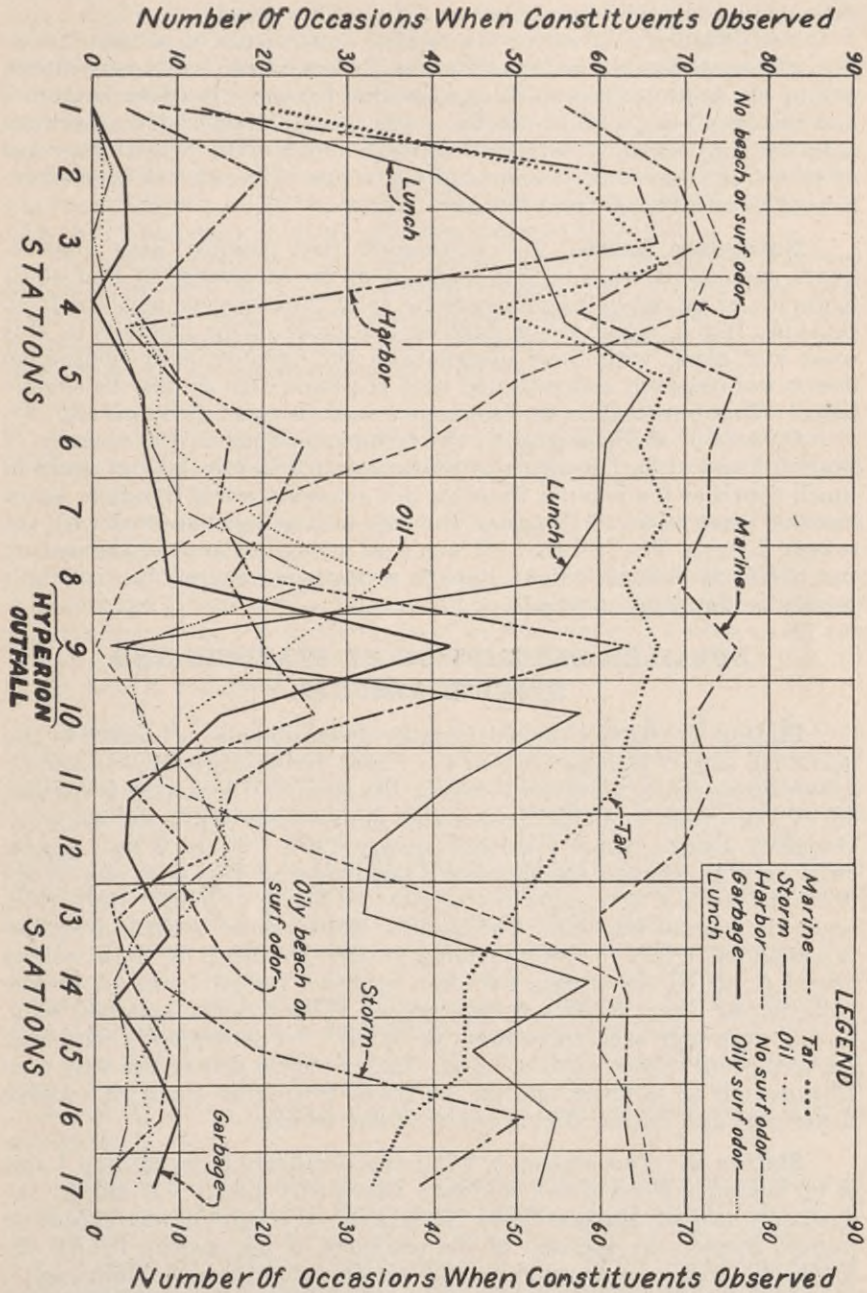

FIG. 29. Comparison of Incidence of Various Forms of Nonsewage Debris Based on Approximately 75 Observations at Each Station.

until somewhere beyond Station 14. Even sewage odors in the surf extended occasionally from Station 4 or 5 to Station 17.

The distance reached by the various constituents of sewage traveling northward reached as far as Station 17, depending on the constituent, and on the south to Station 14 or somewhat beyond. Between Station 5 and Station 13 or 14, all the evidence was closely corroborative of sewage pollution and certainly between Station 5 and Station 13 pollution was of such frequency that decency and protection of health calls for exclusion of human beings from this area.

Nonsewage Debris. It was thought that possibly some constituents, such as oil, which might originate at the Standard Oil Pier at El Segundo, or tar which might originate from the tar seeps seaward from Redondo Beach, might throw light on the travel of the currents on this coast and along with these observations the various other nonsewage debris was observed and recorded with the same care as was the sewage litter. This information is also summarized in chart form on Fig. 29.

Outside of a slight peak in the frequency of oil in the vicinity of Station 9 and of harbor debris at Stations 3 to 9 and occasional peaks in lunch debris at the popular beaches, this chart shows no trends at all or "peaks" that relate to Hyperion Outfall, such as was observed with the sewage debris. The fact that tar was most strongly found in summer on the northerly beaches might signify a northerly current or it might merely be the result of winds.

