STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING

BULLETIN NO. 67

RECLAMATION OF WATER FROM SEWAGE AND INDUSTRIAL WASTES

WATSONVILLE AREA SANTA CRUZ AND MONTEREY COUNTIES

EDMUND G. BROWN
Governor

HARVEY O. BANKS
Director of Water Resources

AUGUST, 1959

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City of Watsonville Sewage and Industrial Waste Screening Plant

Irrigation of Lettuce in Pajaro Valley

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STATE OF CALIFORNIA

Department of Water Resources

SACRAMENTO

August 10, 1959

Honorable Edmund G. Brown, Governor, and
Members of the Legislature of
the State of California

Central Coastal Regional Water Pollution
Control Board (No. 3)
1108 Garden Street
San Luis Obispo, California

Gentlemen:

I have the honor to transmit herewith Bulletin No. 67, "Reclamation of Water from Sewage and Industrial Wastes, Watsonville Area, Santa Cruz and Monterey Counties". This report was prepared under authorization of Section 230 of the Water Code, which directs that the Department

> ". . . shall conduct surveys and investigations relating to the reclamation of water from sewage or industrial wastes . . . and shall report to the Legislature and to the appropriate regional water pollution control board thereon . . ."

These studies indicate that it is physically possible and feasible to reclaim water from sewage and industrial wastes presently discharged to Monterey Bay by the City of Watsonville. These reclaimed waste waters could be utilized for agricultural purposes in Pajaro Valley.

Utilization of reclaimed water for beneficial purposes would, in effect, provide a practical means of alleviating the increasing ground water overdraft in the Pajaro Valley. Based upon conditions predicted for 1985, reclaimed water could provide approximately thirteen per cent of the supplemental water requirements of the Pajaro Unit at that time.

Very truly yours,

Harvey O. Banks

HARVEY O. BANKS
Director

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Executive Secretary

ACKNOWLEDGMENTS

The valuable assistance and data furnished by Mr. Royal E. Fowle, City Engineer of Watsonville, and Mr. Stanley Smith of his staff, and by Mr. Irvin Anderson, Watsonville screening plant operator, are gratefully acknowledged.

Portions of the data on sewage and industrial waste flows, and all population estimates presented in this report were obtained by permission from a report by Hyde, Charles Gilman and Brown and Caldwell, Consulting Engineers, entitled "The Collection, Treatment and Disposal of Sewage and Storm Drainage of the City of Watsonville, California", May, 1953.

Mineral analyses reported herein were performed by the United States Geological Survey, Quality of Water Branch, in their Sacramento laboratory under provisions of a cooperative agreement with the Department of Water Resources. Unless otherwise noted, sanitary analyses were performed in the mobile laboratory of the Department of Water Resources.

The following agencies reviewed and commented upon a preliminary draft of this report:

Brown and Caldwell, Consulting Engineers

Central Coastal Regional Water Pollution Control Board (No. 3)

Department of Fish and Game

Department of Public Health, Bureau of Sanitary Engineering

United States Army Engineer District, San Francisco, Corps of Engineers

In preparation of the final report, thorough consideration was given to comments and suggestions received.

CHAPTER I. INTRODUCTION

The phenomenal growth of California, evidenced in population as well as in agricultural and industrial activity, stresses the need for the orderly development of the State's water resources and the solution of the many complex associated problems.

Many regions of the State experience serious continuing or periodic water shortages. In these areas, large quantities of sewage and industrial wastes frequently are discharged to tidal waters, inland water courses, or are disposed of by application to land. Wastes discharged to tidal waters are irrecoverable. Portions of wastes discharged to inland streams or to land are usually recoverable through subsequent use of ground or surface waters.

Past investigations of the water resources and physical development of the Pajaro Valley, have shown that the rate of ground water extraction, as of 1949, exceeded the safe yield of the aquifers by about 3,700 acre-feet per year. In addition, more recent investigations have shown that there is evidence of sea-water intrusion into the valley floor area, extending inland to a distance of about one and one-quarter miles on a one-mile front paralleling the coast line. Plate 1 depicts ground water levels and the extent of sea-water intrusion in the main producing aquifer of the Watsonville area during the fall of 1957.

A number of alternative plans for the development of a supplemental water supply for this area, by construction or enlargement of surface storage facilities, have been studied by this Department. Another possible source of supplemental supply lies in the reclamation of water from sewage and industrial wastes presently being discharged into Monterey Bay by the City of Watsonville. During 1956, these discharges amounted to

about 3,200 acre-feet. It is expected that with continued growth of the community the quantity of these wastes will increase.

This report discusses the feasibility of supplying a portion of the supplemental water needs of the Pajaro Valley in Santa Cruz and Monterey Counties, with water reclaimed from the sewage and industrial waste discharge of the City of Watsonville.

Authorization

Investigations of the reclamation of water from wastes are authorized by Section 230 of the Water Code, which states in part:

> "230. The department, either independently or in cooperation with any person or any county, state, federal or other agency to the extent of funds allocated, shall conduct surveys and investigations relating to the reclamation of water from sewage or industrial waste for beneficial purposes, including but not limited to the determination of quantities of such water presently wasted, and possibilities of use of such water for recharge of underground storage or for agricultural or industrial uses, . . . ".

In compliance with this directive, the Department conducts continuing state-wide investigations pertaining to quantity and composition of major waste discharges and status of waste water reclamation projects, both existing and proposed. In addition, feasibility studies are made of specific potential projects for waste water reclamation when warranted. These studies consider such variables as local water supply and demand, need for supplemental water supplies, availability of waste discharges, suitability of reclaimed water, and cost of various reclamation works.

In a letter dated April 18, 1955, the City of Watsonville requested the Division of Water Resources to conduct an investigation of the feasibility of using water reclaimed from the city's sewage and industrial wastes as a supplemental water supply, either for ground water recharge or direct agricultural use. This letter is reproduced as Appendix "A" of this report.

Related Investigations and Reports

Many publications and reports have presented data regarding the water resources and water problems of the general area of investigation. A listing of publications and reports referred to in connection with the current investigation follows:

California State Department of Public Works, Division of Water Resources. "Sea-Water Intrusion Into Ground Water Basins Bordering the California Coast and Inland Bays". Water Quality Investigation Report No. 1. December, 1950.

California State Department of Public Works, Division of Water Resources. "Reclamation of Water From Sewage or Industrial Waste". December, 1952.

California State Department of Public Works, Division of Water Resources. "Reclamation of Water From Sewage or Industrial Waste". June, 1954.

California State Department of Water Resources. "Reclamation of Water From Sewage and Industrial Wastes, Progress Report July 1, 1953 - June 30, 1955". January, 1958.

California State Department of Water Resources, Division of Resources Planning. "Water Quality Investigation of Pajaro Valley". (In preparation).

California State Water Resources Board. "Water Resources of California". Bulletin No. 1. 1951.

California State Water Resources Board. "Santa Cruz-Monterey Counties Investigation". Bulletin No. 5. August, 1953.

California State Water Resources Board. "Sea-Water Intrusion in California". Bulletin No. 63. November, 1958.

Hyde, Charles Gilman and Brown and Caldwell. "The Collection, Treatment and Disposal of the Sewage and Storm Drainage of the City of Watsonville, California". May, 1953.

Of particular significance among the foregoing reports were the three waste water reclamation reports published by this Department; State Water Resources Board Bulletin No. 5; and the Hyde, Charles Gilman and Brown and Caldwell report, which was prepared for City of Watsonville.

The Department of Water Resources is presently conducting comparable studies in the San Jose, Los Angeles, and San Diego areas.

Objective and Scope of Investigation

The basic objective of this investigation was to determine the feasibility of using water reclaimed from the sewage and industrial waste discharge of the City of Watsonville for beneficial purposes.

The scope of the investigation included an evaluation of the demand for supplemental water, determination of the quantity and quality of sewage and industrial wastes available for reclamation, an evaluation of legal or financial problems involved, and determination of the feasibility of alternative waste water reclamation projects.

Field Investigation

The field investigation consisted of collecting samples of sewage and industrial wastes which are presently conveyed to the Watsonville screening plant in separate influent lines, obtaining antecedent information on quantities of sewage and industrial waste, ascertaining operation schedules and estimates of future expansion of local industrial food processing plants, making land and water use studies, and making reconnaissance surveys for conveyance lines and reservoirs.

Various crops are processed during different periods of the year. Consequently, wastes were repeatedly sampled to obtain a representative indication of their quality. Sampling was performed during three crop processing periods. These periods were: August, 1955, during processing of leafy green vegetables; October, 1955, while brussels sprouts, lima beans, and berries were being processed; and May, 1956, while peas, spinach, cauliflower, broccoli, asparagus, and berries were being processed. Sampling of

wastes during processing of lima beans in October and peas in May was considered especially important, as these products are floated in a salt solution during processing. In addition, daily samples of industrial waste were obtained at the Watsonville screening plant by city personnel and composited each month from September, 1955 through December, 1956.

Physical, sanitary, and mineral characteristics of the sewage and industrial wastes were determined by analysis of samples collected. These included determination of chloride, conductance, temperature, and pH; bacteriological examination of individual samples; 5-day 20°C biochemical oxygen demand (BOD), settleable solids, and suspended solids determination; and standard mineral analyses of composite samples.

Water Quality Criteria

By far the greatest use of water in the Watsonville area is for agricultural purposes. No industries were found which could use appreciable amounts of reclaimed water. Direct use of reclaimed water for domestic purposes was considered undesirable from health and aesthetic standpoints. Therefore, only those criteria relating to the use of reclaimed water for irrigation are presented.

Water quality criteria for irrigation use fall into two classes: mineral and sanitary.

Criteria for mineral quality of irrigation water used by the Department of Water Resources are those developed at the University of California at Davis, and at the United States Salinity Laboratory at Riverside. Because of diverse climatological conditions, and the variation in crops and soils in California, only general limits of water quality and suitability are suggested. The following broad classifications of irrigation waters are used by the Department:

Class 1* — EXCELLENT TO GOOD. Regarded as safe and suitable for most plants under any condition of soil and climate.

Class 2* — GOOD TO INJURIOUS. Regarded as possibly harmful for certain crops under certain soil conditions.

Class 3* — INJURIOUS TO UNSATISFACTORY. Regarded as probably harmful to most crops and unsatisfactory for all but the most tolerant.

Chemical Property	Class 1 Excellent to good	Class 2 Good to injurious	Class 3 Injurious to unsatisfactory
Conductance (EC x 10^6 at 25°C)	Less than 1,000	1,000 - 3,000	More than 3,000
Total dissolved solids, ppm	Less than 700	700 - 2,000	More than 2,000
Boron, ppm	Less than 0.5	0.5 - 2.0	More than 2.0
Per cent sodium	Less than 60	60 - 75	More than 75
Chlorides, ppm	Less than 175	175 - 350	More than 350

* L. V. Wilcox and C. C. Magistad, "Interpretation of Analyses of Irrigation Waters and the Relative Tolerance of Crop Plants". United States Regional Salinity Laboratory, 1943.

Sewage is defined in Section 13005 of the State Water Code as:

". . . any and all waste substances, liquid or solid, associated with human habitation, or which contains or may be contaminated with human or animal excreta or excrement, offal, or any feculent matter."

Industrial waste is defined in the same code section as:

". . . any and all liquid or solid waste substance, not sewage, from any producing, manufacturing or processing operation of whatever nature."

Sanitary regulations governing the use of sewage to irrigate crops are found in the State Department of Public Health Bulletin No. 59. A copy

of this bulletin is reproduced as Appendix "B". These regulations provide that: (1) untreated sewage (coarse screening and grit removal are not considered to afford adequate treatment) shall not be used to irrigate growing crops; (2) settled or undisinfected sewage shall not be used to irrigate certain specified growing crops; and, (3) no restrictions apply against the use of a well oxidized and reliably disinfected effluent, where the treatment works have adequate safety factors to insure the uninterrupted production of an effluent meeting certain specified bacteriological standards.

In addition to the foregoing, it is important that irrigation operations using sewage effluent must not cause nuisance conditions and must be aesthetically acceptable to the users and to persons in the vicinity of the area of use.

No specific sanitary regulations are known which restrict the use of industrial wastes for irrigation, unless these wastes contain human or animal feculent material. However, the same broad principles regarding nuisance and public acceptance probably would apply equally as well to industrial wastes as to sewage.

Area of Investigation

Description

The area under consideration is the bayward portion of the valley floor area of the Pajaro Valley (Plate 1). The reclaimable water originates as sewage and industrial wastes from the City of Watsonville, the Freedom Sewer Maintenance District, and the Pajaro Sanitation District.

Climate of the Watsonville area is mild and equable, conducive to high productivity of agricultural lands. This climate is characterized by dry summer and wet winter seasons, with nearly 90 per cent of the annual

precipitation occurring during the six months from November through April. The growing season is relatively long, averaging 237 days between killing frosts. Temperatures at Watsonville range from 15°F to 110°F. The average monthly temperature for the 1880-1947 period varied from 49.9°F in January to 61.5°F in July, and the annual average temperature was 56.6°F.

The area tributary to the Pajaro Valley is drained chiefly by the Pajaro River. Smaller streams within the area are Corralitos, Green Valley, and Casserly Creeks, and Watsonville Slough. Four natural lakes north of Watsonville contain water throughout the year; and another, College Lake, has been drained to permit growth of crops on its bed.

Land Use

Land within the area of study, outside the corporate city limits, is devoted primarily to irrigated agriculture and associated industrial activities such as food processing and packaging.

Irrigated crops include sugar beets, flowers, and truck produce such as lettuce, artichokes, cauliflower, corn, cabbage, brussels sprouts, broccoli, and beets. The trend of development is to devote more land to lettuce and artichokes, alternating occasionally with other crops. During the period 1946-1949, 97 per cent of the seasonal demand for irrigation water occurred during the six month period from April 1 to September 30.

Food processing and packaging industries are encroaching upon farm land along Beach Road and this type of development is expected to expand in the future.

The strip of land between Watsonville Slough and Monterey Bay is a recreational beach used for clamming, bathing, and picnicking.

Ground Water Occurrence

Ground water in the Pajaro Valley occurs in relatively well-defined aquifers of late Quaternary fill and Quaternary sands, Pleistocene terrace deposits, the Aromas formation, and the underlying Purisima formation. Underlying these formations are nonwater-bearing rocks of Santa Lucia quartz diorite and related igneous rocks and sediments of the Monterey group which neither absorb, transmit nor yield any appreciable quantity of water.

There are three distinct water producing aquifers underlying the Pajaro Valley floor, namely the shallow, intermediate, and deep aquifers. These aquifers are separated by extensive and relatively well defined blue clay layers.

The shallow aquifer varies in depth from 30 to 100 feet below the valley floor. It contains perched and semiperched bodies of ground water, the lateral movement of which is, in some cases, impeded by surface variation in the clay strata. Except for a few small domestic wells, there is no use made of this water because of low yield of wells and the general poor quality.

