STATE OF CALIFORNIA

The Resources Agency

Department of Water Resources

BULLETIN No. 74-5

Water Well Standards

SAN JOAQUIN COUNTY

Final Supplement

JULY 1969

NORMAN B. LIVERMORE, JR.
Secretary for Resources
The Resources Agency

RONALD REAGAN
Governor
State of California

WILLIAM R. GIANELLI
Director
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FOREWORD

The Preliminary Edition of Bulletin No. 74-5, "Water Well Standards: San Joaquin County", was published in March 1965. In July 1967, results of an extensive ground water quality investigation were published in Bulletin No. 146, "San Joaquin County Ground Water Investigation". Certain parts of the Preliminary Edition of Bulletin No. 74-5 were updated and revised because of findings of the ground water study.

Chapter II of the Preliminary Edition, entitled "Ground Water", has been updated in this Final Supplement as "Chapter I, Ground Water". The portion of Chapter IV in the Preliminary Edition entitled "Supplemental Standards" has been revised and is presented here as "Chapter II, Specific Standards for San Joaquin County". Chapter V of the Preliminary Edition, entitled "Conclusions and Recommendations", has been revised and is included as "Chapter III, Recommendations". The "General Standards" portion of Chapter IV of the Preliminary Edition has been replaced by the provisions included in "Chapter II, Standards" in Bulletin No. 74, "Water Well Standards: State of California", published in February 1968. The remaining portions of the Preliminary Edition did not require revision and therefore are not repeated in this Final Supplement.

"Chapter II. Specific Standards for San Joaquin County" of this Final Supplement presents standards supplemental to the statewide standards and peculiar to San Joaquin County. These standards, together with the statewide standards, are intended to serve as guides for those engaged in the construction of water wells or in the regulation of water well construction and destruction in San Joaquin County.

Because effective protection of the ground water resources of San Joaquin County cannot be achieved without assurance that all drillers operating in the County follow adequate well construction and destruction practices, the County should, at the earliest possible date, adopt and enforce suitable standards and regulations.

William R. Gianelli

William R. Gianelli, Director
Department of Water Resources
The Resources Agency
State of California
June 19, 1969

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FIGURE

AUTHORIZATION

The Water Well Standards Program, under which this report was prepared, is authorized by Section 231 of the Water Code, State of California:

> "231. The department, either independently or in cooperation with any person or any county, state, federal or other agency, shall investigate and survey conditions of damage to quality of underground waters, which conditions are or may be caused by improperly constructed, abandoned, or defective wells through the interconnection of strata or the introduction of surface waters into underground waters. The department shall report to the appropriate regional water quality control board its recommendations for minimum standards of well construction in any particular locality in which it deems regulation necessary to protection of quality of underground water, and shall report to the Legislature from time to time, its recommendations for proper sealing of abandoned wells."

In 1967, the Legislature established a procedure for implementing standards developed under Section 231 by enactment of Chapter 323, Statutes of 1967, which added Sections 13800 through 13806 to the Water Code. In Section 13800, the Department of Water Resources' reporting responsibility is enlarged upon:

> "13800. The department, after such studies and investigations pursuant to Section 231 as it finds necessary, on determining that water well construction, maintenance, abandonment, and destruction, standards are needed in an area to protect the quality of water used or which may be used for any beneficial use, shall so report to the appropriate regional water quality control board and to the State Department of Public Health. The report shall contain such recommended standards for water well construction, maintenance, abandonment, and destruction as, in the department's opinion, are necessary to protect the quality of any affected water."

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

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NORMAN B. LIVERMORE, Jr., Secretary for Resources
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ABSTRACT

This Final Supplement of Bulletin No. 74-5 presents revised and updated information concerning the occurrence and quality of ground waters in San Joaquin County, and on the areas and zones of known water quality problems. This information is related to the necessity for specific standards for water well construction in San Joaquin County.

The County is divided into four major areas: Eastern, Tracy, Delta, and Stockton areas. Based on the latest information available, specific standards are recommended for the Eastern, Tracy, and Stockton areas. The specific standards utilize the concept of a base of fresh water, and contain provisions which are intended to preclude the upward movement of connate waters into overlying fresh water zones. Other specific standards are concerned with determination of water quality during construction, perforations and sealing.

The Department of Water Resources recommends that the Central Valley Regional Water Quality Control Board and the State Department of Public Health establish water well standards in San Joaquin County. The Department of Water Resources further recommends that improperly constructed and abandoned wells in the County be identified and that corrective work be undertaken; and that the County formulate regulations governing drilling in connection with seismic exploration activities.

CHAPTER I. GROUND WATER

Ground water occurs throughout San Joaquin County. The quality and availability, however, vary widely. In some portions of the County quality problems exist, while in other locations problems result from overdraft of ground water supplies.

For the purpose of establishing water well standards for San Joaquin County, the County has been divided into four major areas: Eastern, Tracy, Delta, and Stockton areas. These four areas are shown on Figure 1, pages 8 and 9.

Eastern Area

The Eastern Area encompasses the eastern two-thirds of the County and extends to the foothills of the Sierra Nevada Range.

Occurrence

The Sierra Nevada complex is a tilted fault block that created a mountain chain to the east and a structural trough to the west. The Eastern Area of San Joaquin County is in the eastern half of this trough. Streamborn detritus of the highlands has been brought into this trough, called the Central Valley of California. This detritus includes sediments of Cretaceous to Recent age, which now form a great wedge that is thickest in the center of the Valley and feathers out against the crystalline rocks of the mountains a few miles east of the San Joaquin County line.

Cretaceous marine sediments of unknown thickness overlie the crystalline basement beneath the Eastern Area. Electric well logs indicate that these sediments contain only saline waters. Eocene sediments are present in the Area, but these are mostly of marine origin and contain poor quality water.

The post-Eocene sediments yield fresh water to wells in all but the extreme western part of the Eastern Area and are therefore of major interest. The oldest of these is the Valley Springs Formation, which outcrops in the northeastern part of the County. It is of Miocene age and varies in thickness from 75 to 525 feet, thickening to the west. The Formation yields water of good quality in limited areas of the eastern portion of the County. Due to low permeability, the yield of wells in the Valley Springs Formation is too small to be used for irrigation.

