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BULLETIN No. 74-3

Water Well Standards
DEL NORTE COUNTY

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AUGUST 1966

HUGO FISHER
Administrator
The Resources Agency

EDMUND G. BROWN
Governor
State of California

WILLIAM E. WARNE
Director
Department of Water Resources

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FOREWORD

Bulletin No. 74-3, "Recommended Minimum Water Well Construction and Sealing Standards for the Protection of Ground Water Quality, Del Norte County", gives the results of a comprehensive Ground Water Quality Investigation conducted throughout Del Norte County. This is the final report incorporating the comments and recommendations of cooperating agencies and individuals on our preliminary edition of March 1964. The investigation was conducted under authority of Section 231 of the water code and at the request of interested agencies operating in the County.

This is one of a series of reports designed to formulate and recommend water well construction and sealing standards for particular localities of the State where regulation is deemed necessary for the protection of ground water quality. In Del Norte County, where no such regulation exists, many water wells which have been improperly constructed or abandoned are contributing to quality impairment of ground water. The report concludes that water well construction and sealing standards should be adopted and enforced. The recommended standards presented are based on geologic, hydrologic, and water quality conditions and well construction practices found in Del Norte County. These standards are similar to and should supplement the minimum standards presented in Bulletin No. 74 entitled, "Recommended Minimum Well Construction and Sealing Standards for the Protection of Ground Water Quality, State of California."

The report recommends adoption of water well construction and sealing standards in Del Norte County. The report also recommends continuation of investigational work by the local agencies, leading to the identification and correction of existing improperly constructed and abandoned water wells.

William E. Warne

William E. Warne, Director
Department of Water Resources
The Resources Agency
State of California
June 29, 1966

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ACKNOWLEDGMENTS

Valuable assistance and data used in this report were contributed by agencies of the federal and state governments, by Del Norte County and Crescent City, and by numerous private companies and individuals. This cooperation is gratefully acknowledged.

We are particularly appreciative of the assistance and counsel given during the course of this investigation by Mr. Joe Creisler, Sanitarian for Del Norte County and by Mr. William E. Dent, Farm Advisor, University of California Extension Service. We are also grateful to the water well drillers in Del Norte County, who provided information pertaining to water well construction and sealing.

Special mention is also made of the helpful cooperation of the following:

United States Geological Survey, Ground Water and Quality of Water Branches

California Department of Public Health, Bureau of Sanitary Engineering

North Coastal Regional Water Quality Control Board (No. 1)

Del Norte County Board of Supervisors

Humboldt-Del Norte County Department of Public Health

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

EDMUND G. BROWN, Governor, State of California
HUGO FISHER, Administrator, The Resources Agency
WILLIAM E. WARNE, Director, Department of Water Resources
ALFRED R. GOLZE', Chief Engineer
JOHN R. TEERINK, Assistant Chief Engineer

NORTHERN DISTRICT

Gordon W. Dukleth . . . . District Director

Robert E. Foley. . . . . Chief, Special Investigation Section

This report was prepared
under the supervision of

Robert F. Clawson . . . . Senior Engineer, Water Resources

by

Walter L. Thomas . . . . Assistant Civil Engineer

assisted by

William J. McCune . . . . Assistant Civil Engineer

Richard G. Johnson . . . . Water Resources Technician II

Jerome R. Staley . . . . Engineering Aid II

Robert L. Johnson . . . . Engineering Student Trainee

Geologic portions in this report were
prepared under the supervision of

Philip J. Lorens . . . . Senior Engineering Geologist

by

W. Roger Hail . . . . Assistant Engineering Geologist

Activities of the Statewide Water
Well Standards Program are Coordinated
by the Statewide Planning Office

John M. Haley . . . . Chief, Statewide Planning Office

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-----0-----

WILLIAM M. CARAH
Executive Secretary

ORVILLE ABBOTT
Engineer

CHAPTER I. INTRODUCTION

Ground water represents one of the most important natural resources of the State. Underground storage of water and its extraction through properly constructed wells constitutes a most satisfactory and economical water supply and distribution system.

Del Norte County enjoys, for the most part, an adequate supply of excellent quality ground water which is utilized to provide a large portion of its irrigation and domestic requirements. The development of this supply and the maintenance of its quality has played an important role in the agricultural, industrial, and domestic growth within the county.

Although the present and historic quality of these waters is generally excellent, evidence is now apparent that localized ground water impairment has occurred. The impairment is generally coincident with increased ground water use, resulting from population growth. This condition exists particularly in the suburban and rural areas of the Smith River Plain where individual water supply and sewerage systems have been installed. Apparently, impairment is the result of man-produced wastes which have percolated through the soil or gained entry through improperly constructed, sealed, or abandoned wells.

In October 1953, the Sanitarian for Del Norte County requested a well standards study for the county as provided in Section 231 of the Water Code. His request for a study stated: "There is conclusive evidence that in many of the areas throughout the county there is direct contamination and pollution of the underground water due to poor well construction, abandoned wells and defective wells."

After correspondence and meetings with Del Norte County officials, the State Department of Water Resources initiated a program to study the ground water quality conditions in Del Norte County. This program included studies of geology, hydrology, water quality, and well construction and sealing practices within the county. The results of these studies are included in this report. Recommendations are also presented which, if followed, should provide reasonable protection against further impairment of ground water resources.

Authorization

This investigation was conducted as a result of legislation enacted to protect ground water resources from impairment by recommending proper construction and sealing standards for water wells. The legislation was enacted as Chapter 1552, Statutes of 1949, and is now Section 231, Chapter 2, Division 1 of the California Water Code, which reads:

> "Section 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 interconnection of strata or the introduction of surface waters into underground waters. The department shall report to the appropriate regional water pollution 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."

Purpose and Scope of Investigation

The purpose of this investigation was to obtain and assemble information necessary to formulate and recommend water well construction and sealing standards for protection of ground water quality in Del Norte County. The resulting standards will assist in minimizing future impairment of ground water from improperly constructed or abandoned wells.

All known information, relating to Del Norte County ground water and well construction, collected by the State Department of Water Resources and other agencies was reviewed and used to determine the amount of additional field work required. Considerable effort was expended to standardize and bring to a common base all previously uncoordinated data. From these data, a study and interpretation was made of the geology, hydrology, quality of water, and of significant ground water sources. In addition, a survey was made of existing water well construction and abandonment practices.

Geologic studies for this investigation were largely reconnaissance in nature and consisted of identifying areas of ground water occurrence throughout the county. Hydrologic conditions in the small alluvium-filled valleys in the mountainous coastal and interior portions of the county were not evaluated in detail. However, geologic and hydrologic conditions in Smith River Plain ground water basin were more thoroughly studied in aspects which pertain to well construction and sealing. Much of the data for this area was obtained from a previous joint investigation conducted by the then Division of Water Resources and the U. S. Geological Survey and published in 1957 as Geological Survey Water Supply Paper 1254.

During this investigation, a detailed well construction survey was made on 163 wells. Eight local well drillers were interviewed to obtain information on well construction practices within Del Norte County. Coliform bacteria analyses were made on water from 119 wells in August 1955, which were supplemented with 160 additional well-water bacterial analyses in August 1961. Over 160 ground water samples have been analyzed for complete or partial mineral content, and the results have provided valuable information on water quality.

In addition to the text, there are four appendixes containing supporting data. For convenience of use, Appendix A lists pertinent reports and publications. Appendix B gives a summary of certain definitions and terms used in the text. Appendix C presents well location references and numbering methods used, and Appendix D includes the mineral analyses of ground water in Del Norte County.

Area of Investigation

Del Norte County, which is located in the extreme northwest corner of California, encompasses an area of approximately 643,000 acres. It is bordered by the State of Oregon on the north, Siskiyou County on the east, and Humboldt County to the south. This county is noted for rugged mountains, venerable redwoods, extensive forests, and raging rivers.

Prior to 1850, there was little activity in Del Norte County. However, during the 1850's, Crescent City was incorporated and became a supply center for gold mining operations in the interior mountainous regions. Following the gold rush, a limited economy was established based on lumber, agriculture, and mining. Only minor increases in population and activity occurred until 1940, except for the period during World War I.

A rapid economic growth has occurred in Del Norte County since 1940. The population has steadily increased from 8,080 in 1940 to about 20,000 in 1960. Contributing largely to this economic upsurge in Del Norte County has been the income derived from manufacturing of lumber and wood products.

A significant increase has also occurred during this period in agricultural activities within Del Norte County. Total sales of agricultural products for the county in 1961 was about $3,047,300. This represents a sharp increase over that of 1954 when agricultural production was about $1,110,000. The principal factor for this increase is attributable to the production of specialized crops. Commercial fishing, principally centered about Crescent City, also furnishes a substantial income.

One of the largest assets of Del Norte County is the scenic beauty, especially the forests and coast line. This asset, coupled with tourist travel, camping, and sport fishing, attracts an increasing number of visitors each year.

This investigation was centered in the two major ground water basins of Del Norte County, namely the Smith River Plain and the lower Klamath River Valley area. These two areas with their flat lands, favorable geographic location, rich soils, and readily available ground water, have attracted and supported the largest development within the county. The locations of the Smith River Plain and the lower Klamath River Valley area are shown on the generalized location map (Figure 1).

The Smith River Plain, bordering the Pacific Ocean, is the most western portion of Del Norte County with Crescent City as the population center. This slightly rolling plain comprises an area of about 39,000 acres with a maximum elevation of approximately 100 feet. The Smith River, flowing from the eastern mountainous region, crosses the northern portion of the plain.

Lake Earl, a shallow, brackish body of water occupies nearly 2,100 acres near the central portion of the Smith River Plain. This lake is intermittently connected to the ocean by a narrow neck of water and is subject to periodic flooding both from the Pacific Ocean and surface water runoff.

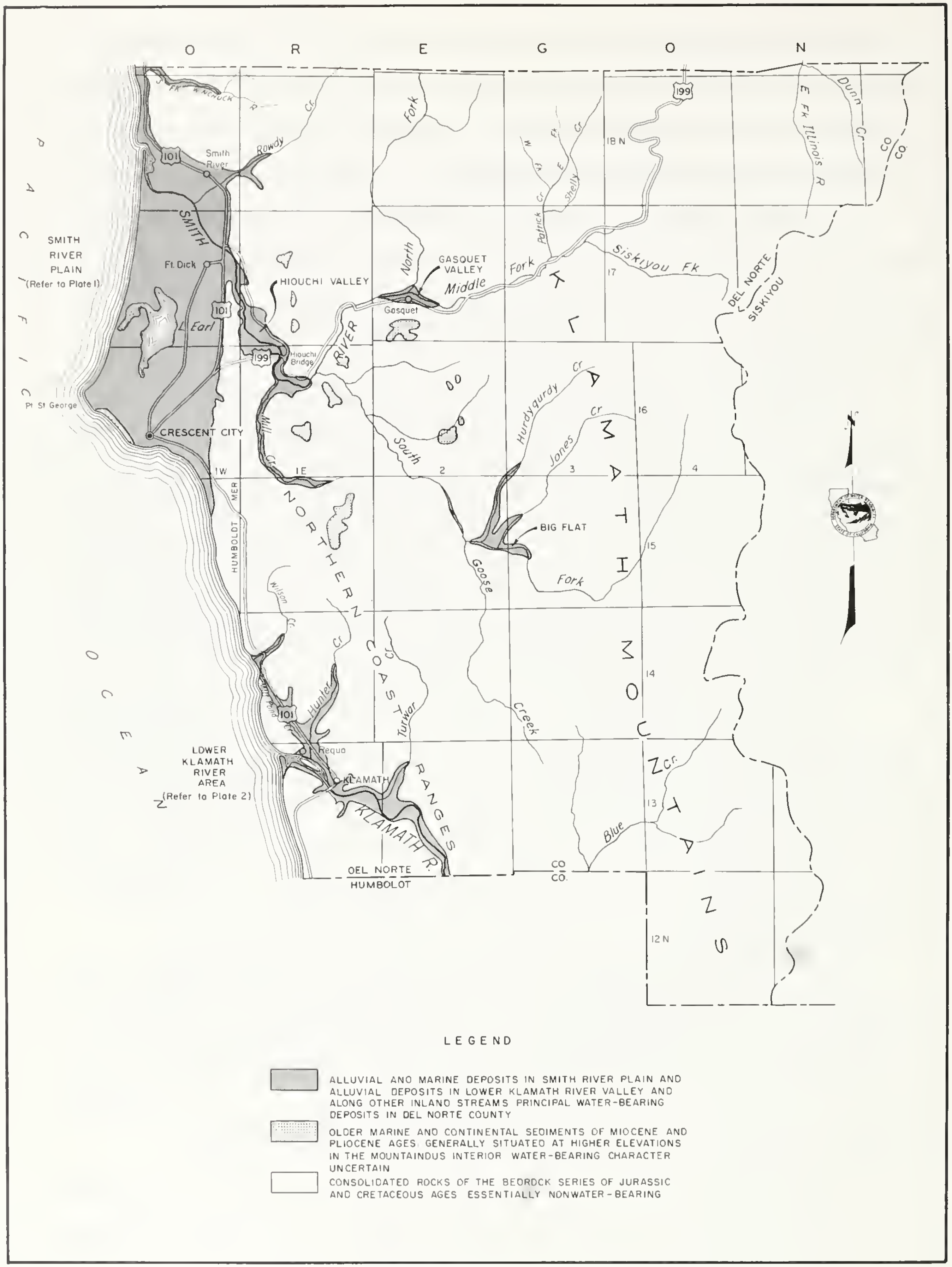


Figure 1. GENERALIZED LOCATION MAP AND GEOLOGIC MAP OF DEL NORTE COUNTY

The Smith River Plain, as indicated by the 1960 census, had a population of 14,860, while Crescent City, the largest city, had a population of 2,960 with a suburban population of about 6,800. The mean annual rainfall is about 75 inches per year and the average yearly temperature is 53°F. Within this plain, about 3,600 acres are subject to irrigation, with bulbs and pasture the major crops.

The lower Klamath River Valley area averages about 1/2 mile wide and extends 10 miles upstream from the mouth of the Klamath River to the county line. The population is estimated to be over 1,000. This basin, with its coastal location and high precipitation, has a climate similar to Smith River Plain.

Other relatively flat areas within the county are situated on river terraces. Included in this group are Hiouchi Valley, Gasquet Valley, and Big Flat.

Prior Investigations and Reports

Published and unpublished reports reviewed or utilized in the preparation of this report are listed in Appendix A. Reports on four investigations which contain information pertaining to water development within Del Norte County were of particular importance. The following is a brief summary of these investigations:

The California Department of Public Health, Bureau of Sanitary Engineering, evaluated sanitary practices of Crescent City watersheds at the request of the Del Norte County Health Department. Results of this survey were released in a report entitled, "Sanitary Survey of Crescent City Watersheds," May 1953. To complement this sanitary survey, the California Department of Public Works, Division of Water Resources, in accordance with an agreement between the County of Del Norte and Crescent City, submitted a "Summary Report on Water Quality, Crescent City and Vicinity, Del Norte County," November 1954. This report included a program of analyses of surface and ground waters for mineral and sanitary quality and a survey to ascertain the permeability of soils within specified areas.

During 1953 the U. S. Geological Survey in cooperation with the California Department of Public Works, Division of Water Resources, made a reconnaissance investigation of ground water conditions of Smith River Plain, Del Norte County. Results of this investigation were published in Geological Survey Water Supply Paper 1254, 1957, "Geology and Ground Water Features of the Smith River Plain, Del Norte County, California."

An investigation was initiated in 1958, by the Department of Water Resources, for the purpose of determining present land and water use and land classification within the Smith River Hydrographic Unit. A preliminary edition of Bulletin No. 94-4, "Land and Water Use in the Smith River Hydrographic Unit," 1962, presents these data.

CHAPTER II. GEOLOGY AND HYDROLOGY

Del Norte County is predominantly a mountainous area with relatively few areas of low relief. Most of the areas of low relief occur in the coastal zone and are principal areas of ground water occurrence. Smith River Plain, which is a large, subrectangular, emerged, marine terrace, is the only major relatively flat area. The lower Klamath River Valley contains a few square miles of land of low relief along stream channels near the coast. Minor alluviated areas of low relief also occur along the South Fork and Middle Fork Smith River, South Fork Winchuck River, Mill Creek, and Wilson Creek as terraces (see Figure 1).

The remaining portion of the county is a rugged mountainous area including the Northern Coast Ranges in the western one-third of the county and the Klamath Mountains in the eastern two-thirds. The Northern Coast Ranges are characterized by elongated ridges that are oriented north to northwest with the structural trend of the bedrock. Structural control of topography has produced a rough trellis drainage. Streams flowing generally westward from the Klamath Mountains tend to bend to the northwest as they leave the Klamath Mountains and cross the Northern Coast Ranges. Along the coast, topography is dominated by rugged headlands rising abruptly from the ocean, interspaced with narrow beaches and elevated terraces.

The Klamath Mountains are an area of deeply-trenched, steep canyons and rugged ridges and peaks. Drainage is dendritic with most of the runoff of eastern Del Norte County funneled into the single channel of Smith River. The general westward course of Smith River and most of its tributaries is across the structural trend of the area. Due to rugged topography, alluviated areas are limited to small, scattered, river-terrace deposits along Smith River and its tributaries. Uplift of the land since Pleistocene time has resulted in rapid downcutting of streams, usually leaving terraces perched well above stream channels. The most important of these terraces are in Hiouchi and Gasquet Valleys along the Smith River, and Big Flat area on the South Fork Smith River.

Geologic units in Del Norte County include sedimentary, metamorphic, and intrusive igneous rock types that vary in age from Jurassic to Recent. In relation to movement and occurrence of ground water, rock units can be grouped into two categories. These are the bedrock series which includes all rocks of pre-Tertiary age, and a sedimentary series of Tertiary to Quaternary age which includes the principal water-bearing units. The bedrock series consists of rocks that are dense and crystalline and contain no appreciable amount of ground water. Small amounts of water are sometimes contained in and transmitted through joints and fractures within this series. The younger sedimentary deposits, in contrast, transmit water through interconnected pore spaces and may contain relatively large amounts of ground water.

The structural trend of rocks in the county is to the north and northwest. Bedding and foliation of rocks and faulting generally follow this trend. Metamorphic and sedimentary rocks of the bedrock series are usually complexly deformed, while deformation of Tertiary and Quaternary deposits is either nonexistent or relatively slight. The only known geologic structure of significance to ground water is the Del Norte fault. The trace of this fault is buried under Quaternary sedimentary deposits along the eastern side of Smith River Plain. Vertical displacement along this fault is apparently responsible for the downdropping of the block that forms the Smith River Plain platform.

Smith River Plain

Smith River Plain is the largest area of unconsolidated marine and alluvial deposits in Del Norte County. It is situated in the northwest corner of the county and is bordered by the Pacific Ocean on the west and by the Northern Coast Range rock types on the east. Comprising an area of about 110 square miles, the plain has a north-south length of about 20 miles and a maximum width of about 6 miles. This area is subrectangular in shape, pinching out to the south against the steep scarp of the mountainous headland, as shown on Plate 1. The north end of the plain narrows abruptly at the mouth of Smith River to a marine terrace less than 1 mile wide and continues north into Oregon.

Smith River Plain was formed by the emergence of a shallow submarine platform during late Pleistocene time. The western edge of the platform from Point St. George north to the mouth of Smith River consists of a broad sandy beach. From Point St. George to Crescent City, the platform is terminated by a sea cliff about 50 feet high overlooking a narrow beach. A similar beach and low sea cliff extends along the coastal strip north of Smith River into Oregon. A broad sandy beach extends southeast from Crescent City to the base of the rugged headland at the southern tip of the plain. The eastern side of the platform is bordered by a remarkably straight, north-south escarpment forming the western front of the Northern Coast Range. This escarpment is apparently a result of vertical displacement along the now buried Del Norte fault (see Plate 1). At the town of Smith River, the mountain front bends northwestward, forming the northern boundary of the plain, except for the narrow coastal strip that extends into Oregon.

The Smith River Plain platform can be divided into five physiographic areas each with distinct geologic units and ground water conditions.

These areas are: (1) the marine terraces; (2) river terraces; (3) Smith River flood plain; (4) sand dunes; and (5) alluvial fans.

1. The marine terrace formed by the Battery formation occupies most of the southern half of the plain. The surface of this area represents the remains of the Pleistocene sea floor. Since emergence of the platform, this surface has been considerably altered by stream erosion and wind action. The most outstanding features of this area are the series of roughly parallel elongated sand ridges that trend in a northwesterly direction. They are about 500 feet wide at the base and rise 30 or 40 feet above the plain. These ridges are interpreted as relict sand dunes that formed before vegetation covered the newly emerged surface at the end of the Pleistocene. Natural drainage is greatly impeded by these ridges. Only Elk and Jordan Creeks have succeeded in cutting channels through to the sea and to Lake Earl, respectively. Marine terrace deposits, correlative with the Battery formation, also occupy the narrow bench forming the northern extension of the plain, extending north of the mouth of Smith River.

2. Terrace deposits were formed during the Pleistocene, when the ancestral Smith River and Rowdy Creek dumped flood plain and stream channel deposits onto the plain from the Fork Dick area to the town of Smith River. Subsequent elevation of the plain and renewed downcutting of streams resulted in removal of large amounts of these deposits, leaving irregular terraces. The largest, the Fork Dick terrace, borders the southern margin of the flood plain of Smith River. The boundary between this terrace and the flood plain is marked by an abrupt escarpment approximately 20 feet high.

Similar but smaller terraces occur north of Smith River and straddle Rowdy Creek.

3. The flood plain of Smith River is only about a quarter mile wide where it flows onto the platform about 1.5 miles east of Fort Dick. Here the flood plain widens gradually to about 4 miles and merges with the flood plain of Rowdy Creek near the tidal mouth of Smith River. The flood plain has a southward extension to Lake Earl along Talawa Slough. As a whole, it is relatively flat and featureless.

4. Sand dunes form a narrow strip about 1 mile wide from Point St. George to the mouth of Smith River. These dunes, on the lee side of the strip, form elongated ridges as much as 60 feet high with the long axis oriented roughly northwest. Some of the dunes are active and are migrating southwestward while others are fairly well stabilized by vegetation. The dune sand is moderately to highly permeable, which permits infiltration of almost all the precipitation. Consequently, no integrated drainage pattern has developed in the dune area. The sand dune area acts as a barrier to surface runoff from the central part of the plain, resulting in the formation of Lake Earl and Lake Talawa.

5. Alluvial fans form the smallest physiographic area within the Smith River Plain. They consist of a narrow, discontinuous apron of alluvial debris along the base of the escarpment bounding the eastern edge of the plain. The fans are marked by a gradual change in slope at their base, gradually steepening until they reach the base of the mountain front. They tend to fan away from the mouths of the many small drainages.

Geologic Formations and Water-bearing Characteristics

Within the Smith River Plain ground water basin are five principal geologic formations in which ground water is stored and transmitted. Each formation is correlative with one of the five physiographic areas previously discussed. Beneath these areas and geologic formations, generally at shallow depths, are two older formations; the bedrock series and the St. George formation, in both of which only minor amounts of ground water occur. Areal distribution of these geologic formations is shown on Plate 1.

Bedrock Series. The rocks that form the "basement" of the Smith River Plain platform and the adjacent Northern Coast Range are Jurassic to Cretaceous in age. They consist of marine sedimentary rocks including sandstone and some shale, and minor amounts of chert, conglomerate, and greenstone. In general, the basement rocks are slightly metamorphosed, poorly bedded, and complexly deformed. These rocks weather rapidly and thick, clayey, residual soils have developed on the mountainous slopes.

The bedrock series underlies the plain south of Lake Earl at depths ranging up to 450 feet beneath the surface. North of Lake Earl, bedrock usually occurs at depths less than 60 feet. Occasional outcrops, which are interpreted as ancient sea stacks, protrude through the younger sediments.

The basement rocks are essentially impermeable; however, small amounts of water are transmitted and contained locally in joints and fractures. These openings give rise to many small springs along the front of the Coast Range. A well at Redwood Union School, which is 218 feet deep, penetrates the bedrock series and reportedly yields 5 gallons per minute (gpm) with a drawdown of 150 feet. Several other wells penetrating basement rocks have reportedly been unproductive. In general, these rocks act as a barrier to ground water movement. The small amount of water present is transmitted only along joints and fractures. Consequently, depth to water, hydraulic gradients, recharge, and discharge features are extremely erratic.

Where the bedrock series is exposed at the ground surface, ground water may occur in open joints and fractures where little filtering action takes place. Under such conditions there is often danger of contamination from surface sources.

St. George Formation. Massive, poorly-indurated, marine siltstone and shale with irregular thin beds of sand are exposed in the sea cliff between Point St. George and Crescent City. These beds are known collectively as the St. George formation and represent deposition of sediments in a bay or lagoon during Pliocene time. Although this formation is exposed only in the above area, it may occur beneath a large portion of the south half of Smith River Plain buried under younger deposits, as shown on geologic cross-section A-A', Plate I. The St. George formation is probably not present beneath the Smith River flood plain area. The thickness of the formation is unknown. A thickness of about 75 feet is exposed in the sea cliff and a maximum thickness of 400 feet has been estimated. Beds of the St. George formation strike N 50° W and dip about 12° northeast, indicating gentle folding before deposition of the overlying Battery formation.

The overall permeability of the St. George formation appears to be very low. However, the hydrologic characteristics of this formation are essentially unknown. The tight nature of the sediments, just north of Crescent City, has been locally demonstrated by test holes 16N/1W-17F1 and 16N/1W-21D1 which were abandoned on the basis of bailer tests. For the method of individual well numbering and method of location, see Appendix C.

The possibility exists of the occurrence of a coarser grained facies that may be more productive, but to date this possibility remains unproven. Similarly, the chemical character of water occurring in this unit is unknown, but it probably tends to be more highly mineralized than water occurring in younger deposits.

Battery Formation. The Pleistocene Battery formation is a thin, flat-lying, marine terrace deposit unconformably overlying the basement rocks and the St. George formation where it is present. A typical section consists of lenticular, poorly-stratified beds of silty sand alternating with thin clay layers. This formation includes some contemporaneous, stream-deposited sand and gravel east of Lake Earl. Subsurface data indicate the thickness of the Battery formation to range from 28 to 66 feet. It underlies most of the plain south and east of Lake Earl and forms the narrow marine terrace north of the mouth of Smith River.

In the Crescent City area, principal aquifers in the Battery formation are lenticular beds of fine sand. These sand beds are usually encountered at about 25 feet but may range from 2 to 40 feet. East of Lake Earl the sands and gravels form a more or less continuous aquifer, extending from Fort Dick to the drainage divide between Jordan and Elk Creeks. Depth to this aquifer ranges from 4 to 27 feet and averages about 20 feet.

The Battery formation is the principal source of water in the Smith River Plain south of Fork Dick. Unconfined ground water occurs in fine sand and sand and gravel aquifers. The permeability of these aquifers ranges from 150 to 900 gallons per day (gpd) per square foot and are commonly on the order of 350 to 450 gpd per square foot. Although the formation is moderately permeable, it is not a prolific producer of water due to its limited saturated thickness. Well yields are large enough for domestic and limited irrigation uses. However, most wells are not drilled through the total thickness of the formation and are completed with an average depth of about 30 feet. If wells were completed through the entire thickness and well screens or gravel packing were used, perhaps yields could be increased appreciably.