DETAILED DESCRIPTION OF STATIONS AND STATION RESULTS

Station 1. This is the most southerly station and is located at the northerly end of Malaga Cove in the Palos Verdes Hills approximately 3,500 feet southerly from the Torrance city limits. The station is reached off of Via Chino in Palos Verdes and joins on the south the old J. J. Haggerty Estate, which overlooks Malaga Cove. There is only sparse building here, though the country is subdivided. This is a very rocky beach at the foot of a quite inaccessible 50-foot high cliff. High tides reach the base of the cliff. The boulder-strewn shore is little used, but it was thought that if sewage tended to drift southerly it might collect here. Actually, the station has been negative for all forms of sewage pollution or litter, such as sewage grease, rubber goods, matches, soap, E. coli, or sewage odor, throughout the study. Of nonsewage debris only seaweed could be seen on most visits. Lunch papers and refuse were seen 13 times out of 73 visits, and tar, 20 times, both from April on. Other nonsewage and harbor debris occurred but seldom.

Station 2. This station is 1.55 miles northerly from Station 1 and is in Torrance close to the Redondo Beach city limits. It lies at the northerly end of Malaga Cove. Primarily, the station was chosen to pursue further the question of the tendency of the cove to funnel the southerly drift of pollution into it. Hollywood Riviera Clubhouse is located just south of the station. Otherwise, this too is a sparsely settled subdivision on a flat mesa above a high bluff which borders the sandy beach. The beach was not maintained in 1942 and considerable miscellaneous sea litter gathered.

The water here appeared clean 63 times out of 73 visits. Twice there was a slight oily smell in the surf but never a smell of sewage. Of nonsewage debris, marine life was nearly always present. Except for degree, this is true of all the stations under observation and the comment will not be repeated. Storm debris was observed on 20 occasions during the first half of the year and none later. Harbor debris was especially conspicuous at this station as well as at Station 3, probably because of a wrecked ship here. Garbage was observed on four occasions and lunch papers and debris on 41 occasions. Tar had also increased in frequency here, being observed 57 times. Oil was noticed only twice.

E. coli exceeded 10 per c.c. only once. A trace of grease was observed 24 times but only once was it readily conspicuous. In the other constituents suggestive of sewage, matches alone were observed, but this was a frequent occurrence, numbering 17 instances during the year and extending over six rather scattered months.

Station 3. This station is 1.45 miles northerly from Station 2, and is at Ainsworth Court and a city park in Redondo Beach. It is a narrow, sandy beach and two blocks south of Monstad Pier. A promenade follows along the edge of the beach.

In the nonsewage debris, the chief changes were in a slight increase in lunch litter and tar.

The water appeared clean on nearly all occasions but two of the constituents recognized as of sewage origin became more noticeable—matches and rubber goods. A small increase in frequency of traces of sewage grease occurred here, mostly in February and March. Twice in the fall of the year E. coli exceeded the 10 per c.c. limit.

Station 4. Station 4 is 0.7 mile north of Station 3 and is at the foot of Beryl Street in Redondo Beach. This is a rather flat beach extending approximately 120 feet from the promenade sidewalk. Though sandy, considerable erosion occurs revealing moonstones, from which this is known as "Moonstone Beach." Hunters gather them nearly every day in winter and spring. This station is opposite to and inside of the Redondo Beach Harbor jetty. On the outside of the jetty, sewage grease tended to gather but it evidently did not penetrate the jetty.

In the nonsewage litter harbor debris and garbage were conspicuously lacking at this station. Lunch debris remained as at Station 3, but tar decreased in frequency from 67 instances at Station 3 to 47 at this one. Frequently the water was dirty the early part of the year.

The water here began to show loss of normal cleanliness. For the year, matches were 30 per cent more frequent than at Station 3. E. coli exceeded 10 per c.c. only once and sewage grease remained practically as at Station 3.

Station 5. This station is 1.3 miles northerly from Station 4 and is at the foot of 14th Street in Hermosa Beach. Hermosa Biltmore Hotel is just north of it. The beach here is broad and sandy with a promenade running along it. This is a most popular beach. In the nonsewage debris, garbage was noted occasionally in the spring months, lunch debris and tar were present nearly all the time. Most significant was the appearance of oil. On five occasions out of 77, the surf smelled oily and on eight occasions oil could be seen on the beach here.

Debris suggestive of sewage began to become noticeable here. Feces, for the first time in order of stationing, was observed here, occurring 15 times out of 77 visits, mostly in the fall months. Rubber goods increased markedly and was observed 31 times, with some tendency to be most common in the fall months. Matches increased markedly and were observed on 59 occasions. Pieces of undissolved soap first began to be noticed at this station. The water became obviously less clean and was classed as dirty nearly half the time. Sewage grease became much more noticeable here and was at least five times greater and twice as frequent as at Station 4. One-third of the time the width of grease band was in excess of three inches. Mainly this condition existed in the fall months, when it appeared that grease and sewage were buffeted about, first by a northeast and later by an on-shore wind.

This is the first station so far discussed to have shown a distinct rise in the frequency of serious contamination of surf by E. coli. On 12 occasions out of 45 samplings, E. coli rose markedly above 10 per c.c. It will be recalled that the beach quarantine imposed by the State Board of Public Health on April 3, 1943, begins here and extends northerly to Station 14 at Brooks Avenue, in Venice.