The Mehrten Formation is exposed at the surface in the eastern part of the County just west of the outcrop belt of the Valley Springs Formation. The Mehrten Formation is an important aquifer in the eastern part of the Eastern Area. Many of the sands of the Mehrten Formation are highly permeable and furnish water of good quality to deep wells. The

Formation is composed principally of siltstone, sandstone, conglomerate, and some beds of unconsolidated sand and layers of volcanic agglomerate, probably derived from mudflows. "Black sands", so named because of their high content of andesitic grains, are reported in logs of wells extending into the Mehrten Formation. In the Mokelumne River area, the thickness of the Mehrten Formation varies from 75 to over 400 feet. The thickness increases southward and westward to about 600 feet near Stockton. The Formation dips about 90 to 180 feet per mile in a southwesterly direction, and west of Stockton it gradually flattens in dip until it is nearly flat-lying in the axial portion of the Central Valley.

The aquifers of the Mehrten Formation receive recharge from a 3-mile long reach of the Mokelumne River east of Clements, from the Calaveras River between one mile west of Bellota to five miles east of Bellota, from Farmington Reservoir on Littlejohns Creek, and from numerous small streams in the outcrop area. West of the outcrop area, water in the Mehrten aquifers is partially confined by relatively impervious strata. The water levels of wells in the Mehrten Formation sometimes show irregularities, and in the spring, when recovery has occurred, they appear to be little different from those of nearby shallower wells, which suggests some degree of hydraulic continuity with overlying sediments containing unconfined ground water.

The Laguna Formation underlies the area of gently rolling hills between the outcrop area of the Mehrten Formation and the more recent sediments of the alluvial plain of the Eastern Area. The Laguna Formation is largely composed of stream-laid sand and silt, but it also contains some gravel and clay. Its composition varies markedly both vertically and laterally. The Formation dips westward throughout most of the Eastern Area and is essentially in conformity with the underlying Mehrten Formation. Like the Mehrten Formation, it also thickens noticeably to the west. The Laguna Formation, at its outcrop area in the vicinity of the Mokelumne River, is up to 400 feet thick and thickens to about 1,000 feet in the Stockton Area.

The hydrologic characteristics of the Laguna Formation are variable. Bodies of perched water are common in its outcrop area. There are no regionally significant fine-grained intervals which could cause ground water confinement, although the heterogeneity of the sediments causes local semiconfinement. Wells perforated in the Laguna Formation also are commonly perforated in the overlying Victor Formation and, in the eastern portion of the County, in the underlying Mehrten Formation.

The Arroyo Seco Gravel is a thin unit between the Laguna and Victor formations. In outcrop, it consists of weathered cobbles, sand, and gravel. The Arroyo Seco is believed to have once covered an extensive pediment, now partly buried beneath the Calaveras and Mokelumne alluvial fans. Like the Laguna Formation, the Arroyo Seco Gravel is believed to thicken westward as it dips further beneath the ground. Sediments of the age of the Arroyo Seco undoubtedly yield water to some wells, but these sediments cannot be differentiated in logs from the underlying and overlying formations. The Arroyo Seco Gravel is inferred to be a coarse fraction of rock waste that was transported from the Sierra Nevada after the Sierran block was again tilted in middle Pleistocene time.

The Quaternary alluvial sediments formed since the deposition of the Arroyo Seco Gravel, excluding the present stream channel deposits, have been mapped as one unit: The Victor Formation, of Pleistocene age. Included in the Victor Formation are alluvial fan deposits composed of sand, gravel, silt, and clay. The fans were laid down by the various streams which debouched from the Sierra Nevada. The sand and gravel stringers represent active channels of the distributaries, in which the coarser sediments were deposited. Silt and clay deposits represent areas between the active distributaries. In these areas, deposits were made only at times of inundation. The position of the active channels shifted continually during the process of building the alluvial fans, and an interfingered network of sand and gravel stringers resulted. The many stringers generally end abruptly, both laterally and vertically, making correlation of well logs often impossible. The Victor Formation has a maximum thickness of approximately 100 to 125 feet along the western edge of the Eastern Area. Because the Victor Formation is limited in thickness, most wells penetrate into deeper aquifers. This is particularly true where the water table lies some distance below the surface. Most of the irrigation wells draw from the deeper formations.

The main importance of the sand, gravel, silt, and clay deposits in the active stream channels is that they transmit water to underlying permeable formations.

Most water used in the Eastern Area is drawn from the Arroyo Seco Gravel, and the Laguna and Mehrten formations. The ground water obtained therefrom is continually being recharged by infiltration of surface waters which originate in the Sierra Nevada Range or adjacent foothills, from direct rainfall, and from waste water and irrigation return.

Over the past few decades, the quantity of ground water available has changed, and this change is reflected in the change of depth to water. The lowering of water levels has been caused by discharge from aquifers exceeding ground water recharge. Increased use for irrigation and domestic needs in the Eastern Area, and the concurrent lowering of the water table at the western boundary of this Area are responsible for this condition. The low water table on the west, around Stockton, resulted in further steepening of ground water gradients. This additional increase in gradient increased the adverse effect of local overdraft within the Eastern Area.

The detrimental effects of this lowered ground water table on the ground water users have been:

1. Higher costs of pumping
2. Increased costs for well construction.
3. Increased capital costs for pumps and appurtenances.
4. Localized intrusion of saline waters.

Water Quality

Except for the Lathrop-French Camp and Manteca problem areas, shown on Figure 1, ground water in the Eastern Area of San Joaquin County is generally of excellent quality for all present beneficial uses. The total dissolved solids content of water samples from irrigation wells ranges from 120 to 550 ppm and averages about 200 ppm.

Most of the domestic wells sampled were found to contain water conforming to the standards for chemical substances in drinking water set by the United States Public Health Service. Some localized instances were noted where individual domestic supplies contained excessive concentrations of coliform bacteria and nitrates, apparently caused by a combination of improperly constructed wells and wells in general disrepair.