Recharge to the Battery formation occurs from subsurface inflow from adjacent alluvial fans to the east, and sand dunes toward the northwest, and from direct infiltration of rainfall. Due to the tight clayey nature of the upper part of the Battery formation and most of the alluvial fan deposits, recharge is slow. Water levels generally continue to decline after late summer and early fall rains and do not rise until late fall and winter. Depth to water averages 10 to 12 feet and ranges from about 2 to 25 feet beneath the surface. Seasonal fluctuations of water levels range from 5 to 10 feet with no noticeable long-term decline. Natural discharge seems to account for most of the seasonal decline in water levels. Discharge occurs as springs and seeps adjacent to the ocean, effluent losses to Elk and Jordan Creeks, and by evapotranspiration. Ground water moves generally from east to west from the base of the hills to Lake Earl and the ocean. A ground water divide exists about 1 mile north of Crescent City. North of this divide, ground water moves toward Lake Earl; and south of it, ground water moves toward the ocean. Ground water in the Battery formation is subject to impairment of quality, because of its generally shallow depth. Another contributing factor is the locally poor drainage conditions between relict sand dune ridges.

River-terrace Deposits. Pleistocene deposits that form the terraces flanking Smith River and Rowdy Creek flood plains consist of silt, sand, and gravel with some clay. Generally, these deposits become coarser with depth and large boulders are often encountered at the base of the geologic unit. Well logs indicate the deposits range in thickness from 30 to 40 feet near Fort Dick to over 55 feet near the community of Smith River. Generally, they are underlain by basement rocks, but locally they may rest on the Battery or St. George formations. The upper 10 to 15 feet are usually clayey due to soil development and weathering.

The river-terrace deposits serve as both aquifers and forebays for ground water recharge. These deposits are generally moderate to highly permeable below the weathered zone, with permeabilities ranging from an estimated 1,000 to 2,000 gpd per square foot. However, due to the limited saturated thickness, yields to wells are not generally high. Several irrigation wells in the Fort Dick and Rowdy Creek areas yield 140 to 400 gpm with specific capacities ranging from 17 to 61 gpm per foot of drawdown. Yields sufficient for domestic wells can almost always be developed, although some of the higher terraces upstream from Highway 101 may not have enough storage to provide water through the summer months.

Recharge is effected by direct infiltration of rainfall, subsurface inflow from alluvial fans to the east, influent seepage from small streams, and infiltration of irrigation water. Water levels in wells show an immediate response to rainfall, indicating a relatively high vertical permeability. Seasonal fluctuations as much as 15 feet have been recorded, and larger fluctuations may occur in the smaller and higher terraces where a constant source of recharge is not available. Water levels stand at 6 to 25 feet below the ground surface and probably average about 15 feet beneath the surface. In the Fort Dick area, water level gradient is about 60 feet per mile. Upstream gradients to the east are steeper. Ground water movement is generally westward to the flood plain deposits.

Because of the relatively high vertical and horizontal permeability and the short distance to ground water, care should be taken in placement of domestic wells. They should not be located in close proximity to and down gradient from sources of impairment.

Alluvial Fan Deposits. Recent alluvial fans form a steep, nearly continuous apron less than 1 mile wide along the base of the mountains. These deposits consist primarily of poorly-sorted, angular rocks in a silty, clay matrix. Occasional sand and gravel lenses occur that represent buried stream channels. The bulk of the unit was probably derived from landslides and possibly mudflows rather than entirely by stream deposition.

Permeability of the fan deposits is generally very low due to large amounts of interstitial clay. However, some lenses of sand and gravel may have a relatively high permeability, particularly at the distal or western end of fans where streams have had a chance to rework and remove much of the clay. In general, yields to wells penetrating only alluvial fan deposits are relatively low and very erratic from place to place. Reportedly, these deposits sometimes do not yield enough water for domestic use.

Ground water moves from the fan head westward into adjacent deposits. Water levels vary primarily with topography and range from about 4 to 32 feet beneath the surface and average between 10 to 15 feet deep. These deposits serve as a rather poor forebay for ground water recharge.

Dune Sand. Recent eolian sand deposits form dunes that cover an area along the ocean more than 10 miles long and about 1 mile wide, from Point St. George to the mouth of Smith River. These deposits consist of well-sorted, medium to fine sand. Finer-grained soils have developed in the interdune areas which are poorly drained. The total thickness is unknown, but the sand ridges stand 60 to 70 feet above the marine terrace surface and above sea level. Therefore, the dune sand can be assumed to reach a maximum thickness of at least 70 feet.

The dune sand appears to be moderate to highly permeable. It yields sufficient water for domestic and stock wells and would probably yield enough water for irrigation wells.

Recharge is derived entirely from precipitation. Ground water moves away from the sand ridges and discharges eastward into Lake Earl and westward into the ocean, and a part is lost by evapotranspiration. It also affords some recharge to adjoining alluvium and sediments of the Battery formation. In the sand dune area, depth to water in wells ranges from about 3 to 25 feet or more, depending on the elevation of the land surface. Ponds often occur in interdune areas where the water table intersects the surface.

There are probably no confining layers to prevent contamination of ground water in this sand dune area by infiltrating surface water. Therefore, domestic wells should be as deep as conditions permit with perforations at the bottom, to take full advantage of the natural filtration properties of the sands. However, lowering of water levels below sea level for any protracted period of time could induce sea-water intrusion which would appear initially in these deeper wells.

Flood Plain Deposits. Recent alluvium underlies the present flood plain of Smith River and its tributaries. These deposits rest on basement rocks and lap onto river terrace deposits along the edge of the flood plain. They extend from the mouth of the river upstream almost to the lower end of Hiouchi Valley. From this point downstream to the mountain front, flood plain deposits are confined to the stream channel and are not more than 1/4 mile wide. Where the river leaves the front of the mountains, the flood plain widens to about 4 miles near the confluence of Rowdy Creek. Alluvial deposits along Rowdy Creek also form an arm that extends about 2 miles eastward into the mountains from the town of Smith River, and they form a southward extension along Talawa Slough to Lake Earl.

Flood plain deposits generally consist of gravel, sand, and some silt. The sands and gravels are well-rounded and sorted. Boulders and cobbles are common where the river flows out of the mountains. As the flood plain spreads out over the platform, the gravels generally become finer. Silty soils, 2 or 3 feet thick, cover the flood plain deposits except in the active channels of Smith River and Rowdy Creek. The flood plain deposits range in thickness from about 40 to 95 feet.

The flood plain deposits contain large amounts of unconfined water and are the most productive aquifers in the Smith River Plain. Consequently, most of the irrigation well development is in this area. Permeabilities range upward from 6,000 gpd per square foot and are estimated to average about 10,000 gpd per square foot. Yields to irrigation wells range from about 200 gpm to 800 gpm and larger yields could be obtained if desired.

Sources of recharge to the flood plain deposits include direct infiltration of precipitation, subsurface inflow from adjacent deposits, seepage of unconsumed irrigation water, and influent seepage of Smith River and Rowdy Creek during high flows. Ground water movement is generally to the northwest to points of discharge into the river or into the tidal area near its mouth. Water levels range from 2 to 24 feet and probably average from about 10 to 15 feet beneath the surface. Water levels are generally shallower in the vicinity of the mouth of the river and along Talawa Slough.

Relatively impervious layers are seldom present in the flood plain deposits. Consequently, there is a minimum of protection from contaminated surface water percolating downward into wells. Domestic wells probably should be drilled to a depth of 40 feet or more to take advantage of naturally filtered water.

Lower Klamath River Valley

The lower Klamath River Valley is a narrow canyon partially filled with alluvium that was incised into the Northern Coast Ranges. The resultant valley fill area is irregular in shape and is confined to the flood plains of Klamath River and its tributaries. The main stem of the valley is about 10 miles long, from the southern boundary of Del Norte County, downstream to the ocean, and one quarter to 1 mile wide. Irregular, narrow arms extend up tributary streams such as High Prairie, Hunter, and Turwar Creeks. Alluvium along Mill Pond Creek forms an extension of the lower Klamath River area, but it is actually a separate ground water basin. The Mill Pond Creek alluvial area is connected along the coast with a small alluvial area along Wilson Creek at False Klamath Cove. These areas are included as part of the lower Klamath River Valley in this report as shown on Plate 2.

The lower Klamath River Valley contains only two geologic units of significance to ground water occurrence. These include the bedrock series that underlies and borders the valley alluvial fill. The bedrock series consists mostly of greenstone, sandstone, and shale. These rocks are dense with most of the pores filled with cementing minerals. Consequently, they contain no appreciable amount of ground water, except in joints and fractures. Deep clayey soils often develop, and slumping and landslides are common. Yields to wells from the bedrock series can be expected to be small to negligible. Locally, jointed and fractured zones may yield enough water for a domestic or stock well. Also, where deep residual soils or an old landslide is present, it may yield small amounts of water to wells. However, the water-bearing properties of these rocks are usually unpredictable, and the risk of not obtaining enough water for even domestic needs is very high. Ground water occurring at shallow depths in these rocks is subject to contamination from surface sources.

The alluvial fill consists of Recent, unconsolidated stream-deposited gravel, sand, and silt with minor amounts of clay. The gravels range in size up to large boulders. These deposits are probably rudely stratified into lenticular beds. Locally, a few Pleistocene river-terrace deposits occur perched on benches above the flood plain. These deposits have been included on Plate 2 with the remainder of the valley fill because of their small extent and similar water-bearing characteristics. Also, a sand bar formed at the mouth of Klamath River is likewise included with Recent stream deposits.

The maximum thickness of alluvial fill in the lower Klamath Valley is unknown. Wells at locations 14N/1E-28G and 13N/1E-11P encountered 108 and 61 feet of alluvium, respectively, and both of these wells are within 300 feet of the edge of the flood plain. Alluvium could be 200 or more feet thick beneath the middle of the flood plain near the community of Klamath. The depth of fill along the tributary arms of the valley is generally less but may be 100 feet in places.

The Recent flood plain deposits are the only reliable source of ground water in the valley. These deposits appear to be generally highly permeable and wells should have yield characteristics similar to those located on the flood plain deposits in the Smith River Plain. Yield data are available for three wells which have specific capacities ranging from 12 to 130 gpm per foot of drawdown. Yields to wells will probably fall within this range nearly anywhere within the flood plain. A possible exception would be alluvium along Mill Pond Creek from the Trees of Mystery to the beach at the mouth of the stream. Alluvium along this stream appears older and more deeply weathered and probably contains more interstitial clay. Alluvium along Wilson Creek appears to be highly permeable.

Recharge to the valley fill is probably by influent seepage from tributary streams and by direct infiltration of precipitation. Ground water movement is probably toward the Klamath River from its tributaries and toward the ocean. No water level measurements have been obtained, but water levels are probably shallow and depend on the proximity to the river and elevation above the river.

Care should be taken in location and construction of wells due to the high vertical permeability of the alluvium. Poor quality waters can easily percolate downward to shallow water tables and into wells unless they are properly constructed.

Mountainous Areas

The remainder of Del Norte County consists of steep and rugged mountainous terrain. The mountains were formed by uplift and deep incision by the Smith and Klamath Rivers and their tributaries. The Smith River drainage basin occupies most of the county except for a small area to the south and several small drainages to the north (See Figure 1). The tops of some ridges represent an old erosion surface with relatively gentle, rolling topography. The slopes break sharply into steep canyons as much as 3,000 feet deep, to streams below. Scattered along the streams are Pleistocene river terraces perched well above the present stream channels. These terraces represent the old channels of the streams as they probably existed during late Pleistocene, when stream gradients were gentle enough to allow the streams to deposit their loads. Renewed uplift since that time has enabled the streams of the Smith River system to erode through old deposits and into the underlying bedrock. River terraces afford the only readily available, relatively flat ground for home sites and a few small ranches. The largest of the terraces form Hiouchi Valley, Gasquet Valley, and Big Flat. Numerous other terraces are scattered along various streams of the Smith River system, but these are too small to be shown on Figure 1. A notable series of terraces occurs along most of the length of Mill Creek south from Hiouchi Valley. Also, some terraces occur along Blue Creek, a tributary of Klamath River, in the rather inaccessible southeastern part of the county. The remainder of the relatively flat areas are some of the ridge tops and a few old landslide areas.

The bedrock series that forms the mountainous areas includes dense, crystalline, igneous, metamorphic, and sedimentary rocks. The Coast Range consists mainly of sandstone, shale, conglomerate, and some greenstone. The Klamath Mountains consist of various schists, greenstone, sandstone, shale, and conglomerate intruded by granite and serpentinized ultra-basic rocks. The bedded rocks are complexly deformed, and fracturing and jointing are common. Deep weathering is common, and clayey residual soils mantle the surface. These rocks are considered to be essentially impermeable, except locally where ground water is transmitted along joints and fractures. These openings give rise to numerous small springs scattered over the area. Yields of wells penetrating these rocks can be expected to be extremely erratic. Yields sufficient for domestic use would not be unusual, providing a fracture zone is intercepted. However, the locations of these zones are generally difficult to predict, so that locating a successful well is very hazardous. Because water occurs along joints and fractures that are open to the surface, contaminated surface water may have easy access to wells, creating a further hazard.

Some of the ridge tops represent a dissected, old-land surface and are underlain by scattered marine and continental, sedimentary deposits (See Figure 1). These sediments were deposited during the development of the old-land surface, named, the Klamath peneplain. The marine sediments, described as the Wimer formation, consist of friable shales, sandstone, and conglomerate, and are believed to be Miocene in age. Channels cut into the Wimer formation contain clayey gravels believed to be Pliocene in age. The water-bearing characteristics of the Wimer formation and the associated continental deposits are unknown. Due to induration and the presence of interstitial clay, their permeabilities are probably very low. However, locally, these deposits might yield sufficient water for domestic use.

The terraces that commonly occur along various streams, some of which are shown on Figure 1, are underlain by unconsolidated stream-deposited gravel, sand, silt, and clay. The upper 10 to 20 feet usually consist of poorly sorted, clayey gravel; the clay being a result of chemical weathering. The remainder consists of clean, poorly sorted sand and gravel with occasional silt lenses up to 3 or 4 feet thick. The sand and gravel particles may be subangular to well-rounded and range in size from fine sand to large boulders.

The river-terrace deposits usually range from 0 to about 50 feet thick, but locally they may be as much as 100 feet thick. They are about 50 feet thick beneath Hiouchi Valley and are probably about the same thickness in Gasquet Valley and in the Big Flat area.

River-terrace deposits are the only reliable source of ground water in the mountainous areas of Del Norte County. In general, the cleaner sand and gravel is highly permeable. Yields to wells are large enough for domestic use and limited irrigation use on the larger terraces. Wells in Hiouchi Valley yield about 16 gpm and have specific capacities of less than 10 gpm per foot of drawdown.

Recharge to the river-terrace deposits occurs from direct infiltration of precipitation and from influent seepage from small side streams. Ground water moves generally towards the main stream channels, where it is discharged near the base of the terrace. The storage capacity of these deposits is generally small, and because of their perched position above the main stream channels they are easily dewatered. Consequently, large seasonal fluctuations of water levels can be expected where a constant source of recharge is not available from a side stream.

Drilling wells in river-terrace deposits is often very difficult due to the presence of large, loose boulders. Consequently, the cost of well construction is often greater. The clayey zone that is usually present in the upper portion of these deposits helps to prevent entry of water from surface sources. However, in many instances, vertical permeability may be high, especially in side-stream channels.

CHAPTER III. WATER SUPPLY

Development and use of ground and surface water in Del Norte County has occurred almost entirely in three general areas; the Smith River Plain, the lower Klamath River area, and on river terraces adjacent to Smith River. Minor withdrawals of ground or surface water occur along other small rivers or creeks. The remainder, and by far the greater portion of the county, is mountainous and almost entirely uninhabited, with but little or no supplemental water requirement.

With the exception of steeply sloping mountainous areas, which are conducive to rapid surface runoff, there is a general excess of ground and surface water available for present and predicted future water requirements in Del Norte County. Water level measurements indicate that ground waters extracted each year by pumping are replenished during periods of heavy precipitation.

Surface Water

Del Norte County, being an area of extremely high precipitation and large resultant runoff, is noted for its many streams and rampaging rivers. These surface waters throughout most of the year are a convenient source of water; however, with the advent of winter storms the rivers and streams often overflow their banks and damaging floods result. These surface waters also play a very important role in the recharge of ground water basins.

Precipitation

The mean annual rainfall in the coastal areas is from 55 to 80 inches. In general, the amount of annual precipitation increases inland with the increase in altitude. In the eastern portion of the county, at higher elevations, annual precipitation may exceed an average of 125 inches.

About 90 percent of the rainfall occurs from October 1 through April. The geographical distribution of total annual precipitation for Del Norte County is shown on Plate 3.

Runoff

Although the amount of runoff within any given area is dependent upon the frequency, intensity, and duration of precipitation, the topographic, hydrologic, and geologic characteristics of the watershed have a significant effect. The mountainous areas of Del Norte County are generally steep and rugged which, coupled with frequent seasonal and at times intense storms, accounts for rather heavy and rapid runoff within the larger drainage basins. This rapid runoff creates the problem of periodic floods. A major flood during the winter 1955 resulted in considerable property loss within Del Norte County. In contrast, during the summer months, the period of lowest runoff, surface water from individual streams may be no more than adequate or even deficient for present water requirements. In such cases, the water supply is often supplemented from ground water sources.

Smith River Basin. Out of a total of about 643,000 acres in Del Norte County, about 392,000 acres are drained by the Smith River above the gaging station near Crescent City. This river, which rises in the easternmost and highest portion of Del Norte County, lies wholly within Del Norte County, excepting a small portion of its north fork, which lies in Oregon. The 50-year mean annual, full natural runoff for Smith River at the gage near Crescent City is estimated to be about 2,640,000 acre-feet. The estimate is based on the 50-year period from 1910-11 to 1959-60. Annual runoff approximates almost 7 acre-feet of water per acre per year.

The variations of streamflow on Smith River are indicated by the streamflow recorded in the water year of 1960-61 near Crescent City.

During this year, flow records indicate a maximum flow of 760,500 acre-feet for the month of March and a minimum flow of 16,930 acre-feet during the month of September. During this water year, the total recorded flow was 2,998,000 acre-feet or about 110 percent of the average annual flow.

Variations of smaller streams are illustrated by streamflow records on Rowdy Creek near the town of Smith River during the water year of October 1960 through September 1961. Mean monthly flows during the months of February and March were 684 to 688 cubic feet per second (cfs), and during August and September were 3 to 5 cfs. The town of Smith River is furnished municipal water from a tributary above the gaging station.

Klamath River. Entering Del Norte County from the southeast, the Klamath River drains about 140,000 acres of this county before discharging into the ocean near the community of Klamath. At the gage near the town of Klamath, estimated full natural runoff for Klamath River for the 50-year mean annual period from 1910-11 to 1959-60 is about 12,000,000 acre-feet. Although somewhat regulated by reservoirs above the station, the recorded flows for the water year of 1960-61 indicated a maximum flow of 2,176,000 acre-feet during March and a minimum flow of 184,000 acre-feet during October. The remainder of Del Norte County is drained by minor rivers and streams with similar variations in flow patterns.

Use of Surface Waters

Less than 1 percent of the average, total annual, surface water runoff in Del Norte County is used. In 1958, 4,500 acre-feet of water were diverted at 31 measured diversions. This amount is believed to be somewhat less than half of the total of the quantity of surface water diverted. It is estimated that about 50 percent of the water requirements within the Smith River drainage basin are supplied by diversion of local stream runoff and the remainder by pumping of ground water.

Due to economic reasons, which involve construction and maintenance of necessary structures, only small amounts of water are stored during periods of heavy runoff. Consequently, with a relatively large underground storage available, considerable ground water is used both for domestic and agricultural purposes. Although surface waters are generally of excellent mineral quality, there is a significant problem of high turbidity (finely suspended material) during periods of increased flows. For this reason, domestic, municipal, and many industrial uses of water will probably remain dependent on underground supply until water treatment facilities are economically justified.

Ground Water

Ground water in Del Norte County, as previously described in Chapter II, Geology and Hydrology, occurs principally within the two major areas of low relief in the coastal zone. These are the Smith River Plain and the lower Klamath River area. The largest of the ground water basins is the Smith River Plain, which borders the Pacific Ocean, in the vicinity of the mouth of the Smith River. The lower Klamath River Valley area includes the valley along Klamath River with irregular narrow arms extending up tributary streams such as High Prairie and Hunter Creeks, and also includes the smaller, nearby Mill Pond and Wilson Creek Valleys directly tributary to the Pacific Ocean. The numerous river terraces scattered along various streams of the Smith River system are also reliable sources of ground water. Yields are generally sufficient for domestic uses and limited localized irrigation.

Recharge

Each year during the season of heavy precipitation, ground water basins in Del Norte County are recharged by infiltration of surface water.

In addition, ground water basins may receive subsurface inflow from higher elevations during the year. Normally, ground water basins in Del Norte County are readily recharged because of the abundant water supply, the high permeability of the ground surface formation, and the low relief of the land surface.

The amount of recharge is partially dependent on hydrologic and geologic characteristics of individual formations. The sand dunes and flood plains are rather permeable and are readily replenished. The terrace deposits are less permeable. The Battery formation and alluvial fans are the least permeable, due to their clay content, and are not as readily replenished.

Ground Water Storage

The U. S. Geological Survey, in 1953, estimated that the ground water basin within the Smith River Plain had a storage capacity of about 99,000 acre-feet between the depths of 10 to 35 feet. All near-surface formations within the ground water basins in Del Norte County inherently contain considerable amounts of water. Within the Smith River Plain, the marine terrace or Battery formation, because of its large areal distribution, probably contains the largest supply of water. The flood plain deposits and sand dunes are the most permeable formations, and have the largest quantity of readily recoverable water.

Fluctuations of Ground Water Level

Ground water levels vary significantly within Smith River Plain and other ground water storage units within Del Norte County. In most instances, ground water is found at depths ranging from 10 to 30 feet.

The U. S. Geological Survey and the Department of Water Resources cooperate in conducting a program of regular water level measurements on selected wells within the Smith River Plain. The depth to water surface within a well is related to the amount of recharge to and discharge from the ground water reservoir. The range of water levels in four typical wells covering the period 1958-63 is shown graphically on Plate 4.

From April to October, the period of the least precipitation and the greatest withdrawals, the average lowering of the water level within the Smith River Plain is about 7 feet. This indicates that, during this period, about 25 percent or less of the estimated storage of about 100,000 acre-feet is utilized or lost by seepage. During the late fall and winter months, when precipitation is heavy, well measurements indicate replenishment of ground water storage.

Use of Ground Water

Total consumptive use of applied water in Del Norte County in 1958 is estimated to have been about 4,000 acre-feet. Of this amount, about 1,600 acre-feet were consumed for irrigation, 1,400 acre-feet for municipal and domestic purposes, and about 1,000 acre-feet for lumber mill operations. About 40 percent of the total consumptive use of applied water is met by pumping ground water.

Presently, throughout Del Norte County, ground water is the most satisfactory source of domestic and municipal supply. Crescent City Municipal Water Department, the largest water service agency within the county, obtains its domestic and municipal water supply from an underground collection system at Smith River. Using the total water connections within the county in 1959-60, it was estimated that 6,080 persons were furnished water by public and private water service agencies. The remainder of the population or about 11,690 persons were dependent on individual water wells for domestic supply. Sufficient domestic ground water of excellent quality is normally available at depths of from 10 to 30 feet within the entire Smith River Plain and from the terraces adjacent to rivers or inland streams.

CHAPTER IV. QUALITY OF WATER

Water, from the time of precipitation, acts as a solvent on minerals and soils. The solvent action may be increased by the presence of certain dissolved gases such as carbon dioxide. During the passage of water, whether on the surface or underground, the amount and kinds of suspended or dissolved constituents reflect the environmental factors present during the hydrological cycle. In addition, salts and other undesirable substances may be added to water by industrial wastes, sewage, and irrigation return wastes. The addition of these impurities may have a significant effect on the chemical behavior of the water and thereby alter its value.

Various measurements have been applied to evaluate the quality of ground water in Del Norte County. These included numerous chemical and bacteriological analyses of water samples taken from representative water wells. Interpretation of these analyses, combined with geological and hydrological studies and well construction surveys in Del Norte County, are the keys to formulating recommendations for water well construction and sealing standards.

Most of the dissolved constituents in water are dissociated into ions. The positively charged ions (cations) are primarily exemplified by calcium, magnesium, sodium, and potassium. The negatively charged ions (anions) include carbonate, bicarbonate, sulphate, chloride, and nitrate.

The mineral character or type of water is noted by determining the predominant cation and anion as indicated in chemical equivalents per million (epm). The name of the cation is used when its chemical equivalents constitute 50 percent or more of the total cations. Similarly, this applies to the anion group. For example, a magnesium bicarbonate character water is one in which the magnesium cation and bicarbonate anion each constitute half or more of the individual totals of cations and anions. Where no single constituent exceeds 50 percent or more of the individual totals of cations and anions, hyphenated combinations are used. An example is a magnesium-calcium bicarbonate water.

This chapter presents a summary of water quality criteria, quality of ground water, and an interpretation of ground water quality conditions. Mineral analyses of ground water samples collected from wells in Del Norte County are listed in Appendix D.

Water Quality Criteria

The quality of water must be maintained at proper levels for each of a wide variety of beneficial uses. Criteria have been established for protection of public health and to provide a reasonable measure of suitability of various waters for many beneficial uses. Water quality criteria are discussed in this chapter for municipal, domestic, irrigation, and industrial uses. The limits presented are the result of continuing experience and research by numerous agencies. Although these recommended limits are subject to change as our knowledge in the field of water quality increases, they do provide a reasonable tool for evaluation. Waters which have an excess of the recommended limiting values may be used in some instances, with judgment, until more suitable supplies are developed and made available. The following criteria are guides for appraisal of the quality of water for various uses.

Municipal and Domestic

The criteria presented for municipal and domestic purposes should be utilized as guides for evaluating the mineral quality of water relative to existing or anticipated uses. Except for those constituents which are considered toxic to human beings, these criteria should be considered as suggested limiting values.

The drinking water standards most widely accepted are those proposed by the U. S. Public Health Service. These standards state that water shall contain no impurities which are offensive to sight, taste, or smell. In addition, the water must be consistently free from toxic compounds and pathogenic organisms. Drinking water should not contain excessive concentrations of dissolved mineral solids. Health standards for drinking water are predicated on two groups of limits:

1. Mandatory limits which constitute grounds for rejection of the water supply. These limits are specified to protect the consumer from increased build-up of toxic constituents.

2. Recommended maximum limits are applicable when chemical substances are present in excess, and consideration should be given for more suitable supplies which are or can be made available.

The U. S. Public Health Service Standards of 1962 apply to water as finally delivered to the consumer.