The next lower, or intermediate, aquifer extends to a depth of approximately 200 to 300 feet and is the most important source of irrigation water in the valley floor area. With the exception of an area immediately adjacent to Monterey Bay, which has been affected by sea-water intrusion, waters from the intermediate aquifer are of excellent mineral quality. Data regarding representative wells producing from this aquifer and results of analyses of water samples collected from these wells are presented in Tables 1 and 2, Appendix"C". Well locations are shown on Plate 1.

The underlying deep aquifer is believed to extend to approximately 800 feet below land surface, based upon data collected subsequent to publication of Bulletin No. 5. At present, only a few wells produce from this

aquifer. A limited number of samples indicate that water from this aquifer is of good quality.

CHAPTER II. RECLAMATION OF WATER FROM SEWAGE AND INDUSTRIAL WASTES

The major use of reclaimed water in California has been for irrigated agriculture although some has also been used for industrial supplies, including cooling, condenser make-up, and boiler-feed waters. The steel industry has used reclaimed water to cool blast furnaces and open hearths, rolls in rolling mills, gas washers, and wire drawing machines; to granulate blast furnace slag; and to clean gases. Other uses of reclaimed water include irrigation of parks and golf courses, fish culture, water for artificial ponds and lakes, and ground water replenishment.

The use of reclaimed water for direct domestic use is rare. However, in Chanute, Kansas, during the fall and winter of 1956-57, the city was forced to recycle treated sewage effluent through its water treatment plant due to the most severe drought in Kansas history. Although it has been reported that no adverse health effects were noted, many people used other sources of water because of aesthetic objections.

In studying the many complex problems associated with orderly development of the State's water resources, reclamation of water from wastes should be considered. Although reclaimed water will probably never provide a major contribution to the total statewide water requirement of California, because of quality problems and other inherent limitations on the use of reclaimed water, it will become increasingly significant in localized areas in the future. Waste water reclamation takes on particular significance in areas that have overdrawn their local resources and are finding it increasingly difficult to find alternate sources of supply.

There does not appear to be any significant demand for industrial use of reclaimed water in the Watsonville area. Direct use of reclaimed water for domestic purposes is generally objectionable from health and

aesthetic standpoints. Therefore, the most logical applications of reclaimed water in this area would be for ground water replenishment or for irrigation.

Direct recharge of the deeper water producing aquifers by percolation is not possible due to an impermeable layer of blue clay overlying the principal aquifer. Replenishment of ground water by means of injection wells is difficult and expensive. Injection of reclaimed water requires a very high degree of treatment and chlorination to prevent organic material from clogging aquifers and thereby increasing the required injection pressure. Additionally, the direct injection of reclaimed water in a subterranean water-bearing stratum may be in conflict with regulations set forth in Section 4458 of the Health and Safety Code, which defines and prohibits the use of "sewer wells". For these reasons, only direct agricultural use has been considered for water reclaimed from sewage and industrial waste discharges of the City of Watsonville.

In the following pages, generalized feasibility criteria for waste water reclamation projects and specific evaluations pertaining to the feasibility of using reclaimed water for irrigation in Pajaro Valley are presented.

Water Reclamation Feasibility Criteria

Feasibility of a waste water reclamation project is controlled by five fundamental factors. These are:

1. A demand for supplemental or substitute water must exist.
2. A significant quantity of waste water must be available for reclamation.
3. Quality of reclaimed water must be suitable for intended beneficial use or uses.
4. There must be no insurmountable legal obstacles to the acquisition and continued use of reclaimed water.
5. A project for waste water reclamation must be financially feasible.

This means that the cost of reclaimed water must be competitive with other available or alternate sources of supplemental water supply and there must be a feasible method for financing the project.

Demand for Supplemental Water

There are a number of conditions which contribute to the demand for supplemental water within a particular area. Among these, insofar as agriculture is concerned, are the seasonal nature of, and disparity between, precipitation and demand; occurring periods of below normal precipitation; and overdevelopment of available water resources. These conditions have influenced the demand for supplemental or substitute water in the Watsonville area. If this demand is not satisfied, present economic development cannot continue.

Data on water requirements in the Pajaro Valley previously have been published in State Water Resources Board Bulletin No. 5. A summary of the annual water requirements in the Pajaro Unit, taken from Bulletin No. 5 is presented in the following tabulation:

ESTIMATED ANNUAL WATER REQUIREMENTS
PAJARO UNIT, SANTA CRUZ AND MONTEREY COUNTIES
(In acre-feet)

Class of land use	Water requirement (1946-49)	Probable increase in water requirement	Probable ultimate water requirement
Irrigated lands	23,900	15,400	39,300
Urban lands	2,600	6,200	8,800
TOTALS	26,500	21,600	48,100

It should be noted that the foregoing statistics apply to the Pajaro Unit which encompasses both the valley floor area and the upper pressure and forebay areas. Of the total water requirement (1946-49), 24,700 acre-feet were derived from ground water and 1,800 from surface water supplies.

In Bulletin No. 5, the safe yield of the Pajaro Unit was estimated to be about 21,000 acre-feet per year. Since the rate of ground water extraction (1946-49) was estimated to be 24,700 acre-feet per year, it is evident that the safe ground water yield of the Pajaro Unit was exceeded. Consequently, the ground water reservoir was overpumped, with the resulting intrusion of sea water.

The intrusion of sea water into the intermediate aquifer is evidenced by data obtained from seven wells located on the bayward portion of the valley floor. Four wells have been abandoned because of excessive salts, a fifth has been abandoned for an unknown reason, and two others have shown high or increasing chloride content. Data regarding these wells, located as shown on Plate 1, are presented in Table 1, Appendix C. Results of analyses of water samples from these wells are shown in Table 3, Appendix C.

It is estimated that the annual requirement for supplemental water in the Pajaro Unit (1946-49) was about 3,700 acre-feet. It is further estimated that this supplemental water requirement will increase to about 25,300 acre-feet annually under ultimate conditions.

Quantity of Sewage and Industrial Wastes

Sewage and industrial waste flows reaching sewage treatment plants are the used waters from communities and from industrial operations. Quantities of waste may fluctuate with the season of the year, day of the week, and hour of the day. Further, under certain circumstances, total plant inflows to

sewage treatment plants can far exceed quantities of used water intentionally discharged to sewers. This results from ground water infiltrating through construction joints or cracks in underground conduits or accidental inflows of surface runoff and/or storm water.

Wastes presently handled by the City of Watsonville originate from four sources: sewage from that city, from the Freedom Sewer Maintenance District, and from the Pajaro Sanitation District; and industrial wastes from several industries in or adjacent to the city. These wastes are combined at the Watsonville screening plant and discharged to Monterey Bay through a submarine outfall.

Early in 1955, a 12-inch Parshall flume was installed at the Watsonville screening plant to measure industrial waste inflow. Prior to that time, industrial waste inflow was not measured separately, but was included in the total recorded waste inflow. To determine the fluctuations in industrial waste and sewage inflow during a representative period (August 15 to 22, 1955), arrangements were made to measure these flows individually. Hourly flow rates observed during this period are shown on Plate 2.

In September, 1955, an automatic recording device was installed at the Parshall flume, and since that time a continuous record of industrial waste inflow has been maintained by the City of Watsonville. A summary of these records for the period from September 1955 through September 1956, are presented in Table 4, Appendix C, and are shown graphically on the upper portion of Plate 3. According to this information, daily industrial waste flow was about 1.4 mgd, or 1,570 acre-feet per year. About 780 acre-feet of wastes were discharged during the six month irrigation season.

Monthly statistics regarding combined sewage and industrial waste flows, for the period March 1950 through December 1956, are listed in Table 5, Appendix C, and are presented graphically in the lower figure on Plate 3.

Flow records prior to 1950 are considered unreliable. Since March 1950, the monthly mean quantities of sewage and industrial waste inflows have ranged from 1.5 to 3.4 mgd during the irrigation season.

In order to establish design criteria for construction of a proposed reclamation project, forecasts of future quantities of sewage and industrial wastes were made. Sewage and industrial waste flow forecasts were based upon estimates of future population of the area, and estimates of future quantities of products to be processed, respectively.

Results of population studies by Hyde, Brown and Caldwell for the Watsonville sewage service area are shown graphically on Plate 4. It is estimated that the population for this area will increase to about 39,000 by 1985.

The future domestic sewage flow was estimated on the basis of population growth in the Watsonville sewage service area, using a flow of 100 gallons per capita per day. Between 1960 and 1985, these flows will increase from 2.3 to about 3.9 mgd. Based upon data obtained from local industries, it was estimated that future industrial waste flows would increase from 1.2 to over 2.3 mgd during the next quarter century. The estimated domestic sewage and industrial waste flows are shown graphically on Plate 4. It is estimated that the combined flow will be in excess of 6.0 mgd by 1985, and will increase to 8.0 mgd by the year 2000.

It is apparent that water reclaimed from domestic and industrial waste flows would not meet the total future supplemental water requirement of the Pajaro Unit. However, the quantity of reclaimed water which could be obtained would appreciably alleviate the increasing ground water overdraft. Based on conditions predicted for 1985, reclaimed water would provide approximately thirteen per cent of the supplemental water requirements of the Pajaro Unit at that time.

Quality Characteristics of Sewage and Industrial Wastes

Liquid waste flowing in a municipal sewer system may consist of sewage from residential, commercial, and industrial areas, either separately or in combination with various types of industrial wastes. In addition to the mineral and organic material already in the water supplied to a community, sewage contains an imposed burden of human excrement, soap, dirt, food wastes, dissolved minerals, and numerous other substances. This imposed waste burden is primarily organic in nature and is carried in suspension, in solution, or as colloids. Although organic material in sewage is composed largely of inanimate substances, a portion is in the form of living organisms. Bacteria, many of which are capable of causing disease and disorder in the human life cycle, comprise the most important group of living organisms in sewage.

Industrial wastes originate from cooling, washing, flushing, extracting, impregnating, chemical treatment, and similar operations. The nature and quality of these industrial wastes are as varied as the products and processes of the operations from which they result. All wastes contain varying amounts of organic and mineral compounds. Some contain substances toxic to plant, animal, or fish life; some are corrosive; while others impart unpleasant tastes and odors in receiving waters.

If water is to be reclaimed from sewage and/or industrial wastes, concentrations of impurities must be reduced to acceptable limits for the intended uses. Reclaimed water must be free from public health hazards or nuisance conditions, and must be aesthetically acceptable.

Reduction of organic impurities can be accomplished by standard sewage treatment procedures and disinfection. Reduction of mineral content, on the other hand, is generally not economical with present methods of treatment. Separate sewer lines may be required to carry the more objectionable

or concentrated wastes in order to keep concentrations of inorganic constituents within acceptable limits.

Mineral and sanitary characteristics of sewage and industrial waste discharges from the City of Watsonville, are shown in Tables 6, 7, 8 and 9 of Appendix C. At times during August, 1955, industrial waste flows were by-passed to the Pajaro River so that representative sewage samples could then be obtained. Conductivity measurements of sewage and industrial wastes, for the period August 15 to 22, 1955, were obtained through use of a continuous recorder. Diagrams showing these conductivity measurements are presented on Plate 2.

A study of Table 6, Appendix C, shows that the total dissolved solids content of the sewage ranged from 637 to 891 ppm, the specific conductance ranged between 1,140 and 1,540, the chloride content ranged from 88 to 200 ppm, and the boron content was less than 0.57 ppm. These concentrations indicate that the sewage was a good Class 2 irrigation water.

Sanitary analyses of the sewage for the period August 15 to 22, 1955, shown in Table 7, Appendix C, indicate that it was of normal strength. Suspended solids ranged from 80 to 249 ppm and averaged 188. The five-day biochemical oxygen demand (BOD) ranged from 63 to 299 ppm and averaged 190. Table 8, Appendix C, shows results of bacterial examination of the sewage.

As shown in Table 6, Appendix C, mineral quality of industrial wastes was generally within the limits of Class 1 irrigation water. However, during processing of peas and lima beans, salt solutions used for flotation are discharged intermittently. These saline solutions alter the sodium chloride content of the industrial wastes, resulting in a poor Class 2 or even Class 3 irrigation water for brief periods of time. For example, for a three-hour period on October 20, 1955, chloride content increased to 645 ppm.

Table 7, Appendix C, shows the sanitary quality of the industrial wastes. As indicated by samples collected during this investigation, suspended solids content of industrial wastes ranged from 23 to 187 ppm and averaged 93. Five-day BOD ranged from 35 to 163 ppm and averaged 84. Analyses indicate that these industrial wastes are equivalent to weak sewage with respect to organic material.

Based upon available data regarding mineral quality, it appears that the use of water reclaimed from sewage would not harm crops presently grown in the area. These data further indicate that water reclaimed from the industrial waste could be utilized if it were diluted with fresh water on those occasions when highly saline waste is discharged.

With respect to sanitary quality, it is believed that waters reclaimed from sewage could be used for irrigation of sugar beets or fodder crops after receiving primary treatment. A very high degree of secondary treatment, including reliable disinfection, would be necessary before these reclaimed waters could be used for general irrigation of local crops.

Results of numerous bacteriological examinations, shown in Table 9, Appendix C, showed that the industrial wastes contained significantly high concentrations of bacteria. Since sewage and industrial wastes arrive at the Watsonville screening plant in separate influent lines, the possibility of fecal contamination of these industrial wastes appear remote. Further, industrial wastes containing organic material and soil particles, have been known to provide a favorable environment for growth of bacteria not of fecal origin. Therefore, it has been assumed that these industrial wastes would not fall within the classification of sewage as previously defined, and after screening, could be utilized safely for limited irrigation. However, for general irrigation of local crops, it is quite possible that bacteriological quality would have public health significance and that treatment and reliable disinfection would be required.

Predicted volumes of sewage and industrial waste (see Plate 4) and average quality values indicate that the intermittent discharge of highly saline industrial wastes would not change the mineral characteristics of the combined sewage and industrial waste flow from Class 2 to Class 3 water. However, every effort should be made to minimize these intermittent discharges in order to obtain a reclaimed water with as low dissolved mineral concentration as possible. Further, a very high degree of secondary treatment coupled with reliable disinfection would be required before water reclaimed from the combined flow could be used for general irrigation.

Based upon the foregoing, it can be concluded that no insurmountable quality problems exist which would preclude the agricultural use of water reclaimed from wastes presently being discharged to Monterey Bay by the City of Watsonville.

Legal Considerations

If any plan to reclaim water from sewage and industrial waste for beneficial use is to be successful, legal aspects must be favorable to the acquisition and continued use of reclaimed water.

Regulation of waste effluent quality is under the jurisdiction of Central Coastal Regional Water Pollution Control Board (No. 3) and the State Department of Public Health. These two agencies have separate and distinct regulatory responsibilities. The pollution control board sets requirements as to effluent or receiving water quality. The State Department of Public Health has power to regulate the use of sewage for irrigation in accordance with regulations published in Department of Public Health Special Bulletin No. 59 (see Appendix B).