Station 6. Station 6 is 1.05 miles northerly from Station 5, and is at the boundary line between Hermosa Beach and Manhattan Beach. This is the north end of a promenade entered off of 35th Street. It is a broad beach and has been a popular one.

Taking the observations as a whole, nonsewage litter was only slightly more frequent than at Station 5. The litter suggestive of sewage, including feces, rubber goods, soap, matches, and impairment of clarity of water, and sewage odor in the surf, all increased here and occurred more frequently than at Station 5. Grease deposits on the beach showed perhaps a 30 per cent increase over Station 5, and were most pronounced in the spring and fall. The least grease occurred in the summer months. The frequency of E. coli findings in excess of 10 per c.c. were substantially the same as at Station 5, aggregating 10 of the sampling periods throughout the study.

Station 7. Station 7 is 1.04 miles north of Station 6 and is at the foot of Marine Avenue in Manhattan Beach. This is a beach which, toward the end of 1942, was operated by the State Park Department. Its promenade extends each way from the station. This, too, is quite a popular beach, used nearly every day.

There was quite an increase in the frequency of oil on this beach, but in other respects, nonsewage debris showed little change over Station 6. Oil was observed on 20 occasions out of 57 visits, without regard to seasons.

All of the constituents indicative of sewage continued to increase consistently and the water continued to become more dirty and suggestive of sewage. For example, feces was observed 34 times in nine months of the year. In several of the winter months it was present on every visit. The water commonly had the smell of sewage in it. Rubber goods were found on the beach over half the time. In several of the winter and even in the summer months, they were found on every visit. It may be said that there was nearly twice as much grease on this beach as at Station 6.

E. coli greatly exceeded the limiting standard of 10 per c.c. on 22 out of 44 samplings, the highest values being in the late spring and fall months. In several of those months, every sample had in excess of 10 E. coli per c.c.

Station 8. This station is at the El Porto county beach and near the lifeguard and comfort station on the strand. It is 1.05 miles north of Station 7. Samples were taken at the foot of 42nd Street in Manhattan Beach. A promenade ends at the El Segundo city limits three blocks north. The beach is broad and sandy and moderate crowds use this beach in spite of the evident deposit of sewage and filth on it.

Presence of oil on the beach reached its height at this station, aggregating 34 occasions out of 76 visits. Oil was found in all months except February.

Sewage pollution was obvious. The water was decidedly unclean 65 times out of 76 visits. Match deposits were common but the frequency showed a tendency to level off at this station. All other sewage constituents continued to increase over Station 7. Feces was present half the time in practically every month of the year, but with the least frequency in the summer months. Wide grease bands were present all the time, and roughly speaking, there was twice as much grease on this beach as there was at Station 7. In only 11 out of 44 samplings was the water below 10 E. coli per c.c., and most of the time E. coli was in excess of 100 per c.c.

Station 9. This station is at the beach where Hyperion Outfall takes off, one-half mile north of the Standard Oil pier. It is 1.5 miles north of Station 8. The beach is owned for about a half mile on either side by the City of Los Angeles, and was acquired years ago in connection with the establishment of the Hyperion Outfall. The beach has been notoriously filthy for years, and efforts have been made to warn people to stay off. When our investigations began, several old warning signs still remained for about a quarter of a mile each side of Hyperion Outfall. Later, during the year, the Army took over portions of this beach and excluded people from the area. Gradually, the length of the beach controlled by the Army was extended. In July, 1942, the Department of Public Works posted about 100 feet apart for over a mile, some very conspicuous and effective signs to warn the people to keep off. Adjoining this posted area on the south is the Standard Oil pier, where the beach is posted by the City of El Segundo with "No Trespassing" signs.

In the class of nonsewage debris, oil showed a decrease compared with Station 8, but garbage and material suggestive of harbor rubbish, vegetable crates, etc., increased markedly at this station and was observed 42 times for garbage and 63 times for harbor debris, on 75 visits. Lunch litter dropped to a low point at this station and other nonsewage debris showed some reduction over Station 8.

This station represents clearly the peak in incidence of sewer-borne constituents. The water was dirty all the time. Feces, rubber goods, matches and sewage odor in the surf were always present. The water was so obviously polluted with sewage that after one or two samplings for bacterial purposes which showed upwards of 500,000 E. coli per c.c., this station was discontinued for analytical purposes. Grease deposits were four or five times greater than at Station 8.

As will be noted on Fig. 26 and 28 earlier in this report, Station 9 represented the height of frequency of occurrence of all forms of sewage

debris and pollution. From this station northerly and southerly all the constituents without exception declined. Taken as a whole, the decline was substantially the same in both directions.

Station 10. This station is at the foot of Century Blvd., about at the southern end of popular use of Playa del Rey Beach, and 1.5 miles north of Hyperion Outfall and Station 9. It is marked by the fine, large Playa del Rey lifeguard and comfort station. The beach here is broad and among the nearest to Los Angeles. Parking is easy on the Coast Highway adjacent to it and all in all this is a popular beach. A photograph of crowds on this beach on a day of moderate use was shown on page 31. It is here the Los Angeles Recreation Department projected an aquatic park in 1933 and 1934.