TABLE 1

CHEMICAL LIMITS IN DRINKING WATER
U. S. PUBLIC HEALTH SERVICE
DRINKING WATER STANDARDS 1962

Constituent	Parts per million
Mandatory	
Arsenic (As)	0.05
Barium (Ba)	1.0
Cadmium (Cd)	0.01
Chromium (Hexavalent) (Cr^{+6})	0.05
Fluoride (F)	2.0*
Lead (Pb)	0.05
Selenium (Se)	0.01

TABLE 1
(Continued)

CHEMICAL LIMITS IN DRINKING WATER
U. S. PUBLIC HEALTH SERVICE
DRINKING WATER STANDARDS 1962

Constituent	Parts per million
Non-mandatory but Recommended	
Alkyl Benzene Sulphonate (ABS)	0.5
Arsenic (As)	0.01
Chloride (Cl)	250
Copper (Cu)	1.0
Cyanide (CN)	0.01
Fluoride (F)	*
Iron (Fe)	0.3
Manganese (Mn)	0.05
Nitrate (NO_3)**	45
Phenols	0.001
Sulphate (SO_4)	250
Total Dissolved Solids	500
Zinc (Zn)	5

* Based on an annual average maximum daily air temperature of 60.0°F at Crescent City, the concentration of naturally occurring fluoride should average not more than 1.3 ppm.

** In areas in which nitrate content of the water is known to be in excess of the listed concentration, the public should be warned of the potential dangers of using the water for infant feeding.

Another factor with which water users are concerned is the hardness of water. Hardness is caused principally by compounds of calcium and magnesium, although other substances such as iron, manganese, aluminum, barium, silica, strontium and free hydrogen can contribute to total hardness. Excessive hardness in water increases the use of soap, which it coagulates to form a precipitate. Also hard water forms a scale thereby reducing the efficiency of boilers and plumbing systems. Total hardness is expressed as calcium carbonate ($CaCO_3$) in ppm. A relative classification of hardness is shown in Table 2.

TABLE 2

HARDNESS CLASSIFICATION OF WATER

Range of hardness expressed as $CaCO_3$ (in ppm)	Relative classification
0 - 100	Soft
101 - 200	Moderately hard
Greater than 200	Hard

Agricultural

The limits of quality of water for irrigation vary according to climate, crops, soils, and irrigation practices in California. These values were developed by the Regional Salinity Laboratories of the U. S. Department of Agriculture in cooperation with the University of California.

The three broad classes of judging the suitability and chemical criteria for irrigation water are listed below:

Class 1. Excellent to Good - Regarded as safe and suitable for most plants under most conditions of soil or climate.

Class 2. Good to Injurious - Regarded as possibly harmful for certain crops under certain conditions of soil or climate, particularly in the higher ranges of this class.

Class 3. Injurious to Unsatisfactory - Regarded as probably harmful to most crops and unsatisfactory for all but the most tolerant.

Suggested limiting values for total dissolved solids, chloride concentration, percent sodium, and boron concentration for the three general classes of irrigation water are shown in Table 3.

TABLE 3

QUALITATIVE CLASSIFICATION OF IRRIGATION WATER

Chemical properties	Class 1	Class 2	Class 3
Total dissolved solids (in ppm)	Less than 700	700 - 2,000	More than 2,000
Chloride (in ppm)	Less than 175	175 - 350	More than 350
Sodium in percent of total cations	Less than 60	60 - 75	More than 75
Boron (in ppm)	Less than 0.5	0.5 - 2.0	More than 2.0

Industrial

The quality of water required for industry varies widely according to the many industrial proccesses or uses. The two largest industrial uses of water are for cooling and processing. No single tabulation of water quality requirements will suffice as a common measure for suitable limits. Most industrial operations normally require a water which is clear, relatively soft, low in iron and manganese, and of approved bacteriological quality. Because the ways of purifying water for industrial purposes are many, a treatment process usually can be selected for the peculiar need of a specific industry. Generally, water which meets drinking water standards is satisfactory for industrial use.

Quality of Ground Water

The investigation of ground water quality in Del Norte County was confined primarily to the two major areas of ground water, namely, the Smith River Plain and the lower Klamath River area. Most of the remaining wells in the county are found on small terraces adjacent to rivers and streams with localized water quality characteristics.

To evaluate the water quality within these areas 152 chemical analyses were made of ground water from 73 representative wells. For location of wells sampled, refer to Plates 1 and 2. Water samples from 17 wells in the Smith River Plain have been collected and subjected to chemical analyses on an annual basis during the period of 1953 through 1962. The analyses indicate that native ground water and waters of the Smith and Klamath Rivers are generally magnesium bicarbonate in character and of excellent mineral quality. The results of mineral analyses of ground water from water wells in Del Norte County are included in Appendix 4. For individual well designation and the method of location, refer to Appendix C.

Smith River Plain

The ground water basin in the Smith River Plain is divided for the purpose of discussion into seven physiographic areas, excluding the tidal mouth of Smith River. They are selected on the basis of geologic units and ground water conditions. Dissolved mineral content of the ground water is closely related to the mineral composition of various components within each geologic unit.

Battery Formation. The Battery formation in the Smith River Plain occurs in two geographic units. The southern unit extends northerly from the vicinity of Crescent City to the community of Fort Dick, and except for sand dunes along the coast the outcrop forms the land surfaces of the southern two-thirds of the plain. The northern unit extends north from the mouth of Smith River into Oregon, forming a narrow terrace adjacent to the ocean. Because the water quality characteristics of these two units differ, they are described separately.

The household domestic water supply in a large residential area, which extends north and east of Crescent City, is primarily derived from individual wells in this formation. The Battery formation with its great areal extent contains the largest estimated underground storage of water within the Smith River Plain. Due to low transmissibility of this formation, the yield of water is small to moderate. As a consequence, the use of water for irrigation is limited.

Water level contours indicate that the flow of ground water in this formation is southerly toward the ocean and northerly toward Lake Earl from an east-west ridge approximately 1 mile north of Crescent City. In the northern portion of this formation the water table slopes westerly from the mountains toward Lake Earl.

The character of the native ground water is uniformly magnesium bicarbonate. This water meets necessary mineral water quality requirements for municipal and domestic uses and is Class 1 for irrigation purposes.

Variations in water quality within this formation appear to be related to both maximum and minimum rainfall and to waste discharges which have penetrated and commingled with ground waters. Ranges of dissolved mineral constituents in water from wells in the southern Battery formation are presented in Table 4.

TABLE 4

RANGES OF CONCENTRATIONS OF MINERAL CONSTITUENTS
IN WATER FROM WELLS IN SOUTHERN BATTERY FORMATION
NEAR CRESCENT CITY

Range	Constituents (in parts per million)									Percent Na
	Ca	Mg	Na	HCO_3	SO_4	Cl	NO_3	TDS	Hardness as $CaCO_3$	
Maximum	31	16	34	127	27	64	49	175	105	56
Median	5.0	8.4	12	47	3.6	16	5.4	110	50	36
Minimum	2.1	2.4	4.5	12	0.0	7.2	1.0	47	14	19

Chemical analyses of water from wells in this formation adjacent to the ocean and Lake Earl, a brackish-water lake, indicate no salt-water intrusion. This absence of intrusion may be the result of restricted transmissibilities of the formation or favorable ground water table gradients which have existed.

The northern portion of the Battery formation and alluvial fan deposits are found on a narrow terrace extending north from the mouth of Smith River along the coast to the California-Oregon state line.

The chemical character of the ground water is variable, within this narrow terrace, ranging from sodium-magnesium chloride to magnesium bicarbonate. Recharge of the ground water is by direct percolation of precipitation and seepage from many small creeks draining the mountains to the east. Analyses of ground water indicate this water is generally of excellent mineral quality; the waters being acceptable for domestic purposes and Class 1 for irrigation uses. Ranges in concentrations of mineral constituents in ground water are presented in Table 5.

TABLE 5

RANGES OF CONCENTRATIONS OF MINERAL CONSTITUENTS IN WATER FROM WELLS IN THE NORTHERN BATTERY FORMATION

Range	Constituents (in parts per million)								Hardness as $CaCO_3$	Percent Na
	Ca	Mg	Na	HCO_3	SO_4	Cl	NO_3	TDS		
Maximum	24	7.8	18	109	5.9	32	21	149	72	44
Median	12	4.3	17	108	2.7	13	2.1	146	58	38
Minimum	5.4	2.9	8.1	12	1.0	12	0.4	62	28	35

Sand Dunes. A sand dune area, averaging 1 mile wide, extends 10 miles northward along the ocean from Point St. George to the mouth of Smith River. The dunes range from about 20 to 75 feet above sea level. Scattered surface pools of water and small marshes indicate the ability of these sand deposits to retain moisture and form a semi-perched water table with the excess ground water partially recharging the adjoining Battery formation and the flood plain deposits. Ground water storage underlying the sand dune area has been estimated at 24,000 acre-feet.

The mineral quality of ground water from these sand dunes varies generally from magnesium bicarbonate to magnesium-calcium bicarbonate. Chemical analyses from seven wells indicate a median total iron content of 0.47 ppm. U. S. Public Health Service Drinking Water Standards of 1962 set a non-mandatory but recommended limit of 0.3 ppm. Although the sands are mainly quartz, they contain ferro-magnesian minerals, and the higher iron content of the waters is probably due to chemical weathering of these iron-magnesium minerals. Ranges of concentrations of mineral constituents in water from wells in the sand dunes are listed in Table 6.

TABLE 6

RANGES OF CONCENTRATIONS OF MINERAL CONSTITUENTS
IN WATER FROM WELLS IN
THE SAND DUNES

Range	Constituents (in parts per million)									Percent Na
	Ca	Mg	Na	HCO_3	SO_4	Cl	NO_3	TDS	Hardness as $CaCO_3$	
Maximum	34	41	33	269	31.0	61	39	445	254	24
Median	21	14	15	126	5.0	22	1.2	188	112	22
Minimum	6.0	6.8	6.3	52	0.2	10	0.0	124	43	16

River-terrace Deposits. Smith River, as it emerges from the mountains onto the Smith River Plain, bisects and divides the river-terrace deposits into two separated geographic units. The largest unit, the Fort Dick terrace, lies south of Smith River and extends from the base of the mountains in a northwesterly direction onto the plain. Similar terrace deposits form a narrow and separate geographic unit extending north, near the base of the mountains, from Smith River to the community of Smith River.

The analyses of ground water from wells in the Fort Dick terrace indicate a chemical character of magnesium bicarbonate. The amount of dissolved mineral constituents in ground water indicates this water is excellent in quality, meeting the mineral requirements for domestic and municipal purposes. It is considered Class 1 for irrigation use. Presented in Table 7 are the ranges of concentrations of mineral constituents in water from wells penetrating river-terrace deposits near Fort Dick.

TABLE 7

RANGES OF CONCENTRATIONS OF MINERAL CONSTITUENTS
IN WATER FROM WELLS IN THE
RIVER-TERRACE DEPOSITS
NEAR FORT DICK

Range	Constituents (in parts per million)									Percent
	Ca	Mg	Na	HCO_3	SO_4	Cl	NO_3	TDS	Hardness as $CaCO_3$	Na
Maximum	9.6	13	6.0	76	3.0	9.5	3.8	98	63	17
Median	5.0	12	5.5	64	3.0	7.5	2.5	95	60	17
Minimum	2.8	9.5	4.2	62	1.7	7.0	0.3	90	60	13

Water-level contours within this deposit indicate the hydraulic gradient of ground water to be 70 feet per mile away from the base of the mountain front and decreasing gradually to 5 feet per mile in the western portion. Recharge to ground water is primarily from percolation of precipitation. The ground water levels start declining in late spring and continue until autumn, as a result of increased extractions, decreased precipitation, and ground water outflow.

The underground waters of the river-terrace deposits north of Smith River vary in chemical character from calcium bicarbonate to magnesium-sodium bicarbonate. Underground waters of this narrow river-terrace deposit apparently are influenced by lateral seepage from higher and parallel alluvial deposits. The general character of ground water from the adjacent alluvial deposits is calcium-sodium bicarbonate. Near the community of Smith River, the river-terrace deposits are bisected with flood plain deposits near the mouths of Rowdy and Dominie Creeks. Ranges of mineral constituents of water from selected wells in the river-terrace deposits north of Smith River are presented in Table 8.

TABLE 8

RANGES OF CONCENTRATIONS OF MINERAL CONSTITUENTS
IN WATER FROM WELLS IN THE
RIVER-TERRACE DEPOSITS
NORTH OF SMITH RIVER

Range	Constituents (in parts per million)									Percent Na
	Ca	Mg	Na	HCO_3	SO_4	Cl	NO_3	TDS	Hardness as $CaCO_3$	
Maximum	7.2	3.8	9.2	32	1.9	9.0	26	70	29	51
Median	5.2	2.6	6.4	25	1.6	7.4	6.5	57	22	34
Minimum	2.8	2.2	5.0	10	1.0	7.0	5.4	57	18	27

Flood Plain Deposits. Low-lying, unconsolidated, flood plain deposits are found on the Smith River Plain adjacent to Smith River and along a narrow extension south to Lake Earl. The largest yield of ground water in the plain is obtained from the unconfined aquifer of these deposits. Recharge to the ground water reservoir is by precipitation augmented by subsurface infiltration from Smith River and the aquifers of adjacent deposits.

Mineral analyses of ground water indicate a chemical character of magnesium bicarbonate, generally of excellent quality and suitable for present beneficial uses. Several wells near the contact with the sand dunes, to the west, show a high iron content up to 10 ppm and a considerable increase in magnesium. This condition suggests commingling with ground waters from the sand dunes. A summary of data from analyses of samples collected from wells in the flood plain deposits is presented in Table 9.

TABLE 9

RANGES OF CONCENTRATIONS OF MINERAL CONSTITUENTS
IN WATER FROM WELLS IN THE
FLOOD PLAIN DEPOSITS

Range	Constituents (in parts per million)									Percent Na
	Ca	Mg	Na	HCO_3	SO_4	Cl	NO_3	TDS	Hardness as $CaCO_3$	
Maximum	15	53	12	289	3.8	24	52	264	245	54
Median	6.2	16	4.8	78	1.2	6.7	2.8	118	67	8
Minimum	1.7	2.7	2.3	14	0.3	4.8	0.4	57	9	4

Alluvial Fan Deposits. Water-bearing, alluvial fan deposits form a narrow discontinuous strip along the western front of the mountains. These fans were deposited at and adjacent to the mouth of mountain streams flowing onto the Smith River Plain. Yield of ground water from this formation is generally low; in some instances not sufficient for domestic use.

Analyses of ground water from these deposits indicate the water is generally of excellent mineral quality and suitable for domestic purposes and Class 1 for irrigation use. The character of ground water extracted from these fan deposits varies from calcium bicarbonate to magnesium-calcium bicarbonate. The iron content of ground water from these deposits occasionally exceeds the concentration recommended by the U. S. Public Health Drinking Water Standards. To indicate the general mineral quality of ground waters within these deposits, ranges of selected dissolved mineral constituents are shown in Table 10.

TABLE 10

RANGES OF CONCENTRATIONS OF MINERAL CONSTITUENTS IN WATER FROM ALLUVIAL FAN DEPOSITS

Range	Constituents (in parts per million)									Percent Na
	Ca	Mg	Na	HCO_3	SO_4	Cl	NO_3	TDS	Hardness as $CaCO_3$	
Maximum	26	14	26	134	8.2	22	1.2	159	95	40
Median	13	9.7	13	125	6.4	9.5	1.1	-	86	32
Minimum	4.8	1.7	5.0	21	0.3	6.2	0.2	-	19	18

Lower Klamath River Area

For the purpose of discussion, the lower Klamath River area has been divided into two geographic units, namely, the lower Klamath River Valley and the contiguous alluvial fill areas which have created small valleys along High Prairie, Hunter, Mynot, and Mill Pond Creeks.

Lower Klamath River Valley. Analyses of water from all wells sampled in the lower Klamath River Valley show excellent mineral quality. The water is suitable for domestic use and Class 1 for irrigation. The character of ground water is bicarbonate with variable amounts of magnesium, sodium, and calcium. The quality of ground waters in this valley, as indicated by analyses of samples, is presented in Table 11.

TABLE 11

RANGES OF CONCENTRATIONS OF MINERAL CONSTITUENTS
IN WATER FROM WELLS IN THE
LOWER KLAMATH RIVER VALLEY

Range	Constituents (in parts per million)									Percent Na
	Ca	Mg	Na	HCO_3	SO_4	Cl	NO_3	TDS	Hardness as $CaCO_3$	
Maximum	21	21	9.7	134	10	9.7	1.7	149	116	41
Median	12.5	13.5	5.6	111	4.8	6.9	0.75	125	94	13
Minimum	5	1.1	4.2	29	2.6	3.9	0	43	22	10

High Prairie, Mynot, Hunter, and Mill Pond Creeks. The alluvial deposits along High Prairie Creek and its tributaries, Mynot and Hunter Creeks, form a separate elongated and relatively narrow ground water basin, which is hydrologically connected to the lower Klamath River Valley. A similar, minor ground water basin in the alluvial deposits occurs along Mill Pond Creek which flows northward from a low divide with High Prairie Creek to the ocean.

Recharge to the alluvial fill is by inflow from streams and infiltration of precipitation. The depth of the wells varies from 18 to 75 feet, with yields sufficient for domestic use. The mineral quality of ground water is excellent, except for occasional wells which yield water with high iron content. The water generally is suitable for domestic use and Class 1 for irrigation purposes. The character of ground water is variable and ranges from sodium bicarbonate to sodium-magnesium or calcium-sodium bicarbonate. Ranges of mineral concentration from samples of well water are summarized in Table 12.

TABLE 12

RANGES OF CONCENTRATIONS OF MINERAL CONSTITUENTS IN WATER FROM WELLS IN MINOR ALLUVIATED AREAS ALONG HIGH PRAIRIE, MYNOT, HUNTER, AND MILL POND CREEKS

Range	Constituents (in parts per million)									Percent Na
	Ca	Mg	Na	HCO_3	SO_4	Cl	NO_3	TDS	Hardness as $CaCO_3$	
Maximum	6.9	6.7	15	78	2.1	10	0.6	95	43	62
Median	6.3	2.2	15	48	0	9.1	0.2	78	22	42
Minimum	4.0	1.2	5.6	28	0	6.3	0.2	46	19	34

Ground Water Impairment

Within the major ground water areas studied as a part of this investigation, namely, the Smith River Plain and the lower Klamath River Valley area, Del Norte County, the mineral quality of undisturbed natural ground water is generally excellent. Although there are minor variations in the concentration of dissolved mineral constituents in the natural ground water, these constituents are seldom of sufficient concentration to render the water undesirable for any of the beneficial uses.

The good quality of native ground waters in Del Norte County ground water basins is primarily the result of adequate annual rainfall for ground water recharge and favorable seaward gradients which have provided a flushing action within the aquifers. Even with these favorable conditions, ground water impairment has occurred.

Man's development has characteristically exerted an adverse effect upon the native quality of waters. Most uses of water by man, such as, for disposal of sewage and industrial waste, as well as for irrigation, add pollutants to the waters with resultant deterioration in quality. Fortunately, with favorable hydrologic conditions and limited development by man, impairment of ground water quality in Del Norte County has not been extensive. However, wastes produced by the growing population of Del Norte County are increasing, and instances of water quality impairment can be expected to increase significantly unless improved waste disposal practices are used.

Sources of Impairment

Numerous wastes are discharged and accumulated for disposal during normal everyday living within a community. These wastes, on contact with surface or underground waters, may have a more serious latent and hidden effect than is often readily apparent. Where impairment of ground water supply has occurred, this condition is the result of excessive or uncontrolled demands placed on this valuable water resource. In general, each additional use of water contributes to its degradation; therefore, as these uses increase it is particularly important to provide for disposal of wastes.

Quality of ground water is lowered by allowing wastes or degraded water to enter directly or infiltrate into the producing aquifers. Serious ground water impairment can result from any one of the following: sewage discharges, surface runoff or flooding, industrial wastes, and irrigation return water. Ground water basins which have contact with salt-water bodies are also in danger of impairment from salt-water intrusion.

The contributions of mineral salts resulting from utilization of water for domestic purposes is not removed by ordinary sewage treatment processes. As a result, ground waters impaired by sewage usually exhibit increases in total dissolved solids, chlorides, and nitrates, and they also may contain hazardous concentrations of bacterial or troublesome detergents.

Sewage Discharges. Within Del Norte County a large portion of the population is dependent upon both individual household water supply and sewage disposal systems. Water supply is available from the ground without difficulty by individual effort through relatively shallow wells. Most of the population must rely upon cesspools, septic tanks, leach lines, or seepage pits for disposal of domestic wastes. The close proximity of shallow wells and sewage disposal sites creates a constant threat of impairment and contamination to ground water.

Disposal of wastes, especially below ground surface, offers a potential source of localized ground water impairment. The suspended solids in liquid wastes are usually filtered out by the soil in a short distance, possibly within the first few inches. Portions of the remaining liquid containing dissolved minerals, organic compounds, and sometimes bacteria, move generally downward through the soil following the most permeable zones to the underlying water table.

Industrial Wastes. Many different types of wastes may result from operations necessary to manufacture or process consumer goods. These wastes may be relatively harmless or may contain high concentrations of acids, caustics, minerals, or toxic substances. Pollution or contamination may result if these wastes are inadequately treated or improperly deposited on the land, discharged to surface water, or allowed to reach our valuable ground water supplies.

All waste discharges in Del Norte County are under the jurisdiction of the North Coastal Regional Water Pollution Control Board. This board monitors waste discharges and establishes waste discharge requirements, so that pollution can be prevented as well as abated.

Lumber, commercial fishing, and mining are the major waste-producing industries presently operating in Del Norte County, and during this investigation no evidence was found that industrial waste products have caused any significant impairment to ground water quality.

Irrigation Return Water. Evaporation and transpiration consume much of the water applied to irrigation crops with little or no reducing effect on total quantity of dissolved minerals originally contained in the water. As a result, the portion of the applied water which percolates below the root zone often contains a higher concentration of dissolved minerals than the water originally applied. It has been estimated that the dissolved mineral content of accumulated residual waters will increase two to eight times over that of irrigation water, although in an area such as Del Norte County the increase will be near the minimum.

When portions of the water containing high concentrations of salts are allowed to percolate below the root zone and intermingle with underlying ground water, impairment of ground water will result.

Many new methods and products have been recently developed to increase agricultural production. Among these are the use of spray irrigation and the application of various pesticide and fertilizer compounds. As a result, irrigation return waters may now contain various amounts of the dissolved residuals of these chemical compounds, and serious impairment can result. In the ground water basins of Del Norte County, especially within the flood plain, marine terrace, and alluvial deposits; shallow-free ground water conditions prevail. This allows a ready access by seepage of return irrigation water.

Sea-water Intrusion. The quality of water in the low-lying coastal ground water basins may be adversely affected by the intrusion and admixture of sea water. Intrusion by sea water into coastal ground water basins is possible when aquifers have hydraulic continuity with the ocean at the shore line or beneath the ocean floor. The intrusion of sea water usually results from overdraft of ground water, and the reversing of the natural seaward hydraulic gradient. This condition allows salt water to move landward into the ground water basin.

Sea-water intrusion is manifest by large increases in mineral content and is particularly notable in the chloride ion. Mineral analyses from wells along the coast indicate no high concentrations of chlorides or dissolved solids which can be directly attributed to sea-water intrusion.

Mineral Quality Impairment

During this investigation samples of ground water in Del Norte County were analyzed not only to determine the mineral quality but to detect any impairment which had occurred. Where ground water analyses indicated increased mineralization or showed fluctuations in quality, the analyses were compared with the quality of other nearby native quality ground waters to determine the nature and magnitude of impairment.

As indicated previously in this chapter, the native ground waters in Del Norte County appear to be relatively uniform in mineral quality and character. The low level of mineralization demonstrated by the median values shown in Tables 4 through 12 is considered to be typical of native quality waters and indicates their excellent quality.

A study of the available data fortunately shows no large areas of impairment in mineral quality, but indicates localized impairment in many wells. Presented in Table 13 is a group of analyses of ground waters which shows typical impairment. It is notable that when these analyses are compared with the native quality, in most instances, the significant increases appear to be in total dissolved solids, nitrates, and chlorides. This type of change is typical of impairment caused by domestic waste.

TABLE 13

ANALYSES OF GROUND WATER FROM SELECTED WELLS
IN SMITH RIVER PLAIN

State well number	Date sampled	Constituents (in parts per million)								Percent Na
		Ca	Mg	Na + K	HCO_3	SO_4	Cl	NO_3	TDS	
					Battery Formation					
16N/1W-20A2	4-30-53	3	7	22	45	12	19	7	105	55
	7-30-62	7	16	26	54	8	30	49	185	39
16N/1W-20H1	4-30-53	4	8	16	26	4	23	25	102	43
	10-29-58	8	17	18	61	4	37	33	180	28
	7-30-62	6	12	16	58	7	19	24	132	33
16N/1W-26D1	4-30-53	4	6	18	30	2	23	23	101	52
	10-20-59	18	14	19	80	0	32	34	180	28
	9-17-62	7	10	22	38	2	39	23	141	44
					Flood Plain Deposits					
17N/1W-2P2	6-13-62	6	20	6	64	2	8	52	144	10
					Sand Dunes					
17N/1W-20P2	11-6-62	34	41	69	269	31	61	39	445	19
					River-terrace Deposits					
18N/1W-26D2	8-30-61	6	4	7	10	2	9	26	70	31
	9-15-62	7	5	9	9	1	10	42	88	32

It is also noteworthy that the majority of wells showing impairment are located in or adjacent to populated areas where individual sewage disposal systems are utilized.

Bacteriological Quality

During 1955 and 1961 bacteriological examinations were made of domestic water from selected wells in Del Norte County. Except for about

10 wells sampled in the lower Klamath River area, bacterial sampling was restricted to ground waters within the Smith River Plain ground water basin. In 1955 water samples were collected from 119 wells and a routine examination made on each sample for the presence of the coliform group of bacteria. This process was repeated in 1961, when 160 wells were sampled and similarly examined. At the time of these surveys, construction and nearby sanitary conditions were recorded for each of the wells visited.

To evaluate bacterial impairment of the ground waters in Del Norte County, the test for the coliform group of bacteria was utilized. The chief advantages in using this test are: (1) the coliform group is always found in the intestinal tract of human beings and other warm blooded animals and eliminated in large numbers with fecal wastes, (2) the absence of the coliform group in water is a good indication of bacteriologically safe water, and (3) the amount of contamination in a water is usually proportional to the density of the coliform group present.

Results of the tests for the coliform group are expressed in terms of the Most Probable Number (MPN) of coliform organisms per 100 milliliters (ml). Low densities of the coliform group of an MPN of 1 or below may indicate a safe water, while the presence of coliform in large numbers indicates possible pollution of the water from sewage or other sources.

The bacteriological analyses were made in the mobile laboratory of the Department of Water Resources stationed at Crescent City. The confirmed test was used in analyses for the coliform group and was performed in accordance with the technique set forth in the 11th edition of "Standard Methods for the Examination of Water and Waste Water." Five tubes each of 10 ml volume with one tube of 1 ml volume and one tube of 0.1 ml volume were used.