The City of Watsonville has contracted to receive and discharge waste from the collection systems of the Freedom Sewer Maintenance District and the Pajaro Sanitation District. Study of these contracts reveals no

legal obstacles to the use of this waste in a water reclamation program. However, the contracts should include a renewal clause so that the availability of the waste will be assured. Consideration should also be given to adoption of local ordinances to prevent future degradation of the waste supply by highly mineralized industrial discharges.

Plans for Water Reclamation

A number of alternative plans for the utilization of water reclaimed from sewage and industrial waste discharges of the City of Watsonville have been considered. Of these plans, the direct application of reclaimed water for irrigation on the valley floor was found most feasible. In furtherance of such a reclamation project, a progressive program of stage construction appears desirable. Potential Phase I and Phase II Projects are discussed in the following pages. Possible service areas for each of these projects are indicated on Plate 5.

Phase I Project

The Phase I Project contemplates direct agricultural use of only those untreated industrial wastes which are presently discharged to Monterey Bay during the irrigation season, April 1 to September 30. Such a proposal could be undertaken immediately since these industrial wastes flow in a separate sewer to the Watsonville screening plant and, after fine screening, could be put to beneficial use for irrigation of such field crops as sugar beets, hay, and grain. On the other hand, utilization of water reclaimed from sewage for any type of irrigation would require at least primary treatment.

In the Watsonville area, it is common practice to irrigate only during daylight hours or for about twelve hours per day. The Phase I Project

contemplates use of only those industrial waste flows which are available during irrigating hours. During 1956, the total waste flow averaged 1.4 mgd (see Table 4). Thus, about 390 acre-feet were available for reclamation over the six month irrigation season.

The Phase I Project would include a device to automatically measure the conductivity of the industrial wastes, since they are subject to sudden variations in salinity. The device would be connected to a relay system which would activate a pump to furnish fresh water from an existing well at the Watsonville sewage screening plant when necessary to dilute saline waters. A 20-horsepower, 2.0 mgd pump would lift the reclaimed water to an existing 22-inch outfall (presently unused) which would then convey the water to the service area (see Plate 5).

During the seven-day sampling period in August, 1955, total industrial waste flow was approximately 2.9 million gallons and averaged about 0.42 mgd. Flow and conductivity are shown on Plate 2. In order to prevent the conductivity of reclaimed water from exceeding 800 micromhos at 25°C (1000 recommended limit for Class 1 irrigation water less 20 per cent safety factor), fresh dilution water would have been required in an amount equal to five per cent of the delivered water (0.15 mg or 0.02 mgd). Dilution water quality was assumed to be equal to that of a sample taken from the well at the screening plant in January, 1956. Thus, available industrial waste flows have been increased by five per cent for the addition of dilution water, and it has been assumed that approximately 410 acre-feet of water would be available for each irrigation season. Costs of pumping dilution water have been included in reclamation project cost estimates.

Agricultural statistics compiled by the Federal Agricultural Stabilization and Conservation Committee indicate that about 350 acres of cropland in Santa Cruz County were devoted to the production of sugar beets, in 1956.

Since the majority of sugar beet production is Santa Cruz County is centered in the Pajaro Valley, it has been assumed that sufficient acreage of this type exists in proximity to the abandoned 22-inch outfall to utilize water reclaimed from the Phase I Project. Reclaimed water could be applied to a 350-acre area of sugar beets with a unit use of water of 1.2 acre-feet per acre. This assumed rate of application is slightly higher than the 1.15 acre-feet per acre value reported in Bulletin No. 5 for the 1947-49 period. Potential acreage which might be served under the proposed Phase I Project is shown on Plate 5.

Based upon 1958 costs (Engineering News Record, ENR construction cost index 743), capital cost of the automatic salinity control and pumping facilities is estimated to be $2,400. Using an interest rate offour per cent over a 40-year replacement period, annual costs, including debt service, operation, and maintenance, are estimated to be $1,600. It should be noted that estimated costs have been developed, based on the following considerations:

(1) That untreated industrial wastes would be available without charge;

(2) That transmission losses in the existing 22-inch outfall line would be insignificant; and,

(3) That because of the strategic location of the existing 22-inch outfall line, only minimum lengths of distribution ditches would be required, and conveyance losses would be negligible.

Under these conditions, reclaimed water could be delivered (ditch side) for a cost of about $3.90 per acre-foot.

Phase II Project

Design criteria for the proposed Phase II Project are based upon a combined sewage and industrial waste flow of 6.0 mgd, predicted to occur in about 25 years (see Plate 4, for predicted flows). Such a project could be

accomplished in conjunction with plans presently being developed by the City of Watsonville for primary sewage treatment facilities necessary to comply with waste discharge requirements of the Central Coastal Regional Water Pollution Control Board.

The proposed Phase II Project would utilize combined sewage and industrial waste flows during the irrigation season; and by 1985 an estimated 3,350 acre-feet of water could be reclaimed each year. This reclaimed water could be applied to a service area of 3,500 acres which comprises the irrigable lands west of Highway 1 (see Plate 5). In Bulletin No. 5, it was estimated that the ultimate weighted average unit application of water to irrigated lands would be about 1.5 acre-feet per acre. Water reclaimed from this proposed project could serve the entire area with an average delivery of about 0.95 acre-feet per acre or could furnish the estimated ultimate application rate to a lesser area of about 2,200 acres.

As indicated in the discussion of quality characteristics of sewage and industrial wastes, when predicted volumes and average quality values are considered, the combined waste flow would generally fall within the characteristics of Class 2 irrigation water. Accordingly, water reclaimed from such a project should be of satisfactory mineral quality for irrigation use on all locally grown crops.

The combined waste flow would receive primary clarification, biological oxidation, secondary clarification, sand filtration, and disinfection. Although any of the standard secondary biological oxidation processes would be satisfactory, cost estimates for this project are based upon the assumption that trickling filters would be used due to their ability to accommodate extremely variable loadings. It is believed that this degree of treatment will produce an effluent which will meet the regulations of the State Department of Public Health pertaining to irrigation and any requirements established

by the Central Coastal Regional Water Pollution Control Board.

To effectively utilize all of the treated waste water, some reservoir storage should be provided. The addition of storage also would allow more time for natural purification and oxidation processes to occur, thereby further reducing populations of bacteria. Reclaimed water could be stored either in the river channel or in off-stream ponds.

Storage in the river channel could be provided by constructing an eight-foot dam across the Pajaro River near the treatment plant, as schematically shown on Plate 6. Such a dam would provide about 75 acre-feet of storage, which is sufficient capacity for about four days discharge at design flow. For purposes of cost estimating, it was considered that this dam would consist of nine six-foot spans of 8-inch by 12-inch flashboards held in place by steel piling enbedded 20 feet into the streambed. Costs for providing protection from stream erosion by means of a concrete apron and wingwalls and for providing a fish ladder and other appurtenances for protection of fishlife were also included. Under this plan, the proposed service area could be served with reclaimed water diverted from the river channel.

In the event that a reservoir in the Pajaro River does not appear to be desirable, off-stream storage could be provided in ponds located near the treatment plant as shown on Plate 7. Twelve acres of ponds, six feet deep, would provide approximately the same amount of storage as the dam and channel reservoir. Reclaimed water could be diverted either directly from the ponds to adjacent cropland, or could be discharged to an upstream point in the Pajaro River through a pipeline. Under this latter plan, reclaimed water would be available for use from the river channel. In order to make reclaimed water available to the portion of the service area upstream from the treatment plant, a pipeline 7,500 feet in lenth would be required.

Under certain circumstances, a distribution system would be necessary to deliver water reclaimed by the Phase II Project to areas of use. For the purposes of this report, it has not been considered necessary to design and estimate the cost of such a system. However, since a progressive program of phase construction has been suggested, the possibility of integrating the abandoned 22-inch outfall into such a distribution system should be considered.

Costs of primary treatment and disinfection have not been considered chargeable to the reclamation project, as this is assumed to represent the cost necessary to meet the requirements of the Central Coastal Regional Water Pollution Control Board for ocean disposal. Costs chargeable to reclamation would be those additional expenditures resulting from construction and operation of facilities for biological oxidation, secondary clarification, sand filtration and storage. In case of off-stream storage, additional allowances have been made for the 7,500-foot pipeline to supply upstream users.

Of the two alternative methods, storage in the river channel would be less expensive. In computing annual costs, an interest rate of four per cent and a repayment period of 40 years were used. In addition, transmission and conveyance losses were considered to be insignificant. Estimates indicate the capital costs with river channel storage would be $846,000, and annual costs $73,100. Reclaimed water would therefore cost $22.00 per acre-foot. If off-stream storage is provided, capital costs would be $984,000, annual costs $80,100, and cost per acre-foot of reclaimed water $24.00.

The Phase II Project could be expanded at a later date to accommodate additional flows. It is estimated that a combined sewage and industrial waste flow of 8.0 mgd will be available for use by year 2000. This flow will amount to 4,500 acre-feet during the irrigation season (April 1 through September 30). This quantity of reclaimed water could serve the 3,500 acre service area at a unit application rate of about 1.3 acre-feet per acre or could furnish the

estimated ultimate application rate (1.5 acre-feet per acre) to a lesser area of about 3,000 acres.

Plans for Water Development from Alternative Sources

When cost of treating wastes is not a principal factor, water of almost any desired quality may be obtained. If water costs are the controlling factor, as is usually the case, treatment and conveyance costs for the waste water must be competitive with the cost of obtaining waters from alternate sources.

Four alternative proposals to solve conditions of overdraft in the Pajaro Valley are presented in State Water Resources Board Bulletin No. 5. These are: (1) shifting the center of heavy pumping; (2) conservation of run-off of Corralitos Creek by off-stream storage in an enlarged Pinto Lake; (3) conservation of runoff of the Pajaro River by off-stream storage in a reservoir on Elkhorn Slough; and (4) conservation of runoff of the Pajaro Valley by off-stream storage in a reservoir in Corn Cob Canyon. Of these four alternative proposals, the last, called the "Watsonville Project", was found to be most favorable. Principal features of this project include a pumping plant, canal, and diversion weir. The cost per acre-foot of water estimated in Bulletin No. 5 for the Watsonville Project adjusted to the 1958 ENR construction cost index of 743 and to current (four per cent) interest rates, was found to be $26.40. This cost is about 10 per cent greater than that of water reclaimed from wastes under the proposed Phase II Project with off-stream storage, and about 20 per cent greater than that estimated for water reclaimed under the proposed Phase II Project with river channel storage.

Methods of Financing

It is not sufficient merely to determine the cost of reclaiming water from wastes, methods of financing reclamation projects must also be considered. Consideration should be given to the type of agency or district which could be formed to construct and operate such a project, and means of obtaining funds for construction, operation, and maintenance.

A reclamation project to serve an area, westerly of State Highway 1, between Watsonville Slough and the bluffs, could be operated by a public district. There are a number of district organization acts which could be utilized in forming such a district. These include: the Community Service District Law (Government Code, Title 6, Division 2, comprising Sections 30000-33901), the Irrigation District Law (Water Code, Division 11, comprising Sections 20500-29978), and the Public Utility District Act (Public Utilities Code, Division 7, comprising Sections 15501-18004). The Municipal Utility District Act (Public Utilities Code, Division 6, comprising Sections 11501-14509) might also be suitable if the City of Watsonville were to be included in the district. If none of these enabling acts is considered appropriate, the Legislature could be requested to authorize formation of a special district.

Capital expenditures might be financed with available funds or by issuing general obligation bonds, revenue bonds, or perhaps some combination of the latter two. General obligation bonds are secured by the taxing power of the issuing agency and are on a higher plane of credit soundness than revenue bonds. Therefore, general obligation bonds can be marketed at a lower interest rate, providing a decided advantage to the financing of a project. However, the amount of bonded indebtedness that the agency may assume under these bonds is limited. Revenue bonds, repaid from the proceeds of a project, are self-liquidating and are usually marketed at a higher interest rate than general

obligation bonds. The revenue must be sufficient to cover all costs of debt service, operation and maintenance, replacement, and other expenses. Bonds of this type have been used increasingly by state and political subdivisions.

Annual operation and maintenance cost could be paid out of revenue obtained from the sale of reclaimed water. However, to initiate such a reclamation project, a special assessment against property owners within the district might be required to establish a fund for initial construction plus any unforseeable contingencies.

CHAPTER III. SUMMARY AND CONCLUSIONS

Summary

The most recent water resources survey in the Pajaro Valley, the results of which were published in State Water Resources Board Bulletin No. 5, indicated an existing supplemental water requirement of about 3,700 acre-feet annually. In satisfying this water requirement, overdraft on the underlying ground water supplies has occurred, resulting in the intrusion of sea-water along the coast. Probable supplemental water requirements, under ultimate conditions of development, are expected to increase to about 25,300 acre-feet annually.

The City of Watsonville is discharging an estimated 3,200 acre-feet of sewage and industrial waste annually to Monterey Bay. It is estimated that this discharge will increase to a quantity in excess of 6,700 acre-feet by 1985 and to about 9,000 acre-feet annually in the year 2000.

Analyses of samples collected from sewage and industrial waste discharges of the City of Watsonville show that, except during the seasons for processing of lima beans and peas, mineral quality of water reclaimed from industrial wastes would fall within the limits of Class 1 irrigation water. Water reclaimed from domestic sewage, being somewhat more highly mineralized, would fall within the limits of Class 2 irrigation water.

The Freedom Sewer Maintenance District and the Pajaro Sanitation District at present contract with the City of Watsonville to dispose of wastes from their systems. Study of these contracts does not reveal any legal obstacle to the use of this waste in a water reclamation program.

Plans for the agricultural utilization of water reclaimed from sewage and industrial wastes are suggested for implementation in two phases.

The Phase I Project could be undertaken immediately and would utilize untreated industrial wastes. With this project, 410 acre-feet of waste water including the addition of 20 acre-feet of pumped fresh water for dilution of saline waters, could be reclaimed annually. Water would be conveyed to points of application through an existing 22-inch pipe formerly used as an outfall line. The plan would include a system to automatically measure the waste and control its mineral quality by dilution with fresh ground waters.

The Phase II Project could be accomplished in conjunction with plans presently being developed by the City of Watsonville for primary sewage treatment facilities necessary to comply with waste discharge requirements of the Central Coastal Regional Water Pollution Control Board. This project, designed for conditions predicted to occur in about 25 years, would utilize all sewage and industrial waste flows discharged during the irrigation season and would reclaim an estimated 3,350 acre-feet of water per year. This plan proposes that wastes, after primary treatment, will receive supplemental treatment consisting of biological oxidation, secondary clarification, and sand filtration, and will be reliably disinfected. This degree of treatment should produce an effluent meeting regulations of the State Department of Public Health pertaining to use of reclaimed water for irrigation and any requirements established by the Central Coastal Regional Water Pollution Control Board.