Outside of a decided increase in lunch litter on 58 occasions, the nonsewage debris fell off in most constituents compared with Station 9. Though sewage debris fell off, it was still high in all constituents. Feces were observed on 54 of the 75 visits and rubber goods and matches 65 and 72 times, respectively. Grease in conspicuous amount greater than a 3-inch band was present all the time and perhaps 10 per cent greater deposit than at Station 8 on the opposite side of Hyperion Outfall. E. coli was higher than 10 per c.c. 38 times out of 44 samplings. This was distinctly a filthy station, yet it has been a most popular beach.

Station 11. This station is at Fowling Street, a block north of fashionable West Port Beach Club at Playa del Rey. It is 0.85 mile from Station 10. The beach is largely private and is fenced.

Except that tar and marine life held up at the same levels as previously, viz., 60 or more times out of 74 visits, other nonsewage debris dropped quite sharply here.

Though sewage debris also dropped, all the constituents were still high. Out of 74 visits, feces was observed 45 times; grease as wide as a 3-inch band, 70 times; rubber goods, 52; matches, 66; and surf water was unclean from sewage with similar frequency. However, the grease deposits fell off nearly 40 per cent over Station 10.

Station 12. This station is six blocks north of Ballona Creek in the oil well district of Venice at 51st Street. It is one mile north of Station 11. Beach here is very broad but is lightly used.

So far as nonsewage debris is concerned, this was the cleanest of the beaches.

In sewage debris, it also showed an improvement over Station 11. On 74 visits, feces was observed 21 times; rubber goods, 38; matches, 65; and water was still unclean. Grease band reduction over Station 12 was about 50 per cent, but was in excess of a 3-inch band 60 times out of the 74 visits. E. coli exceeded 10 per c.c., roughly half the time the surf was sampled.

Station 13. This station is beyond the Venice oil wells at 26th Street in Venice, and is approaching the heart of popular beach recreation in Venice. In itself it is popular. Sunset Pier is two blocks north. It is 1.15 miles from Station 12.

Nonsewage debris continued at a low level, similar to Station 12, and tar, though found 48 times out of 76 visits, began to drop noticeably. Lunch litter was noted 32 times, garbage 9 times, and oil 10 times.

Sewage debris also decreased over Station 12, e.g., feces, 21 times decreased to 4 times; rubber goods, 38 to 18; matches, 65 to 51. The grease deposits were not over half those at Station 12, but were conspicuous on over 50 visits. E. coli in excess of 10 per c.c. were found in the surf 17 times out of 45 samplings.

Station 14. This station is at Brooks Avenue in Venice in the heart of large beach apartments. The beach here is broad and popular. It is 0.75 mile from Station 13, and about seven short blocks south of Santa Monica city limits and Ocean Park pier. There are cooking places on the beach and much lunching. The beach is well maintained, and though most of the signs of nonsewage debris are low, lunch debris increased here to 59 times observed out of 75 visits.

For the first time since leaving Station 4, feces was not found here but other signs of sewage persisted. E. coli was in excess of 10 per c.c. 9 times out of 44 samplings, or over 20 per cent of the time. Roughly, 12 per cent of the time an objectionable amount of grease prevailed in excess of a 3-inch equivalent width of deposit. Rubber goods were seen 11 times, and matches, 48 times.

Station 15. This station is at Bay Street in Santa Monica in the vicinity of old Crystal Pier, now abandoned, Del Mar Club and City Park. It is 1.33 miles from Station 14 in Venice. Shallow water reaches out fully 300 feet from the high tide line. This beach is popular, especially with Negroes. There was a good deal of lunch litter. Storm debris also tended to gather. A 16-inch storm drain emptied here at high tide line and street drains also spilled onto this beach.

In sewage debris, the station showed little overall tendency to improve over Station 14. Feces was noted only once. Grease deposits in excess of an equivalent grease band 3 inches wide occurred 10 times out of 75 observations—or once more than at Station 14. Rubber goods was noted 9 times against 7 at Station 14. Frequency of E. coli in excess of 10 per c.c. was 9 times out of 45 samples, which is substantially the same as for Station 14. It is recommended that this station and vicinity be studied further as to its sanitary condition.

Station 16. This station is at the extension of Wilshire Blvd., and adjoins Variety Beach Club in Santa Monica Beach. It is 1.0 mile north of Station 15. Santa Monica Yacht Harbor is just south of here. Quite a large storm drain empties onto the beach but the beach is wide and seldom did its contents contact the surf during the investigation.

Nonsewage litter tended to be more noticeable, especially storm debris, which remained on 50 occasions out of 74 visits.

Sewage debris was less frequently observed than at Station 15. Feces was never found. Grease in significant amount but under a 3-inch band was observed 22 times out of 75 visits; rubber goods, 9 times; and matches, 28 times.

E. coli was the lowest since leaving Station 4, with only 3 samplings out of 44, revealing E. coli in excess of 10 per c.c. These occasions were in August, September and October. There was no comparable finding of E. coli at Station 15, on these occasions, but on the same dates the E. coli count was also high at Station 17.

Station 17. This is the most northerly station in this study. It is 1.26 miles north of Station 16 and 300 feet south of the mouth of Santa Monica Canyon, where the creek empties across Santa Monica State Park Beach. The canyon runs water all year. A single test in June, 1942, indicated that the creek was not clean, according to tests for E. coli. The count was 24 per c.c. The beach and even the bay formed by the canyon water are most popular.