Results of the 1955 and 1961 surveys were remarkably similar. In each year, approximately 30 percent of well waters sampled showed coliform concentrations exceeding MPN values of 20 per ml, while about 15 percent of waters sampled showed concentrations exceeding MPN values of 100 per ml. Although the distribution of well waters showing higher concentrations of coliform bacteria was studied, no large areas of impairment were found which indicated that the impairment was localized. There did, however, appear to be a more frequent occurrence of high MPN values in heavily populated areas. As shown in Table 14 there were significantly more high MPN values observed in samples collected from shallow wells than from deeper ones.

TABLE 14

COMPARISON OF MOST PROBABLE NUMBER (MPN) OF COLIFORM ORGANISMS PER 100 ML FOUND IN WELLS WITH DEPTH OF WELL DEL NORTE COUNTY, 1961

Coliform bacteria MPN/100 ml	Depth 10' - 20' Wells		Depth 21' - 30' Wells		Depth 31' - 50' Wells		Depth 50' + Wells	
	No.	%	No.	%	No.	%	No.	%
2	7	22	22	43	24	52	2	50
2 - 20	14	44	13	25	12	26	2	50
21 - 100	2	6	8	16	6	13	0	0
100 plus	9	28	8	16	4	9	0	0
Total	32	100	51	100	46	100	4	100

Of special note is that, of the wells sampled in the 10 to 20-foot depth range, 28 percent indicated a coliform count of greater than 100.

None of the wells included in this survey in the depth range of 10 to 20 feet were drilled by professional drillers. Almost all wells drilled by licensed drillers are over 31 feet deep, and in this depth category 8 percent of the wells sampled indicated a coliform count of over 100.

These results indicate that bacterial impairment of ground water has occurred in the Smith River Plain ground water basin in numerous localized areas, and that such impairment is greatest in the waters nearest the ground surface.

CHAPTER V. WELL CONSTRUCTION PRACTICES IN DEL NORTE COUNTY

To formulate recommendations for minimum water well construction and sealing standards in Del Norte County, it is important that surveys be made of existing wells to determine whether the well construction practices in use are adequate to protect the water user and the quality of ground water. Two such surveys were made during the course of this investigation. Among the items observed during these surveys of water wells were: type of construction, well dimensions, local surface drainage, and presence of surface seals. The distance from each well to the nearest health hazard, such as a sewage disposal site, was also determined where possible.

The first of the two surveys was conducted in 1955 and the second in 1961. From these surveys well construction data were obtained from about 160 wells. These data, as presented in Table 15 include both the lower Klamath River area and each of the geologic units within the Smith River Plain. For comparison, the results are also presented as percentages of those wells surveyed.

In 1955, eight licensed well drillers, who were operating or known to have operated in Del Norte County, were interviewed to obtain information regarding the materials and methods used during well construction. These interviews provided valuable information on well construction practices in Del Norte County.

Types of Well Construction

The methods of well construction may be classified as drilled, dug, bored, driven, or jetted. Within Del Norte County all above methods of well construction were commonly encountered except jetting. Each well construction method has certain economic advantages. Selecting the type of

TABLE 15

WATER WELL CONSTRUCTION SURVEY
DEL NORTE COUNTY

Survey item	Del Norte County Wells		Smith River Plain: Battery Wells		Smith River Plain: Sand dunes Wells		Smith River Plain: River terrace Wells		Smith River Plain: Flood plain Wells		Smith River Plain: Alluvial fan Wells		Total Smith River Plain Wells		Lower Klamath River Valley and contiguous areas Wells	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Type of Construction																
Drilled	85	56	53	51	0	--	6	75	9	64	8	62	76	54	9	90
Dug	61	40	47	46	1	25	2	25	5	36	5	38	60	42	1	10
Driven	3	2	3	3	3	75	--	--	--	--	--	--	3	2	--	--
Bored	3	2	0	--	--	--	--	--	--	--	--	--	3	2	--	--
Total	152		103		4		8		14		13		142		10	
Depth																
0' - 10'	2	2	0	0	0	0	1	5	1	6	0	0	2	2	0	0
11' - 20'	37	26	14	19	9	82	5	26	5	31	3	18	36	26	1	20
21' - 30'	64	44	42	55	1	9	7	37	5	31	9	53	64	46	0	0
31' - 40'	29	20	19	25	1	9	3	16	3	19	1	6	27	19	2	40
41' +	12	8	1	1	0	0	3	16	2	13	4	23	10	7	2	40
Total	144		76		11		19		16		17		139		5	
Diameter																
-4"	13	8	4	5	6	55	0	0	1	6	1	6	12	8	1	14
6" - 8"	61	39	30	35	2	18	12	60	8	47	6	35	58	38	3	43
12" +	84	53	52	60	3	27	8	40	8	47	10	59	81	54	3	43
Total	158		86		11		20		17		17		151		7	

TABLE 15

WATER WELL CONSTRUCTION SURVEY
DEL NORTE COUNTY
(Continued)

Survey item	Del Norte County Wells No.	Del Norte County Wells %	Smith River Plain: Battery Wells No.	Battery Wells %	Sand dunes Wells No.	Sand dunes Wells %	River terrace Wells No.	River terrace Wells %	Flood plain Wells No.	Flood plain Wells %	Alluvial fan Wells No.	Alluvial fan Wells %	Total Smith River Plain Wells No.	Total Smith River Plain Wells %	Lower Klamath River Valley and contiguous areas Wells No.	Lower Klamath River Valley and contiguous areas Wells %
Type of Casing																
Metal	67	47	27	36	8	80	12	57	10	62	6	43	63	46	4	57
Wood	10	7	7	9	1	10	2	9	0	0	0	0	10	7	0	0
Concrete	45	31	25	33	1	10	6	29	4	25	8	57	44	32	1	14
None	22	15	17	22	0	0	1	5	2	13	0	0	20	15	2	29
Total	144		76		10		21		16		14		137		7	
Depth of Casing																
Full	45	78	22	85	3	100	4	57	10	91	4	50	43	78	2	33
Partial	13	22	4	15	0	0	3	43	1	9	4	50	12	22	1	67
Total	58		26		3		7		11		8		55		3	
Natural Drainage																
Toward Well	20	14	13	15	2	29	1	8	1	6	3	18	20	14	0	0
Away from Well	126	86	73	85	5	71	11	92	17	94	14	82	120	86	6	100
Total	146		86		7		12		18		17		140		6	
Subject to Flooding																
Yes	31	22	14	16	2	29	3	23	7	50	3	17	29	21	2	67
No	109	78	71	84	5	71	10	77	7	50	15	83	108	79	1	33
Total	140		85		7		13		14		18		137		3	

TABLE 15

WATER WELL CONSTRUCTION SURVEY
DEL NORTE COUNTY
(Continued)

Survey item	Del Norte County Wells No.	Del Norte County Wells %	Smith River Plain: Battery Wells No.	Battery Wells %	Sand dunes Wells No.	Sand dunes Wells %	River terrace Wells No.	River terrace Wells %	Flood plain Wells No.	Flood plain Wells %	Alluvial fan Wells No.	Alluvial fan Wells %	Total Smith River Plain Wells No.	Total Smith River Plain Wells %	Lower Klamath River Valley and contiguous areas Wells No.	Lower Klamath River Valley and contiguous areas Wells %
Is Platform Sealed to Casing?																
Yes	34	25	18	24	1	13	5	36	4	25	4	23	32	25	2	29
No	102	75	56	76	7	87	9	64	12	75	13	77	97	75	5	71
Total	136		74		8		14		16		17		129		7	
Does Pump Provide Surface Seal?																
Yes	33	24	18	23	1	14	2	18	5	31	3	19	29	23	4	67
No	102	76	61	77	6	86	9	82	11	69	13	81	100	77	2	33
Total	135		79		7		11		16		16		129		6	
Distance Domestic Disposal Sites																
-50'	44	28	25	28	5	50	6	38	3	21	4	18	43	28	1	12
51' - 100'	56	35	29	33	2	20	9	56	5	37	7	30	52	34	4	50
101' - 150'	20	13	15	17	0	0	1	6	3	21	0	0	19	13	1	12
151' +	39	24	19	22	3	30	0	0	3	21	12	52	37	25	2	25
Total	159		88		10		16		14		23		151		8	

well construction is primarily based on the characteristics of the strata encountered, ground water conditions, sanitary protection required, and costs to produce a satisfactory well.

Of the wells inspected during field surveys, 56 percent were drilled, with an average depth of 35 feet. In the drilling of wells in Del Norte County, both percussion (cable tool) and rotary hydraulic methods are extensively used. During both of these drilling operations, mechanical means and power are normally available to properly drill, case, and seal a well.

Inspections, combined with interviews, revealed that 40 percent of the wells were dug wells with an average depth of 23 feet. Seldom are dug wells constructed by licensed well drillers. Dug wells generally require larger excavations, are limited to relatively shallow depths, and are confined to loosely consolidated deposits which are easily penetrated. Although dug wells may furnish adequate ground water supply; inherently, due to construction limitations, satisfactory sanitary conditions may be difficult to maintain. The most common lining of dug wells in Del Norte County is precast concrete pipe. Of the wells included in the survey, 31 percent were found to be lined with precast concrete pipe. This pipe, if sealed, provides an excellent lining for wells. Approximately 2 percent of the wells are bored with an average depth of 22 feet and 2 percent driven with an average depth of 18 feet. All of the driven wells are located within the sand dune area.

The median depth of all wells included in the two surveys was 27 feet, with 44 percent within the depth range of 21 to 30 feet. Forty-two percent of the wells were noted as constructed by hand methods, with a median depth of 22 feet, while drilled wells indicated a median depth of 34 feet. As a matter of interest, one well was as shallow as 8 feet.

Types of casings within the wells in Del Norte County vary widely. Forty seven percent of the wells have metal casings. Fifteen percent, or 22 of 144 wells surveyed, had no casing. Wood linings were found in 7 percent of the wells. Seventy-eight percent of the cased wells surveyed were reported as fully cased; the remainder were partially cased.

Surface Drainage

Any surface waters which enter wells can cause impairment to the quality of water in the well and to ground water in the vicinity of the well. Surface waters, depending on their previous environment, may carry pollutants from many sources among which are barnyards, streets, irrigated fields, and sprayed or fertilized areas. Shallow wells are especially subject to impairment from surface flow. Natural surface flow should always be directed away from a well.

All well drillers reported attempts were made to prevent the entry of flood waters or surface waters into wells. Of the wells canvassed, 22 percent were subject to flooding, and 20 percent indicated drainage to be toward the well. It was noted, in some instances, that the top of the casing was open and nearly flush with ground surface, and that during heavy precipitation the possibility of direct entry of surface water existed. It is noteworthy that four well drillers recommended that casing should extend only a minimum of 1 inch above ground or pump platform.

Surface Sealing

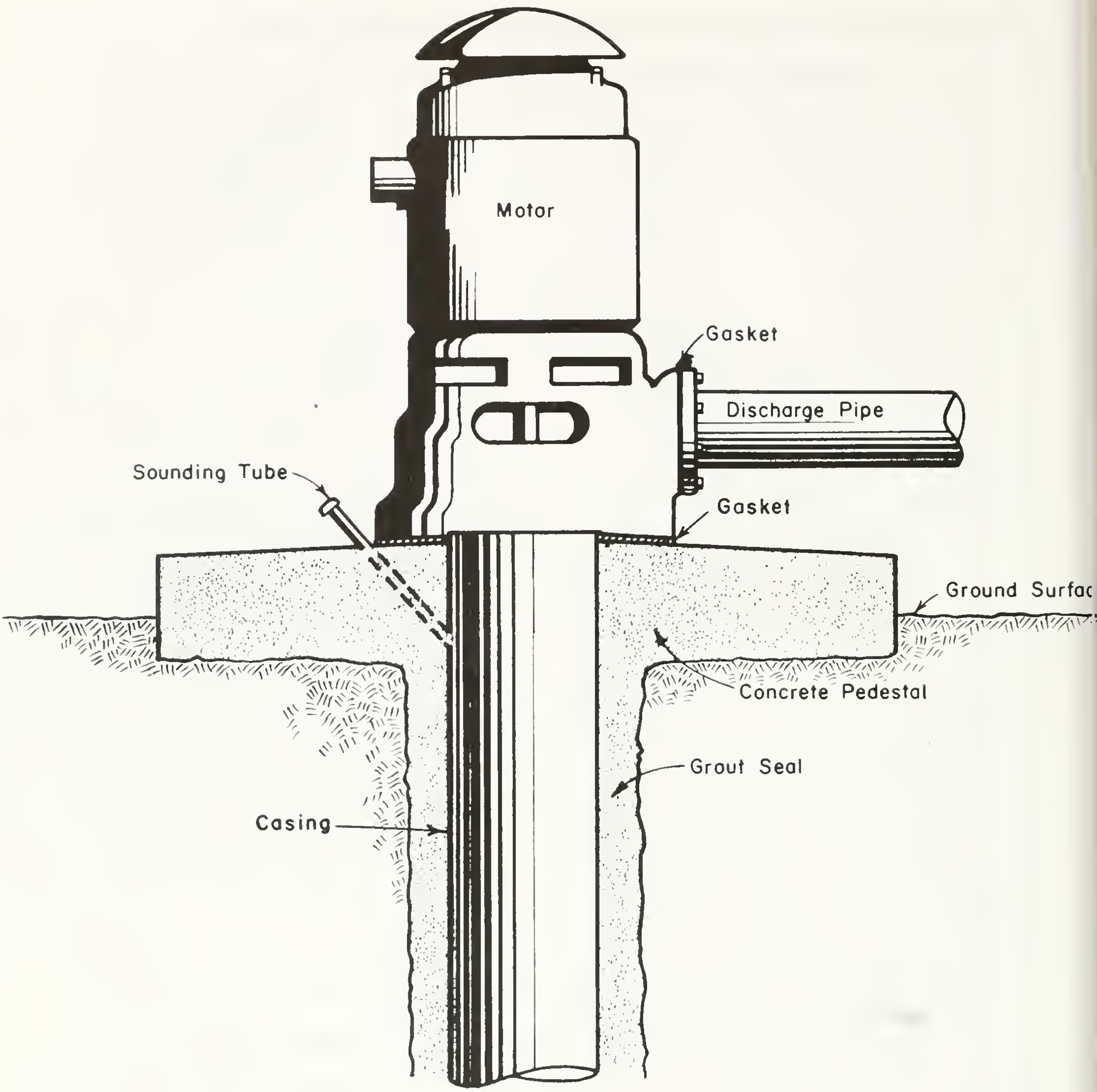
Openings into a well at the surface should be sealed or constructed in a manner to prevent surface water or other foreign matter from entering the well. To prevent surface water from moving down along well casing, a concrete pedestal should be constructed around the well and extend several feet laterally. The platform of the pedestal also normally serves as a base for the pump. Surface construction features are shown in Figure 2.

All of the well drillers interviewed reported that the customer usually specified the type of platform, if any. It was noted during the well survey that about 75 percent of domestic wells do not have a surface platform which would prevent the entrance of surface water. It is important to note that no surface seal was provided around the casings of 76 percent of the wells. Where the pump is installed directly over the casing, watertight seals should be provided between the pump and casing, the pump and the pump pedestal, and the pump and the column pipe. Of the drillers interviewed, four recommended rubber gaskets for pump seals and four made no recommendations.

Results of interviews with well drillers and of the survey of approximately 300 wells in Del Norte County indicate most of the well construction practices are dictated by the well owner. For economic reasons, the majority of wells in Del Norte County have been constructed by individuals. To realize a saving in cost, the individual almost invariably constructs a shallow well. All well drillers interviewed recommended sanitary sealing of wells. However, the decision for the type and amount of sealing usually was specified by the customer.

Water Supply and Waste Disposal

Disposal of wastes upon or below the ground surface creates a potential source of impairment to ground water. In many cases, water supply systems and their related disposal facilities have been constructed by individuals without benefit of supervision or knowledge of the hazards involved. Proper design and overall layout of both these systems is necessary to safeguard the quality of underground water from industrial and



NOT TO SCALE

Figure 2

SURFACE FEATURES OF A PROPER WATER WELL INSTALLATION domestic wastes. The distance between the waste disposal and water supply should be sufficient to prevent transfer of deleterious chemical constituents or of bacteria.

In suburban areas, frequently, the source of domestic water supply and the waste disposal systems are confined within the property lines of relatively small lots. Where this crowded condition exists, special attention should always be given to make use of the maximum natural purifying capacity of the ground. The relative locations of water supply and waste disposal systems also should be chosen to minimize any danger to or from neighboring water users.

Because ground water quality may be endangered by disposal of wastes to ground, it is essential to plan for, recognize, and understand the following factors: amount and type of waste water discharged, direction and gradient of surface and underground flow, the horizontal and vertical distance between the waste disposal and water supply sites, and the geologic nature of underground formations.

In addition, when water is pumped, drawdown of the water level often creates a cone of depression in the underground water surface. This drawdown cone of depression may cause a reversal of the ground water gradient in the vicinity of the well. Drawdown effects are illustrated in Figure 3.

Of the domestic water supply wells surveyed, 28 percent had either pit privies, cesspools, septic tanks, or other domestic waste disposals to the ground within a horizontal distance of 7 to 50 feet. The eight well drillers interviewed recommended various minimum distances ranging from 50 to 100 feet between the disposal site and the water supply.

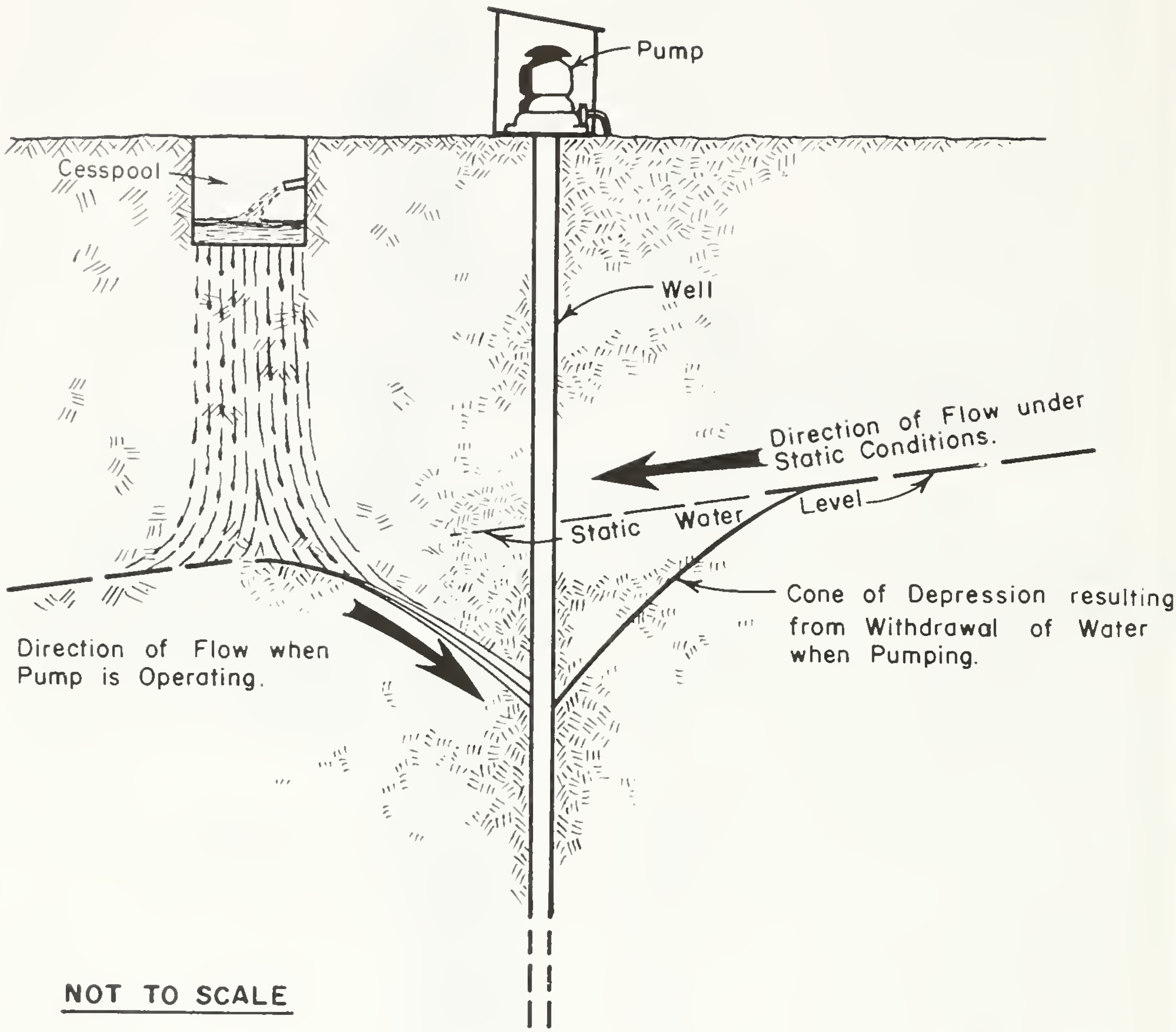


Figure 3

EFFECT OF REVERSAL OF GROUND WATER GRADIENT NEAR A WELL DUE TO PUMPING

CHAPTER VI. RECOMMENDED MINIMUM WATER WELL CONSTRUCTION AND SEALING STANDARDS

A detailed discussion of water well construction and sealing practices used throughout California together with recommended standards are presented in Bulletin No. 74 entitled, "Recommended Minimum Well Construction and Sealing Standards for the Protection of Ground Water Quality, State of California." The statewide minimum standards recommended in Bulletin No. 74 are considered applicable and reasonable for use in Del Norte County and are recommended in this chapter.

The greater portion of water-bearing materials within ground water basins in Del Norte County were originally deposited by streams carrying debris from the mountains onto the flood plains. Other formations were formed offshore in a marine environment. These deposits, due to their general heterogenous character and simplicity of original formation, have no extensive confined aquifers. In addition, most of the water-bearing formations are very shallow and readily recharged by surface waters. Therefore, water quality impairment cannot be prevented by prescribed well standards. However, standards such as the recommended statewide standards can reasonably minimize ground water impairment. Further limitations on well construction could result in unreasonable reduction in yield or increased cost without providing insurance against ground water impairment.

The objective of prescribing minimum water well construction or destruction standards is to provide reasonable protection for the ground waters of Del Norte County as they exist and assure that ground water being extracted through a well will not be unreasonably impaired before it can be put to beneficial use. As shown in previous chapters, there is considerable variation in present water well construction practices in Del Norte County, and in many instances they are inadequate and provide little or no protection. Although geologic, hydrologic, and ground water conditions differ somewhat throughout the county, the standards recommended in this chapter should be satisfactory for water well construction and abandonment in all areas of the county.

Recommended Minimum Standards for Water Well Construction

For convenience, recommended minimum standards for water well construction have been divided into five categories: (1) well location, (2) sanitary requirements, (3) casing and annular space, (4) well development, and (5) water quality sampling. In most instances, the recommendations are self-explanatory. However, where some explanation of the statement appears necessary, or where its derivation is unclear, the subject is discussed in more detail.

Well Location

Because of the many variables involved in determination of the safe distance of a well from potential sources of contamination, no one set of distances will be adequate and reasonable for all conditions. However, because most of the factors involved are usually not known, a set of distances is given which, on the basis of past experience and general knowledge, is safe where dry upper formations, less porous than sand, are encountered.

No well shall be located closer than the following distances from specified sources of contamination.

Sewer, watertight septic tank, or pit privy	50 feet
Subsurface sewage leaching field	100 feet
Cesspool or seepage pit	150 feet

In areas where adverse conditions exist, the above distances shall be increased.

In addition, if possible, the well shall be located so that it is up the ground water gradient (upstream) from the specified sources of contamination.

Where possible, wells shall be located on high ground so that the top of the casing is well above any known conditions of flooding.

Sanitary Requirements

The following recommendations are primarily concerned with protection of ground water in and around the well, or closely adjacent wells, against contamination by surface and shallow, subsurface waters or by entrance of foreign material into the well.

A. The annular space between the well casing and the wall of the drilled hole or between the conductor casing and the wall of the drilled hole shall be filled with cement grout or puddled clay between ground surface into an impervious formation overlying the uppermost aquifer. Where such an impervious formation does not exist, the annular space between the casing and the wall of the drilled hole should be filled with sealing material to sufficient depth to prevent contaminated water from entering the well. In any event, the annular space should be sealed to a depth of at least 50 feet. Depths of the seal should be greater than 50 feet where formations overlying the uppermost aquifer are more porous than soil or fine sand. For shallow wells -- 65 feet or less in depth -- the annular space shall be sealed three-fourths of the depth of the well from the top, and special precautions shall be taken in locating the well with respect to possible sources of contamination. The thickness of the seal shall be at least 1 and 1/2 inches. The sealing material shall be applied, if possible, in one continuous operation from the bottom of the interval to be sealed to the surface. Figure 4 depicts the sealed annular space. The three following methods of grouting may be used in sealing; however, other methods may be used as approved by the enforcing agency.

1. Grouting Pipe Method. In this method a grout retainer seal is provided in the annular space below the interval to be sealed. A grouting pipe is lowered to near the bottom of the annular space to be sealed. If the annular space is restricted, it may be necessary to jet the grout pipe to the proper depth. The grout is then forced into the annular space in one continuous operation with the grout pipe continually submerged in the sealing material during placement.

2. Pressure Cap Method. In the pressure cap method, the casing or inner pipe is suspended about 2 feet above the bottom of the drilled hole. A pressure cap is placed over the casing and a grout pipe inserted through the cap to the bottom of the hole. Impervious grout is forced through the grout pipe and up the annular space, outside of the casing, to the surface. The casing is lowered to its permanent position after the grout is placed. After the grout has set, any plug formed within the casing is removed when drilling is resumed.

3. Dump Bailer Method. In this method impervious grout is placed in the casing, using a bailer which dumps the grout at the desired level, to fill the lower 20 to 40-foot portion of the hole. The casing is raised with the bottom of the casing within the grout.