Cost estimates for the two projects are as follows:

Project	Capital Cost	Annual Cost	Water reclaimed annually, in acre-feet	Water cost, per acre-foot
Phase I	$ 2,400	$ 1,600	410[a]	$ 3.90
Phase II				
River channel storage	846,000	73,100	3,350	22.00
Off-stream storage	984,000	80,100	3,350	24.00

a Includes 20 acre-feet of water added for dilution purposes.

The Phase II Project could be expanded as greater quantities of wastes become available.

Cost per acre-foot of water estimated in Bulletin No. 5 from the most feasible alternative source (Watsonville Project), adjusted to current cost conditions, was $26.40. This is about 10 per cent greater than the estimated cost for water reclaimed from wastes under the proposed Phase II Project with off-stream storage, and about 20 per cent greater than that estimated for water reclaimed under the proposed Phase II Project with river channel storage.

A public district could construct and operate any of the suggested water reclamation projects. Either general obligation or revenue bonds could be used for financing.

Funds to meet annual operation and maintenance expenditures could be obtained from sale of reclaimed water. However, it might be necessary to levy a special assessment in the early stages of operation to provide a contingency reserve.

Conclusions

It is physically possible and feasible to reclaim water from sewage and industrial wastes presently discharged to Monterey Bay by the City of Watsonville. These reclaimed waste waters could be utilized for agricultural purposes in Pajaro Valley. Utilization of reclaimed water for beneficial purposes would, in effect, provide a practical means of alleviating the increasing ground water overdraft in the Pajaro Valley. Based upon conditions predicted for 1985, reclaimed water could provide approximately thirteen per cent of the supplemental water requirements of the Pajaro Unit at that time.

SANTA CLARA CO.

SANTA CRUZ CO.

LEGEND

AI ◆ WELL LOCATION (MINERAL ANALYSIS)

—5— LINES OF EQUAL ELEVATION OF GROUND WATER IN FEET

EXTENT OF CHLORIDE DEGRADATION
(IN EXCESS OF 350 PARTS PER MILLION)

STATE OF CALIFORNIA

DEPARTMENT OF WATER RESOURCES

DIVISION OF RESOURCES PLANNING

RECLAMATION OF WATER FROM SEWAGE
AND INDUSTRIAL WASTES-WATSONVILLE AREA

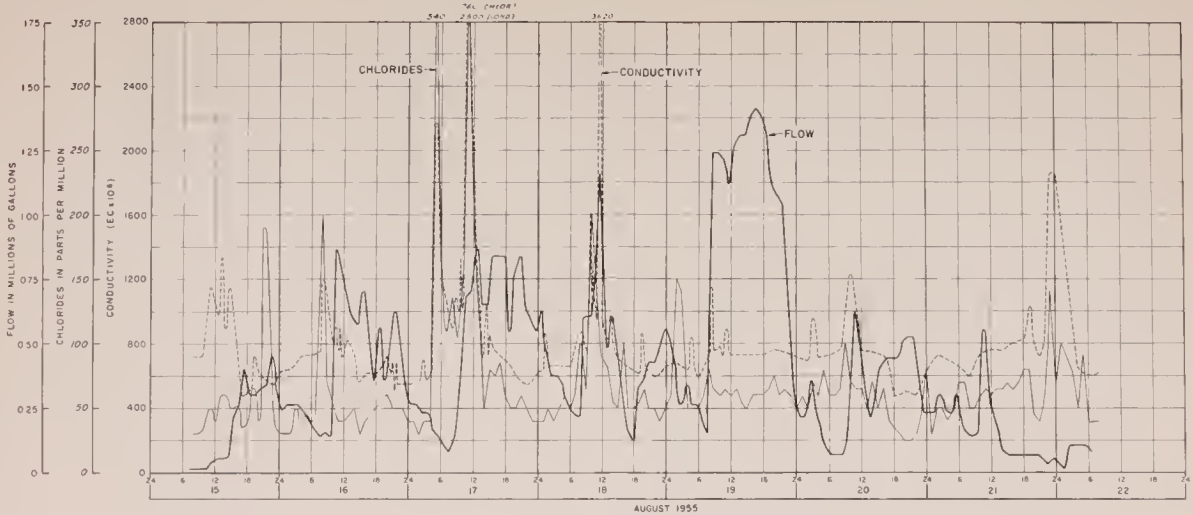
GROUND WATER LEVELS
AND
EXTENT OF CHLORIDE DEGRADATION
INTERMEDIATE AQUIFER
FALL 1957

SCALE OF FEET

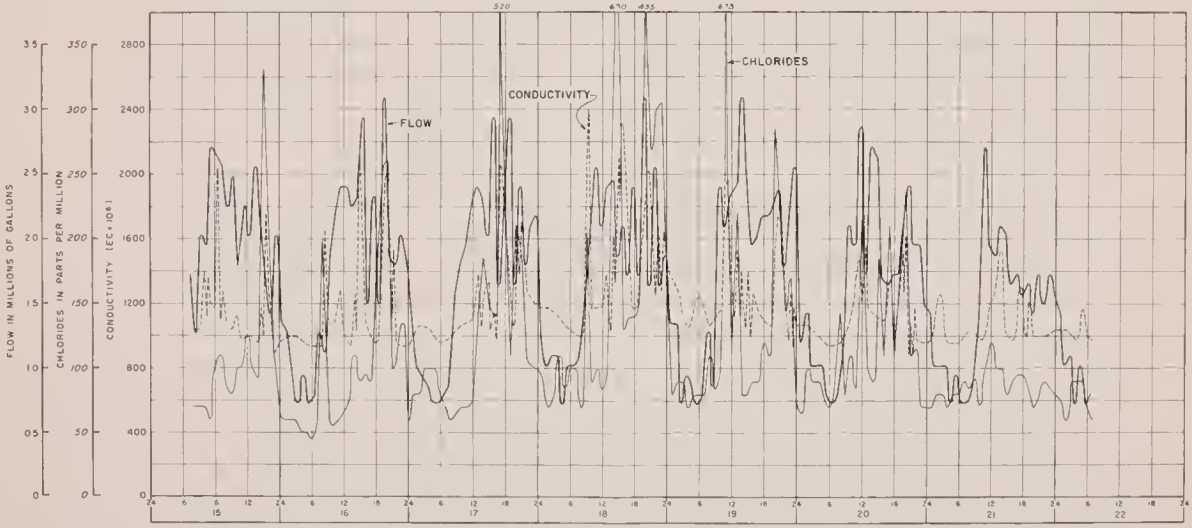
0 2000 4000 6000 8000

PLATE 1

DEPARTMENT OF WATER RESOURCES 1959



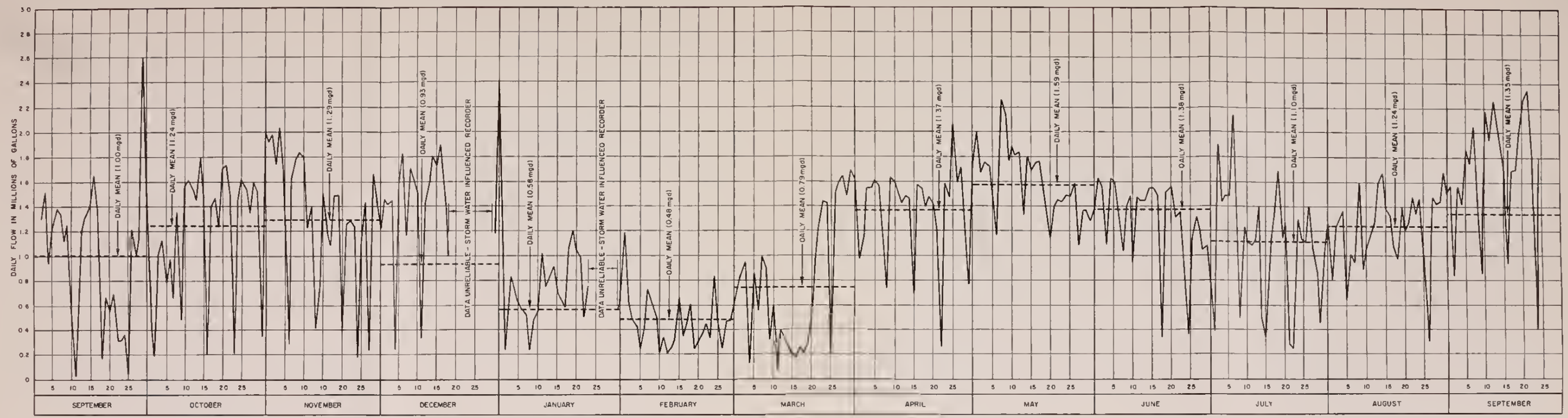
INDUSTRIAL WASTES



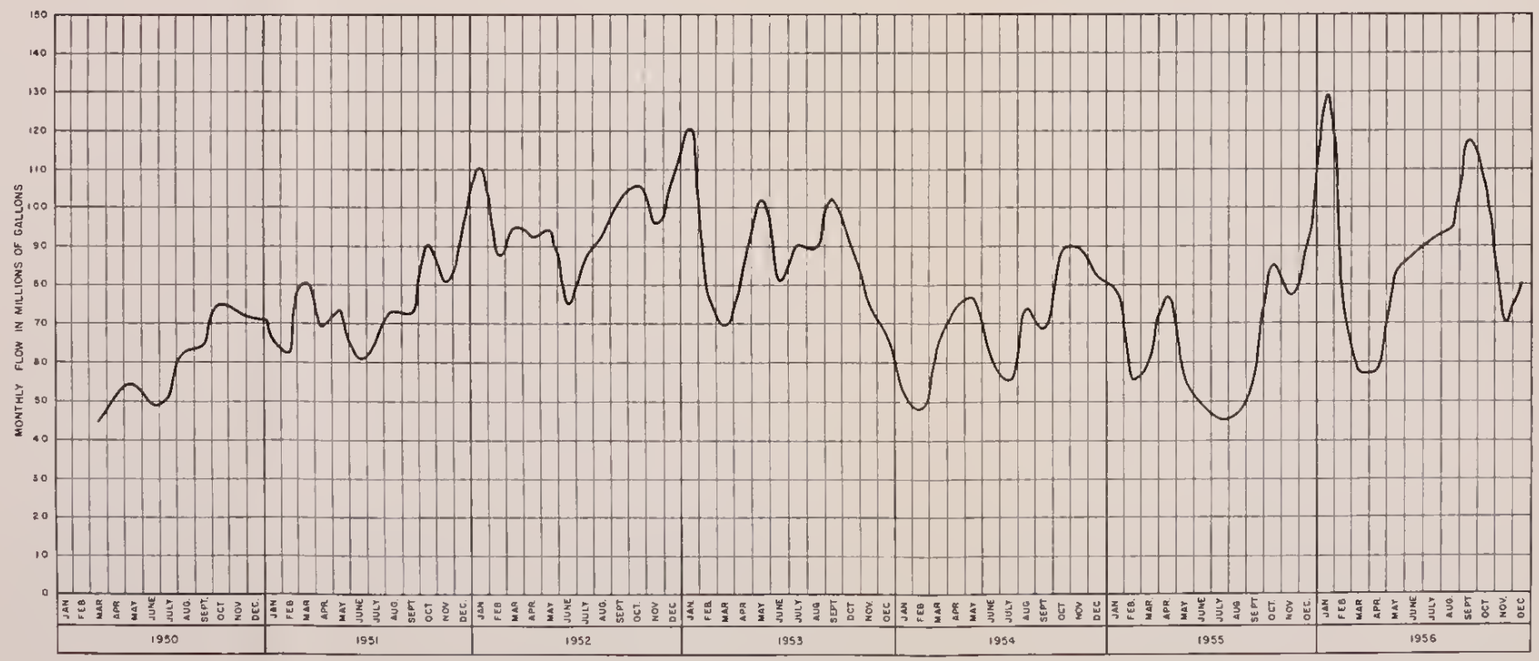
SEWAGE

CHARACTERISTICS OF SEWAGE AND INDUSTRIAL WASTES
CITY OF WATSONVILLE

DEPARTMENT OF WATER RESOURCES 1959



INDUSTRIAL WASTE



COMBINED SEWAGE AND INDUSTRIAL WASTE

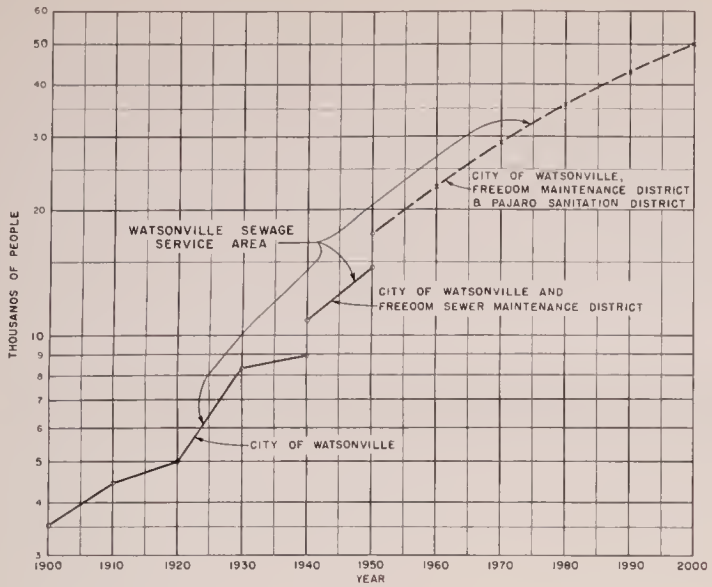
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING

RECLAMATION OF WATER FROM SEWAGE AND INDUSTRIAL WASTES - WATSONVILLE AREA

SEWAGE AND INDUSTRIAL WASTE FLOW

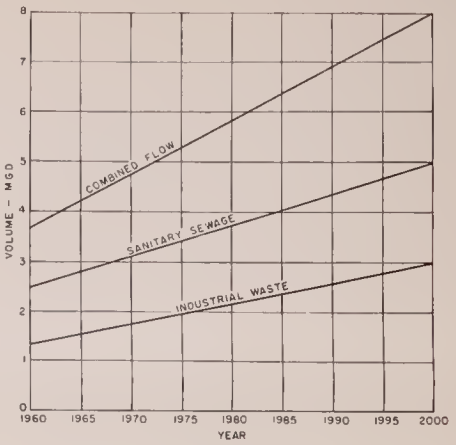
CITY OF WATSONVILLE

DEPARTMENT OF WATER RESOURCES 1959



POPULATION

(FROM HYDE, CHARLES GILMAN AND BROWN AND CALDWELL "THE COLLECTION, TREATMENT AND DISPOSAL OF THE SEWAGE AND STORM DRAINAGE OF THE CITY OF WATSONVILLE, CALIFORNIA" MAY 1953)