Ground water in the Eastern Area is generally of moderate hardness, with samples from most wells ranging between 50 to 200 ppm, expressed as calcium carbonate ($CaCO_3$). Two centers of excessive hardness are located in the vicinity of Waterloo and Peltier roads, north of Lockeford. In these two locations, wells were found to contain water with hardness ranging from 200 to 700 ppm.

Because data available on ground water quality in the Eastern Area prior to the late 1940's are very limited, overall trends cannot be determined other than for the 1949-1963 period. No permanent increases in any of the minerals for which analyses were made could be detected for the 1949-1963 period.

The Mokelumne and Stanislaus rivers, and to a minor degree the Calaveras River and smaller eastside streams that originate in the Sierra Nevada, recharge the ground water basin with excellent quality waters.

Tracy Area

The Tracy Area lies in the Southwestern portion of San Joaquin County. The Area is underlain by alluvial material, deposited principally by intermittent streams flowing eastward from the Diablo Range.

Occurrence

A series of northwest-trending mountains composed of sedimentary, metamorphic, and associated intrusive and volcanic rocks are in the southwest portion of the Tracy Area, which lies in the central section of the Diablo Range. The plain, south of the Delta Area and west of the San Joaquin River, comprises the remainder of the Tracy Area. This plain, which received most of its younger continental sediments from the older rocks of the Diablo Range, is an important ground water producing area in San Joaquin County.

The most important water-bearing sediments occur in the continental Plio-Pleistocene Tulare Formation. The Tulare Formation outcrops as a thin band in the lower foothills of the Diablo Range on the west side of

the San Joaquin Valley, plunges rapidly into the subsurface, and extends north to the Delta. The Formation is composed largely of clay, silt, and sand lenses containing ill-sorted deposits of sand and gravel. The Recent alluvium is of lesser importance as a source of ground water. It is generally less than 100 feet thick. Some domestic wells obtain water from shallow, unconfined aquifers but most large irrigation, industrial, and municipal wells penetrate deeper into the Tulare Formation. The lithologic characteristics of the Tulare Formation and the overlying alluvium are similar, thus it is hard to distinguish between the two deposits. All of the formations older than the Tulare Formation are of marine origin and do not bear fresh water.

Near the top of the Tulare Formation, a regionally extensive clay bed, the Corcoran Clay, separates the continental sediments into upper and lower portions. The aquifers in the lower portion are confined by this clay. Most water well drillers log the Corcoran Clay as "blue clay". The clay is considered to be of Pleistocene age. An important distinguishing feature of the Corcoran Clay is the large amount of diatoms it contains. The clay is well-sorted, and no sand is noticeable. Marginal zones, however, have lenses of sand, silt, and gravel interfingering with the clay bed. Most of the clay was formed in fresh water as a lucustrine deposit. Its thickness in the Tracy Area ranges from 10 to 160 feet.

The unconfined aquifers in the Recent alluvium and in the upper portion of the Tulare Formation are recharged by infiltration and percolation of water from rainfall, streams, and excess irrigation. This infiltrating water cannot permeate the Corcoran Clay and is recovered by wells drawing from the upper water-bearing zone. The confined aquifers are probably recharged from the Sierran foothills. Prior to heavy withdrawals, ground water in the Tracy Area is believed to have moved generally northeast toward the Delta Area. At the present time, limited data indicate that ground water moves toward areas of heavy withdrawal.

Water Quality

Significant portions of the ground water in the Tracy Area are not particularly good sources for agricultural or domestic supplies. The water used for irrigation often falls within the Class 2 category of "good to injurious".

The southwestern portion of the County, near Tracy, contains a small but important source of ground water of good mineral quality. This ground water body can roughly be described as existing below the Corcoran Clay. The wells which supply the City of Tracy and produce water of better than average quality for this Area are believed to be supplied from this ground water body. An analysis of typical City of Tracy water in 1965, showed total dissolved solids to be 500 ppm, chlorides to be 75 ppm, and total hardness to be 190 ppm. In the last few years some of the Tracy wells have shown increases in chloride concentrations.

In adjacent locations, water containing total dissolved solids in excess of 1000 ppm and total hardness above 500 is common. Much of this poorer quality water may be attributed to improper well construction.

Water used for irrigation has been affected by high concentrations of dissolved solids, chloride, sulfate, sodium, and boron. During 1963, approximately 65 wells in the Tracy Area were sampled for boron; concentrations generally increased toward the foothills. In the process of collecting samples for boron analyses, it was discovered that water from many large irrigation wells east of Tracy had deteriorated in quality, and a few of the wells had been abandoned. These abandoned wells are a potential hazard; they may provide conduits for poor quality waters to enter aquifers containing good quality water. The principal source of deterioration is from the upper aquifer, which yields less desirable water than the lower aquifer.

Many "islands" of poor quality waters result from leakage or interconnection between the lower and upper aquifers in the Tracy Area. These "islands" could extend over several hundred acres, or even larger sections of the Area.

The lower zone produces good quality water for domestic and agricultural use within the boundaries of the Tracy Area. The pumping demand on this zone is high, and the water pressure surface is pulled down during the summer and fall of every year. The trend over the years has been a lowering of the pressure surface. The lowering pressure levels in the lower zone can increase the threat of degradation since this zone is surrounded from above, below, to the west, to the north, and to the southeast by waters of inferior quality. The result of this lowering on the present and future water supply of the Tracy Area cannot be evaluated at this time; however, the United States Geological Survey, Water Resources Division, in cooperation with the California State Department of Water Resources, is currently conducting a ground water investigation covering the westside portion of the County, which includes this part of the Tracy Area, south to about Gustine, and the results of the study should provide adequate basis for this evaluation.

Deterioration of water quality in a lower aquifer, resulting from movement of poorer quality water from an upper aquifer through gravel-packed wells, is illustrated in the Tracy Area by the water supply of the Deuel Vocational Institution. Some of the wells in a well field used by the Institution provided a conduit between the two aquifers, thereby adversely affecting the quality of water produced. To correct the problem, two of the five wells serving the Institution were destroyed, and one well was sealed. A significant improvement in the quality of water produced by the remaining wells was evident upon completion of this work.