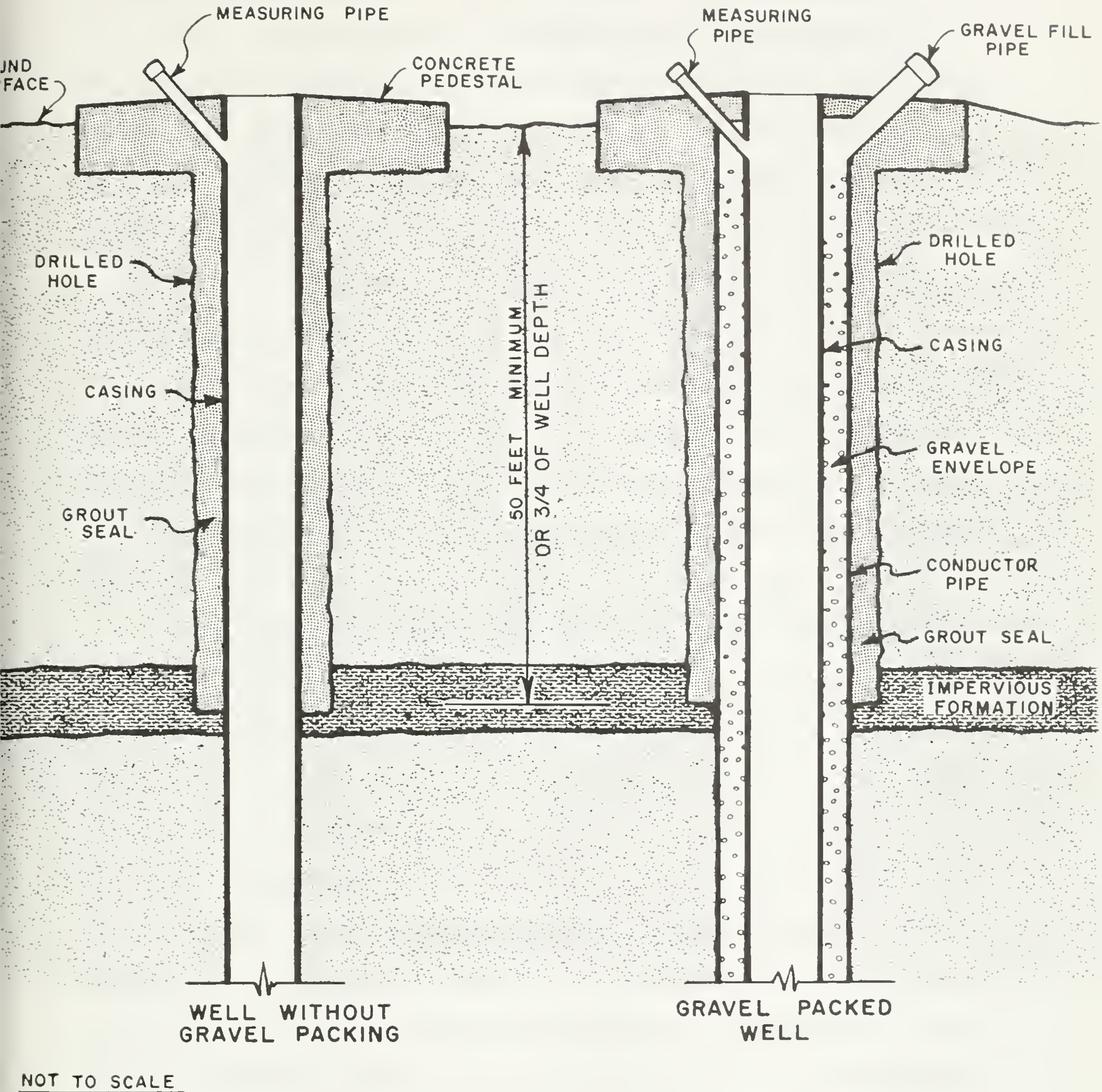


Figure 4

PROPERLY SEALED ANNULAR SPACE

The casing is filled with water, capped, and lowered to the bottom of the hole. The resulting action should force the grout up the annular space. To maintain pressure, the casing must remain capped until the grout has set. If difficulty is anticipated in raising and lowering the casing, water may be added to the top of the grout. The amount of water added should equal the volume of grout. The resultant pressure should force the grout out of the lower end of the annular space to the surface.

B. A concrete pedestal, or base, shall be constructed around the top of the well for all wells, irrespective of whether the pump is mounted over the well, whether it is offset from the casing, or whether the pump is of the submersible type. The top of the pedestal shall rise above ground surface at least 6 inches and slope away from the casing.

C. The opening in the top of the well casing shall be provided with a watertight seal. Where the pump is installed directly over the casing, a watertight seal can be obtained by sealing the pump base to the pump pedestal or well cover, sealing the opening between the casing and the column pipe, or setting the pump to secure a watertight seal between the pump base and the rim of the casing. All holes in the pump base which open into the well shall be sealed. Where the pump is offset from the well, where the dimensions of the pump base are smaller than the diameter of the casing, or where a submersible pump is used, the opening between the well casing and any pipes or cables which enter the well shall be closed by a watertight seal. If the pump is not installed immediately upon completion of the well, or if there is a prolonged interruption in construction of the well, a watertight plug or cap shall be provided at the top of the casing. Pump discharge piping shall be located above the ground where possible, and in the event of a below-ground discharge there shall be a watertight seal between the discharge pipe and the well casing.

D. Access openings into well casings shall be protected against entrance of surface waters or foreign matter by installation of watertight caps, screens, or downturned "U" bends.

E. The use of well pits shall be avoided whenever possible. Well pits shall not be constructed where the pit will extend to a depth below the water table. Where a pit is necessary, the lining shall be constructed of monolithic reinforced concrete, watertight in all respects. The top of the pit shall be covered with a structurally sound, watertight concrete slab or with a house of satisfactory construction. The pit shall be constructed and protected so that rain, flood, or seepage waters cannot enter it. Adequate provision shall be made for drainage of water from the pit.

F. Mud and water used in drilling shall be free from sewage contamination and come from acceptable sources.

G. Gravel used in gravel-packed wells shall come from clean sources and shall be washed before being placed in the well. If the source of gravel is questionable, the gravel shall be thoroughly washed and chlorinated before being placed in the well. Gravel purchased from a supplier should be washed at the pit or plant prior to delivery to the well site.

H. All wells, except strictly agricultural wells, shall be disinfected following construction or repair, or when work is done on the pump, before the well is placed in service. The following procedure is satisfactory for disinfecting a well; however, other methods may be utilized provided it can be demonstrated that they will yield comparable results.

1. The proper amount of disinfectant, such that the concentration of chlorine in the well water shall be at least 50 ppm available chlorine, is added to the well. Table 16 lists quantities of various chlorine compounds required to dose 100 feet of water-filled casing at 50 ppm for diameters ranging from 2 to 24 inches.

2. After the disinfectant has been placed in the well, the water shall be agitated to thoroughly mix the disinfectant with water in the well.

3. The well shall be allowed to stand without pumping for 24 hours.

4. The water shall then be pumped to waste until the odor or taste of chlorine is no longer detectable.

TABLE 16

CHLORINE COMPOUND REQUIRED TO DOSE 100 FEET OF WATER-FILLED CASING AT 50 PARTS PER MILLION

Diameter of pipe or casing (in inches)	Chlorine compounds		
	(70%) HTH Perchloron, etc. (Dry weight)	(25%) Chloride of Lime (Dry weight)	(5.25%) Purex Clorox, etc. (Liquid measure)
2	1/4 ounce	1/2 ounce	2 ounces
4	1 ounce	2 ounces	9 ounces
6	2 ounces	4 ounces	20 ounces
8	3 ounces	7 ounces	2-1/8 pints
10	4 ounces	11 ounces	3-1/2 pints
12	6 ounces	1 pound	5 pints
16	10 ounces	1-3/4 pounds	1 gallon
20	1 pound	3 pounds	1-2/3 gallons
24	1-1/2 pounds	4 pounds	2-1/3 gallons

NOTE: It is suggested that where wells to be treated are of unknown depth or volume, at least 1 pound of 70 percent available chlorine or 2 gallons of household bleach such as Clorox or Purex (5.25 percent chlorine) may be added in lieu of the use of the above table.

Casing and Annular Space

With regard to casing material, its installation, and the disposition of the annular space, it is recommended:

A. Casing Material. Well casing shall be of sufficient strength, toughness, and thickness to resist all forces and stresses imposed during and after installation, and shall be watertight. Damaged or defective material shall not be used. Suggested thicknesses for metal well casings for various depths are presented in Table 17. Concrete casing poured in place shall be adequately reinforced and watertight. Single-layer brick walls shall be surrounded on the outside by concrete at least 6 inches thick. Wood shall not be used as casing.

B. Installation of Casing. All casing shall be placed with sufficient care to avoid damage to casing sections or joints. The uppermost perforations shall be at least 50 feet below ground surface, and preferably below an impervious stratum wherever possible. For shallow wells -- 65 feet or less in depth -- the uppermost perforations shall be at least three-fourths of the depth from the top and special precautions shall be taken in locating the well with respect to possible sources of contamination. All joints in the casing shall be watertight. Where the diameter of the casing is reduced, the annular space between the two casings shall be watertight.

C. Gravel-packed Wells. A conductor pipe shall be placed between the casing and the wall of the drilled hole so as to contain the gravel and to preclude the entrance of undesirable water. The annular space between the conductor casing and the wall of the drilled hole shall be sealed to a depth of at least 50 feet with cement grout or puddled clay. A watertight cover shall be installed between the conductor pipe and the well casing at the ground surface. A gravel fill pipe may be installed through the seal, but

TABLE 17

SUGGESTED MINIMUM THICKNESS FOR STEEL WATER WELL CASING*

Depth of casing (in feet)	Diameter (in inches)										
	6	8	10	12	14	16	18	20	22	24	30
					Single Casing						
0 - 100	12	12	10	10	8	8	1/4	1/4	1/4	1/4	5/16
100 - 200	12	10	10	8	8	3/16	1/4	1/4	1/4	1/4	5/16
200 - 300	10	10	8	8	1/4	1/4	1/4	1/4	5/16	5/16	5/16
300 - 400	10	8	8	3/16	1/4	1/4	1/4	5/16	5/16	5/16	3/8
400 - 600	10	8	3/16	1/4	1/4	5/16	5/16	5/16	5/16	3/8	3/8
600 - 800	3/16	3/16	1/4	1/4	5/16	5/16	3/8	3/8	7/16	7/16	7/16
Over 800	1/4	1/4	1/4	5/16	5/16	3/8	3/8	7/16	7/16	1/2	1/2

Depth of casing (in feet)	Diameter (in inches)								
	10	12	14	16	18	20	22	24	30
			Double Casing (California Stovepipe)						
0 - 100	12	12	12	12	10	10	10	10	8
100 - 200	12	12	12	10	10	10	10	8	8
200 - 300	12	12	10	10	10	10	8	8	8
300 - 400	12	12	10	10	10	8	8	8	8
400 - 600	10	10	10	10	8	8	8	8	8
600 - 800	10	10	10	8	8	8	8	8	8
Over 800	10	8	8	8	8	8	8	8	8

* Values in whole numbers are U. S. standard gage.
Values in fractional numbers are thickness, in inches.

the fill pipe shall be made watertight at the ground surface. The gravel envelope shall not be permitted to connect the waters of two or more aquifers where the quality of water in one or more aquifer is undesirable. The construction components of the well proper are illustrated in Figure 5.

D. Sealing Off Strata. Where a well penetrates more than one aquifer, and one or more of the aquifers contains water of unsatisfactory quality, the strata which contain the unsatisfactory water shall be sealed off to prevent entrance of such water into the well or other aquifer. Sealing material shall consist of cement grout or other suitable impervious material. Sufficient sealing material shall be applied to fill the annular space between the casing and the wall of the drilled hole in the interval to be sealed, and to fill voids which might absorb the sealing material. Sealing material shall be placed from the bottom to the top of the interval to be sealed. Sealing shall be accomplished by a method which has been approved by the enforcing agency. Two common methods which may be used in sealing off strata or aquifers are:

1. Pressure Grouting Method. This method is used where the casing is perforated opposite the interval to be sealed and an annular space exists between the well casing and the wall of the drilled hole. The zone of undesirable strata is sealed by placing a packer or plug set at the bottom of the perforations. Grout is placed into the casing by either a pump, bailer, or grout pipe. Pressure is applied within the well casing to force impervious grout, such as portland cement, through the perforations into the annular space and the formation surrounding the well. After the grout has set, the packer and material remaining within the casing are drilled out.

2. Liner Method. When no annular space exists between the well casing and the drilled hole, the liner method may be used.

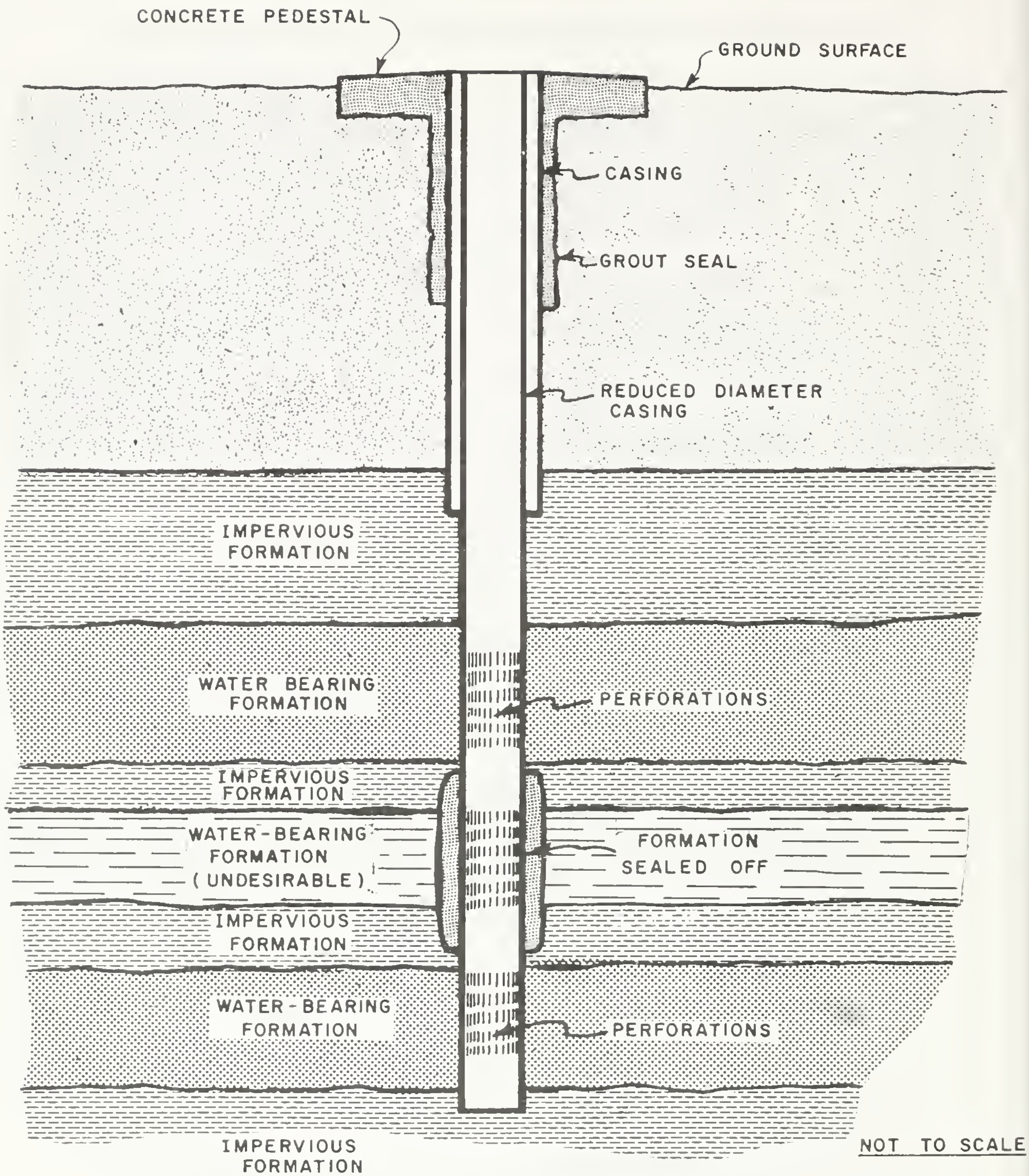


Figure 5

THE WELL PROPER
(TYPICAL)

This method involves the placing of a smaller diameter metal liner within the original casing, extending at least 10 feet above and below the perforated interval to be sealed. A seal is placed at the base of the liner to retain the grout between the liner and the well casing. The grouting pipe is then placed in the opening between the liner and the casing and annular space is filled with grout.

Well Development

Developing, redeveloping, or conditioning of a well shall be done with care and by methods which will not cause damage to the well or cause adverse subsurface conditions that may destroy barriers to the vertical movement of water between aquifers. The latter recommendation is particularly applicable when the quality of water from one of the aquifers is undesirable. Methods used in developing, redeveloping, or conditioning of a well shall be subject to approval of the enforcing agency.

Water Quality Sampling

In order to determine the quality of ground water which will be available from the well and its suitability for intended uses, it is recommended that the water in all wells be sampled immediately following construction and development, and appropriate analyses based upon intended uses be made. It may be advisable to collect samples of the ground water for mineral analysis during construction.

The sample shall be collected after the well has been pumped for a long enough time to remove standing water, and to insure that formation water has entered the well. The water sample shall be collected in a chemically clean container, preferably obtained from the laboratory which has been selected to perform the analysis. The container should be rinsed several times with the water to be sampled prior to collecting the sample. The laboratory performing the analysis should issue instructions regarding the quantity of sample required. However, in general, 1/2 gallon is sufficient when analysis for heavy metals is not required, and 1 gallon when it is required.

Recommended Standards for Destruction of Wells

The following recommendations should govern the destruction of wells:

1. For purpose of definition, a well is considered "abandoned" when it has not been used for a period of 1 year, unless the owner declares his intention to use the well again. As evidence of his declaration of intent the owner shall properly maintain the well in such a way that:

   a. The well has no defects which will facilitate the impairment of quality of water in the well or in the water-bearing formations developed;

   b. The well is covered with an appropriate locked cap;

   c. The well is marked so that it can be clearly seen; and

   d. The area surrounding the well is kept clear of brush or debris.

If the pump has been removed for repair or replacement, the well shall not be considered "abandoned," provided that evidence of repair can be shown. During the repair period, the well shall be adequately covered to prevent injury to people and to prevent entrance of undesirable water or foreign matter.

Wells used in the investigation or management of ground water basins by federal, state, or local agencies or other appropriate engineering research organizations, are not considered "abandoned" so long as they are maintained for this purpose. However, such wells shall be covered with an appropriate locked cap when measurements are not being made.

2. All "abandoned" wells should be destroyed so that they will not produce water or act as a channel for the movement of water.

3. To adequately destroy an "abandoned" well, the hole shall be filled with cement grout or other suitable impervious material from the bottom of the well up. Where cement grout is used, it shall be poured in one continuous operation. Prior to filling the hole, an investigation shall be made of the condition of the well. If there are any obstructions, they shall be eliminated by redrilling or cleaning out the hole. Where necessary, to insure that the sealing material fills not only the well casing but also any annular space as well, the casing should be ripped or perforated. For gravel-packed wells, the sealing material shall be applied within the casing, completely filling it, and then forced out under pressure, if necessary, into the gravel envelope.

CHAPTER VII. FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Results of the studies and investigations of water quality in Del Norte County are summarized in the following findings and conclusions. The recommendations are based on the findings and conclusions and give emphasis for the need for adopting well construction and sealing standards in Del Norte County.

Findings and Conclusions

1. In parts of Del Norte County, ground water, due to its general high quality, abundance, and ease of extraction, is presently and will remain one of the most important sources of water supply.

2. Ground water in Del Norte County occurs primarily in three general areas. These are: Smith River Plain, lower Klamath River Valley area, and terraces along the rivers and streams. Ground water is stored mainly within emerged marine formations near the coast, river terraces, flood plains, alluvials, and sand dunes.

3. Mineral quality of the ground water in Del Norte County, excepting occasional high iron content, is generally excellent and suitable for established beneficial uses.

4. Ground waters in Del Norte County are generally found in unconfined aquifers at shallow depths. This increases the threat of ground water impairment by decreasing the distance wastes must travel in reaching ground water, thus limiting natural filtration provided by travel through soils.

5. Heavy rainfall, and numerous streams and rivers provide an abundance of water for annual recharge of ground water basins. These recharge waters are generally excellent in quality and as long as they remain so they

will tend to preserve the good quality of ground water by providing dilution and flushing the aquifers.

6. Even with favorable recharge conditions, both mineral and bacterial impairment of ground water has occurred in localized areas.

7. In many instances, present methods of well construction and sealing in Del Norte County are inadequate to provide reasonable protection of valuable ground water supplies.

8. Improperly constructed and sealed wells probably have increased the instances of ground water impairment in Del Norte County.

9. To minimize further ground water impairment in Del Norte County, adequate water well construction and sealing standards must be employed.

10. As many existing wells in Del Norte County are potential avenues for pollution due to their poor construction, it will be necessary to repair and improve these wells so that impairment can be minimized.

Recommendations

To protect the valuable ground water resources in Del Norte County, it is recommended that:

1. Adequate water well construction and sealing standards be adopted and enforced for the protection of ground water quality in Del Norte County;

2. Del Norte County Board of Supervisors and the City Council of Crescent City initiate, at an early date, a coordinated program to provide for the adoption and enforcement of such standards;

3. The information provided in Department of Water Resources Bulletin No. 74 and in this bulletin be utilized as a guide to develop adopted standards;

4. The responsible agencies in Del Norte County continue and accelerate their program to correct existing improperly constructed and abandoned wells.

It is requested that Del Norte County keep the North Coastal Regional Water Quality Control Board and this department informed of any steps taken pursuant to these recommendations.

APPENDIX A

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APPENDIX A

BIBLIOGRAPHY

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APPENDIX B

DEFINITION OF TERMS

APPENDIX B

DEFINITION OF TERMS

The following definitions apply to terms used in this report:

Abandoned Well - A well whose original purpose and use has been permanently discontinued or which is in such a state of disrepair that its original purpose cannot be reasonably achieved.

Active Well - An operating water well.

Annular Space - The space between two well casings or a well casing and the drilled hole.

Aquifer - A formation or part of a formation which transmits water in sufficient quantity to supply pumping wells or springs.

Casing - A tubular retaining structure, generally metal or concrete, which is installed in the excavated hole to maintain the well opening.

Cement Grout - A fluid mixture of cement and water of a consistency that can be forced through a pipe and placed as required. Various additives, such as sand, bentonite, and hydrated lime, are included in the mixture to meet certain requirements.

Clay - A predominantly fine-grained material (having a large proportion of grains less than 0.005 mm in diameter) which has very low permeability and is plastic.

Conductor Pipe or Casing - A tubular retaining structure installed between the drilled hole and the inner casing, generally in the upper portion of a well.

Cone of Depression - The water surface in the water-bearing formation within the area of influence of a pumping well. It resembles the shape of a cone with its apex at the pumping level in the well.

Confined Ground Water - A body of ground water overlain by material sufficiently impervious to sever free hydraulic connection with overlying ground water except at the intake. Confined ground water moves in conduits under pressure due to the difference in head between the intake and discharge areas of the confined water body.

Contamination - Defined in Section 13005 of the California Water Code: ". . . an impairment of the quality of the waters of the State by sewage or industrial waste to a degree which creates an actual hazard to the public health through poisoning or through the spread of disease." Jurisdiction over matters regarding contamination rests with the State Department of Health and local health officers.

Degradation - Impairment in the quality of water due to causes other than disposal of sewage and industrial waste.

Destroyed Well - A well that has been filled or plugged so that it will not produce water nor act as a conduit for the movement of water.

Deterioration - An impairment of water quality.

Drilled Well - A well for which the hole is generally excavated by mechanical means such as the rotary or cable tool methods.

Formation - A fairly widespread group of rocks or unconsolidated materials having characteristics or origin, age, and composition sufficiently distinctive to differentiate the group from other units. The formation is the fundamental geologic unit.

Free Ground Water - A body of ground water moving under control of the water table slope.

Gravel-packed Well - A well in which a gravel envelope is placed in the annular space to increase the effective diameter of the well, and to prevent fine-grained sediments from entering the well.

Ground Water - That part of subsurface water which is in the zone of saturation.

Ground Water Basin - A ground water basin consists of an area underlain by permeable materials which are capable of furnishing a significant water supply; the basin includes both the surface area and the permeable materials beneath it.

Impairment - A change in quality of water which makes it less suitable for beneficial use.

Industrial Waste - Defined in Section 13005 of the California Water Code: ". . . any and all liquid or solid water substance, not sewage, from any producing, manufacturing or processing operation of whatever nature."

Liner - A section of casing of reduced diameter permanently installed within an existing casing to seal openings in the existing casing.

Native Water - This term, when used with respect to quality of water, signifies the quality of waters prior to development of the area by man. As a practical matter, however, it is usually used to signify the quality found at the time of the first mineral analysis of the water in areas where there are no evidences of pollution or deterioration.

Packer - A device placed in a well which plugs or seals the well at a specific point.

Perforations - A series of openings in a well casing, made either before or after installation of the casing, to permit the entrance of water into the casing.

Permeability - The permeability (or perviousness) of a material is its capacity for transmitting a fluid. Degree of permeability depends upon the size and shape of the pores, the size and shape of their interconnections, and the extent of the latter.

Pollution - Defined in Section 13005 of the California Water Code: ". . . an impairment of the quality of the waters of the State by sewage or industrial waste to a degree which does not create an actual hazard to the public health but which does adversely and unreasonably affect such waters for domestic, industrial, agricultural, navigational, recreational or other beneficial use, or which does adversely and unreasonably affect the ocean waters and bays of the State devoted to public recreation." Regional Water Pollution Control Boards are responsible for prevention and abatement of pollution.

Pressure Grouting - A method of forcing impervious grout into specific portions of a well, such as the annular space, for sealing purposes.

Sewage - Defined in Section 13005 of the California Water Code: ". . . any and all waste substance, 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."

Transmissibility - The characteristic property of the entire saturated portion of the aquifer to transmit water.

APPENDIX C

WELL NUMBERING SYSTEM

APPENDIX C

WELL NUMBERING SYSTEM

The well numbers used in this report are referenced by use of the U. S. Public Land Survey System, and to the Humboldt Base and Meridian (HB&M). The well identification consists of a township, range, and section number, a letter which indicates the 40-acre plot in which the well is located, and a final number which indicates the identity of the particular well within the lot. The subdivision of a section 1 mile square is shown below:

D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

20

For example, 16N/1W-20A2, HB&M, is the second well to be identified in Lot A of Section 20 of Township 16 North, Range 1 West, Humboldt Base and Meridian. Locations of wells are shown on Plates 1 and 2. These wells are those which have been sampled and the ground water analyzed for mineral content.