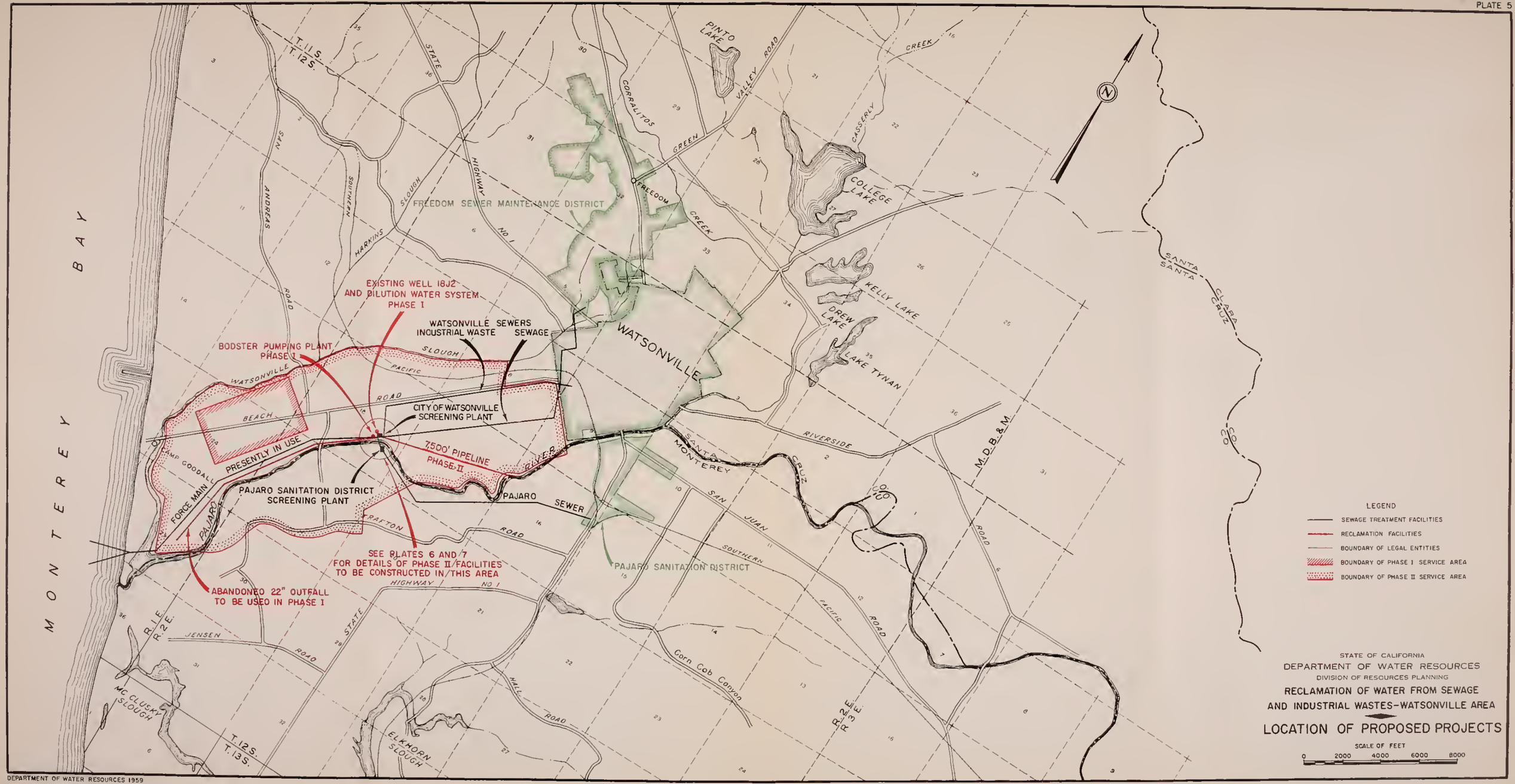


WASTE FLOW

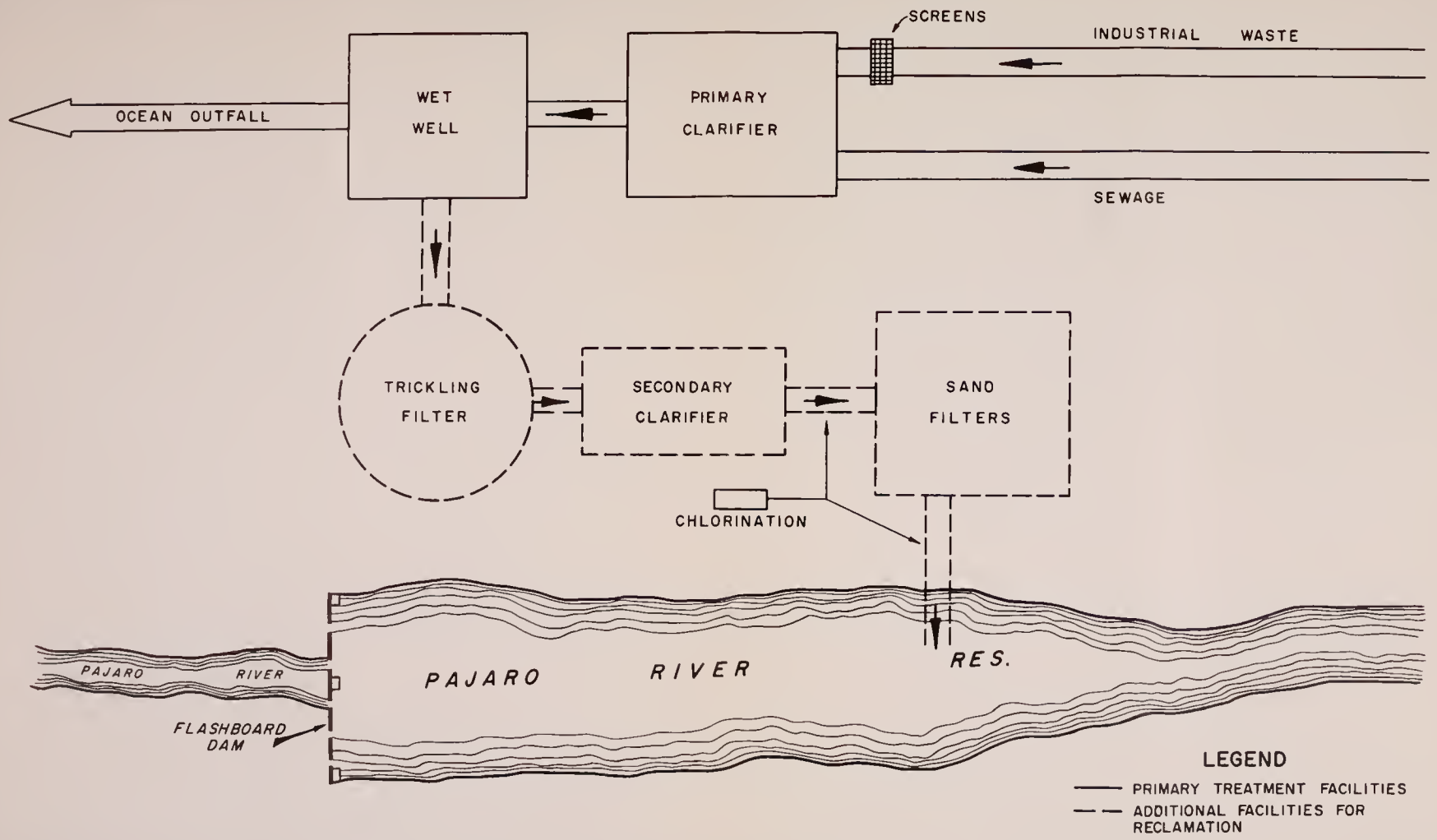
(WASTE FLOW PREDICTIONS MADE BY DEPARTMENT OF WATER RESOURCES IN 1955-56)

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
RECLAMATION OF WATER FROM SEWAGE AND INDUSTRIAL WASTES - WATSONVILLE AREA

POPULATION AND WASTE FLOW PREDICTIONS
WATSONVILLE SEWAGE SERVICE AREA

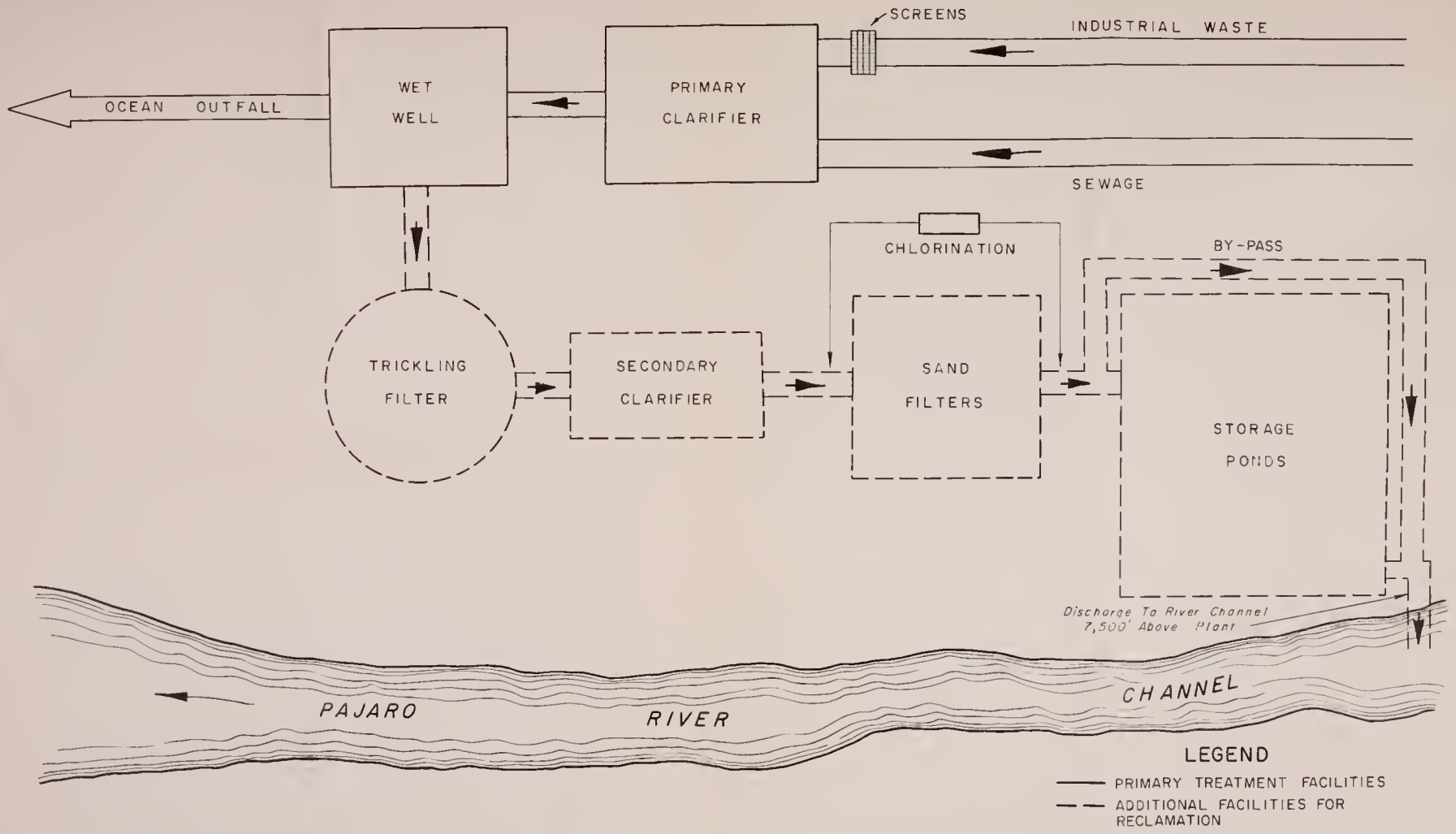


DEPARTMENT OF WATER RESOURCES 1959



SCHEMATIC DIAGRAM–PHASE II PROJECT WITH RIVER CHANNEL STORAGE

DEPARTMENT OF WATER RESOURCES 1959



SCHEMATIC DIAGRAM—PHASE II PROJECT WITH OFF-STREAM STORAGE

APPENDIX A

Letter from City of Watsonville Requesting Investigation by Division of Water Resources

WATSONVILLE CITY WATER WORKS
R. E. FOWLE
MANAGER
WATSONVILLE, CALIFORNIA

April 18, 1955

Mr. A. D. Edmonston, State Engineer
Division of Water Resources
P. O. Box 1079
Sacramento 5, California

Dear Mr. Edmonston:

It has come to the attention of the Mayor and Board of Aldermen of the City of Watsonville, that under provisions of Section 230 of the California State Water Code, the Department of Public Works, acting through the State Engineer, is empowered to conduct investigations of the feasibility of reclaiming sewage and industrial wastes for beneficial uses. It is understood also that certain financial provision is made annually by the Legislature for prosecution of such studies by the Division of Water Resources.

In an investigation carried out jointly by the State Water Resources Board and the counties of Santa Cruz and Monterey, and reported in Bulletin No. 5 of the State Water Resources Board, the conclusion was drawn that extraction of ground waters in the Pajaro Unit, centering around Watsonville, exceeded mean recharge by about three thousand acre-feet annually. The present yearly discharge of waste waters from metropolitan Watsonville approximately equals this amount. Examination of data on sewage reclamation, as presented in your "First Progress Report on Reclamation of Water from Sewage and Industrial Wastes, 1952," indicates the possibility that a significant part of the deficit in ground water replenishment might be satisfied by the reclamation and re-use of waste waters from this city, which are now being discharged into the ocean.

It is our understanding that a cardinal principle of the California Water Plan is the full development and conservation of local water supplies to meet requirements in the areas of their origin. It is suggested that the sewage flow of Watsonville, if properly conditioned, would offer a source of supplemental water supply either for ground water recharge or for direct agricultural use. The assistance of your office in investigating this possibility is therefore cordially invited, and the City of Watsonville will be pleased to extend its cooperation to representatives of the Division of Water Resources in carrying out such a study.

I wish to take this opportunity to express my appreciation for the fine cooperation we have always received from you and the men of your Department. Our State is indeed fortunate in having such outstanding representation.

Very truly yours,

R. E. Fowle

R. E. Fowle
City Engineer & Water Department
Manager

REF/gjb

APPENDIX B

Special Bulletin No. 59, State of California

Department of Public Health

STATE OF CALIFORNIA

DEPARTMENT OF PUBLIC HEALTH

SPECIAL BULLETIN NO. 59

REGULATIONS ON USE OF SEWAGE FOR IRRIGATING CROPS

May 27, 1933

Adopted May 27, 1933, under the provisions of the Public Health Act, and General Law

"Note—Attention is called to the fact that the disposal of sewage, sewage effluent or sludge for irrigation or fertilizing purposes requires the holding of permit therefor issued by the State Board of Public Health under the Public Health Act, to the city, town, district, firm or person owning or operating the sewer system. Users of the sewage, effluent or sludge are, however, liable as agents for the violation of such permit or the Public Health Act. Sale or disposal of any crop dangerous to the public health is subject to various other state health laws. Rules governing the crops which may or may not be watered or fertilized by sewage, effluent or sludge, are as follows:

"RULE 1. Raw Sewage. Raw, i. e., untreated, sewage containing human excrement shall not be used for irrigating growing crops. Use of bar screens, grit, or detritus tanks is not to be considered as sewage treatment under these regulations.