In nonsewage debris the beach was comparable to those at adjacent stations.

Sewage debris in all forms reached what appears to be a stationary low here, but with none of the constituents entirely lacking, as was the case at Station 1. For example, Station 17 revealed a trace or more of grease 38 times out of 74 visits, and on 16 occasions the grease band was up to 3 inches wide. Rubber goods were observed 6 times, and matches, 26 times. E. coli in excess of 10 per c.c. showed a rise to 9 occasions out of 43 samplings. The explanation of this rise, however, is more likely E. coli from animal manure brought down the canyon from corrals of two clubs and several private corrals that border the creek or its branches.

COMPLAINTS

The files of the Bureau of Sanitary Engineering contain reams of complaints against this Hyperion sewage disposal. These have gone on almost incessantly for 40 years. Selecting one of these letters of complaint from the many, it tells in the language of another who is obviously fair and dispassionate how these conditions strike the layman.

"Venice, California
March 18, 1940

State Department of Public Health
Bureau of Sanitary Engineering
703 State Building
Los Angeles, California

Dear Sirs:

"As a resident of the State of California for the past nine years, a taxpayer, a voter and a nature lover I wish to suggest that it might be advisable for the State Department of Public Health, and for any other person or persons, commissions or departments having any authority in the management of the physical affairs of the State, to give serious thought to the question as to whether or not it might be practical to make plans to dispose of the sewage of Los Angeles City, and the nineteen other communities now tributary to our sewerage system, in some other manner than by depositing it in the waters of Santa Monica Bay.

"I have walked along the shore many times between Santa Monica and Manhattan Beach and have often found disgusting conditions to exist due to the pollution of the water and the beach by sewage. Bad odors, grease (not oil) sticking to the soles of a person's feet and fringes of sewage particles on the beach following the recession of each wave are among the disagreeable things noticed. I have at times seen unmistakable evidences of sewage pollution north of Venice, at a distance of four or five miles from the sewer outlet, and similar evidences of pollution are at times in evidence at an equal distance to the south of the sewer outlet.

"As for the immediate vicinity of the submarine outfall sewer, there is a strip of beach two miles or so in length which, so far as the topography of the region is concerned, seems to be excellent for bathing purposes and which, if clean, might be of great value to the citizens of the entire Los Angeles area for recreational purposes. But, due to sewage disposal, it is a veritable 'no man's land' of stench and corruption, entirely unfit for bathing or picnicking, and hardly decent to even walk on. It may help matters somewhat to have the sewage put through a screen so that it doesn't wash up on the shore in chunks, but it is there in the water just the same.

"If there were no other way of disposing of the sewage of this great city and its environs than that of dumping it into the waters in which its citizens bathe by the millions, I, for one, would cheerfully make the best of it, although it would still seem unethical for one community to dump its sewage onto another community. But I am told that now-a-days there are entirely practicable methods of disposing of sewage without creating any such nuisance as that which I have described. I am not sufficiently informed on the subject to be able to state positively that this is so. But if it can be done, I sincerely hope that those in authority will make plans to proceed in that direction in the future disposal of the sewage of the Los Angeles area, not only in the interests of health and decency, but also in the interest of property values along the beach and the value of the beach itself, Los Angeles' greatest recreational asset.

"I understand that, according to the standards set up by the State Health Commission, as many as from about 24% to 32% of the tests made of the sea water by the authorities, over a period of 3½ years (from Jan. 1, 1936 to April 24, 1939) showed sufficient pathogenic bacteria present in the water on the days the tests were made to make bathing unsafe to health, even as far north of the submarine outfall as Avenue 43 in Venice and as far south of the submarine outfall sewer as 27th Street in Manhattan —a total span of approximately six miles. As a general thing, the nearer the testing points were to the sewer outlet the greater was the percentage of unsafe bathing times. At points about ⅛ of a mile on either side of the submarine outfall, as an average, only from about 40% to about 60% of the tests showed safe bathing conditions from the standpoint of health on the days the tests were made. As the drift of the sewage changes from time to time the average person has no way of determining, except by observation, when the water is in a sanitary condition for bathing at any given point, and observation may not be a very reliable guide. At any rate the average beach patron is either uninformed of, or gives little thought to, the fact that there is an admixture of sewage in the water in which he is bathing, and is totally unaware that he may be endangering his health.

"Aside from this menace to health, I do not like the idea, when I go in bathing, of getting my hair, eyes, ears, nose and mouth full of the diluted sewage of over a million and a half people, and of needing a very thorough bath afterward for the sake of cleanliness.

"Respect. yours,"

(NAME WITHHELD)

SPECIAL BACTERIOLOGICAL STUDIES

Salt Water Forms of E. coli. Occasionally, early in the work atypical strains of the E. coli members of the coliform group were noted in the course of culturing. During the first month detailed microscopic study was made of these different types of colonies as obtained on the Eosine Methylene Blue (E.M.B.), plates. Both confirm as typical E. coli in the standard completed test for that organism but both are easily distinguished even in the routine test for E. coli.