APPENDIX D

ANALYSES OF GROUND WATER
DEL NORTE COUNTY

APPENDIX D

ANALYSES OF GROUND WATER

DEL NORTE COUNTY

Owner and use	State well number and other 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)	Other constituents	Total dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ N.C. ppm	Analyzed by c
						Mineral constituents in parts per million / equivalents per million																	
A. C. Graf Abandoned	13N/1E-3N1	6/13/55	--	243	7.9	12 / 0.60	21 / 1.72	5.7 / 0.25	1.1 / 0.03	0 / 0.00	134 / 2.20	5.5 / 0.12	7.0 / 0.20	0.9 / 0.02	0.1 / 0.01	0.03	30	Fe 0.01 ppm	149[a]	10	116	6	U.S.G.S.
V. C. Farmer Domestic	4F1	6/13/55	--	101	7.4	5.0 / 0.25	4.0 / 0.33	9.7 / 0.42	0.8 / 0.02	0 / 0.00	46 / 0.75	4.0 / 0.08	7.5 / 0.21	0.0 / 0.00	0.1 / 0.01	0.06	11	Fe 0.13 ppm	65[a]	41	29	0	U.S.G.S.
Ray Conner Destroyed	9J1	6/13/55	--	236	8.0	21 / 1.05	14 / 1.16	5.5 / 0.24	0.6 / 0.02	0 / 0.00	120 / 1.97	10 / 0.21	6.8 / 0.19	0.6 / 0.01	0.0 / 0.00	0.05	24	Fe 0.01 ppm	142[a]	10	110	12	U.S.G.S.
Murphy-Manery Domestic	10Q1	6/13/55	--	232	8.2	13 / 0.65	17 / 1.40	7.1 / 0.31	1.3 / 0.03	0 / 0.00	118 / 1.93	6.5 / 0.14	9.7 / 0.27	0.9 / 0.02	0.0 / 0.00	0.07	30	Fe 0.01 ppm	144[a]	13	102	5	U.S.G.S.
Myers Motel Domestic	10Q2	9/6/57	--	202	6.0	13 / 0.65	13 / 1.07	5.6 / 0.24	1.3 / 0.03	0 / 0.00	104 / 1.70	4.1 / 0.09	5.0 / 0.14	1.7 / 0.03	0.0 / 0.00	0.05	14		109[a]	-	86	-	D.W.R.
M. Del Ponte Abandoned	14D1	6/13/55	--	64.6	7.1	6.9 / 0.34	1.1 / 0.09	4.2 / 0.18	0.6 / 0.02	0 / 0.00	29 / 0.48	2.6 / 0.05	3.9 / 0.11	0.1 / 0.00	0.0 / 0.00	0.03	10	Fe 0.01 ppm	43[a]	29	22	0	U.S.G.S.
George Robinson Everything Except Dom.	14N/1E-28D1	11/8/62	--	156	7.9	6.3 / 0.31	6.7 / 0.55	15 / 0.65	0.9 / 0.02	0 / 0.00	78 / 1.28	0.0 / 0.00	10 / 0.28	0.2 / 0.00	0.2 / 0.01	0.04	21	Fe(dis)-0.06 (total)-21 Al 0.09 Zn 4.9 Pb 0.02 d	98[a] 95[b]	42	43	0	D.W.R.
G. Humphrey Domestic	29A1	11/8/62	--	104	7.7	4.0 / 0.20	2.2 / 0.18	15 / 0.65	0.6 / 0.02	0 / 0.00	48 / 0.79	0.0 / 0.00	9.1 / 0.26	0.2 / 0.00	0.1 / 0.00	0.02	24	Fe(dis)-0.16 (total)-18 Al 0.04 Zn 0.97 Pb 0.04 d	79[a] 78[b]	62	19	0	D.W.R.
Robert Bullen Domestic	34Q1	11/8/62	--	72.6	7.4	6.9 / 0.34	1.2 / 0.10	5.6 / 0.24	0.6 / 0.02	0 / 0.00	28 / 0.46	2.1 / 0.04	6.3 / 0.18	0.6 / 0.01	0.1 / 0.00	0.05	9.2	Fe(dis)-0.01 (total)-0.11 Zn 0.25 Cu 0.01 Pb 0.01 d	47[a] 46[b]	34	22	0	D.W.R.
Alms Ranch None	15N/2E-24E1	6/8/55	--	169	7.0	12 / 0.60	9.4 / 0.78	2.6 / 0.11	0.5 / 0.01	0 / 0.00	84 / 1.38	4.1 / 0.09	2.3 / 0.07	0.6 / 0.01	0.0 / 0.00	0.03	17	Fe (total) 5.4 ppm	90[a]	8	69	0	U.S.G.S.
T. F. McNamara Irrigation, Domestic	15N/1W-2D1	7/17/53	57	147	6.9	7.7 / 0.38	6.3 / 0.52	12 / 0.52	0.4 / 0.01	0 / 0.00	41 / 0.67		17 / 0.48	—	—	—	—	Fe 0 ppm	64[a]	36	45	12	U.S.G.S.
Bud Pyke Domestic	16N/1E-9K1	8/28/53	--	201	7.6	5.1 / 0.25	22 / 1.81	3.2 / 0.14	0.0 / 0.00	0 / 0.00	120 / 1.97	1.3 / 0.03	7.0 / 0.20	1.5 / 0.02				Fe 0.05 ppm	---	6	103	5	U.S.G.S.
Rellim Lumber Co. Abandoned	32P1	6/11/55	60	143	7.0	11 / 0.55	4.9 / 0.40	10 / 0.44	0.8 / 0.02	0 / 0.00	72 / 1.18	0.0 / 0.00	8.0 / 0.23	0.2 / 0.00	0.1 / 0.01	0.03	12	Fe (total) 2.2 ppm	82[a]	31	48	0	U.S.G.S.

a. Determined by addition of constituents.
b. Gravimetric determination.
c. Analysis by U.S. Geological Survey, Quality of Water Branch (U.S.G.S.), or State Department of Water Resources (D.W.R.), as indicated.
d. Iron (Fe), Aluminum (Al), Arsenic (As), Copper (Cu), Lead (Pb), Manganese (Mn), Zinc (Zn), and Chromium (Cr). Were reported as 0.00 ppm except as noted.

APPENDIX D (Cont.)

ANALYSES OF GROUND WATER

DEL NORTE COUNTY

Owner and use	State well number and other 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)	Other constituents	Total dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ N.C. ppm	Analyzed by c
						Mineral constituents in parts per million / equivalents per million																	
Edward C. Johnson Abandoned	16N/1W-2J1	7/30/53	--	268	6.9	10 / 0.50	14 / 1.15	26 / 1.13	0.5 / 0.01	0 / 0.00	134 / 2.20		22 / 0.62					Fe (total) 9.0 ppm	---	40	82	0	U.S.G.S.
K. J. Cunningham Domestic	2M1	7/7/53	--	111	6.4	4.7 / 0.24	4.2 / 0.35	8.7 / 0.38	3.1 / 0.08	0 / 0.00	34 / 0.56		15 / 0.42					Fe (total) 0.3 ppm	---	36	29	1	U.S.G.S.
Arlet Short Domestic	2Q1	11/29/56	53	239	7.2	15 / 0.75	14 / 1.13	16 / 0.70	0.3 / 0.01	0 / 0.00	138 / 2.26	0.0 / 0.00	11 / 0.31	5.2 / 0.08	0.1 / 0.01	0.15	39		169[a]	27	94	0	U.S.G.S.
		10/2/57	--	241	7.8	16 / 0.80	12 / 0.98	16 / 0.70	0.7 / 0.02	0 / 0.00	132 / 2.16	0.4 / 0.01	14 / 0.39	1.0 / 0.02	0.1 / 0.01	0.00	39	Fe 0.02 ppm	164[a]	28	89	0	U.S.G.S.
		6/23/58	--	256	7.1	15 / 0.74	13 / 1.08	18 / 0.79	0.3 / 0.01	0 / 0.00	122 / 2.00	13 / 0.27	13 / 0.34	0.0 / 0.00	0.0 / 0.00	0.10	22	Fe (dis) 0.47 ppm	184[b]	30	91	-	D.W.R.
		8/14/59	--	231	7.8	15 / 0.75	12 / 0.98	17 / 0.74	0.5 / 0.01	0 / 0.00	123 / 2.02	5.4 / 0.11	10 / 0.28	0.8 / 0.01	0.0 / 0.00	0.0	39	Fe(dis) 0.00 ppm Fe (total) 0.81 ppm	116[a]	30	86	0	U.S.G.S.
		9/60	--	214	7.9	13 / 0.65	10 / 0.87	15 / 0.65	0.4 / 0.01	0 / 0.00	103 / 1.69	6.7 / 0.14	10 / 0.28	1.3 / 0.02	0.2 / 0.01	0.07	38	Fe (total) 10 ppm Br 0.0 ppm	146[a]	30	76	0	D.W.R.
		8/29/61	--	232	7.1	16 / 0.80	12 / 0.98	16 / 0.70	0.4 / 0.01	0 / 0.00	127 / 2.08	0.3 / 0.01	11 / 0.31	1.2 / 0.02	0.2 / 0.01	0.06	40	Fe (total) 7.2 ppm Zn 0.02 ppm d	159[a]	28	89	0	D.W.R.
		Summer 1962	--	229	8.2	16 / 0.80	12 / 0.96	17 / 0.74	0.4 / 0.01	0 / 0.00	133 / 2.18	1.0 / 0.02	13 / 0.37	0.5 / 0.01	0 / 0.00	0	38		164[a] 146[b]	29	88	0	U.S.G.S.
George Moore Domestic	3N7	6/12/62	58	131	6.9	4.7 / 0.23	8.4 / 0.69	7.3 / 0.32	0.3 / 0.01	0 / 0.00	39 / 0.64	2.6 / 0.05	12 / 0.34	12 / 0.19	0.0 / 0.00	0.06	20		86[a]	26	46	14	D.W.R.
Ed Cadra Domestic	5L1	8/27/53	--	126	6.7	6.0 / 0.30	6.8 / 0.56	6.3 / 0.27	2.4 / 0.06	0.0 / 0.00	52 / 0.85	2.3 / 0.05	10 / 0.28	1.3 / 0.02				Fe 0.20 ppm	---	23	43	0	U.S.G.S.
Loren C. Bliss Abandoned	7F1	9/28/53	--	282	7.6	22 / 1.10	14 / 1.15	15 / 0.65	1.1 / 0.03	0 / 0.00	128 / 2.10	5.2 / 0.11	22 / 0.62	3.7 / 0.06				Fe 0.02 ppm	---	22	112	8	U.S.G.S.
Loren C. Bliss Domestic	7F2	10/29/58	--	290	7.7	20 / 0.99	17 / 1.36	13 / 0.55	1.5 / 0.04	0 / 0.00	142 / 2.33	7 / 0.15	18 / 0.51	0 / 0.00	0 / 0.00	0.32	18	Fe (dis) 0.01 ppm	214[b]	18	117	-	D.W.R.
		9/14/59	--	304	8.1	26 / 1.30	14 / 1.14	17 / 0.74	1.6 / 0.04	0 / 0.00	146 / 2.39	4.6 / 0.10	26 / 0.73	0.1 / 0.00	0.0 / 0.00	0.1	26	Fe (dis) 0.00 ppm Fe (total) 0.40 ppm	187[a]	23	122	2	D.W.R.

a. Determined by addition of constituents.
b. Gravimetric determination.
c. Analysis by U.S. Geological Survey, Quality of Water Branch (U.S.G.S.), or State Department of Water Resources (D.W.R.), as indicated.
d. Iron (Fe), Aluminum (Al), Arsenic (As), Copper (Cu), Lead (Pb), Manganese (Mn), Zinc (Zn), and Chromium (Cr). Were reported as 0.00 ppm except as noted.

APPENDIX D (Cont)

ANALYSES OF GROUND WATER

DEL NORTE COUNTY

Owner and use	State well number and other 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)	Other constituents	Total dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ N.C. ppm	Analyzed by c
						Mineral constituents in parts per million / equivalents per million																	
Loren C. Bliss Domestic	16N/1W-7F2	9/60	55	347	8.2	32 1.60	14 1.16	17 0.74	1.0 0.02	0 0.00	159 2.61	1.0 0.02	29 0.82	0.9 0.01	0.1 0.00	0.05	19	Fe (total) 2.7 ppm Br 0.0 ppm	192[a]	21	138	8	D.W.R.
		8/30/61	--	308	8.1	31 1.55	12 1.03	16 0.70	1.0 0.02	0 0.00	150 2.46	0.8 0.02	26 0.73	1.2 0.02	0.1 0.00	0.04	19	Fe (total) 2.1 ppm Al 0.01 ppm Zn 0.06 ppm d	181[a]	21	129	6	D.W.R.
		9/17/62	--	329	8.3	33 1.65	13 1.05	16 0.70	1.0 0.03	2 0.07	155 2.54	0.2 0.00	32 0.90	0.6 0.01	0 0.00	0	20		194[a] 191[b]	20	135	5	U.S.G.S.
Harry Bigham Domestic	7H1	6/14/62	55	336	7.9	21 1.05	18 1.51	19 0.83	1.0 0.02	0 0.00	131 2.15	5.1 0.11	40 1.13	1.1 0.02	0.1 0.00	0.05	27		196[a]	24	128	21	D.W.R.
E. H. Knowlton Domestic	9H1	8/27/53	--	57.3	6.4	2.1 0.10	2.4 0.20	4.8 0.21	0.1 0.00	0.0 0.00	15 0.25	2.1 0.04	8.8 0.25	4.9 0.08				Fe 0.03 ppm		41	15	3	U.S.G.S.
L. L. Early Domestic	15C1	8/27/53	53	117	6.4	4.2 0.21	6.3 0.52	7.7 0.34	0.3 0.01	0.0 0.00	34 0.56	1.8 0.04	11 0.31	17 0.27				Fe 0.17 ppm		31	36	9	U.S.G.S.
		12/4/56	50	129	6.6	4.4 0.22	6.8 0.56	9.2 0.40	0.5 0.01	0 0.00	39 0.64	0.0 0.00	9.0 0.25	19 0.31	0.1 0.01	0.00	17		85[a]	34	39	7	U.S.G.S.
		12/4/57	--	142	7.1	5.2 0.26	8.5 0.70	9.4 0.41	0.7 0.02	0 0.00	38 0.62	3.8 0.08	12 0.34	23 0.37	0.0 0.00	0.00	19	Fe 0.01 ppm	101[a]	29	48	17	U.S.G.S.
		10/29/58	56	129	7.4	5 0.26	7 0.57	10 0.45	0 0.0	0 0.0	49 0.80	5 0.10	9 0.24	6 0.10	0.10 0.0	1.1	19	Fe (dis.) 0 ppm	90[b]	[illegible]	41	-	D.W.R.
		10/59	--	102	7.7	3.8 0.19	[illegible]	8.1 0.3	0.2 [illegible]	0 0.0	42 [illegible]	0.6 0.01	7.2 0.20	[illegible]	0.0 0.00	0.0	19	Fe (dis.) [illegible] ppm Fe (total) 0.0 ppm		[illegible]	33	0	D.W.R.
		[illegible]	--	[illegible]	[illegible]	[illegible] 0.14	[illegible] 0.42	7.2 0.31	0.6 0.02	0 0.00	[illegible] 0.43	2.1 0.04	12 0.34	[illegible] 0.08	[illegible]	0.04	[illegible]	Fe (total) [illegible] ppm Br 0.2 ppm	[illegible][a]	[illegible]	[illegible]	7	D.W.R.
		[illegible]	--	152	6.3	[illegible] 0.27	[illegible] 0.77	9.2 0.40	[illegible] 0.01	0 0.00	44 0.72	1.6 0.03	14 0.39	18 0.29	[illegible]	0.02	22	Fe (total) 0.01 ppm Al 0.01 ppm Zn 0.05 ppm Cu 0.02 ppm d	102[a]	29	[illegible]	16	D.W.R.
		9/5/62	--	101	7.7	[illegible]	[illegible]	7.1 0.31	0.4 0.01	0 0.00	40 0.66	2.0 0.04	[illegible] 0.23	[illegible] 0.07	0 0.00	0	19		71[a] 73[b]	32	33	0	U.S.G.S.

a. Determined by addition of constituents.
b. Gravimetric determination.
c. Analysis by U.S. Geological Survey, Quality of Water Branch (U.S.G.S.), or State Department of Water Resources (D.W.R.), as indicated.
d. Iron (Fe), Aluminum (Al), Arsenic (As), Copper (Cu), Lead (Pb), Manganese (Mn), Zinc (Zn), and Chromium (Cr). Were reported as 0.00 ppm except as noted.

APPENDIX D (Cont)

ANALYSES OF GROUND WATER

DEL NORTE COUNTY

Owner and use	State well number and other 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)	Other constituents	Total dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ N.C. ppm	Analyzed by c
						Mineral constituents in parts per million / equivalents per million																	
Pine Grove School Domestic	16N/1W-1601	4/30/53	--	147	6.6	4.9 / 0.25	6.3 / 0.52	13 / 0.57	0.5 / 0.01	0 / 0	46 / 0.75	2.0 / 0.04	19 / 0.54	3.3 / 0.05	0 / 0	0.01	16		88[a]	42	38	0	U.S.G.S.
	16D2	12/4/56	52	182	6.8	8.0 / 0.40	13 / 1.04	11 / 0.48	0.3 / 0.01	0 / 0.00	88 / 1.44	1.0 / 0.02	16 / 0.45	1.8 / 0.03	0.1 / 0.01	0.00	29		123[a]	26	72	0	U.S.G.S.
		9/11/57	--	176	7.4	6.4 / 0.32	12 / 0.97	10 / 0.44	0.6 / 0.02	0 / 0.00	69 / 1.13	1.9 / 0.04	20 / 0.56	1.9 / 0.03	0.0 / 0.00	0.00	28	Fe 0.00 ppm	115[a]	25	65	8	U.S.G.S.
		7/6/58	--	184	7.5	8 / 0.40	12 / 1.00	12 / 0.50	0.3 / 0.01	0 / 0	73 / 120	0 / 0	25 / 0.70	2 / 0.03	0 / 0	0.04	8	Fe (dis.) 0 ppm	130[b]	26	70		D.W.R.
		9/4/59	--	192	7.6	6.2 / 0.31	13 / 1.09	11 / 0.48	0.4 / 0.01	0 / 0.00	73 / 1.20	3.0 / 0.06	20 / 0.56	1.5 / 0.02	0.0 / 0.00	0.0	28	Fe (dis.) 0.00 ppm Fe (total) 0.23 ppm	119[a]	25	70	10	U.S.C.S.
		9/60	54	201	8.0	8.2 / 0.41	13 / 1.11	10 / 0.44	0.6 / 0.02	0 / 0.00	88 / 1.44	3.3 / 0.07	16 / 0.45	1.6 / 0.02	0.0 / 0.00	0.02	26	Fe (total) 3.7 ppm Br 0.0 ppm	122[a]	22	76	4	D.W.R.
		8/29/61	--	189	7.5	6.9 / 0.34	13 / 1.06	10 / 0.44	0.4 / 0.01	0 / 0.00	73 / 1.20	1.6 / 0.03	22 / 0.62	2.3 / 0.04	0.1 / 0.00	0.03	28	Fe (total) 0.09 ppm Al 0.01 ppm Zn 0.46 ppm d	120[a]	24	70	10	D.W.R.
		9/5/62	--	195	8.1	7.4 / 0.37	13 / 1.11	11 / 0.48	0.4 / 0.01	0 / 0.00	81 / 1.33	3.0 / 0.06	21 / 0.59	1.7 / 0.03	0 / 0.00	0 —	28		126[a] 127[b]	24	74	8	U.S.G.S.
Harry Mattson Abandoned	17K3	10/29/58	--	210	7.5	5 / 0.24	11 / 0.89	22 / 0.93	0.3 / 0.01	0 / 0	57 / 0.94	6 / 0.12	25 / 0.70	21 / 0.33	0.09 / 0.0	0.62	14	Fe (dis.) 0.01 ppm	147[b]	44	56		D.W.R.
North-Cal Plywood Corp. Domestic	18F1	8/27/53	53	251	7.0	7.6 / 0.38	14 / 1.51	19 / 0.83	0.4 / 0.01	0 / 0.00	79 / 1.30	5.5 / 0.11	36 / 1.02	3.4 / 0.05				Fe 2.3 ppm		35	76	12	U.S.G.S.
		12/4/56	52	292	6.9	6.8 / 0.34	19 / 1.60	24 / 1.04	0.2 / 0.01	0 / 0.00	116 / 1.90	1.9 / 0.04	38 / 1.07	0.1 / 0.00	0.0 / 0.00	0.08	25		172[a]	35	97	2	U.S.G.S.
		12/4/57	--	319	7.8	7.2 / 0.36	20 / 1.66	27 / 1.17	0.5 / 0.01	0 / 0.00	128 / 2.10	4.6 / 0.10	36 / 1.02	0.0 / 0.00	0.0 / 0.00	0.02	24	Fe 0.05 ppm	182[a]	37	101	0	U.S.G.S.
		9/25/58	--	313	7.3	7 / 0.36	18 / 1.52	29 / 1.24	0.3 / 0.01	0 / 0	110 / 1.80	5 / 0.10	44 / 1.23	6 / 0.09	0.28 / 0.01	0.71	21	Fe (dis.) 0.13 ppm	219[b]	40	94		D.W.R.
Ralph Deo Domestic	19J1	4/30/53	--	157	6.7	4.9 / 0.25	8.9 / 0.73	10 / 0.44	0.6 / 0.02	0 / 0	48 / 0.79	4.2 / 0.09	14 / 0.40	6.1 / 0.10	0 / 0	0.02	17	Fe 0.04 ppm	89[a]	30	49	10	U.S.G.S.
Nora Pullen Domestic	20A2	4/30/53	--	175	6.8	3.1 / 0.16	7.1 / 0.58	21 / 0.91	0.5 / 0.01	0 / 0	45 / 0.74	12 / 0.25	19 / 0.54	6.8 / 0.11	0 / 0	0.06	13	Fe 0.01 ppm	105[a]	55	37	0	U.S.C.S.

a. Determined by addition of constituents.
b. Gravimetric determination.
c. Analysis by U.S. Geological Survey, Quality of Water Branch (U.S.G.S.), or State Department of Water Resources (D.W.R.), as indicated.
d. Iron (Fe), Aluminum (Al), Arsenic (As), Copper (Cu), Lead (Pb), Manganese (Mn), Zinc (Zn), and Chromium (Cr). Were reported as 0.00 ppm except as noted.

APPENDIX D (Cont.)

ANALYSES OF GROUND WATER

DEL NORTE COUNTY

Owner and use	State well number and other 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)	Other constituents	Total dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ N.C. ppm	Analyzed by c
						Mineral constituents in parts per million / equivalents per million																	
Nora Pullen Domestic	16N/1W-20A2	12/4/56	52	159	6.5	3.6 / 0.18	6.8 / 0.56	16 / 0.70	0.4 / 0.01	0 / 0.00	45 / 0.74	4.8 / 0.10	12 / 0.34	19 / 0.31	0.0 / 0.00	0.00	23		108[a]	48	37	0	U.S.G.S.
		12/4/57	--	257	6.7	4.4 / 0.22	14 / 1.12	22 / 0.96	1.0 / 0.03	0 / 0.00	46 / 0.75	12 / 0.25	19 / 0.54	48 / 0.77	0.0 / 0.00	0.05	23	Fe 0.01 ppm	166[a]	41	67	29	U.S.G.S.
		10/29/58	--	174	7.0	6 / 0.30	7 / 0.63	16 / 0.71	0.3 / 0.01	0 / 0	44 / 0.72	6 / 0.13	17 / 0.49	16 / 0.26	0 / 0	0.1	7	Fe (dis.) 0 ppm	116[b]	43	46		D.W.R.
		9/18/59	--	208	6.9	5.6 / 0.28	11 / 0.88	19 / 0.83	0.9 / 0.02	0 / 0.00	48 / 0.79	8.0 / 0.17	22 / 0.62	25 / 0.40	0.0 / 0.0	0.0	25	Fe (total) 0.09 ppm	141[a]	41	58	19	U.S.G.S.
		9/60	--	298	7.4	5.6 / 0.28	15 / 1.26	22 / 0.96	0.8 / 0.02	0 / 0.00	45 / 0.74	8.6 / 0.18	26 / 0.73	49 / 0.79	0.0 / 0.0	0.04	22	Fe (total) 0.14 ppm Br 0.0 ppm	171[a]	38	77	40	D.W.R.
		8/29/61	--	197	6.4	4.3 / 0.21	8.4 / 0.69	20 / 0.87	0.6 / 0.02	0 / 0.00	37 / 0.61	9.9 / 0.21	20 / 0.56	27 / 0.44	0.0 / 0.0	0.07	20	Fe (total) 0.18 ppm Zn 0.04 ppm Cu 0.02 ppm d	128[a]	49	45	15	D.W.R.
		7/30/62	56	297	7.8	7.2 / 0.36	16 / 1.31	25 / 1.09	0.7 / 0.02	0 / 0.00	54 / 0.89	8.0 / 0.17	30 / 0.85	49 / 0.79	0 / 0.00	0	22		195[a] 180[b]	39	84	40	U.S.G.S.
	20A3	1961	--	172	7.7	5.4 / 0.27	9.1 / 0.75	14 / 0.61	0.6 / 0.02	0 / 0.00	58 / 0.95	4.4 / 0.09	15 / 0.42	12 / 0.19	0.0 / 0.0	0.07	25	Fe (total) 0.05 ppm Al 0.03 ppm Zn 0.16 ppm Cu 0.04 ppm Pb 0.03 ppm d	114[a]	37	51	3	D.W.R.
Jess Patterson Domestic	20B1	4/30/53	--	210	7.6	5.3 / 0.26	13 / 1.07	17 / 0.74	0.4 / 0.01	0 / 0.00	69 / 1.13	6.3 / 0.13	22 / 0.62	8.3 / 0.13	0 / 0.0	0.03	26	Fe 0.04 ppm	132[a]	35	67	10	U.S.G.S.
		12/4/56	52	195	6.9	4.8 / 0.24	11 / 0.88	17 / 0.74	0.4 / 0.01	0 / 0.1	72 / 1.18	5.8 / 0.12	12 / 0.34	14 / 0.23	0.0 / 0.0	0.00	27		127[a]	40	56	0	U.S.G.S.
		12/4/57	--	206	7.0	3.2 / 0.16	13 / 1.04	19 / 0.83	0.8 / 0.02	0 / 0.00	72 / 1.18	12 / 0.25	16 / 0.45	14 / 0.23	0.0 / 0.0	0.01	27	Fe 0.02 ppm	140[a]	40	60	1	U.S.G.S.
		6/14/62	--	230	7.4	6.5 / 0.32	13 / 1.10	18 / 0.78	0.7 / 0.02	0 / 0.00	85 / 1.39	4.9 / 0.10	16 / 0.45	19 / 0.31	0.0 / 0.00	0.06	26		146[a]	35	61	1	D.W.R.
Walter Story Domestic	20H1	4/30/53	--	172	6.5	4.4 / 0.22	7.8 / 0.64	15 / 0.65	0.7 / 0.02	0 / 0.00	26 / 0.43	3.5 / 0.07	23 / 0.65	25 / 0.40	0.0 / 0.00	0.09	9.2	Fe 0.05 ppm	102[a]	43	43	22	U.S.G.S.
		12/4/56	51	181	6.7	4.8 / 0.24	11 / 0.88	13 / 0.57	0.5 / 0.01	0 / 0.00	58 / 0.95	3.8 / 0.08	16 / 0.45	19 / 0.29	0.0 / 0.00	0.01	19		115[a]	34	55	8	U.S.G.S.

a. Determined by addition of constituents.
b. Gravimetric determination.
c. Analysis by U.S. Geological Survey, Quality of Water Branch (U.S.G.S.).
or State Department of Water Resources (D.W.R.), as indicated.
d. Iron (Fe), Aluminum (Al), Arsenic (As), Copper (Cu), Lead (Pb), Manganese (Mn), Zinc (Zn), and Chromium (Cr). Were reported as 0.00 ppm except as noted.

APPENDIX D (Cont.)