"RULE 2. Raw or Undigested Sludge. No sludge or screenings shall be distributed or used for fertilizing any growing vegetables, garden truck or low growing fruits or berries, unless the sludge or screenings shall have been rendered innocuous and free of danger of spreading disease by such measures as (a) kiln drying, (b) bed drying or aging in storage, and in either case for not less than 30 days, (c) conditioning or treating to the satisfaction of the State Department of Public Health, (d) digestion to a point where the sludge or screenings is practically odorless, drains readily and not over 50 per cent of the total solid matter is in the volatile form.

"RULE 3. Settled or Undisinfected Sewage Effluents. Effluents of septic tanks, Imhoff tanks or of other settling tanks, or partially disinfected effluents of sprinkling filters or activated sludge plants or similar sewages, shall not be used to water any growing vegetables, garden truck, berries, or low-growing fruits such that the fruit is in contact with the ground, or to water vineyards or orchard crops during seasons in which the windfalls or fruit lie on the ground. Such sewage, effluents or any sludge or screenings shall not be permitted in ditches or pipes which may be used to irrigate vegetables, garden truck, berries, or low-growing fruit.

"Nursery stock, cotton, and such field crops as hay, grain, rice, alfalfa, sugar beets, fodder corn, cowbeets, and fodder carrots may be watered with such settled or undisinfected or partially disinfected sewage effluents provided that no milch cows are pastured on the land while it is moist with sewage, or have access to ditches carrying such sewage.

"Amendment January 2, 1934: However, such sewage may be used for irrigating growing vegetables grown exclusively for seed purposes in fields where crops are raised and watered not in conflict with this rule.

"RULE 4. Oxidized Effluent Highly Disinfected or Otherwise Treated for Bacterial Removal. The foregoing restrictions do not apply against the use of well oxidized nonputrescrible, and reliably disinfected or filtered effluents which always meet the following bacterial standard: in any 20 consecutive samples, from which five 10 c.c. portions each are examined, not over 10 portions shall be positive for members of the Coli-aerogenes group, and in no single sample shall over half the 0.1 c.c. portions of the sample of the effluent be positive for the above organisms. Samples shall be analyzed according to the latest Standard Methods of Examination of Water and Sewage of American Public Health Association.

"The works and methods used for the production of such oxidized and disinfected effluent must be correctly adapted to the purpose and designed with adequate factors of safety to produce uniformly, a well-oxidized, odorless and inoffensive effluent, thoroughly filtered, treated or disinfected to meet the above standard.

"For example, where disinfection is employed apparatus and equipment for applying disinfecting agent or agents shall be in duplicate throughout, including machines, weighing scales and reserve supply of disinfectant for each machine. The disinfecting agent or agents shall be kept in separate rooms from the metering mechanism to prevent corrosion thereof. Each room shall be provided with a suitable source of heat so as to prevent interruptions of the disinfection in cold weather. Sewage flow shall be measured and flow of the disinfectant regulated to provide an adequate dose of disinfectant at all times. The feed of disinfectant shall provide an excess over actual needs and be divided between two or more metering machines so that interruption in the action of one will still yield the bacterial results prescribed. Appropriate laboratory tests to show that the disinfection is adequate shall be made at frequent intervals and at least twice daily. For such routine bacterial control negative 24-hour presumptive tests for the Coli-aerogenes group in the prescribed dilutions will be recognized as sufficient in the absence of other evidence that the presumptive test is insufficient. Proper records shall be kept on actual operations and results. In short, precautions shall be of an order fully equal to those taken by cities using reliable, modern methods of disinfecting water, obtained from a contaminated source of supply.

"RULE 5. Cross Connections. No cross connections shall be permitted between any pipe line or works which may contain sewage, sewage effluent or sludge and any pipe line or works to be used for domestic water supply or drinking purposes. Signs warning that the water is not a drinking water should be placed on pipes at ditches, faucets, etc., that may contain any sewage effluent, sewage or sludge."

APPENDIX C

BASIC DATA

Table Number	
1	Well Data, Watsonville Area
2	Mineral Analyses of Ground Water, Intermediate Aquifer, Watsonville Area
3	Mineral Analyses of Degraded Ground Water, Intermediate Aquifer, Watsonville Area
4	Industrial Waste Flows, City of Watsonville
5	Combined Sewage and Industrial Waste Flows, City of Watsonville
6	Mineral Analyses of Sewage and Industrial Wastes, City of Watsonville
7	Sanitary Analyses of Sewage and Industrial Wastes, City of Watsonville
8	Bacteriological Examinations of Sewage, City of Watsonville
9	Bacteriological Examinations of Industrial Wastes, City of Watsonville

TABLE I

WELL DATA

WATSONVILLE AREA

State well number and other number	Location	Owner	Date completed	Use [a]	Ground surface elevation [b]	Size of casing in inches	Total depth in feet	Intervals of perforated casing in feet	Data available		
									Log	Water levels	Analyses
12S/1E-24G1	25 feet northwest of Beach Road, 0.70 mile southwest of San Andres Road	Robert Trafton	-------	Dom. & irr.	9.4	12	200	-------	No	Yes	Yes
-24L1	South side of Beach Road at intersection of Beach Road and Sunset Beach Road	J. Foster	-------	Irr.	---	12	163	147-162	Yes	No	Yes
-24R1	0.5 mile southeast of intersection of Beach Road and Sunset Beach Road, 0.25 mile northeast of Rodgers Road	L. Delfino	-------	Aban-doned	10.5	---	---	-------	No	Yes	Yes
-24R2	0.5 mile southeast of intersection of Beach Road and Sunset Beach Road, 0.25 mile northeast of Rodgers Road	L. Delfino	-------	Aban-doned	---	---	---	-------	No	No	Yes
-25A1	0.5 mile southeast of Beach Road at intersection of Beach Road and Sunset Beach Road. 100 feet northwest of Pajaro River	Rossi Brothers	-------	Dom. & irr.	11.8	---	---	-------	No	Yes	Yes
-25A3	1.3 miles south of intersection of San Andres and Beach Roads. 1.0 mile southeast of Beach Road	C. McCullom	-------	Aban-doned	---	12	198	-------	Yes	No	Yes
-25B1	1.0 mile southeast of Beach Road, 0.5 mile east of Bay	T. C. Morley	-------	Aban-doned	7.0	12	174	135-168	Yes	Yes	Yes
12S/2E-7K1	1.2 miles west of Watsonville, 0.5 mile northwest of Beach Road	A. L. Waugaman	7/1947	Irr.	20.0	12	263	-------	Yes	No	Yes
-8P1	On north side of Beach Road, 0.2 mile east of Lee Road	Muramoto	-------	Dom. & Irr.	16.5	---	180	85-90, 128-130	Yes	Yes	Yes
-9C1	Corner of Van Ness Avenue and Second Street, Auditorium well in Watsonville	City of Watsonville	-------	Aban-doned	35.0	---	183	100-150	Yes	No	Yes
-16H1	0.1 mile west of Highway 1, 0.25 mile south of Southern Pacific Railroad	Eiskamp	-------	Irr.	23.0	14	---	-------	No	Yes	Yes
-17L1	150 feet north of Pajaro River, 0.13 mile southwest of Judd Road	Judd & Wood	-------	Irr.	17.0	---	---	-------	No	Yes	Yes
-18J1	50 feet north of Pajaro River, 0.69 mile northeast of Thurwachter Road	Kellog	-------	Irr.	18.0	---	150	-------	Yes	Yes	Yes

a Domestic (Dom), Municipal (Mun), Irrigation (irr), Industrial (Ind), and Livestock (Stk)

b U.S. Geological Survey datum. (Feet above mean sea level unless otherwise indicated)

TABLE 1 (Continued)

WELL DATA

WATSONVILLE AREA

State well number and other number	Location	Owner	Date completed	Use [a]	Ground surface elevation [b]	Size of casing in inches	Total depth in feet	Intervals of perforated casing in feet	Data available		
									Log	Water levels	Analyses
12S/2E-18J2	At pump building, city screening plant	City of Watsonville	-------	---	---	---	---		No	No	Yes
-19L1	0.38 mile west of Thurwachter Road, 500 feet south of Pajaro River	Sneevers	-------	Irr.	11.1	14	203		Yes	No	Yes
-20A1	South side of Trafton Road, 1.15 miles west of Highway 1	T. E. Trafton	-------	Irr.	19.4	---	---		No	Yes	Yes
-30F1	West side of Trafton Road, 0.2 mile north of Bluff Road	Yappert	4/1936	---	37.4	12	330		Yes	Yes	Yes
-30F2	0.1 mile west of Trafton Road, 0.4 mile north of Bluff Road	A. Fini	-------	Abandoned	---	12	220		Yes	No	Yes

a Domestic (Dom), Municipal (Mun), Irrigation (Irr), Industrial (Ind), and Livestock (Stk)

b U.S. Geological Survey datum. (Feet above mean sea level unless otherwise indicated)

TABLE 2

MINERAL ANALYSES OF GROUND WATER[a], INTERMEDIATE AQUIFER
WATSONVILLE AREA

Source	Well number	Date sampled	Temp. in °F	Specific conductance (micromhos at 25°C)	pH	Mineral constituents in parts per million / equivalents per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Total[b] dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$: Total ppm	Hardness as $CaCO_3$: N.C. ppm	Remarks
Robert Trafton Irrigation Well	12S/1E-24G1	10/18/51	68	545	8.2	37 / 1.85	33 / 2.71	26 / 1.13	3.1 / 0.08	0.0 / 0.00	274 / 4.49	34 / 0.71	21 / 0.59	0.0 / 0.00	0.1 / ---	0.13 / ---	37 / ---	326	20	228	4	
		7/29/53	65	515	8.1	38 / 1.90	31 / 2.55	27 / 1.17	3.5 / 0.09	0.0 / 0.00	264 / 4.33	---	22 / 0.62	---	---	0.07 / ---	---	---	20	222	6	
		6/29/54	68	513	7.5	36 / 1.80	31 / 2.55	27 / 1.17	2.5 / 0.09	0.0 / 0.00	263 / 4.31	33 / 0.69	20 / 0.56	---	0.1 / 0.01	0.25 / ---	45 / ---	326	21	216	0	
		6/23/55	67	508	---	---	---	23 / 1.00	---	---	---	---	22 / 0.62	---	---	---	---	---	---	216	-	
		8/13/57	66	523	7.5	40 / 2.00	31 / 2.56	27 / 1.17	3.7 / 0.09	0.0 / 0.00	274 / 4.49	33 / 0.69	22 / 0.62	0.3 / 0.01	0.1 / 0.01	0.10 / ---	36 / ---	329	20	228	-	
J. Foster Irrigation Well	12S/1E-24L1	9/14/51	--	610	8.8	54 / 2.69	34 / 2.80	34 / 1.48	2.3 / 0.06	24 / 0.80	288 / 4.72	41 / 0.85	26 / 0.73	0.0 / 0.00	0.0 / 0.00	0.71 / ---	34 / ---	391	21	274	0	
		8/14/57	64	612	7.5	58 / 2.89	30 / 2.50	32 / 1.39	3.1 / 0.08	0.0 / 0.00	318 / 5.21	38 / 0.79	29 / 0.82	0.1 / 0.00	0.3 / 0.02	0.15 / ---	29 / ---	376	20	270	-	
A. L. Waugaman Irrigation & Stock Well	12S/2E-7K1	10/17/51	66	492	7.6	49 / 2.45	25 / 2.06	20 / 0.87	2.0 / 0.05	0.0 / 0.00	254 / 4.16	36 / 0.75	17 / 0.48	1.0 / 0.02	0.0 / 0.00	0.20 / ---	38 / ---	313	16	226	18	
		7/29/53	60	493	8.1	49 / 2.45	23 / 1.89	21 / 0.91	2.3 / 0.06	0.0 / 0.00	252 / 4.13	---	16 / 0.45	---	---	0.02 / ---	---	---	17	217	10	
		6/29/54	64	463	7.5	43 / 2.15	23 / 1.89	25 / 1.09	2.3 / 0.06	0.0 / 0.00	258 / 4.23	13 / 0.27	24 / 0.68	0.2 / 0.00	0.2 / 0.01	0.44 / ---	29 / ---	287	21	202	0	
		6/22/55 1600 PST	63	492	---	---	---	22 / 0.96	---	---	---	---	18 / 0.51	---	---	---	---	---	---	217	-	
		8/13/57	62	483	7.2	50 / 2.50	22 / 1.80	20 / 0.87	2.6 / 0.07	0.0 / 0.00	245 / 4.02	36 / 0.75	16 / 0.45	1.1 / 0.02	0.3 / 0.02	0.08 / ---	34 / ---	302	17	215	-	
Muramoto Domestic & Irrigation Well	12S/2E-8P1	10/16/51	66	945	7.4	91 / 4.54	48 / 3.95	56 / 2.44	2.6 / 0.07	0.0 / 0.00	464 / 7.60	83 / 1.73	56 / 1.58	0.9 / 0.01	0.0 / 0.00	0.21 / ---	29 / ---	595	22	424	44	
		6/29/54	66	873	7.6	79 / 3.94	41 / 3.36	53 / 2.30	3.5 / 0.09	0.0 / 0.00	407 / 6.67	81 / 1.69	43 / 1.21	0.1 / 0.00	0.1 / 0.01	0.31 / ---	29 / ---	530	24	365	31	
		10/5/55 1515 PST	63	782	---	---	---	44 / 1.91	---	---	---	---	39 / 1.10	---	---	---	---	---	---	328	-	
		8/20/57	64	523	7.9	50 / 2.50	24 / 1.98	21 / 0.91	3.5 / 0.09	0.0 / 0.00	283 / 4.64	19 / 0.40	21 / 0.59	0.3 / 0.01	0.3 / 0.02	0.18 / ---	11 / ---	289	17	224	-	

a. Mineral analyses made by United States Geological Survey, Quality of Water Branch.

b. Determined by addition of analyzed constituents.