One strain forms very minute pin-point colonies, and a distinct metallic sheen on E.M.B. agar. Repeated transplantation of this organism failed to cause production of any larger type colonies.

The other strain forms relatively large colonies which are of a brownish brick color. They are not moist or mucoid, as is B. aerogenes. Only a faint metallic sheen is produced.

These strains may be found far out at sea in unpolluted sea water. We ran a number of samples of relatively unpolluted sea water from Santa Monica Bay in 10 c.c. amounts for these strains. The cultures were frequently completely negative and only occasionally were these two organisms found. It was concluded that their presence in sea water was not an index of sewage pollution. They were occasionally observed in the course of our routine testing of surf water but were omitted from the results as not indicative of sewage pollution.

Overgrowths. It was found in streaking the lactose broth cultures of sea water in which acid and gas had formed, that there was usually a very heavy overgrowth of other organisms which frequently obscured or somewhat camouflaged scattered E. coli colonies. The cultures that were run at greatest dilution of sample gave the most distinct E. coli colonies. As a routine matter the greatest dilution in these tests was .01 c.c. Hence there is a possibility that the stations showing the highest contamination would have shown still higher frequency of E. coli, rather than less if higher dilutions could have been run. Very few streptococci were ever found.

The persistent spore-former, *Clostridium Welchii*, was found to be extremely common in the more polluted surf. In the laboratory the organism revealed itself in several ways. When the lactose broth cultures were allowed to remain in the incubator longer than 48 hours, renewal of or increased gas production occurred in nearly all those tubes which had been positive for E. coli according to the confirmation tests made when gas appeared earlier in the tubes. In such tubes the Andrade's Indicator which had been red from the formation of acid turned yellow. There was also a definite butyric odor. From cultures transplanted to hot deep agar typical *Clostridium Welchii* cultures were identified.

Density of E. coli at Outfall and Adjacent Stations. Since routine tests for E. coli in the surf at Station 9, the outfall station, were abandoned early in the work, a number of tests were made to determine the maximum density of E. coli in the surf at the outfall and at stations a mile and a half each side. Five cultures were made in the surf immediately at Hyperion Outfall. All five samples contained E. coli in cultures that were made from dilutions of from 1:100,000 to 1:1,000,000 c.c. showing approximate density of close to 500,000 E. coli per c.c. The surf was cultured in similarly high dilutions at Stations 8 and 10, which are 1.5 miles each side of the outfall. Greatest density of E. coli found at these stations was 2,000 per c.c. One thousand E. coli per c.c. were found at Station 11, 2.25 miles north of the outfall.

E. coli Survival Tests. Following the comparison of the results of cultures made in the State Laboratory in Berkeley, with those made in the University of California Laboratory at Los Angeles, the time element in culturing sea water samples was investigated to ascertain the reliability of E. coli findings in surf water corresponding to variations in transit conditions and time in transit of samples. In April and May, 1942, four weekly sets of samples were tubed into lactose broth immediately when taken at beach side. These sample bottles themselves were then kept at normal temperature and cultured in the University laboratory at the end of the trip. The time that elapsed between culturing the sample at beach side and again at the laboratory ranged from 1.5 to 7 hours, depending on whether the sample was the one taken at the start of the trip or at the end. It was found that there was a slight drop in the density of coliform bacteria in those samples which were cultured after more than four hours of storage at normal temperatures.

Dr. Claude ZoBell, Associate Professor of Bacteriology at Scripps Oceanographic Institute at La Jolla, has reported on a study of the bacteriocidal properties of sea water on fresh water bacteria in Proceedings of the Society of Experimental Biology and Medicine, Vol. 34, page

113, 1936. He showed that when cultures of E. coli were suspended in semipermeable porous porcelain tubes in sea water, there was very little decrease during the first hour, but a 93.6 per cent decrease in two hours. He also found that autoclaved sea water was considerably less bacteriocidal than natural sea water. Berkefeld filtered sea water was somewhat less bacteriocidal than natural sea water but more bacteriocidal than autoclaved sea water. He also found that 5 to 10 per cent of autoclaved sea water apparently favored the growth of E. coli. This organism survived better in cultures containing from 3 per cent to even 6 per cent sodium chloride solution than in natural sea water, but its growth in autoclaved sea water was much superior to that in the 3 per cent sodium chloride solution. There appears to be a thermolabile germicidal substance in the sea water. The addition of organic matter was found to reduce the bacteriocidal power of sea water.

Our survival tests of E. coli, designed to simulate the conditions as normally created in analysis of water in public health laboratories, were not comparable to the scientifically measured and controlled work of Dr. ZoBell. In our procedure, a sample of polluted surf was collected and immediately inoculated into lactose broth at seaside in dilutions representing 1, 0.1, 0.01, .005, .002, .001, .0005, .0002, and .0001 c.c. portions. Both the samples and the cultures were then taken to the laboratory where the samples were stored at room temperature, and reinoculated after storage periods of 4, 6, 8, 12, 18, 24, and 48 hours, or some selection out of those intervals.

A few samples in the survival tests were also divided in aliquot amounts after the initial inoculation into lactose broth had been made at beach side. One part was stored at room temperature and the other part was stored in the refrigerator for the desired storage interval.