ANALYSES OF GROUND WATER

DEL NORTE COUNTY

Owner and use	State well number and other 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)	Other constituents	Total dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ N.C. ppm	Analyzed by c
						Mineral constituents in parts per million / equivalents per million																	
Walter Story Domestic	16N/1W-20H1	12/4/57	--	250	7.5	6.4 0.32	15 1.22	16 0.70	0.9 0.02	0 0.00	43 0.70	6.7 0.14	33 0.93	30 0.48	0.0 0.00	0.0	19	Fe 0.01 ppm	148[a]	31	77	42	U.S.G.S.
		10/29/58	--	260	6.6	8 0.40	17 1.40	17 0.74	0.7 0.02	0 0	61 1.00	4 0.08	37 0.92	33 0.53	0 0	0	7	Fe (dis.) 0 ppm	180[b]	28	90		D.W.R.
		9/18/59	--	237	7.7	7.6 0.38	15 1.26	15 0.65	0.8 0.02	0 0.00	70 1.15	10 0.21	22 0.62	18 0.29	0.1 0.01	0.0	23	Fe (total) 0.08 ppm	146[a]	28	82	25	U.S.G.S.
		11/29/60	57	126	7.0	2.2 0.11	5.2 0.43	11 0.48	0.9 0.02	0 0.00	20 0.33	6.7 0.14	14 0.39	9.5 0.15	0.0 0.00	0.06	10	Fe (total) 0.78 ppm Br 0.2 ppm	70[a]	46	27	11	D.W.R.
		8/29/61	--	167	7.2	5.0 0.25	9.1 0.75	13 0.56	0.6 0.02	0 0.00	45 0.74	6.7 0.14	17 0.48	15 0.24	0.1 0.00	0.06	17	Fe (total) 0.59 ppm	106[a]	35	50	13	D.W.R.
		7/30/62	56	211	7.5	6.0 0.30	12 1.02	15 0.65	0.9 0.02	0 0.00	58 0.95	7.0 0.15	19 0.54	24 0.39	0 0.00	0	19		132[a] 118[b]	33	66	18	U.S.G.S.
Floyd Fees Domestic	20H2	4/30/53	--	186	6.5	7.6 0.38	10 0.82	11 0.48	0.8 0.02	0 0.00	61 1.0	14 0.29	13 0.37	1.0 0.02	0 0	0.12	7.6	Fe 0.0 ppm	95[a]	28	60	10	U.S.G.S.
S. R. Mattson Domestic	20H4	9/18/59	--	208	6.9	8.0 0.40	14 1.12	14 0.61	0.5 0.01	0 0.00	72 1.18	14 0.29	23 0.65	2.2 0.04	0.2 0.01	0.0	32	Fe (total) 0.04 ppm	143[a]	29	76	17	U.S.G.S.
		11/29/60	57	205	7.8	5.5 0.27	14 1.15	12 0.52	0.5 0.01	0 0.00	69 1.13	4.6 0.10	19 0.54	8.3 0.13	0.1 0.00	0.05	30	Fe (total) 0.12 ppm Br 0.0 ppm	128[a]	27	71	15	D.W.R.
		1961	--	208	7.7	6.7 0.33	15 1.23	11 0.48	0.5 0.01	0 0.00	73 1.20	3.3 0.07	25 0.70	5.5 0.09	0.0 0.00	0.03	29	Fe (total) 0.06 ppm Al 0.01 ppm Zn 0.02 ppm d	132[a]	23	78	18	D.W.R.
		7/30/62	59	204	8.1	5.6 0.28	16 1.28	11 0.48	0.6 0.02	0 0.00	76 1.25	5.0 0.10	24 0.68	4.8 0.08	0 0.00	0	28		132[a] 137[b]	23	78	16	U.S.G.S.
Crescent City Water Company, Abandoned	20Q1	4/30/53	--	232	6.8	8.0 0.40	12 0.99	17 0.74	0.8 0.02	0 0.00	61 1.00	6.7 0.14	28 0.79	13 0.21	0.2 0.01	0.11	19	Fe 0.3 ppm	135[a]	34	69	19	U.S.G.S.
		12/4/56	49	239	6.7	8.4 0.42	12 1.00	18 0.78	0.7 0.02	0 0.00	63 1.03	6.7 0.14	30 0.85	18 0.29	0.0 0.00	0.0	20		145[a]	35	71	19	U.S.G.S.
		12/5/57	--	215	7.9	7.6 0.38	11 0.90	16 0.70	1.0 0.03	0 0.00	58 0.95	9.6 0.20	26 0.73	11 0.18	0.0 0.00	0.0	17		128[a]	35	64	16	U.S.G.S.

a. Determined by addition of constituents.
b. Gravimetric determination.
c. Analysis by U.S. Geological Survey, Quality of Water Branch (U.S.G.S.).
or State Department of Water Resources (D.W.R.), as indicated.
d. Iron (Fe), Aluminum (Al), Arsenic (As), Copper (Cu), Lead (Pb), Manganese (Mn), Zinc (Zn), and Chromium (Cr). Were reported as 0.00 ppm except as noted.

APPENDIX D (Cont)

ANALYSES OF GROUND WATER

DEL NORTE COUNTY

Owner and use	State well number and other 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)	Other constituents	Total dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ N.C. ppm	Analyzed by c
						Mineral constituents in parts per million / equivalents per million																	
Del Norte County Infirmary Domestic	16N/1W-21M1	5/1/53	--	149	7.3	7.8 / 0.39	6.7 / 0.55	12 / 0.52	0.7 / 0.02	0 / 0.00	56 / 0.92	3.4 / 0.07	17 / 0.48	1.6 / 0.03	0.0 / 0.00	0.04	14		91[a]	35	47	1	U.S.G.S.
		8/20/54	57	161	7.2	7.3 / 0.36	8.2 / 0.68	12 / 0.52	0.4 / 0.01	0 / 0.00	56 / 0.92	4.5 / 0.09	21 / 0.59	1.2 / 0.02	0.3 / 0.02	0.25	20	Fe 0.20 ppm Al 0.01 ppm Mn 0.01 ppm Cr 0.01 ppm Zn 0.01 ppm d	103[a]	33	52	6	U.S.G.S.
		12/4/56	51	178	6.6	5.6 / 0.28	11 / 0.92	13 / 0.57	0.3 / 0.01	0 / 0.00	78 / 1.28	1.0 / 0.02	16 / 0.45	1.1 / 0.02	0.0 / 0.00	0.02	22		108[a]	32	60	0	U.S.G.S.
		12/4/57	--	179	7.2	4.8 / 0.24	11 / 0.88	14 / 0.61	0.8 / 0.02	0 / 0.00	74 / 1.21	0.0 / 0.0	18 / 0.51	1.2 / 0.02	0.0 / 0.00	0.02	24	Fe 0.10 ppm	110[a]	35	56	0	U.S.G.S.
Frank D. Patton Abandoned	22Q1	5/26/52	--	109	6.8	4.8 / 0.24	2.9 / 0.24	11 / 0.48	0.8 / 0.02	0 / 0.00	22 / 0.36	3.7 / 0.08	18 / 0.51	3.5 / 0.06	0.0 / 0.00	0.04	8.6		64[a]	49	24	6	U.S.G.S.
Joe Nunes Domestic & Stock	23D1	8/27/53	59	72.4	7.1	3.4 / 0.17	4.1 / 0.34	4.5 / 0.20	0.3 / 0.01	0.0 / 0.00	32 / 0.52	0.7 / 0.02	7.2 / 0.20	1.8 / 0.03				Fe 0.27 ppm		28	25	0	U.S.G.S.
H. C. Kirkland Domestic	26D1	4/30/53	--	154	6.6	4.0 / 0.20	6.4 / 0.53	18 / 0.78	0.2 / 0.01	0 / 0.00	30 / 0.49	1.6 / 0.03	23 / 0.65	23 / 0.37	0 / 0.00	0.06	10	Fe 0.03 ppm	101[a]	52	36	12	U.S.G.S.
		10/20/59	--	299	7.6	18 / 0.90	14 / 1.12	18 / 0.78	0.6 / 0.02	0 / 0.00	80 / 1.31	0.0 / 0.00	32 / 0.90	34 / 0.55	0.1 / 0.01	0.0	24	Fe (total) 0.07 ppm	180[a]	28	101	35	U.S.G.S.
		9/60	--	275	6.5	6.8 / 0.34	10 / 0.82	24 / 1.04	0.4 / 0.01	0 / 0.00	32 / 0.52	0.6 / 0.01	30 / 0.85	49 / 0.79	0.0 / 0.00	0.04	13	Fe (total) 0.22 ppm	150[a]	47	58	32	D.W.R.
		8/31/61	--	304	7.7	8.0 / 0.40	13 / 1.04	30 / 1.30	0.0 / 0.00	0 / 0.00	54 / 0.89	1.0 / 0.02	42 / 1.18	35 / 0.56	0.1 / 0.01	0.0	19		175[a]	47	72	28	D.W.R.
		9/17/62	--	239	7.4	7.1 / 0.35	10 / 0.85	22 / 0.96	0 / 0.00	0 / 0.00	38 / 0.62	2.0 / 0.04	39 / 1.10	23 / 0.37	0 / 0.00	0	19		141[a] 144[b]	44	60	29	U.S.G.S.
J. C. Buchanan Domestic	26E1	4/30/53	--	255	7.2	31 / 1.55	6.7 / 0.55	12 / 0.52	1.0 / 0.03	0 / 0.00	127 / 2.08	3.3 / 0.07	14 / 0.40	4.3 / 0.07	0 / 0.00	0.02	12	Fe 0.04 ppm	147[a]	20	105	1	U.S.G.S.
John Morse Domestic	26M5	6/14/62	55	77.5	6.3	2.7 / 0.13	1.8 / 0.15	8.0 / 0.35	0.2 / 0.00	0 / 0.00	12 / 0.20	1.0 / 0.02	11 / 0.31	7.3 / 0.12	0.0 / 0.00	0.04	9.0		47[a]	56	14	4	D.W.R.
V. Sally Willits Domestic	26N1	4/30/53	--	216	8.1	17 / 0.85	5.5 / 0.45	22 / 0.96	1.3 / 0.03	0 / 0.00	104 / 1.70	3.6 / 0.08	18 / 0.51	3.9 / 0.06	0.3 / 0.02	0.03	15	Fe 0.08 ppm	138[a]	42	65	0	U.S.G.S.
W. J. Newman Domestic	16N/2W-13E1 & E2	9/23/53	--	380	6.7	15 / 0.75	14 / 1.15	34 / 1.48	1.0 / 0.03	0 / 0.00	65 / 1.07	27 / 0.56	64 / 1.80	2.5 / 0.04				Fe 0.02 ppm		43	95	42	U.S.G.S.

a. Determined by addition of constituents.
b. Gravimetric determination.
c. Analysis by U.S. Geological Survey, Quality of Water Branch (U.S.G.S.). or State Department of Water Resources (D.W.R.), as indicated.
d. Iron (Fe), Aluminum (Al), Arsenic (As), Copper (Cu), Lead (Pb), Manganese (Mn), Zinc (Zn), and Chromium (Cr). Were reported as 0.00 ppm except as noted.

APPENDIX D (Cont.)

ANALYSES OF GROUND WATER

DEL NORTE COUNTY

Mineral constituents in parts per million / equivalents per million

Owner and use	State well number and other 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)	Other constituents	Total dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ N.C. ppm	Analyzed by c
Evo Mello Irrigation, Stock	17N/1W-2G1	11/29/56	52	95.9	6.8	4.4 / 0.22	7.1 / 0.58	5.4 / 0.23	0.1 / 0.00	0 / 0.00	44 / 0.72	1.9 / 0.04	7.0 / 0.20	3.1 / 0.05	0.0 / 0.00	0.05	19		70[a]	22	40	4	U.S.G.S.
		9/15/58	--	109	7.5	2 / 0.12	8 / 0.68	6 / 0.26	0 / 0.0	0 / 0.0	43 / 0.71	5 / 0.10	9 / 0.24	2 / 0.04	0 / 0	0.08	10	Fe (dis.) 0.01 ppm	64[b]	24	40		D.W.R.
		8/27/59	--	110	7.5	4.6 / 0.23	6.9 / 0.57	6.8 / 0.30	0.2 / 0.01	0 / 0.00	49 / 0.80	1.4 / 0.03	7.1 / 0.20	3.0 / 0.05	0.0 / 0.00	0.0	18	Fe (dis.) 0.00 ppm Fe (total) 0.68 ppm	72[a]	27	40	0	U.S.G.S.
		9/60	--	115	7.5	3.8 / 0.19	7.4 / 0.61	6.5 / 0.28	0.3 / 0.01	0 / 0.00	46 / 0.75	2.1 / 0.04	7.5 / 0.21	3.5 / 0.06	0.0 / 0.00	0.04	20	Fe (total) 0.16 ppm Br 0.4 ppm	74[a]	26	40	2	D.W.R.
		8/30/61	--	107	6.9	4.8 / 0.24	6.3 / 0.52	6.8 / 0.30	0.2 / 0.00	0 / 0.00	47 / 0.77	1.2 / 0.02	7.8 / 0.22	4.2 / 0.07	0.1 / 0.00	0.03	18	Fe (total) 0.02 ppm Al 0.01 ppm Zn 0.12 ppm d	72[a]	28	38	0	D.W.R.
Homer Martin Domestic	2P1	8/27/53	--	130	6.8	4.2 / 0.21	13 / 1.07	3.4 / 0.15	0.3 / 0.01	0 / 0.00	78 / 1.28	1.5 / 0.03	5.8 / 0.16	1.9 / 0.03				Fe 0.07 ppm		10	64	0	U.S.G.S.
P. Saxton Domestic	2P2	6/13/62	56	223	7.5	6.5 / 0.32	20 / 1.62	4.8 / 0.21	0.8 / 0.02	0 / 0.00	64 / 1.05	1.8 / 0.04	7.6 / 0.21	52 / 0.84	0.0 / 0.00	0.05	20		144[a]	10	97	45	D.W.R.
Guy Labarra Irrigation	4J1	11/29/56	55	244	7.3	5.6 / 0.28	28 / 2.28	4.2 / 0.18	0.3 / 0.01	0 / 0.00	151 / 2.47	1.9 / 0.04	7.0 / 0.20	2.1 / 0.03	0.0 / 0.00	0.01	36		159[a]	7	128	4	U.S.G.S.
		9/12/57	--	242	8.1	7.2 / 0.36	25 / 2.05	4.9 / 0.21	0.5 / 0.01	0 / 0.00	145 / 2.38	0.0 / 0.00	9.5 / 0.27	1.4 / 0.02	0.0 / 0.00	0.00	34		154[a]	8	121	2	U.S.G.S.
		7/18/58	--	256	7.6	4 / 0.20	28 / 2.29	6 / 0.24	0.3 / 0.01	0 / 0	150 / 2.46	4 / 0.09	9 / 0.24	2 / 0.04	0 / 0	0.18	27	Fe (dis.) 0.01 ppm	194[b]	8	124		D.W.R.
		9/3/59	--	251	8.1	6.0 / 0.30	27 / 2.22	5.5 / 0.24	0.3 / 0.01	0 / 0.00	155 / 2.54	2.0 / 0.04	6.0 / 0.17	1.4 / 0.02	0.0 / 0.00	0.0	35	Fe (dis.) 0.00 ppm Fe (total) 0.11 ppm	159[a]	9	126	0	U.S.G.S.
		9/14/60	--	260	8.2	4.6 / 0.23	28 / 2.35	4.8 / 0.21	0.4 / 0.01	0 / 0.00	150 / 2.46	2.3 / 0.05	7.1 / 0.20	1.9 / 0.03	0.0 / 0.00	0.03	33	Fe (total) 1.0 ppm Br. 0.8 ppm	156[a]	8	129	6	D.W.R.

a. Determined by addition of constituents.
b. Gravimetric determination.
c. Analysis by U.S. Geological Survey, Quality of Water Branch (U.S.G.S.). or State Department of Water Resources (D.W.R.), as indicated.
d. Iron (Fe), Aluminum (Al), Arsenic (As), Copper (Cu), Lead (Pb), Manganese (Mn), Zinc (Zn), and Chromium (Cr). Were reported as 0.00 ppm except as noted.

APPENDIX D (Cont.)

ANALYSES OF GROUND WATER

DEL NORTE COUNTY

Owner and use	State well number and other 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)	Other constituents	Total dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ N.C. ppm	Analyzed by c
						Mineral constituents in parts per million / equivalents per million																	
Guy Labarra Irrigation	17N/1W-4J1	8/30/61	--	250	7.7	6.5 / 0.32	27 / 2.22	4.8 / 0.21	0.4 / 0.01	0 / 0.00	149 / 2.44	0.8 / 0.02	8.1 / 0.23	2.2 / 0.04	0.1 / 0.00	0.04	34	Fe (total) 0.02 ppm Al 0.01 ppm Zn 0.06 ppm d	157[a]	8	127	5	D.W.R.
		9/7/62	--	240	8.2	6.0 / 0.30	26 / 2.16	4.7 / 0.20	0.4 / 0.01	0 / 0.00	151 / 2.47	1.4 / 0.03	9.1 / 0.26	2.0 / 0.03	0 / 0.00	0	34		158[a] 138[b]	7	123	0	U.S.G.S.
Manual Silva Irrigation	4L1	8/27/53	59	363	7.1	6.4 / 0.32	42 / 3.45	8.5 / 0.37	0.1 / 0.00	0 / 0.00	228 / 3.74	0.5 / 0.01	12 / 0.34	2.0 / 0.03				Fe 6.5 ppm		9	189	0	U.S.G.S.
		6/13/62	58	465	7.6	11 / 0.55	53 / 4.35	8.0 / 0.35	0.3 / 0.01	0 / 0.00	289 / 4.74	0.8 / 0.02	14 / 0.39	1.5 / 0.02	0.1 / 0.00	0.04	33		264[a]	7	245	8	D.W.R.
Manual Silva Abandoned	4L2	8/27/53	67	352	7.0	6.0 / 0.30	43 / 3.54	7.0 / 0.30	0.0 / 0.00	0 / 0.00	231 / 3.79	0.7 / 0.02	9.5 / 0.27	0.4 / 0.01				Fe 9.7 ppm		7	192	32	U.S.G.S.
Roger Oliver Irrigation	11A2	9/60	--	117	7.4	1.7 / 0.08	10 / 0.82	4.1 / 0.18	0.1 / 0.00	0 / 0.00	40 / 0.66	0.5 / 0.01	5.0 / 0.14	16 / 0.26	0.0 / 0.00	0.03	21	Br 0.5 ppm	78[a]	17	45	12	D.W.R.
Pressly Tryon Domestic	11F1	7/30/53	57	257	7.1	7.7 / 0.38	28 / 2.30	3.1 / 0.14	0.3 / 0.01	0 / 0.00	150 / 2.46		5.8 / 0.16					Fe (total) 0.0 ppm		5	134	11	U.S.G.S.
Alice Henry Domestic	13G1	8/27/53	--	139	7.2	5.5 / 0.27	13 / 1.07	2.3 / 0.10	0.2 / 0.01	0 / 0.00	79 / 1.30	1.7 / 0.03	4.8 / 0.14	1.2 / 0.02				Fe 0.13 ppm		7	67	2	U.S.G.S.
Redwood Union Elementary School Domestic	14C1	9/28/53	--	324	8.0	21 / 1.05	19 / 1.56	20 / 0.87	2.1 / 0.05	0 / 0.00	185 / 3.03	10 / 0.21	8.5 / 0.24	3.3 / 0.05				Fe 0.03 ppm		25	130	0	U.S.O.S.
		10/9/58	--	370	8.0	18 / 0.90	11 / 0.93	47 / 2.04	2.8 / 0.07	0 / 0	186 / 3.05	13 / 0.27	27 / 0.75	0 / 0	0.40 / 0.01	1.5	16	Fe (dis.) 0 ppm	284[b]	51	91		D.W.R.
		8/14/59	--	367	8.4	21 / 1.05	15 / 1.22	39 / 1.70	3.3 / 0.08	5 / 0.17	191 / 3.13	15 / 0.31	14 / 0.39	0.7 / 0.01	0.0 / 0.00	0.1	20	Fe (dis.) 0.00 ppm Fe (total) 0.01 ppm	227[a]	42	113	0	U.S.G.S.
		9/15/60	--	384	8.3	19 / 0.95	14 / 1.15	41 / 1.78	2.6 / 0.07	0 / 0.00	196 / 3.21	14 / 0.29	15 / 0.42	0.6 / 0.01	0.1 / 0.00	0.23	20	Fe (total) 0.09 ppm Br 0.5 ppm	222[a]	45	105	0	D.W.R.
		1961	--	364	8.1	22 / 1.10	16 / 1.28	35 / 1.52	2.5 / 0.06	0 / 0.00	195 / 3.20	14 / 0.29	15 / 0.42	1.3 / 0.02	0.1 / 0.00	0.18	22	Fe (total) 0.03 ppm Al 0.02 ppm Zn 0.22 ppm Pb 0.01 ppm d	224[a]	38	119	0	D.W.R.
		9/15/62	--	367	8.3	25 / 1.25	13 / 1.04	35 / 1.52	2.9 / 0.07	6 / 0.20	193 / 3.16	13 / 0.27	15 / 0.42	0.9 / 0.01	0 / 0.00	0.1	23		229[a] 211[b]	39	115	0	U.S.G.S.

a. Determined by addition of constituents.
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APPENDIX D (Cont.)

ANALYSES OF GROUND WATER

DEL NORTE COUNTY

Owner and use	State well number and other 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)	Other constituents	Total dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ N.C. ppm	Analyzed by c
						Mineral constituents in parts per million / equivalents per million																	
W. Kiodel	17N/1W-14F1	5/28/52	--	136	7.2	9.6 / 0.48	9.5 / 0.78	6.0 / 0.26	0.4 / 0.01	0 / 0.00	76 / 1.25	1.7 / 0.04	7.5 / 0.21	0.3 / 0.01	0.0 / 0.00	0.16	24		95[a]	17	63	1	U.S.G.S.
Paul E. Johnson Domestic	15E1	7/30/53	--	126	7.0	2.8 / 0.14	12 / 0.99	4.1 / 0.18	0.3 / 0.01	0 / 0.00	60 / 0.98		8.5 / 0.24					Fe (total) 0.0 ppm		14	56	7	U.S.G.S.
		8/30/61	--	136	7.7	5.0 / 0.25	12 / 0.95	4.2 / 0.18	0.3 / 0.01	0 / 0.00	64 / 1.05	3.0 / 0.06	7.0 / 0.20	3.8 / 0.06	0.0 / 0.00	0.04	24	Fe (total) 0.04 ppm Zn 0.08 ppm Cu 0.01 ppm Pb 0.01 ppm d	90[a]	13	60	8	D.W.R.
Paul E. Johnson Abaondoned	15E2	11/29/56	52	145	6.8	3.2 / 0.16	13 / 1.10	5.8 / 0.25	0.4 / 0.01	0 / 0.00	69 / 1.13	1.9 / 0.04	8.0 / 0.23	4.6 / 0.07	0.0 / 0.00	0.04	23		94[a]	16	63	6	U.S.G.S.
		9/14/57	--	130	7.8	2.4 / 0.12	12 / 0.98	5.0 / 0.22	0.5 / 0.01	0 / 0.00	64 / 1.05	0.6 / 0.01	10 / 0.28	1.5 / 0.02	0.0 / 0.00	0.00	25		89[a]	17	55	3	U.S.G.S.
		6/25/58	--	146	8.2	4 / 0.22	13 / 1.08	6 / 0.25	0.3 / 0.01	0 / 0	72 / 1.18	2 / 0.04	9 / 0.28	2 / 0.04	0 / 0	0	14	Fe (dis.) 0 ppm	104[b]	16	65		D.W.R.
		9/30/59	--	136	7.5	2.8 / 0.14	13 / 1.06	5.5 / 0.24	0.5 / 0.01	0 / 0.00	62 / 1.02	3.0 / 0.06	9.5 / 0.27	2.5 / 0.04	0.1 / 0.01	0.0	30	Fe (total) 0.03 ppm	98[a]	17	60	9	U.S.G.S.
H. A. Kortie Domestic	20P1	7/8/53	--	282	7.5	22 / 1.10	16 / 0.32	12 / 0.52	3.2 / 0.08	0 / 0.00	126 / 2.07	22.8 / 0.47	17 / 0.48					Fe (total) 0.8 ppm		17	121	17	U.S.G.S.
	20P2	11/6/62	--	746	8.3	34 / 1.70	41 / 3.37	33 / 1.44	36 / 0.92	0 / 0.00	269 / 4.41	31 / 0.64	61 / 1.72	39 / 0.63	0.3 / 0.02	0.11	38	Fe (total) 0.30 ppm Al 0.03 ppm Zn 0.19 ppm Cu 0.02 ppm Pb 0.02 ppm d	445[a] 496[b]	19	254	34	D.W.R.
D. H. Schroeder Irrigation	25E1	6/13/62	54	248	7.7	18 / 0.90	10 / 0.86	19 / 0.83	1.0 / 0.02	0 / 0.00	132 / 2.16	0.0 / 0.00	13 / 0.37	4.5 / 0.07	0.4 / 0.02	0.15	29		160[a]	32	88	0	D.W.R.
O. B. Herrick Domestic	26R1	8/27/53	--	208	7.0	26 / 1.30	7.3 / 0.60	9.4 / 0.41	0.6 / 0.02	0 / 0.00	123 / 2.02	8.2 / 0.17	6.2 / 0.18	0.2 / 0.00				Fe 3.0 ppm		18	95	0	U.S.G.S.
Ed McLaughlin Abandoned	32M1	8/27/53	--	117	6.7	6.8 / 0.34	8.0 / 0.66	4.1 / 0.18	0.5 / 0.01	0 / 0.00	55 / 0.90	4.3 / 0.09	6.5 / 0.18	1.5 / 0.02				Fe 0.47 ppm		15	50	5	U.S.G.S.
		10/29/58	--	170	7.9	7 / 0.35	14 / 1.15	7 / 0.30	1.9 / 0.05	0 / 0.0	85 / 1.40	5 / 0.10	11 / 0.31	0 / 0.0	0 / 0.0	0.18	17	Fe (dis.) 1.3 ppm	124[b]	16	75		D.W.R.

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b. Gravimetric determination.
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d. Iron (Fe), Aluminum (Al), Arsenic (As), Copper (Cu), Lead (Pb), Manganese (Mn), Zinc (Zn), and Chromium (Cr). Were reported as 0.00 ppm except as noted.

APPENDIX D (Cont.)