TABLE 2 (Continued)

MINERAL ANALYSES OF GROUND WATER[a], INTERMEDIATE AQUIFER
WATSONVILLE AREA

Source	Well number	Date sampled	Temp. in °F	Specific conductance (micromhos at 25°C)	pH	Mineral constituents in parts per million / equivalents per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Total dissolved solids[b] in ppm	Percent sodium	Hardness as $CaCO_3$: Total ppm	Hardness as $CaCO_3$: N.C. ppm	Remarks
Watsonville Municipal well	12S/2E-9C1	5/28/48	---	719	7.7	77 / 3.84	29 / 2.38	41 / 1.77	---	0 / 0.00	339 / 5.56	58 / 1.21	30 / 0.85	23 / 0.37	---	---	31 / ---	456	22	312	---	
		10/17/51	68	535	7.4	51 / 2.54	27 / 2.22	26 / 1.13	2.1 / 0.05	0 / 0.00	244 / 4.00	47 / 0.98	23 / 0.65	5.0 / 0.08	0.2 / ---	0.40 / ---	36 / ---	470	21	319	0	
		9/11/57	63	713	7.4	72 / 3.59	30 / 2.46	37 / 1.61	2.8 / 0.07	0 / 0.00	316 / 5.18	60 / 1.25	38 / 1.07	18.0 / 0.29	0.2 / 0.01	0.12 / ---	34 / ---	447	21	303	---	
Eiskamp Irrigation well	12S/2E-16H1	8/7/52	---	779	8.0	72 / 3.59	39 / 3.21	47 / 2.04	2.5 / 0.06	0 / 0.00	432 / 7.08	31 / 0.65	36 / 1.02	0.0 / 0.00	0.1 / 0.01	0.25 / ---	34 / ---	474	23	340	0	
		8/22/57	63	594	8.5	23 / 1.15	39 / 3.17	49 / 2.13	2.2 / 0.06	10 / 0.33	266 / 4.36	33 / 0.69	39 / 1.10	5.9 / 0.10	0.1 / 0.01	0.32 / ---	37 / ---	370	33	216	---	
Judd & Wood Dom.& irr.well	12S/2E-17L1	10/18/51	68	696	7.7	62 / 3.09	39 / 3.21	36 / 1.57	3.2 / 0.08	0 / 0.00	348 / 5.70	56 / 1.17	34 / 0.96	0.0 / 0.00	0.1 / 0.01	0.13 / ---	22 / ---	434	20	315	30	
Kellogg Irrigation well	12S/2E-18J1	4/14/55 1130 PST	64	530	8.4	54 / 2.69	22 / 1.85	29 / 1.26	2.5 / 0.06	6.0 / 0.20	272 / 4.46	37 / 0.77	19 / 0.54	0.3 / 0.00	0.0 / 0.00	0.11 / ---	37 / ---	341	22	227	---	
		5/7/56 1500 PST	64	526	7.9	53 / 2.64	23 / 1.90	29 / 1.26	2.2 / 0.06	0 / 0.00	275 / 4.51	38 / 0.79	16 / 0.45	0.6 / 0.01	0.1 / 0.01	0.08 / ---	37 / ---	334	22	227	1	
		8/13/57	64	622	7.1	66 / 3.29	27 / 2.22	30 / 1.30	2.6 / 0.07	0 / 0.00	327 / 5.36	42 / 0.87	23 / 0.65	0.2 / 0.00	0.2 / 0.01	0.20 / ---	34 / ---	386	19	276	---	
City of Watsonville Ind.& dom.well	12S/2E-18J2	1/24/56 0920 PST	64	474	8.1	48 / 2.40	19 / 1.56	25 / 1.09	2.1 / 0.05	0 / 0.00	238 / 3.90	38 / 0.79	14 / 0.39	0.0 / 0.00	0.2 / 0.01	0.09 / ---	38 / ---	301	21	198	3	
Seevers Irrigation well	12S/2E-19L1	7/29/53	60	653	8.1	64 / 3.19	32 / 2.63	34 / 1.48	2.5 / 0.06	0 / 0.00	330 / 5.41	---	28 / 0.79	---	---	0.15 / ---	---	---	20	291	20	
		6/29/54	68	499	8.0	50 / 2.50	25 / 2.04	28 / 1.22	2.2 / 0.06	0 / 0.00	261 / 4.28	57 / 1.19	14 / 0.39	0.3 / 0.00	0.2 / 0.01	0.43 / ---	45 / ---	351	21	227	13	
		8/21/57	65	593	7.6	48 / 2.40	31 / 2.54	33 / 1.44	2.7 / 0.07	0 / 0.00	277 / 4.54	53 / 1.10	28 / 0.79	0.4 / 0.01	0.3 / 0.02	0.25 / ---	36 / ---	369	22	247	---	
T. E. Trafton Irrigation well	12S/2E-20A1	9/26/51	63	862	7.6	70 / 3.49	50 / 4.11	49 / 2.13	1.4 / 0.04	0 / 0.00	448 / 7.34	53 / 1.10	44 / 1.24	1.1 / 0.02	0.1 / ---	0.36 / ---	36 / ---	525	22	360	13	
		10/20/55 1510 PST	62	778	8.1	55 / 2.74	48 / 3.92	50 / 2.18	2.5 / 0.06	0 / 0.00	387 / 6.34	57 / 1.19	45 / 1.27	2.1 / 0.03	0.2 / 0.01	0.38 / ---	35 / ---	486	24	333	16	
		8/20/57	65	809	7.6	66 / 3.29	46 / 3.82	39 / 1.70	2.1 / 0.08	0 / 0.00	416 / 6.82	40 / 0.83	46 / 1.30	2.0 / 0.03	0.5 / 0.03	0.25 / ---	35 / ---	---	19	356	---	

a. Mineral analyses made by United States Geological Survey, Quality of Water Branch.
b. Determined by addition of analyzed constituents.

MINERAL ANALYSES OF DEGRADED GROUND WATER[a]
INTERMEDIATE AQUIFER
WATSONVILLE AREA

Mineral constituents in parts per million / equivalents per million

Source	Well number	Date sampled	Temp. in °F	Specific conductance (micromhos at 25°C)	pH	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Total[b] dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ N.C. ppm	Remarks
L. Delfino Domestic and irrigation well	12S/1E-24R1	10/51	---	642	7.5	62 / 3.09	33 / 2.71	30 / 1.30	2.4 / 0.06	0.0 / 0.00	330 / 5.41	56 / 1.17	22 / 0.62	0.4 / 0.01	0.1 / 0.01	0.15 / ---	36 / ---	404	18	290	20	
		8/20/57	64	3140	7.2	270 / 13.47	181 / 14.90	61 / 2.65	5.1 / 0.13	0.0 / 0.00	231 / 3.79	125 / 2.60	881 / 24.84	0.5 / 0.01	0.0 / 0.00	0.14 / ---	20 / ---	1660	8	1420	---	Abandoned 1957
L. Delfino Irrigation well	12S/1E-24R2	10/51	---	673	7.5	61 / 3.04	36 / 2.96	32 / 1.39	2.4 / 0.06	0.0 / 0.00	314 / 5.15	56 / 1.17	38 / 1.07	0.5 / 0.01	0.0 / 0.00	0.14 / ---	35 / ---	416	19	300	42	Abandoned
Rossi Brothers Dom. & irr.well	12S/1E-25A1	8/13/57	57	2410	6.9	208 / 10.38	129 / 10.60	58 / 2.52	5.4 / 0.14	0.0 / 0.00	278 / 4.56	81 / 1.69	619 / 17.46	0.0 / 0.00	0.0 / 0.00	0.15 / ---	31 / ---	1270	11	1050	---	
C. McCullom Irrigation well	12S/1E-25A3	9/13/51	---	2170	8.6	185 / 9.23	126 / 10.36	63 / 2.74	4.0 / 0.10	20 / 0.67	264 / 4.33	86 / 1.79	540 / 15.23	2.8 / 0.05	0.0 / 0.00	0.22 / ---	35 / ---	1190	12	980	730	
		9/13/51	---	2100	9.1	60 / 2.99	123 / 10.12	63 / 2.74	2.0 / 0.05	35 / 1.17	90 / 1.47	83 / 1.73	540 / 15.23	2.2 / 0.04	0.0 / 0.00	0.25 / ---	35 / ---	1050	14	656	524	
		6/29/54	62	446	7.6	16 / 0.80	22 / 1.85	48 / 2.10	3.6 / 0.09	0.0 / 0.00	208 / 3.42	49 / 1.03	15 / 0.42	0.2 / 0.01	0.1 / 0.01	0.24 / ---	24 / ---	280	43	132	0	Abandoned
T. C. Morley Irrigation well	12S/1E-25B1	4/21/47	---	1570	7.9	165 / 8.23	60 / 4.90	50 / 2.17	---	25 / 0.83	225 / 3.70	75 / 1.50	340 / 9.60	---	---	0.18 / ---	---	---	---	857	430	
		7/15/47	---	2100	8.1	220 / 10.98	90 / 7.40	55 / 2.39	---	10 / 0.33	260 / 4.30	80 / 1.70	500 / 14.10	---	---	0.16 / ---	---	---	---	919	687	
		7/29/49	---	2470	7.9	226 / 11.28	140 / 11.53	93 / 4.06	---	---	281 / 4.60	101 / 2.10	696 / 19.62	6.0 / 0.10	---	0.17 / ---	---	---	15	1141	721	
		9/13/49	---	---	---	----	----	---	---	---	---	---	740 / 20.86	---	---	---	---	1500	---	---	---	
		10/2/49	---	---	---	---	---	---	---	---	---	---	229 / 6.44	---	---	---	---	---	---	---	---	
		10/2/51	63	1260	8.2	126 / 6.29	3.2 / 0.26	142 / 6.17	7.6 / 0.19	0.0 / 0.00	376 / 6.16	5.8 / 0.12	229 / 6.46	0.3 / 0.01	0.0 / 0.00	0.29 / ---	11 / ---	710	48	328	20	
		6/29/54	70	471	8.0	23 / 1.15	23 / 1.85	45 / 1.96	2.7 / 0.07	0.0 / 0.00	213 / 3.49	50 / 1.04	14 / 0.40	0.1 / 0.00	0.0 / 0.00	0.05 / ---	31 / ---	294	34	150	0	Abandoned
Yappert Irrigation well	12S/2E-30F1	9/14/51	---	519	9.0	34 / 1.70	32 / 2.63	34 / 1.48	2.1 / 0.05	20 / 0.67	211 / 3.46	62 / 1.29	15 / 0.42	0.34 / 0.01	0.0 / 0.00	0.25 / ---	38 / ---	341	25	210	20	
		4/16/52	---	512	8.4	22 / 1.10	36 / 2.96	30 / 1.30	5.2 / 0.13	9.0 / 0.30	232 / 3.80	55 / 1.14	14 / 0.39	1.2 / 0.02	0.2 / ---	0.50 / ---	34 / ---	323	24	203	0	
		6/29/54	69	550	8.4	35 / 1.75	32 / 2.65	34 / 1.48	2.7 / 0.07	4.0 / 0.13	232 / 3.80	58 / 1.21	26 / 0.73	2.1 / 0.03	0.0 / 0.00	0.08 / ---	28 / ---	336	25	220	23	
		4/14/55 1450 PST	68	1310	---	---	---	---	---	---	---	---	276 / 7.78	---	---	---	---	---	---	---	548		Present status unknown

a. Mineral analyses made by United States Geological Survey, Quality of Water Branch.
b. Determined by addition of analyzed constituents.

TABLE 3 (Continued)

MINERAL ANALYSES OF DEGRADED GROUND WATER[a], INTERMEDIATE AQUIFER WATSONVILLE AREA

Source	Well number	Date sampled	Temp. in °F	Specific conductance (micromhos at 25°C)	pH	Mineral constituents in parts per million / equivalents per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Total dissolved solids[b] in ppm	Percent sodium	Hardness as $CaCO_3$: Total ppm	Hardness as $CaCO_3$: N.C. ppm	Remarks
A. Pini Irrigation well	12S/2E-30P2	4/14/49	---	6400	7.5	445 / 22.20	350 / 29.00	360 / 15.70	---	---	205 / 3.40	240 / 5.00	2075 / 58.50	---	---	0.0 / ---	---	---	---	---	---	
		7/7/49	---	---	---	---	---	---	---	---	---	---	2190 / 61.50	---	---	---	---	---	---	---	---	
		7/29/49	---	7300	7.4	544 / 27.13	454 / 37.35	469 / 20.40	---	---	180 / 2.95	317 / 6.60	2560 / 72.20	6.0 / 0.09	---	0.69 / ---	---	---	---	---	---	
		4/6/52	---	---	---	---	---	---	---	---	---	---	2350 / 38.10	---	---	---	---	---	---	---	---	
		7/29/54	---	---	---	---	---	---	---	---	---	---	524 / 14.80	---	---	---	---	---	---	---	---	Abandoned

a. Mineral analyses made by United States Geological Survey, Quality of Water Branch.
b. Determined by addition of analyzed constituents.

TABLE 4

INDUSTRIAL WASTE FLOWS
CITY OF WATSONVILLE

(In Million Gallons)

	1955	1956
January		18.0[b]
February		13.4[b]
March		24.5[b]
April		41.0
May		49.4
June		38.3
July		34.1
August		38.5
September	29.9[a]	40.4[b]
October	38.5	59.0
November	38.8	30.7[b]
December	28.8	19.6[b]
Total	130.0[c]	406.9
Mean Daily	1.1	1.1
Mean Daily Apr.-Sept.	1.0	1.4

a Collection of industrial waste in separate line began.
b Incomplete monthly records
c Total of September-December period.

TABLE 5

COMBINED SEWAGE AND INDUSTRIAL WASTE FLOWS
CITY OF WATSONVILLE

(In Million Gallons)

	1950[a]	1951[a]	1952	1953	1954	1955	1956
January	b	71.3[c]	110.8[c]	120.2[d]	51.8[d]	79.2	129.4
February	b	61.6	87.2[d]	78.5	48.3	60.0[d]	75.2
March	46.5	80.6	92.3[d]	69.5	65.3	67.7[d]	60.9
April	51.0	69.0	92.4	85.0	74.8	77.6	56.9
May	55.8	74.4	94.7[d]	102.1	76.8	55.0	83.6
June	48.0	60.0	74.9	80.4	60.4[e]	49.5	87.2
July	52.7	65.8	86.2	90.2	55.6	50.5[d]	91.8
August	62.0	73.4	92.3	90.2[d]	74.2	47.0	94.2
September	63.0	72.0	101.6	111.3	71.8[d]	57.4[d]	118.4
October	74.4	90.8	105.6	89.1	89.2	85.3	107.0
November	72.0[c]	82.7[d]	95.6	75.4	89.8	77.2	69.7
December	71.3[c]	92.2[d]	107.6	67.8[d]	82.4	118.5	82.3
Total	596.7	893.8	1,141.2	1,059.7	840.4	824.9	1,055.6
Mean Daily Flow	1.9	2.4	3.1	2.9	2.3	2.3	2.9
Mean Daily Flow Apr.-Sept.	1.8	2.3	3.0	3.1	2.3	1.8	3.0

a January 1950 - June 1951 - Estimated from average daily flows reported in Hyde, Charles Gilman and Brown and Caldwell - "The Collection, Treatment and Disposal of Sewage and Storm Drainage of the City of Watsonville, California". Table 9.
b No record - plant being enlarged.
c Excluding days flow by-passed.
d Flow estimated for days when by-passed.
e Collection of industrial wastes in separate line began.