The inferior quality upper-zone is believed to come from two separate sources; principally, from sediments in the Diablo Range which supply ground water high in chloride, sulfate, and boron. A secondary source of inferior quality water is believed to be a narrow strip to the west of the San Joaquin River. Ground water from these sources has many characteristics similar to those found in ground water in the Delta Area. These characteristics are believed to result from a residual of ground water forced out of the trough of the San Joaquin Valley to the south.

The problem of excessive amounts of boron in the soil and in the ground water is not new to the Tracy Area or to the San Joaquin Valley as

a whole. Although boron is not generally regarded as hazardous to human beings, it can be injurious to plants. As early as 1922, observations in the vicinity of Bakersfield established that boron applied to plants in the form of borax, along with fertilizer, injured the plants. Later observations led to an investigation of the Valley between Stockton and the Tehachapi Mountains, conducted by Frank M. Eaton of the United States Department of Agriculture, in the early 1930's. The results of this investigation confirmed that high boron concentrations were prevalent in the soil and ground water on the west side of the San Joaquin Valley.

Delta Area

The Delta Area lies in the northwest portion of San Joaquin County. The Area is a structural basin that has received sediments from many sources, including the San Joaquin River. As the sediments built up, the trough of the basin sank and the Delta channels were left at near sea level.

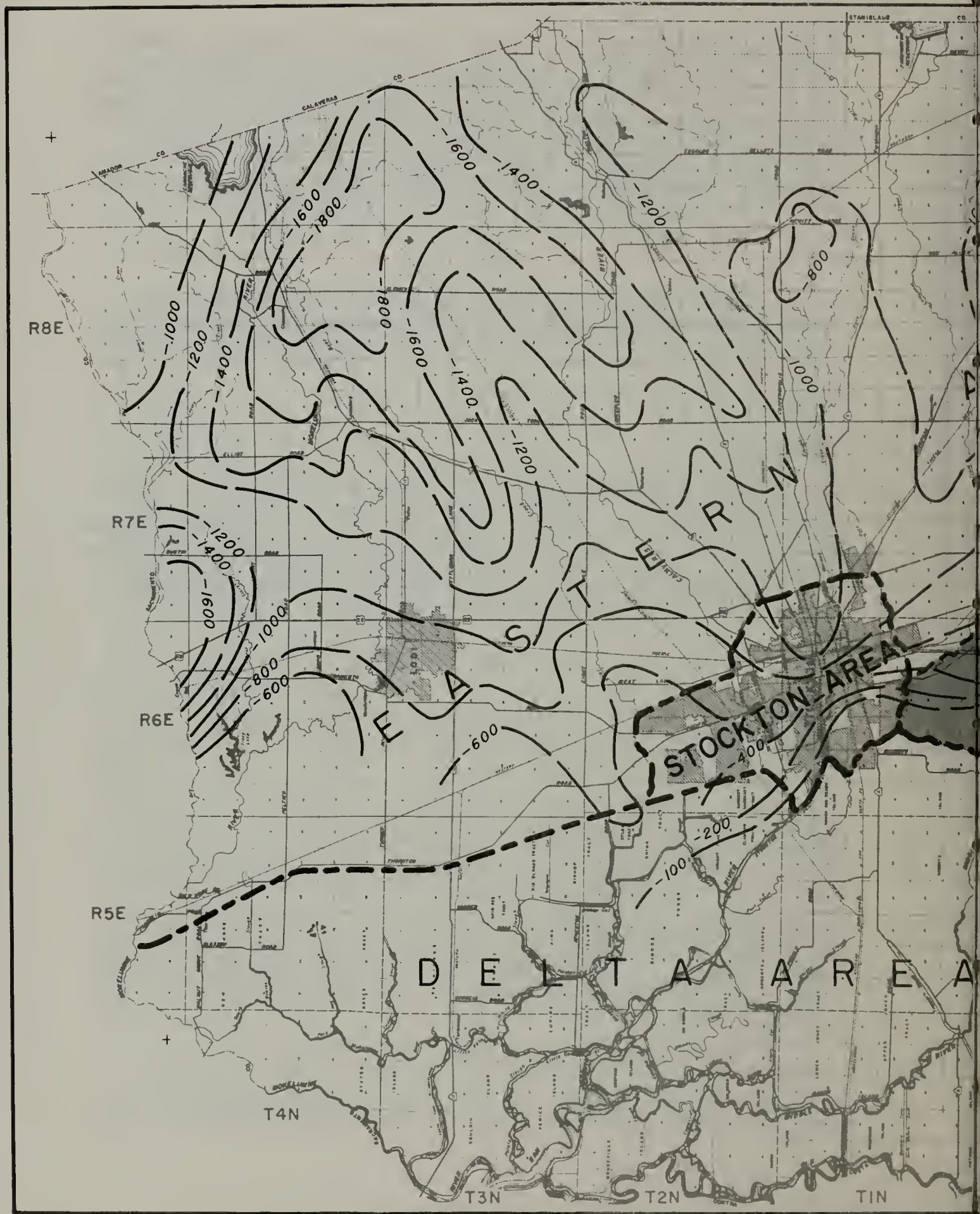
Occurrence

Delta deposits underlying the Delta Area, often referred to as "flood basin deposits", are the distinguishing geologic feature of the Delta Area. These Delta deposits include all of the fine-grained sediments of post-Mehrten age. The Recent alluvium, the Victor and Laguna formations in the eastern Stockton Area, and the continental sediments in the Tracy Area are contemporaneous with the Delta deposits. The undifferentiated nature of the Delta deposits makes the identification of their age difficult.

The Delta deposits consist of Recent age stream channel and organic flood basin deposits. The stream channel deposits, composed of clay, silt and sand, have low permeability. The flood basin deposits consist of organic clay and silt with interbedded peat. They were deposited in overflow basins during flood stages. The Delta deposits are of considerable thickness, often in excess of 1,000 feet.