In summarizing the results, it seems that there is a marked decrease in the density of E. coli during the first 24 hours of storage of sample at room temperature. However, when the sample was kept on ice, there appeared to be little or no decrease in the number of E. coli until after about 12 hours of storage. The following figures denote the number of E. coli found in the cultures on samples stored after the indicated time. The figures represent the per cent of E. coli remaining, considering the number in unstored samples as 100 per cent.

No. of Samples	*Temp.*	*Immediate Culture*	*Storage of Sample:* *4-hr.*	*8-hr.*	*24-hr.*
12	Room	100%	25 to 80%	10 to 25%	1.0 to 2.5%
4	Iced	100%	100%	50 to 100%	5.0 to 20%

Graphic charts of the results of these few survival tests give a logarithmic curve which is similar to the normal logarithmic curve of the death rate of bacteria in an unfavorable medium.

E. coli in Grease Particles. Because it was evident that sewage grease on the beaches had congealed, either in the sewer or on reaching the cold sea water and therefore might contain sewage organisms, special studies were made of the bacteriology of the grease at various stations and positions on the beach as related to freshness of the particles.

Some of the grease rows studied were those left high on the hot dry sands. Others were the freshly deposited wet material. Both kinds of

grease were sampled a total of 23 times from Station 5 to 15. Samples of grease with such sand as attached were scooped up by a sterile spatula and about 30 c.c. placed in a sterile bottle.

In the laboratory each sample of polluted sand and grease was ground up and mixed with an equal volume of sterile water. The resulting fluid was then cultured in the same manner and dilutions as were the regular surf samples.

The samples of the damp material showed coliform count of 24 per c.c. or higher and 50 per cent were in excess of 110 E. coli per c.c. The coliform counts obtained in the samples of dry polluted sand showed a wide variation, from zero to 24 coliform bacteria per c.c. The majority ran around 2.3 and 1.3 per c.c. The low values and wider range may be a measure of the bacteriocidal effect of time, sunlight and heat on grease deposits on the dry beaches.

E. coli in Air. Because the spray along Coast Highway opposite Playa del Rey even smelled of sewage during on-shore storm winds, E. M. B. plates were exposed from the open window of a car at various places between Playa del Rey and Manhattan Beach under conditions conducive to the escape of sewage organisms from the surf into the air over the highway. All plates were exposed for 5 seconds and the plates incubated in the regular manner. Typical colonies were confirmed by inoculating into lactose broth for gas formation.

The following colony counts were obtained on the plates:

Place and Distances from Outfall	*E. coli*	*B. aerogenes*
Waterview Ave.—2 miles north	228	128
Fontainebleau Ave.—1 mile north	250	150
Outfall	500	100
1 mile south of outfall	15	4
North limits Manhattan Beach	1	5

Occasions as severe as this for high density of E. coli in the air are rare. Moreover, the portion of sewage organisms that might reach the intestines through the breathing of sewage-laden air is highly speculative. The most to be said now is that the idea of breathing sewage in the form of air is repulsive. The health hazard however may deserve more research.

Isolation of Pathogenic Bacteria. Pathogenic bacteria were isolated by the investigator in November, 1942, from samples taken within 200 to 300 feet of the Outfall, and the organisms identified as Paratyphoid A and B by agglutination with specific antisera to a titer of 1:640.

Samples of both surf and beach material were collected and handled after the manner used in the tests for E. coli. The first sample, taken November 17, 1942, was found to contain Paratyphosum B in specific agglutination titer of 1:640. From the other sample, taken November 24, 1942, both Paratyphosum A and B were isolated. A sample of polluted surf at Station 10 on December 22, 1942, contained Para B also with specific agglutination of 1:640. Two samples of pure sewage taken at the sewage plant were found to contain both Para A and Para B in numbers dense enough to be obtained by merely streaking several platinum loopfuls of sample on the surface of bismuth sulphite agar.

In culturing, two flasks were prepared containing 100 c.c. each of Difco Tetrathionate broth. Into each flask was placed 10 c.c. of thoroughly shaken sample of surf or sample. After incubation for 24 hours in this special nourishment medium, loopfuls were streaked onto plates of Difco bismuth sulphite or Salmonella Shiga agar.

Characteristic colonies were picked from these plates and grown on nutrient agar slants. Colonies from pure cultures were run through the sugar fermentation tests. Those pure cultures showing the typical Paratyphoid fermentation reactions were then washed down with 0.2 per cent formalin in saline preparatory to running the agglutination tests.

Through the cooperation of Dr. T. D. Beckwith, Professor of Bacteriology, and Dr. A. J. Salle, Assistant Professor of Bacteriology in the University of California at Los Angeles, a series of additional tests was made by two advanced students during the spring semester of 1943 under the observation of the investigator and the close supervision and direction of Dr. Salle. They cultured samples taken in a total of nine different weeks. The first three samples were discarded because of errors of technique.

The results of these examinations are listed in the order of stations in Table 9, and show that out of 10 such cultures 6 reveal the presence of Paratyphoid A or B bacteria.

The worth of additional study of the pathogen content of surf, grease and sand in Santa Monica Bay is strongly indicated from the frequency and titer with which the pathogenic organisms responded in the work we were able to do.