ANALYSES OF GROUND WATER

DEL NORTE COUNTY

Owner and use	State well number and other 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)	Other constituents	Total dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$: Total ppm	Hardness as $CaCO_3$: N.C. ppm	Analyzed by c
A. S. Hunter Domestic	17N/1W-34C1	5/27/52	--	103	6.9	4.8 / 0.24	5.8 / 0.48	6.0 / 0.26	2.0 / 0.05	0 / 0.00	42 / 0.69	2.1 / 0.04	9.5 / 0.27	2.9 / 0.05	0.0 / 0.00	0.0	16		70[a]	25	36	1	U.S.G.S.
Irv Hardleben Domestic	34G1	6/14/55	55	134	6.8	7.4 / 0.37	8.3 / 0.68	5.7 / 0.25	0.6 / 0.02	0 / 0.00	45 / 0.74	7.4 / 0.15	8.0 / 0.23	14 / 0.23	0 / 0.00	0.0	16	Fe 0.05 ppm		19	53	16	U.S.G.S.
Ray W. Struebing Domestic	18N/1W-5G1	11/29/56	54	168	6.5	7.6 / 0.38	7.1 / 0.58	14 / 0.61	0.4 / 0.01	0 / 0.00	33 / 0.54	3.8 / 0.08	27 / 0.76	12 / 0.19	0.0 / 0.00	0.04	10		98[a]	39	48	21	U.S.G.S.
		9/11/57	--	168	6.2	6.8 / 0.34	5.1 / 0.42	15 / 0.65	0.8 / 0.02	0 / 0.00	17 / 0.28	4.8 / 0.10	30 / 0.85	13 / 0.21	0.1 / 0.01	0.0	11		95[a]	45	38	24	U.S.G.S.
		8/11/58	--	155	7.5	6.2 / 0.31	4.0 / 0.33	15 / 0.64	0.3 / 0.01	0 / 0	10 / 0.16	5 / 0.11	31 / 0.87	12 / 0.19	0 / 0	0.42	6	Fe (dis.) 0.02 ppm	104[b]	49	32		D.W.R.
		8/27/59	--	106	6.6	7.2 / 0.36	0.7 / 0.6	11 / 0.48	0.7 / 0.02	0 / 0.00	18 / 0.30	1.0 / 0.02	20 / 0.56	1.7 / 0.03	0.2 / 0.01	0.1	14	Fe (total) 0.30 ppm	66[a]	52	21	6	U.S.G.S.
		9/60	--	183	6.8	7.1 / 0.35	5.7 / 0.47	15 / 0.65	0.7 / 0.02	0 / 0.00	12 / 0.20	4.0 / 0.08	31 / 0.87	19 / 0.31	0.0 / 0.00	0.03	10	Fe (total) 0.24 ppm Br 1.1 ppm	98[a]	44	41	31	D.W.R.
		8/30/61	--	174	6.9	8.8 / 0.44	5.1 / 0.42	16 / 0.70	0.7 / 0.02	0 / 0.00	12 / 0.20	4.0 / 0.08	32 / 0.90	21 / 0.34	0.0 / 0.00	0.05	10	Fe (total) 0.18 ppm Zn 0.11 ppm Cu 0.09 ppm Pb 0.03 ppm d		44			
		Summer 1962	--	186	7.4	8.8 / 0.44	5.4 / 0.44	16 / 0.70	0.8 / 0.02	0 / 0.00	16 / 0.26	5.4 / 0.11	31 / 0.87	21 / 0.34	0 / 0.00	0	9.6		106[a] 107[b]	44	44	11	U.S.G.S.
Harvey Wilkins Domestic	8G2	8/20/54	62	102	6.6	5.4 / 0.27	3.5 / 0.29	8.1 / 0.35	0.4 / 0.01	0 / 0.00	25 / 0.41	5.9 / 0.12	12 / 0.34	3.2 / 0.05	0.0 / 0.00	0.14	12	Fe 0.01 ppm Mn 0.02 ppm Zn 2.0 ppm d	62[a]	38	28	8	U.S.G.S.
M. J. Sierka Domestic	17R3	11/29/56	54	215	7.0	11.0 / 0.55	13 / 1.07	14 / 0.61	0.2 / 0.01	0 / 0.00	114 / 1.87	0.0 / 0.00	16 / 0.45	0.1 / 0.00	0.0 / 0.00	0.12	33		143[a]	27	81	0	U.S.G.S.
		12/4/57	--	154	7.6	8.4 / 0.42	8.9 / 0.73	9.5 / 0.41	0.5 / 0.01	0 / 0.00	72 / 1.18	1.9 / 0.04	13 / 0.37	0.3 / 0.00	0.0 / 0.00	0.03	29		107[a]	26	57	0	U.S.G.S.
		10/59	--	254	7.7	14 / 0.70	14 / 1.15	20 / 0.87	0.5 / 0.01	0 / 0.00	139 / 2.28	0.0 / 0.00	16 / 0.45	0.3 / 0.00	0.0 / 0.00	0.0	17	Fe 7.5 ppm	150[a]	32	93	0	D.W.R.
		8/30/61	--	213	7.0	16 / 0.80	7.8 / 0.64	18 / 0.78	0.5 / 0.01	0 / 0.00	109 / 1.79	1.0 / 0.02	13 / 0.37	0.4 / 0.01	0.1 / 0.00	0.09	35	Fe (total) 3.5 ppm Zn 0.11 ppm Cu 0.05 ppm Pb 0.03 ppm d	146[a]	35	72	0	D.W.R.

a. Determined by addition of constituents.
b. Gravimetric determination.
c. Analysis by U.S. Geological Survey, Quality of Water Branch (U.S.G.S.), or State Department of Water Resources (D.W.R.), as indicated.
d. Iron (Fe), Aluminum (Al), Arsenic (As), Copper (Cu), Lead (Pb), Manganese (Mn), Zinc (Zn), and Chromium (Cr). Were reported as 0.00 ppm except as noted.

APPENDIX D (Cont)

ANALYSES OF GROUND WATER

DEL NORTE COUNTY

Owner and use	State well number and other 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)	Other constituents	Total dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ N.C. ppm	Analyzed by c
						Mineral constituents in parts per million / equivalents per million																	
M. J. Sierka Domestic	18N/1W-17R2	10/29/58	--	212	7.8	11 0.54	13 1.10	12 0.52	0.0 0.00	0 0.00	104 1.70	0.0 0.00	17 0.49	0 0.00	0.18 0.01	0.0	30		149[a]	24	82		D.W.R.
		8/27/59	--	203	7.9	11 0.55	13 1.07	12 0.52	0 0.00	0 0.00	108 1.77	0.6 0.01	13 0.37	0.1 0.00	0.0 0.00	0.0	34		137[a]	24	81	0	D.W.R.
		8/30/61	--	211	7.4	24 1.20	2.9 0.24	18 0.78	0.5 0.01	0 0.00	109 1.79	1.3 0.03	13 0.37	1.0 0.02	0.1 0.00	0.09	34	Fe (total) 3.9 ppm Cu 0.05 ppm Pb 0.02 ppm d	149[a]	35	72	0	D.W.R.
A. W. Pemberton	25N1	8/21/52	--	58	6.6	4.8 0.24	1.7 0.14	5.0 0.22	0.6 0.02	0 0.00	21 0.34	6.4 0.04	8.0 0.23	1.1 0.18	0.0 0.00	0.1	10			35	19	2	D.W.R.
Arnold Samuelson Irrigation	26D1	11/28/56	54	66	6.4	2.8 0.14	3.2 0.26	6.8 0.30	0.2 0.01	0 0.00	24 0.39	1.0 0.02	6.5 0.18	6.5 0.10	0.0 0.00	0.07	14		53[a]	42	20	0	U.S.G.S.
		10/2/57	--	84	6.7	2.8 0.14	2.7 0.22	9.2 0.40	0.6 0.02	0 0.00	26 0.43	1.9 0.04	7.5 0.21	6.5 0.10	0.0 0.00	0.01	13		57[a]	51	18	0	U.S.G.S.
		9/4/58	--	66	7.7	1 0.04	3 0.25	7.0 0.29	0.3 0.01	0 0.00	17 0.29	1 0.02	7 0.21	7 0.11	0.0 0.00	0.10	16		44[b]	49	14		D.W.R.
Arnold Samuelson Domestic	26D2	8/30/61	--	101	6.1	5.5 0.27	3.8 0.31	6.3 0.27	0.3 0.01	0 0.00	10 0.16	1.6 0.03	9.0 0.25	26 0.42	0.0 0.00	0.06	12	Fe (total) 0.08 ppm Zn 0.07 ppm Cu 0.05 ppm Pb 0.03 ppm d	70[a]	31	29	21	D.W.R.
		9/15/62	--	124	7.0	6.8 0.34	4.9 0.40	8.2 0.36	0.5 0.01	0 0.00	9.0 0.15	0.6 0.01	10 0.28	42 0.68	0 0.00	0.09	11		88[a] 100[b]	32	37	30	D.W.R.
C. A. Brogan Domestic	27F1	7/30/53	--	72	6.0	3.6 0.18	2.8 0.23	5.0 0.22	0.3 0.01	0 0.00	17 0.28	--	7.2 0.21					Fe 0.2 ppm		35	20	7	U.S.G.S.
		6/12/62	56	84	6.4	5.7 0.28	2.7 0.22	5.1 0.22	0.4 0.01	0 0.00	14 0.23	0.3 0.01	7.3 0.20	17 0.27	0.0 0.00	0.05	11		57[a]	30	25	14	D.W.R.
N. C. Jepson Domestic, Stock	34M2	7/30/53	56	332	7.2	11 0.55	36 2.96	3.4 0.15	0.5 0.01	0 0.00	208 3.41	--	6.2 0.18					Fe 0.00 ppm		4	176	5	U.S.G.S.
		8/20/54	56	341	8.0	8.9 0.44	39 3.24	3.2 0.14	0.5 0.01	0 0.00	216 3.54	6.6 0.14	6.0 0.17	3.2 0.05	0.1 0.01	0.05	38	Fe 0.01 ppm Cr 0.01 ppm	212[a]	4	184	7	U.S.G.S.
		8/11/58	--	348	8.3	13 0.65	39 3.15	4 0.18	0.7 0.02	0 0.00	224 3.66	0 0.00	9 0.25	6 0.09	0 0.00	0.34	4		274[b]	4	190		D.W.R.

a. Determined by addition of constituents.
b. Gravimetric determination.
c. Analysis by U.S. Geological Survey, Quality of Water Branch (U.S.G.S.).
or State Department of Water Resources (D.W.R.), as indicated.
d. Iron (Fe), Aluminum (Al), Arsenic (As), Copper (Cu), Lead (Pb), Manganese (Mn), Zinc (Zn), and Chromium (Cr). Were reported as 0.00 ppm except as noted.

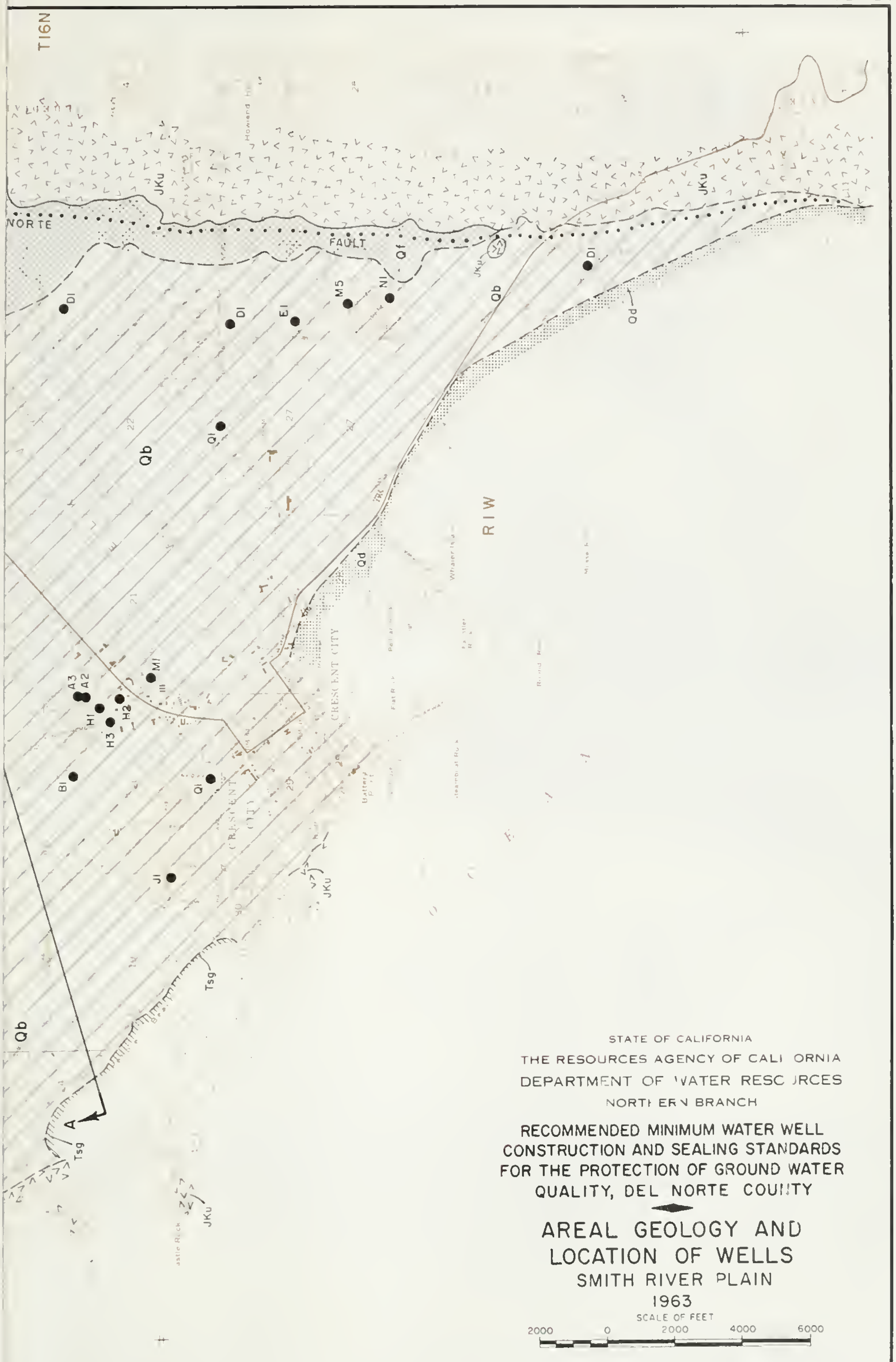
APPENDIX D (Cont.)

ANALYSES OF GROUND WATER

DEL NORTE COUNTY

Owner and use	State well number and other 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)	Other constituents	Total dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$ Total ppm	Hardness as $CaCO_3$ N.C. ppm	Analyzed by c
						Mineral constituents in parts per million / equivalents per million																	
N. C. Jepson Domestic, Stock	18N/1W-34M2	9/3/59	--	329	8.3	12 / 0.60	36 / 2.95	4.3 / 0.19	0.7 / 0.02	3 / 0.10	205 / 3.36	4.0 / 0.08	4.0 / 0.11	5.1 / 0.08	0 / 0.00	0.0	37	Fe 0.02 ppm	207[a]	5	178	5	D.W.R.
		9/30/60	--	381	8.4	13 / 0.65	42 / 3.45	3.8 / 0.16	0.7 / 0.02	2 / 0.07	232 / 3.80	4.6 / 0.10	5.0 / 0.14	4.7 / 0.08	0 / 0.00	0.05	39	Fe 0.03 ppm Br 0.5 ppm	229[a]	4	205	11	D.W.R.
		8/30/61	--	356	7.6	15 / 0.75	37 / 3.07	3.8 / 0.16	0.8 / 0.02	0 / 0.00	222 / 3.64	3.8 / 0.08	5.8 / 0.16	5.3 / 0.08	0 / 0.00	0.07	40	Fe 0.02 ppm Zn 0.07 ppm Pb 0.02 ppm d	221[a]	4	191	9	D.W.R.
		9/7/62	--	343	8.2	14 / 0.70	36 / 2.99	3.7 / 0.16	0.8 / 0.02	0 / 0.00	222 / 3.64	5.0 / 0.10	6.7 / 0.19	5.1 / 0.08	0.0 / 0.00	0	37		217[a] 192[b]	4	184	2	U.S.G.S.
United Lily Growers Irrigation	35B2	11/28/56	54	69	7.0	4.4 / 0.22	2.4 / 0.20	5.9 / 0.26	0.2 / 0.01	0 / 0.00	27 / 0.44	1.9 / 0.04	6 / 0.17	2.0 / 0.03	0 / 0.00	0.05	14		50[a]	38	21	0	U.S.G.S.
		9/13/57	--	78	7.0	5.2 / 0.26	2.2 / 0.18	6.5 / 0.28	0.6 / 0.02	0 / 0.00	25 / 0.41	1 / 0.02	7.4 / 0.21	5.4 / 0.09	0 / 0.00	0 / 0.00	17		57[a]	38	22	2	U.S.G.S.
Irwin McIndoe	35G1	7/29/53	--	83	6.6	7.2 / 0.36	2.6 / 0.21	5.0 / 0.22	0.4 / 0.01	0 / 0.00	32 / 0.52		7.0 / 0.20					Fe 0.3 ppm		27	29	2	U.S.G.S.
T. F. McKenna Domestic	19N/1W-32L1	8/20/54	60	127	6.8	6.1 / 0.30	4.6 / 0.38	12 / 0.52	0.4 / 0.01	0 / 0.00	28 / 0.46	3.3 / 0.07	24 / 0.68	2.8 / 0.04	0.1 / 0.01	0.03	11	Fe 0.01 ppm Al 0.005 ppm Zn 1.0 ppm Cr 0.000 ppm d	78[a]	43	34	11	U.S.G.S.
Simonson Logging Co. Abandoned	33F1	6/7/55	64	46	6.5	1.4 / 0.07	1.2 / 0.10	5.0 / 0.22	0.5 / 0.01	0 / 0.00	6 / 0.1	4.4 / 0.09	5.9 / 0.17	3.3 / 0.05	0.1 / 0.01	0.09	8	Fe (total) 0.1 ppm		54	9	4	D.W.R.

a. Determined by addition of constituents.
b. Gravimetric determination.
c. Analysis by U.S. Geological Survey, Quality of Water Branch (U.S.G.S.), or State Department of Water Resources (D.W.R.), as indicated.
d. Iron (Fe), Aluminum (Al), Arsenic (As), Copper (Cu), Lead (Pb), Manganese (Mn), Zinc (Zn), and Chromium (Cr). Were reported as 0.00 ppm except as noted.



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DEPARTMENT OF WATER RESOURCES
NORTHERN BRANCH

RECOMMENDED MINIMUM WATER WELL CONSTRUCTION AND SEALING STANDARDS FOR THE PROTECTION OF GROUND WATER QUALITY, DEL NORTE COUNTY

AREAL GEOLOGY AND LOCATION OF WELLS
SMITH RIVER PLAIN
1963

PLATE I

T18N
T17N
T16N
R1W
DEL NORTE FAULT
Qal
Qf
Qd
Qb
JKu
LEGEND
DUNE SAND
FLOOD-PLAIN AND STREAM CHANNEL DEPOSITS
QUATERNARY
TERRACE DEPOSITS
BATTERY FORMATION
TERTIARY
JURASSIC-CRETACEOUS
A
A'
ELEVATION IN FEET - U.S.C.&G.S. DATUM
LENGTH IN THOUSAND FEET
GEOLOGIC SECTION A-A'
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LEGEND

Qal — ALLUVIAL VALLEY FILL
UNCONSOLIDATED DEPOSITS OF SAND, SILT, AND GRAVEL IN RIVER TERRACES, FLOOD PLAINS, AND STREAM CHANNELS. HIGHLY PERMEABLE AND YIELDS MODERATE TO LARGE QUANTITIES OF WATER TO WELLS

JKu — BEDROCK SERIES
CONSOLIDATED SERIES OF HIGHLY DEFORMED SANDSTONE, SHALE, AND GREENSTONE. MAY YIELD SMALL QUANTITIES OF WATER TO SHALLOW WELLS

GEOLOGIC CONTACT

● F2 WATER WELL WITH MINERAL ANALYSIS

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AREAL GEOLOGY AND LOCATION OF WELLS
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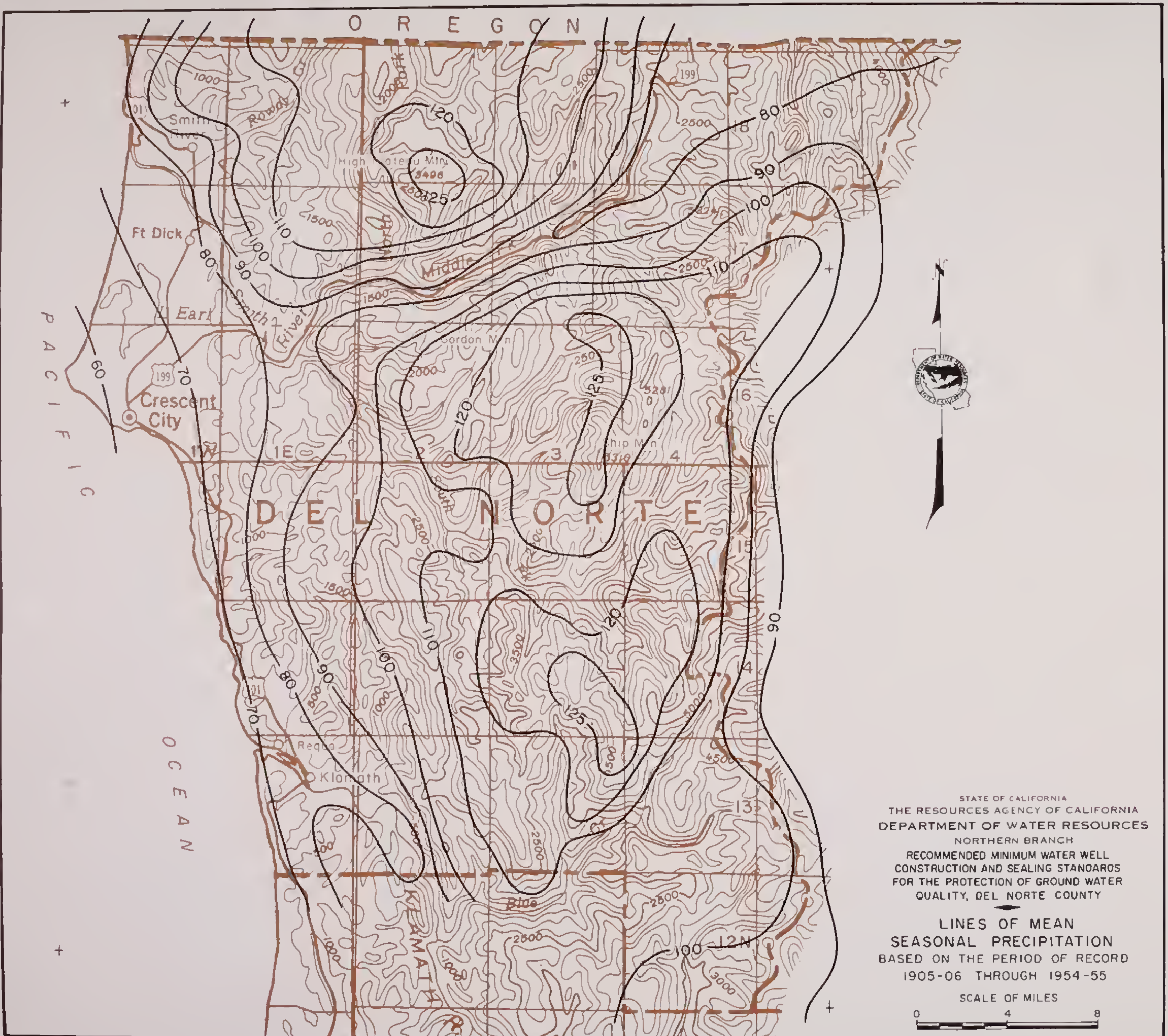
1963

SCALE OF FEET
2000 0 2000 4000 6000



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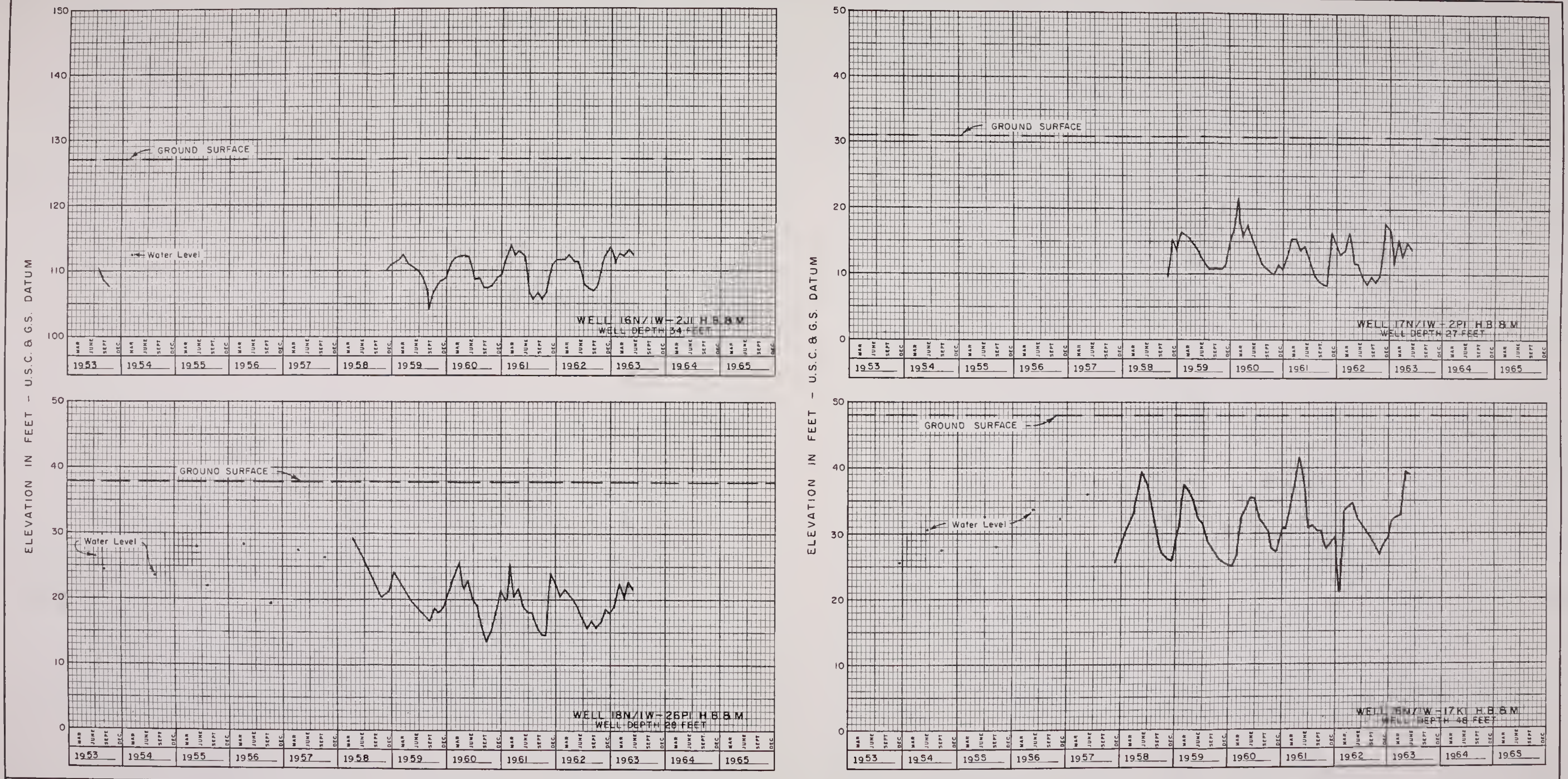
LINES OF MEAN SEASONAL PRECIPITATION
BASED ON THE PERIOD OF RECORD 1905-06 THROUGH 1954-55

SCALE OF MILES



FLUCTUATION OF WATER LEVEL IN WELLS IN DEL NORTE COUNTY

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