In the zone of contact, the Delta deposits and the coarser alluvial deposits interfinger. Ground water in the Delta Area occurs in a series of poorly connected sand and gravel lenses, locally confined by silts and clays which cause artesian effects in some localities. The large percentage of fine-grained materials and the lenticular nature of the deposits result in low permeability. Wells in this material usually yield only moderate quantities of water, with large draw-downs. The base of the fresh water is quite shallow and generally coincides with the base of the organic deposits. It is difficult to obtain a sufficient amount of ground water of suitable quality for domestic and irrigation purposes in a large portion of the Delta Area.

Saline waters are found throughout all depths in the Delta deposits except for the thin lenses of fresh water extending usually to a depth of less than 150 feet. The deltaic sediments apparently were deposited in marine or brackish water. The fine-grained composition of the


-1600
-1400
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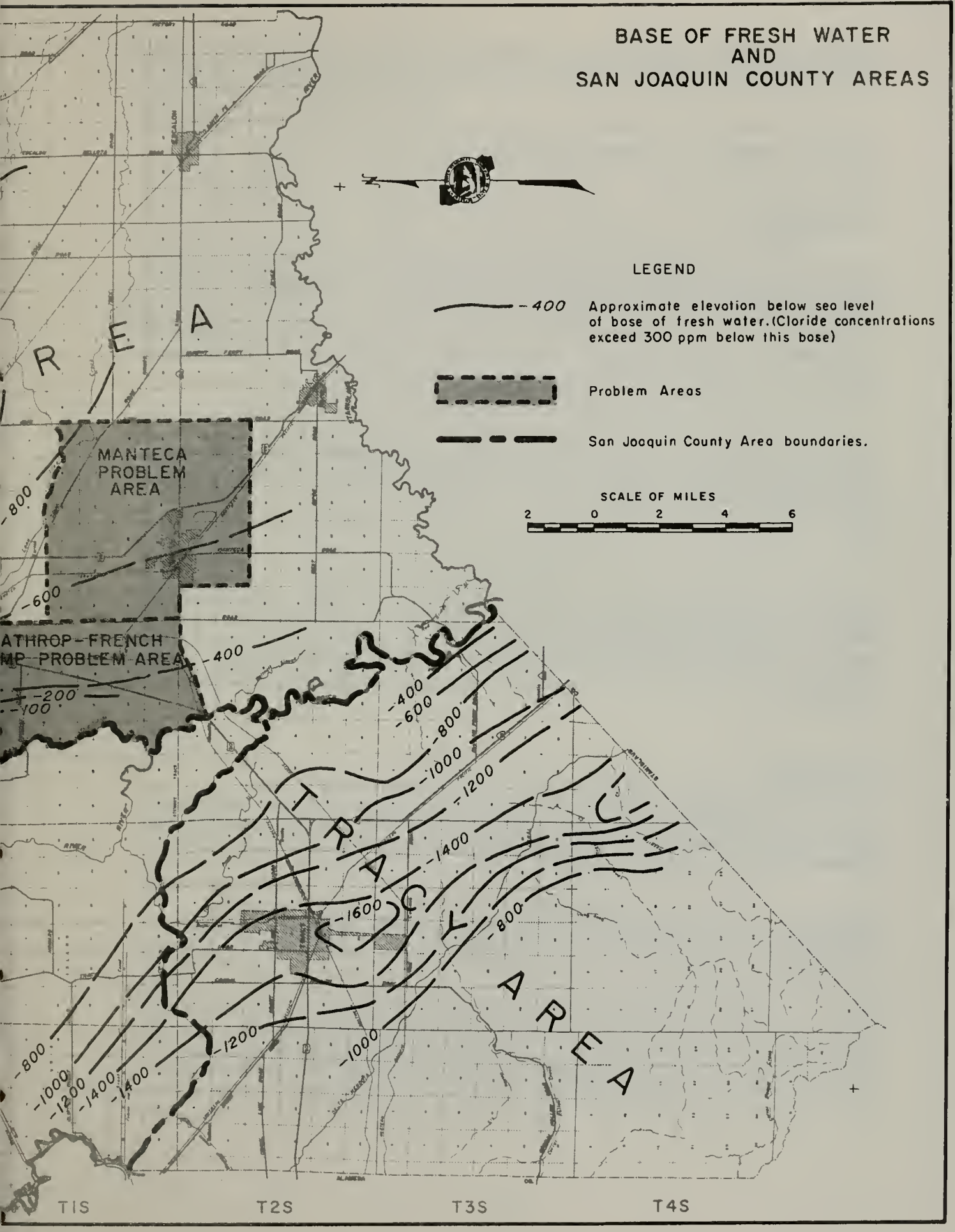
EASTERN
STOCKTON AREA
DELTA AREA
R8E
R7E
R6E
R5E
T4N
T3N
T2N
TIN


BASE OF FRESH WATER
AND
SAN JOAQUIN COUNTY AREAS
LEGEND
-400
Approximate elevation below sea level of base of fresh water. (Chloride concentrations exceed 300 ppm below this base)
Problem Areas
San Joaquin County Area boundaries.
SCALE OF MILES
2 0 2 4 6
MANTECA PROBLEM AREA
ATHROP-FRENCH MP PROBLEM AREA
TRACY AREA
-800
-600
-400
-200
-100
-1000
-1200
-1400
-1600
T1S
T2S
T3S
T4S

sediments has prevented the better quality water of the fresh water sloughs within the Delta and the good quality water surrounding the Delta Area from replacing the saline water.

Fresh water recharge to the Delta Area is obtained from infiltration of rainfall and excess irrigation water.

Water Quality

It is becoming increasingly difficult to find ground water of suitable quality in the Delta Area. According to several well drillers, water of suitable mineral quality could be found at one time on some of the Delta islands, but it is almost impossible to find such supplies now. These observations seem to be supported by the fact that most fresh ground water is contained in small pockets surrounded by saline water. If the withdrawal rate exceeds the rate of recharge, the fresh water pockets are replaced and degraded by surrounding saline waters.