TABLE 9. RESULTS OF EXAMINATION OF ALL SAMPLES OF SURF, SAND AND GREASE FOR TYPHOID GROUP

Sample	Station	Date	Typhoid group	Titer	E. Coli per c.c.		
					Surf	Damp sand	Dry sand
Surf	8	3/29/43	Negative		2.3	110+	1.3
Surf	8	4/ 5/43	Para A	1:300	24.0	24	0.6
Surf	Outfall	11/17/42	Para B	1:640	70.0	110+	6.2
Surf	Outfall	11/24/42	Para A, B	1:640			
Surf	10	12/22/42	Para B	1:640	110+	110+	3.2
Surf	13	4/19/43	Para B	1:300	1.3	70	6.2
Surf	13	4/26/43	Negative		0	6.2	0
Sand and grease	13	4/26/43	Negative		0	6.2	0
Sand and grease	13	5/ 3/43	Para B	1:300	1.3	24.0	0
Surf	15	5/ 3/43	Negative		1.3	24.0	0

DISEASE FROM BEACH POLLUTION

During this investigation, though no particular effort to discover cases of disease which could reasonably have been contracted from this beach was made, one case came to our attention. This is the case of one of the lifeguards at El Porto Lifeguard Station between El Segundo and Manhattan Beach. On July 4, 1942, he was obliged to make a rescue in the surf off El Porto Beach, in the course of which he gulped several swallows of surf water. Two days later he noticed the first signs of illness. By July 10th, six days later, he was severely ill but did not see

a physician until July 13th. From the history and the clinical evidence, his physician made a presumptive diagnosis of a severe case of paratyphoid fever. On July 14th, the first and only agglutination test on serum from this patient was run and was positive in low titer for Paratyphoid A. and more strongly for Paratyphoid B. The agglutination test was negative for typhoid. Unfortunately, the agglutination tests were not repeated for further confirmation and for the establishment of a rising titer, and hence a positive evidence of Paratyphoid A. or B.

The man was incapacitated for a total of six weeks. Some time in November he submitted his case to the State Compensation Commission. We understand that the claim was disallowed for failure to submit subsequent and confirmatory agglutination tests. These were not made because the subject then entered the Navy. The history of this case is too strongly suggestive of the surf water as the cause of the infection to dismiss it lightly in weighing the safety of surf or beach recreation affected by the Hyperion Outfall. Other lifeguards have reported severe enteric disease that incapacitated them for days, after making rescues in polluted surf water.

The literature is lacking in specific cases of the contraction of typhoid fever from bathing waters. The source of typhoid fever is frequently obscure—a fact that keeps typhoid fever a disease to be reckoned with constantly. The Quarterly Reports of the Health Department in New York City frequently have shown cases of typhoid fever in that city attributed to bathing in polluted waters. One such report before us for the Third Quarter of 1932 lists 51 cases contracted from bathing in polluted waters. The Second Quarterly Report for 1932 features the discussion of typhoid fever from bathing in polluted waters and states "from all the data on hand it is very probable that most of the increase (in typhoid fever) may be charged to bathing in polluted harbor waters condemned by the Department of Health."

Still earlier in New York City there is record of a report by one of the well known sanitarians of the time, Dr. Daniel D. Jackson, made to the Merchants Association in New York on the general subject of the pollution of public waters. He found that the incidence of typhoid fever was much greater in the city blocks bordering the waterfronts. He also found that the fly population was also increased in this area at the same season and his inspections showed large areas of fecal pollution on the tide flats, from which he concluded that the flies could infect human beings for some distance back from the waterfront.

Public Health News, of New York State Department of Health, Volume 12, No. 3, pages 402 and 403, has a short editorial on coastal pollution which is quoted here in conclusion of this report.

"The use of the (sewage) receiving waters should receive first consideration because of its direct bearing upon the health of its users. Certainly it is an undisputed fact that disease can be transmitted by polluted waters. The literature is voluminous with reference to epidemics of typhoid caused by the pollution of natural waters with sewage, and the matter has been so thoroughly investigated and demonstrated that there is no longer any doubt in the minds of the sanitarians concerning the causation of this disease. From our examination of other records, it also was noted that there is a well-formed opinion among sanitarians and medical experts that diseases other than typhoid may be contracted by coming in contact with polluted waters. These diseases, in general, are not of the type that are as important to the individual as typhoid, inasmuch as the person's life may not be endangered by them. The group as a whole, however, is an important item in injuring the health of the persons infected and causing

a consequent loss due to lost time and medical treatment. We believe that in the aggregate this loss at the present time may be a greater one, financially, than that of typhoid fever, although its significance has long remained hidden.

"Among those infections which, with the opening of the artificial bathing places, are becoming more severe, may be mentioned conjunctivitis, infections of the nasal passages, otitis, tonsilitis, rhinitis, sinusitis, sore throat, furuncles, laryngitis, diphtheria, dysentery and ringworm. Information with reference to these epidemics, in general, is suppressed, due to the fact that they often occur in sections which are devoted to recreation. It is for this reason, together with the fact that most of these diseases are not reportable, that the literature of this country is not more complete, as remedies have been sought and installed in order to prevent any possible condemnation of the questionable waters."

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