TABLE 6

MINERAL ANALYSES OF SEWAGE AND INDUSTRIAL WASTES[a]

CITY OF WATSONVILLE

Source	Sampling location	Time-date sampled PST	Mean daily discharge mgd	Temp °F	Specific conductance (micromhos at 25°C)	pH	Mineral constituents in parts per million / equivalents per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Total dissolved solids ppm[b]	Per cent sodium	Hardness as $CaCO_3$: Total ppm	Hardness as $CaCO_3$: N C ppm	Remarks
Screened sewage	Screens at sewage treatment plant	8/15-16/55 0800-0700	1.73	66-71	1,180	6.9	88 / 4.39	13 / 1.10	119 / 5.17	13 / 0.33	0 / 0.00	478 / 7.83	96 / 2.00	99 / 2.79	0.5 / 0.01	1.2 / 0.06	0.45	40	705	41	275	0	
		8/16-17/55 0800-0700	1.73	67-70	1,250	6.8	57 / 2.84	37 / 3.04	126 / 5.48	15 / 0.38	0 / 0.00	454 / 7.44	124 / 2.58	110 / 3.10	0.5 / 0.01	2.0 / 0.11	0.25	40	771	40	294	0	
		8/17-18/55 0800-0700	1.74	67-70	1,300	6.8	72 / 3.59	27 / 2.25	128 / 5.57	15 / 0.38	0 / 0.00	471 / 7.72	66 / 1.37	139 / 3.92	0.4 / 0.01	2.0 / 0.11	0.49	40	754	41	292	0	
		8/18-19/55 0800-0700	1.71	66-71	1,540	6.8	82 / 4.09	24 / 1.99	170 / 7.39	16 / 0.41	0 / 0.00	487 / 7.98	84 / 1.75	200 / 5.84	0.5 / 0.01	1.2 / 0.06	0.57	43	891	47	304	0	
		8/19-20/55 0800-0700	1.79	66-71	1,350	6.9	66 / 3.29	31 / 2.59	138 / 6.00	14 / 0.36	0 / 0.00	514 / 8.42	50 / 1.04	147 / 4.15	0.3 / 0.00	0.8 / 0.04	0.50	42	778	42	294	0	
		8/20-21/55 0800-0700	1.63	67-70	1,240	6.9	63 / 3.14	21 / 1.74	128 / 5.57	15 / 0.38	0 / 0.00	492 / 8.06	58 / 1.21	117 / 3.30	0.2 / 0.00	1.6 / 0.08	0.52	43	726	42	244	0	
		8/21-22/55 0800-0700	1.46	66-70	1,140	7.1	74 / 3.69	27 / 2.19	91 / 3.96	13 / 0.33	0 / 0.00	465 / 7.62	46 / 0.95	88 / 2.48	0.6 / 0.01	0.8 / 0.04	0.32	39	637	34	294	0	
Industrial Waste	Parshall flume at sewage treatment plant	8/15-16/55 0800-0700	0.20	65-68	715	6.8	69 / 3.44	18 / 1.46	52 / 2.26	17 / 0.43	0 / 0.00	359 / 5.88	34 / 0.71	41 / 1.15	0.2 / 0.00	0.4 / 0.02	0.24	40	449	30	245	0	Oil = 9.1 ppm
		8/16-17/55 0800-0700	0.40	65-78	728	6.8	70 / 3.49	18 / 1.49	52 / 2.26	20 / 0.51	0 / 0.00	339 / 5.56	31 / 0.65	56 / 1.58	0.2 / 0.00	0.4 / 0.02	0.08	40	455	29	249	0	Oil = 9.1 ppm
		8/17-18/55 0800-0700	0.54	66-76	916	6.9	65 / 3.24	23 / 1.86	86 / 3.74	16 / 0.41	0 / 0.00	324 / 5.31	41 / 0.85	114 / 3.22	0.2 / 0.00	0.6 / 0.03	0.19	38	544	40	255	0	Oil = 9.1 ppm
		8/18-19/55 0800-0700	0.43	66-79	768	6.8	70 / 3.49	21 / 1.72	54 / 2.35	10 / 0.26	0 / 0.00	327 / 5.36	30 / 0.62	71 / 2.00	0.2 / 0.00	0.3 / 0.02	0.08	39	457	30	260	0	Oil = 6.0 ppm
		8/19-20/55 0800-0700	0.86	66-75	754	7.4	78 / 3.89	21 / 1.75	42 / 1.83	10 / 0.26	0 / 0.00	306 / 5.01	44 / 0.92	76 / 2.14	0.1 / 0.00	0.2 / 0.01	0.20	34	460	23	282	31	Oil = 6.1 ppm
		8/20-21/55 0800-0700	0.33	66-71	675	6.7	65 / 3.24	22 / 1.84	39 / 1.70	9.2 / 0.24	0 / 0.00	323 / 5.29	34 / 0.71	40 / 1.13	0.3 / 0.00	0.3 / 0.02	0.22	37	406	24	254	0	Oil = 8.1 ppm
		8/21-22/55 0800-0700	0.12	65-69	763	7.0	61 / 3.04	34 / 2.82	56 / 2.44	6.1 / 0.16	0 / 0.00	336 / 5.51	67 / 1.39	54 / 1.52	5.3 / 0.09	0.5 / 0.03	0.05	39	489	29	293	17	Oil = 5.4 ppm
		10/20/55 0900-1500	2.42	71-75	1,170	7.7	36 / 1.80	42 / 3.48	118 / 5.13	25 / 0.64	0 / 0.00	314 / 5.15	41 / 0.85	178 / 5.02	1.9 / 0.03	0.5 / 0.03	0.04	37	634	46	264	7	
		10/20/55 3 hours 1800-2100	1.53	70-71	2,680	7.6	42 / 2.10	43 / 3.54	425 / 18.49	37 / 0.95	0 / 0.00	414 / 6.79	21 / 0.44	645 / 18.19	1.4 / 0.02	0.6 / 0.03	0.14	41	1,460	74	282	0	
		11/1-30/55 1 month	1.48	—	740	7.4	67 / 3.34	23 / 1.92	45 / 1.96	18 / .46	0 / 0.00	320 / 5.24	51 / 1.06	55 / 1.55	.6 / 0.01	0.4 / 0.02	1.6	38	462	25	263	1	
		12/1-31/55 1 month	1.63	—	742	7.4	65 / 3.24	28 / 2.31	40 / 1.74	15 / .38	0 / 0.00	292 / 4.79	52 / 1.08	55 / 1.55	16 / .26	0.4 / 0.02	.11	36	452	23	278	39	

a. Analyses by United States Geological Survey, Quality of Water Branch.
b. Determined by addition of analyzed constituents.

TABLE 6 (Continued)

MINERAL ANALYSES OF SEWAGE AND INDUSTRIAL WASTES[a]

CITY OF WATSONVILLE

Source	Sampling location	Time-date sampled PST	Mean daily discharge mgd	Temp. °F	Specific conductance (micromhos at 25°C)	pH	Mineral constituents in parts per million / equivalents per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Total dissolved solids ppm[b]	Per cent sodium	Hardness as $CaCO_3$: Total ppm	Hardness as $CaCO_3$: N.C. ppm	Remarks
Industrial Waste (continued)	Parshall flume at sewage treatment plant	1/1-31/56 1 month	0.74	-	848	7.8	62 / 3.09	40 / 3.31	59 / 2.57	9.6 / 0.25	0 / 0.00	332 / 5.44	70 / 1.46	62 / 1.75	23 / 0.37	1.0 / 0.05	0.18	30	521	28	320	48	
		2/1-29/56 1 month	0.49	-	826	7.3	65 / 3.24	35 / 2.90	57 / 2.48	9.7 / 0.25	0 / 0.00	343 / 5.62	64 / 1.33	66 / 1.86	2.7 / 0.04	0.6 / 0.03	0.20	37	506	28	307	26	
		3/1-30/56 1 month	0.88	-	1,250	7.6	81 / 4.04	39 / 3.22	114 / 4.96	14 / 0.36	0 / 0.00	295 / 4.84	56 / 1.17	217 / 6.12	0.2 / 0.01	21 / 0.34	0.50	19	707	39	363	121	
		4/1-30/56 1 month	1.46	-	832	7.4	62 / 3.09	32 / 2.64	51 / 2.22	25 / 0.64	0 / 0.00	383 / 6.28	47 / 0.98	53 / 1.49	0.5 / 0.01	0.8 / 0.04	0.19	38	498	26	286	0	
		5/8/56 0700-2300	2.16	65-74	1,070	6.9	67 / 3.34	26 / 2.14	102 / 4.44	26 / 0.67	0 / 0.00	353 / 5.79	39 / 0.81	143 / 4.03	0.7 / 0.01	0.5 / 0.03	0.19	37	615	42	274	0	
		5/9-10/56 1000-0100	1.76	66-73	971	7.3	64 / 3.19	28 / 2.29	89 / 3.87	15 / 0.38	0 / 0.00	328 / 5.38	44 / 0.92	122 / 3.44	0.4 / 0.01	0.4 / 0.02	0.14	37	562	40	274	5	
		5/1-31/56 1 month	1.65	-	1,110	7.1	64 / 3.19	29 / 2.37	113 / 4.92	17 / 0.43	0 / 0.00	345 / 5.65	40 / 0.83	170 / 4.79	1.2 / 0.02	- / -	0.17	37	641	45	278	0	
		6/1-30/56 1 month	-	-	1,290	7.2	62 / 3.09	29 / 2.41	161 / 7.00	11 / 0.28	0 / 0.00	309 / 5.06	50 / 1.04	233 / 6.57	0.7 / 0.01	1.0 / 0.05	0.19	36	736	55	275	22	
		7/1-31/56 1 month	-	-	793	6.8	72 / 3.59	30 / 2.49	52 / 2.26	77 / 0.20	0 / 0.00	350 / 5.74	38 / 0.79	64 / 1.80	0.7 / 0.01	0.4 / 0.02	0.20	41	478	26	304	17	

a. Analyses by United States Geological Survey, Quality of Water Branch.
b. Determined by addition of analyzed constituents.

TABLE 7

SANITARY ANALYSES OF SEWAGE AND INDUSTRIAL WASTES

CITY OF WATSONVILLE

Source	Sampling location	Time-date sampled P.S.T	Discharge mgd	Temp °F	Ammonia[a] ppm	Nitrate[a] ppm	Phosphate[a] ppm	Ether soluble[a] ppm	Suspended solids[b] Total ppm	Suspended solids[b] Volatile ppm	Settleable solids[b] ml/l	Oxygen demand Bio chemical[b] 5-day 20°C ppm	Oxygen demand Chemical[a] ppm	Remarks
Screened Sewage	Screens at sewage treatment plant	0800-0700 8/15-16/55	1.73	66-71	31	0.5	25	—	221	165	4.5	182	—	
		8/16-17/55	1.73	67-70	35	0.5	—	—	249	202	8.0	299	—	
		8/17-18/55	1.74	67-70	32	0.4	26	27	234	191	6.0	250	—	
		8/18-19/55	1.71	66-71	30	0.5	22	22	166	129	6.5	63	—	
		8/19-20/55	1.79	66-71	35	0.3	12	31	188	143	6.0	152	—	
		8/20-21/55	1.63	66-70	37	0.2	17	41	181	142	5.5	232	—	
		8/21-22/55	1.46	66-70	28	0.6	28	37	80	64	2.0	138	—	
Industrial waste	Parshall flume at sewage treatment plant.	0800-0700 8/15-16/55	0.20	65-68	—	0.2	—	—	138	70	8.8	130	15	
		8/16-17/55	0.40	65-78	—	0.2	—	—	187	87	5.5	163	0	
		8/17-18/55	0.54	66-76	—	0.2	—	9.1	136	70	5.5	90	28	
		8/18-19/55	0.43	66-79	—	0.2	—	6.0	158	68	7.5	80	12	
		8/19-20/55	0.86	66-75	3.2	0.1	—	6.1	121	48	2.5	35	3	
		8/20-21/55	0.33	66-71	—	0.3	—	8.1	70	55	4.5	106	11	
		8/21-22/55	0.12	65-6?	—	5.3	—	5.4	23	17	1.5	68	9.8	
		0845-1200 5/9/56	2.16	64-74	—	—	—	—	104	60	1.3	118	—	
		0900-1200 5/10/56	1.76	66-73	—	—	—	—	74	28	0.7	43	—	

a. Analyses by United States Geological Survey, Quality of Water Branch.

b. Analyses by Department of Water Resources, Mobile Laboratory.

TABLE 8

BACTERIOLOGICAL EXAMINATIONS OF SEWAGE
CITY OF WATSONVILLE

Before Chlorination

Date	Time	Coliform Organisms MPN/ml.
8/15/56	0900	1.7×10^3
	1230	1.8×10^6
	2030	7×10^4

After Chlorination

Date	Time	Cl_2 Dosage ppm	Cl_2 Residual ppm	Coliform Organisms MPN/ml.
8/16/56	1600	24.9	4.5	over 16
		36.8	12.3	over 16
	2000	16.7	0	over 16
		32.8	6.7	5.1
8/17/56	0820	18.8	9.1	over 16
		34.6	23.6	9.2
	1210	16.6	1.1	over 16
		32.5	5.6	5.1
	1615	8.8	5.6	over 16
		17.5	12.3	5.1
		25.9	19.1	2.2
8/18/56	1600	14.8	6.7	50
		28.9	23.6	4.5
		42.6	32.6	6
8/20/56	1200	11.2	3.4	13
		22.0	13.5	95
		32.5	21.3	23
	2000	16.0	9.0	4.6
		31.1	21.3	23
	1200	15.8	5.6	13
		31.3	23.6	6
8/21/56	1600	16.6	7.9	6
		47.9	37.1	6

TABLE 9

BACTERIOLOGICAL EXAMINATIONS OF INDUSTRIAL WASTES
CITY OF WATSONVILLE

Date	Time	Coliform Organisms MPN/ml.
8/15/55	0900	2.4×10^5
	1230	2.4×10^5
	1600	2.4×10^4
	2000	2.4×10^5
	2400	1.6×10^5
8/16/55	0400	2.4×10^5
	0900	7×10^5
	1200	6.2×10^6
	1600	2.3×10^5
	2000	2.3×10^7
	2400	2.3×10^6
8/17/55	0400	2.3×10^6
	0800	2.3×10^7
	1200	2.3×10^7
	1600	2.3×10^7
	2000	2.3×10^7
	2400	2.3×10^7
8/18/55	0400	2.3×10^7
	0800	2.3×10^6
	1200	2.3×10^7
	1600	2.3×10^7
	2000	6.2×10^6
	2400	6.2×10^6
8/19/55	0400	2.3×10^7
	0800	6.2×10^6
	1200	6.2×10^5
	1600	6.2×10^7
	2000	6.2×10^5
	2400	2.4×10^7
8/20/55	0400	2.4×10^7
	0800	7×10^7
	1200	1.3×10^6
	1600	2.3×10^6
	2000	2.4×10^7
	2400	2.1×10^4
8/21/55	0400	2.3×10^5
	0800	6.2×10^6
	1200	2.3×10^5
	1600	1.3×10^6
	2000	2.1×10^6
	2400	2.3×10^6
8/22/55	0400	2.3×10^4
	0700	6.2×10^5