Water from the fresh water lenses is classified as calcium-magnesium-sodium bicarbonate water. The poorer quality ground water contains large amounts of dissolved solids. Sodium chloride water typifies the saline water of the Delta Area.

Stockton Area

The Stockton Area lies in the center of San Joaquin County and includes the densely populated metropolitan area of the City. Historically, the Stockton Area has had an abundant supply of good quality ground water, and the protection of this water supply is of paramount importance. This supply is being slowly encroached upon by the poor quality water underlying the Delta.

Occurrence

The geologic formations underlying the central and eastern portions of the Stockton Area are continuations of the Recent alluvium, the Arroyo Seco Gravel, and the Victor, Laguna, Mehrten, and Valley Springs formations of the Eastern Area.

Ground water in the western portion of the Stockton Area is stored, for the most part, in fine-grained deltaic deposits. Generally, the water is too saline for most beneficial uses, but shallow pockets of fresh water do exist.

Usable ground water in the central and eastern portions of the Stockton Area is stored to a depth of approximately 1100 feet in parts of the unconsolidated alluvium, and in the Victor and Laguna formations. These are not homogeneous sediments, but are composed of discontinuous sand and gravel layers separated by variable thicknesses of sandy silt and clay. Underlying this upper fresh water-bearing section is a deep zone of

saline water stored in the semiconsolidated Mehrten and Valley Springs formations, and in the Eocene and Cretaceous sediments. Ground water is replenished largely by lateral movement of water that has percolated into the ground in the Eastern Area.

The principal difference between the physical character of the sediments in the water-bearing formations beneath the Stockton and the Eastern areas is the coarseness of their grain. Comparison of well logs has shown a gradual change in an east to west direction from coarse to fine grain. Recent studies published in Bulletin No. 146, "San Joaquin County Ground Water Investigation", in July 1967, indicated that no "barrier" to the eastward movement of ground water exists in the Stockton Area; water is free to move at a rate dictated by the geologic and hydraulic parameters governing the Area. These recent studies showed that poor quality chloride waters are moving into the Stockton Area at a lateral rate of 140 to 150 feet per year.

Since 1953, the ground water depression beneath the City of Stockton has increased by an average of 20 to 25 feet. Undoubtedly, there has been an increase in the hydraulic gradient across the so-called "barrier" first discussed in Department of Water Resources Report No. 7, "Quality of Ground Water in the Stockton Area San Joaquin County", published in 1955, but well measurements taken in the spring of 1963 were too few to make a quantitative comparison. The gradient of 45 feet per mile, reported for 1953, was based on a horizontal distance of less than a mile across the so-called "barrier". Since publication of Report No. 7, Tillie Lewis Foods, a large canning factory on the west side of the Stockton Area, has contracted with the California Water Service Company for water supplies to meet all the needs of the factory because of the poor quality ground water found in certain parts of the canning factory property. This large canning factory no longer uses ground water, thus further increasing the hydraulic gradient.

Water Quality

Ground water obtained from the Victor and Laguna formations east of the westerly edge of Stockton, that was once thought to be a "barrier", is generally of good to excellent mineral quality. Ground water in the Stockton Area contains slightly higher dissolved solids than water in the Eastern Area. In some of the western portions, the water quality resembles that of the Delta Area.

Most of the ground water contained in the Victor and the Laguna formations above 600 feet is calcium bicarbonate. Water contained in the Laguna Formation between 600 and 1100 feet is sodium bicarbonate and generally contains less than 300 ppm dissolved solids. Ground water below 1100 feet seldom, if ever, is of suitable quality for industrial or domestic use. These are sodium chloride waters with dissolved solids ranging between 700 and 3,000 ppm. The dissolved solids generally increase with depth in the deeper Mehrten and Valley Springs formations.

The contact between the fresh and saline waters slopes steeply upward toward the west. The exact depth of contact varies both in a north-south and east-west direction. West of Stockton, the point of contact is practically at ground level; fresh water is found only in isolated pockets. To the east, exceptions to good quality ground waters occur in localized situations where supplies have been degraded by poor quality waters. The poor quality waters may be connate waters that have entered the aquifers containing the good quality water through abandoned gas or water wells.

The upward migration of saline, connate waters through conduits, such as abandoned gas wells, is attributed to the high piezometric level of the connate waters. Some of the gas wells drilled in the early 1900's were abandoned because of decrease in pressure. These wells were known to produce water under artesian flow and their abandonment provided conduits for the rise of connate water.

Evidence found during this study established the existence of an abandoned gas well, which may still be degrading fresh water aquifers. The gas well is located under a large building and is now inaccessible; therefore, the condition of the well is unknown. Two neighboring water wells, each 350 feet deep, produce water with chlorides ranging between 200 and 400 ppm, and total hardness in excess of 350 ppm. Three other nearby wells produce good quality water with chlorides and total hardness averaging 50 ppm. One of these wells is 250 feet deep and the other two are each about 1000 feet deep with perforations below 500 feet. This suggests that the abandoned gas well has degraded the ground water only in the 350-foot interval, since no sign of degradation is evident above the 250-foot depth, or below the 500-foot depth.

The California Water Service Company has kept records of water quality analyses from Company wells in the City of Stockton since the early 1930's. Presently, most wells are sampled annually. Wells showing a deterioration in water quality are analyzed more frequently, and various pump tests are performed on these wells. Wells producing poor quality water are permanently sealed with an impermeable material if the water quality cannot be improved. The excellent long-term chemical data for wells in the City of Stockton, together with data available from other sources, allowed investigators to chart the chloride concentration in critical wells against time and against distance from a base line, chosen to be the 300 ppm chloride line for 1953, and, to determine the rate of eastward movement while pinpointing the location where this movement is most pronounced. The movement is north of east rather than south of east, toward the center of the cone of depression, which was located just northeast of the intersection of South Wilson Way and East Charter Way in the City of Stockton, in fall of 1964.

The eastward movement of poor quality waters also varies with depth. Poor quality ground water in the shallow zone is believed to have invaded farther eastward and at a greater rate than the poor quality water in the lower strata.

Complete mineral analyses of water from wells owned by the City of Stockton in the Lincoln Village subdivision are performed on an intermittent basis. Analyses show the water in these wells to be of excellent mineral quality. However, on the western side of Lincoln Village, poor quality water was found at the shallower depths during the drilling stages and the wells were not perforated near the surface.

CHAPTER II. SPECIFIC STANDARDS FOR SAN JOAQUIN COUNTY

Within the boundaries of San Joaquin County there are several bodies of ground water of inferior quality. These ground water bodies are cause for concern because of their areal extent, high salinity, or proximity to important ground water supplies. Based on existing data and information, specific standards were developed for the Eastern, Tracy, and Stockton areas of San Joaquin County. Because of the limited availability of good quality ground water, specific standards have not been developed for the Delta area.

Water Quality Problems And Their Relation to Specific Standards

Poor quality ground water must not be permitted to enter aquifers producing good quality ground water, through improperly constructed wells. Specific standards which prescribe requirements for constructing wells should be instrumental in preserving and protecting good quality ground water producing aquifers.

Causes of Ground Water Quality Problems

Ground water quality problems in San Joaquin County may result from:

1. Lateral movement of poor quality ground waters; and

2. Vertical movement of poor quality ground waters.

Either of these conditions may be due to natural causes, to causes related to water well construction, or to a combination of these causes.

Natural Causes. Naturally caused lateral movement of poor quality ground waters is exemplified by recharge of the highly mineralized waters from the Diablo Range in the Tracy Area. Naturally caused vertical movement of poor quality waters is exemplified by movement of poor quality waters through interruptions or marginal zones of aquicludes (clays, etc.) and adverse head conditions which permit interchange of waters between normally separated aquifers.

Causes Related to Well Construction. Although lateral movement, or migration, of poor quality ground waters is largely due to overdraft, the vertical movement of these waters is frequently caused by interconnection of aquifers through improperly constructed or abandoned water wells.

Necessity for Specific Standards

Both lateral and vertical movement of poor quality water can be due to natural causes which no standards for well construction are likely to alleviate. Furthermore, standards will do little to relieve problems due to overdraft. However, specific standards for well construction within San Joaquin County, in addition to general standards, are essential to minimize spreading of poor quality ground water into aquifers containing good quality waters. Limitation of well size, well density, and pumping rates could lessen the opportunity for overdraft.

An inherent difficulty in establishing specific standards for well construction in San Joaquin County lies in the fact that the aquifers that produce ground water in the County are basically all part of one ground water basin. While virtually no ground water basin is entirely homogeneous, a relatively small basin, with definite boundary conditions, lends itself to establishment of specific standards far better than parts of a large basin. The difficulty here is further increased because ground water quality conditions change continuously and the lateral and vertical boundaries of locations where specific standards must apply may be expected to change with conditions.

On Figure 1 (pages 8 and 9), the four areas of San Joaquin County referred to in this bulletin are shown, together with the problem areas within the Eastern Area. Ground water quality problems are known to exist to some degree throughout the County.

In San Joaquin County there is a bottom zone of ground water, often referred to as connate water. The ground water in this zone is unsuitable for most beneficial water uses and penetration of this zone brings with it an imminent danger of degradation of the shallower aquifers which produce good or acceptable quality ground water. The upper limit of this zone is called the base of fresh water; it is defined as the depth below which chloride ion concentrations always exceed 300 ppm. The contours shown on Figure 1 were determined mainly by interpretation of electric logs and represent the approximate base of fresh water in San Joaquin County.

Specific Standards

Although the contours shown on Figure I are not sufficiently precise to be considered as the lower limit of well exploration, they serve as a good limit for planning. If a new well depth comes close to the contour, ground water quality characteristics should be determined.

Compliance with these specific standards for the Eastern, Tracy, and Stockton Areas of San Joaquin County will permit development of good quality ground water and prohibit future construction of wells that allow the intermingling of connate or other poor quality waters with fresh water supplies.

It is recognized that in some instances production may be desired from poor quality waters lying below the base of fresh water and/or from overlying zones which contain poor or marginal quality water in all aquifers penetrated. It is not the intent of these specific standards to preclude such situations; rather, the enforcing agency should prescribe alternative requirements which are "equal to" these specific standards in terms of protection afforded fresh ground water supplies (as specified in Section 3, Chapter II, Bulletin No. 74).

Eastern Area

Ground water in most of the Eastern Area is generally of excellent quality for all present beneficial uses; however, isolated problem areas do exist. These problem areas are shown on Figure 1.

Water Quality Conditions. Each of the so-called problem areas within the Eastern Area has differing water quality conditions.

Lathrop-French Camp. In the vicinity of Lathrop-French Camp, there have been for some time, local, seemingly unrelated ground water quality problems. This problem area roughly includes the land between the San Joaquin River and Airport Way (Durham Ferry Road). The problem area is bounded on the north by French Camp Slough, on the south by Highway 120, and encompasses about 30 square miles. The main problem here is an eastward intrusion of inferior quality ground water, principally due to local depression in the ground water levels stemming from high concentrations of pumping. The intrusion is not expected to advance eastward beyond Airport Way, due to the ground water ridge which extends northwest from the Stanislaus River.

Manteca. Near the town of Manteca, very hard, perched ground water is present at shallow depths above about 50 feet. Total hardness concentrations of up to 617 ppm have been noted.

Standards for Eastern Area

Determination of Water Quality During Construction. Well drilling operations shall include provisions for determining ground water quality characteristics (at least an indication of chloride ion):

1. Within each penetrated aquifer of the Lathrop-French Camp problem area deeper than 150 feet below ground surface and lying above the base of fresh water, as shown on Figure 1.

2. Within each penetrated aquifer in the remainder of the Eastern Area lying less than 100 feet above the base of fresh water, as shown on Figure 1.

Depth Limitation. Wells shall not extend into saline waters lying below the base of fresh water. If these saline waters are penetrated during construction, wells shall be sealed (backfilled) with impervious material from the lowest level of drilling to 100 feet above the base of fresh water.

Perforations. Casings of wells penetrating more than one aquifer in the Lathrop-French Camp problem area shall not be perforated opposite aquifers containing poor quality water (300 ppm of chloride ion).

Sealing-Off Strata. In wells penetrating more than one aquifer in the Lathrop-French Camp problem area, aquifers containing poor quality water (300 ppm of chloride ion) shall be sealed-off (as specified in Section 13, Chapter II, Bulletin No. 74).

Sealing the Upper Annular Space. In wells in the Manteca problem area, the annular space shall be sealed (as specified in Section 9, Chapter II, Bulletin No. 74) to exclude the poor quality perched water in aquifers lying between the ground surface and depths of approximately 50 feet.

Tracy Area

The majority of quality problems in the deeper aquifers underlying the Tracy Area are a result of leakage from or interconnection with overlying poor quality waters. Gravel packed wells producing ground water from all strata provide a means for this interconnection. "Islands" of poor quality water in the deeper aquifers have resulted from interchange. As ground water levels rise in the upper aquifers and fall in the lower aquifers, interchange can become more pronounced.

A few problems in the Tracy Area appear to be the result of wells penetrating the base of fresh water.

Water Quality Conditions. Boron, hardness, and moderately high to high chlorides are problems in parts of the Tracy Area. Generally poor quality water is found at the shallow depth interval of around 100 to 200 feet. Throughout much of this Area, the principal fresh water-bearing aquifer is located at a depth of about 400 to 500 feet. The principal fresh water-bearing zone is underlain by deep formations containing saline waters of marine origin. The base of fresh water is 400 to 1,600 feet below sea level.

Standards for Tracy Area

Determination of Water Quality During Construction. Well drilling operations shall include provisions for determining ground water quality characteristics (at least an indication of chloride ion) within each penetrated aquifer deeper than 100 feet below ground surface if the well is to extend into aquifers lying below the Corcoran Clay.

Depth Limitation. Wells shall not extend into saline waters lying below the base of fresh water. If these saline waters are penetrated during construction, wells shall be sealed (backfilled) with impervious material from the lowest level of drilling to 100 feet above the base of fresh water.

Perforations. Casings of wells penetrating aquifers lying below the Corcoran Clay shall not be perforated opposite aquifers containing poor quality water, which are situated at depths of about 100 to 200 feet below ground surface.

Sealing-Off Strata. In wells penetrating aquifers lying below the Corcoran Clay, aquifers containing poor quality water, which are situated at depths of about 100 to 200 feet below ground surface, shall be sealed-off (as specified in Section 13, Chapter II, Bulletin No. 74).

Delta Area

The availability of fresh ground water is extremely limited in the Delta Area. Well drilling operations must be conducted in a manner that will prevent spreading of the problems of water quality in the Area and will protect local sources of good quality waters.

Water Quality Conditions. Chloride, hardness, and to a lesser extent, boron, are problems in many parts of the Delta Area. Most fresh ground water in this Area is contained in small pockets, or lenses, at depths of less than 150 feet. The pockets and lenses of fresh water are surrounded by saline water. An exception to this general condition is found in the northwest part of San Joaquin County where surplus surface water and ground water from the Mokelumne River system have flushed out, or diluted, poor quality ground waters.

There are several possible explanations for the poor quality ground waters underlying the Sacramento-San Joaquin Delta, but their origin is still a matter of speculation. It is generally believed that the deltaic sediments of the Delta were deposited in marine or brackish waters. Saline waters are generally found at all depths in these deltaic deposits. With the exception of a minor portion of the Delta Area, the base of fresh water has not been determined.

Standards for Delta Area. Specific standards have not been developed for the Delta Area. The standards presented in Chapter II, Bulletin No. 74, are sufficient to protect ground water quality.

Stockton Area

The problem of encroachment of poor quality ground water in the Stockton Area has been developing for some time, but has become more noticeable in the last several years.

Water Quality Conditions. The most recent investigation of water quality conditions in the Stockton Area indicated that no "barrier" exists in the Area to prevent the eastward movement of poor quality waters. In fact, poor quality waters from the west are moving into the aquifers in the Stockton Area. The rate of movement is governed by the laws of fluid mechanics, the constant geologic parameters, and the variable current hydraulic parameters by which ground water is controlled. There are no lithologic or apparent consistent hydraulic discontinuities which would stop intrusion of water eastward from the Sacramento-San Joaquin Delta. The eastward movement of poor quality ground waters varies with depth.

Standards for Stockton Area

Determination of Water Quality During Construction. Well drilling operations shall include provisions for determining ground water quality characteristics (at least an indication of chloride ion) within each penetrated aquifer deeper than 150 feet below ground surface.

Depth Limitation. Wells shall not extend into saline waters lying below the base of fresh water. If these saline waters are penetrated during construction, wells shall be sealed (backfilled) with impervious material from the lowest level of drilling to 100 feet above the base of fresh water.

Perforations. Casings of wells penetrating more than one aquifer shall not be perforated opposite aquifers containing poor quality water (300 ppm of chloride ion).

Sealing-Off Strata. In wells penetrating more than one aquifer, aquifers containing poor quality water (300 ppm of chloride ion) shall be sealed-off (as specified in Section 13, Chapter II, Bulletin No. 74).

CHAPTER III. RECOMMENDATIONS

Based upon ground water investigations conducted in San Joaquin County and documented in this bulletin and its preliminary edition, the Department of Water Resources recommends that:

1. In accordance with Section 13800 of the Water Code, the Central Valley Regional Water Quality Control Board and the State Department of Public Health take appropriate action to establish water well standards for San Joaquin County.

2. The standards to be established, be based upon those in Chapter II of Department of Water Resources Bulletin No. 74, "Water Well Standards: State of California", together with the specific standards presented in this bulletin.

3. Responsible agencies in San Joaquin County, as soon as possible, identify improperly constructed and abandoned wells, and initiate corrective measures so that wells in the County will meet the standards; initial emphasis in the program of correction be directed toward the Lathrop-French Camp problem area and the Tracy and Stockton Areas.

4. The County formulate regulations governing drilling in connection with seismic exploration activities.