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Geological Survey

Preliminary report on water-storage capacity of unconsolidated deposits beneath the Lompoc Plain, Santa Barbara County, California

by

Joseph E. Upson

Prepared in cooperation with the U. S. Engineer
Office at Los Angeles and with the
County of Santa Barbara, California

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ILLUSTRATIONS

Preliminary report on water-storage capacity of unconsolidated deposits beneath the Lompoc Plain, Santa Barbara County, California

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Introduction

General geographic and hydrologic features

The Lompoc Plain is the central lowland of a topographic and structural basin that forms the western and lower part of the Santa Ynez Valley in Santa Barbara County, California. It extends inland about 11 miles from the coast and is from 1 mile to about 3 miles wide (see pl. 1).

Plate 1. - Preliminary geologic map of the Lompoc Basin.

This plain, the principal agricultural area of the Santa Ynez Valley, is underlain by unconsolidated deposits which store a considerable volume of water and whose most permeable beds yield water freely to about 110 irrigation wells. These unconsolidated deposits rest on consolidated and semi-consolidated rocks which are essentially impermeable and which crop out in the hills and mesas that almost entirely surround the Lompoc Plain.

The Santa Ynez River enters the Lompoc Plain at its southeast corner through the "Narrows" at the downstream end of a canyon reach which is carved in the consolidated rocks of the Santa Rita Hills. This canyon is here termed the "Santa Rita Canyon". Westward from the Narrows, the river traverses the plain in a relatively broad trench no more than 45 feet deep, and enters the ocean near Surf. In recent dry years, this stream ordinarily has flowed perennially in relatively short reaches at the upstream and downstream ends of the Lompoc Plain; in the reach through the central part of the plain it commonly has been intermittent. Tributaries to the Santa Ynez River enter the Lompoc Plain at the heads of alluvial fans which form the marginal parts of the plain. All these streams have drainage areas of only a few square miles and are intermittent within the area of the plain. Those from the north drain a terrane underlain by unconsolidated alluvial deposits; those from the south drain the consolidated rocks of the foothills. Upon entering the Lompoc Plain all these streams lose a portion of their flow by infiltration into the unconsolidated deposits.

Purpose and scope of the report

This report presents geologic and hydrologic data bearing on the volume of water-bearing deposits beneath the Lompoc Plain, the proportion of those deposits that is seasonally unwatered by natural discharge and by pumping from wells, and, accordingly, the extent to which the deposits can be utilized for storing flood water of the Santa Ynez River. As the data on which the report is based are largely qualitative, the conclusions determined are also largely qualitative.

Acknowledgments

The basic data have been gathered by the Geological Survey in cooperation with the United States Engineer Office and with the County of Santa Barbara in a county-wide inventory of water resources. The work is under the direction of A. M. Piper, Senior Geologist in charge of ground-water investigations in the Pacific coast area, who has ~~critically~~ constructively reviewed ~~and revised~~ the manuscript in its various stages. Geologic mapping was begun by G. F. Brown and completed by the writer. The writer is indebted to A. M. Piper and to G. A. La Rocque, Jr., for clarification and thorough discussion of the hydrologic relationships expressed. The report has been improved as a result of criticism by O. E. Meinzer, Geologist in charge of the Division of Ground Water of the Geological Survey, and by L. K. Wenzel.

Character, extent, and water-bearing properties of the unconsolidated deposits

General features

With respect to water-bearing properties the geologic formations of the Lompoc Plain and its vicinity may be divided into consolidated rocks which are essentially impermeable and unconsolidated deposits in which certain coarse-grained members are moderately to highly permeable.

The consolidated rocks include siliceous and diatomaceous shale, siltstone, and mudstone. These rocks comprise several formations which underlie the unconsolidated deposits of the Lompoc Plain, and crop out in the Purisima Hills, the Santa Rita Hills, and the foothills of the Santa Ynez Range. They lie at shallow depth beneath the surface of the Burton Mesa and the northern part of the Lompoc Terrace. On plate 1 these formations are grouped together as Tertiary rocks, undivided. As they are fine-grained and firmly consolidated, they are essentially impermeable; probably they neither yield water to the overlying unconsolidated deposits nor take up water from them in material volume.

The unconsolidated deposits are here divided into six formations, of which four contain extensive water-bearing strata. In order of increasing age these four formations are river-channel deposits, younger alluvium, older alluvium, and the so-called "Careaga sand" of local petroleum geologists. In general, the extensive water-bearing strata in these four formations can be grouped into three zones, which are designated in this report as the main, secondary, and shallow water-bearing zones. The other two unconsolidated formations are terrace deposits and eolian deposits which locally conceal the water-bearing formations in whole or in part, but which generally are above the zone of saturation and are not known to be tapped for water supplies. They are not discussed further in this report.

Plate 1 shows the areal distribution of the unconsolidated formations and of the undifferentiated consolidated formations in and adjacent to the Lompoc Plain. Plates 2 and 3 show the inferred

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Plate 2. - Longitudinal section of the Lompoc Plain.
Plate 3. - Transverse sections of the Lompoc Plain.

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relationships of the geologic formations and the water-bearing zones to one another and to the impermeable consolidated rocks beneath the plain; also their subsurface characteristics as far as known. The formations and zones are described in detail beyond.

River-channel deposits

The river-channel deposits underlie and form the flood channel of the Santa Ynez River. With the river they traverse the Lompoc Plain in a winding band, ranging from about 300 feet to about 2,500 feet wide, which extends from within the Santa Rita Canyon and the Narrows to a point about 1½ miles from the sea. There they merge with the tidal deposits of the river estuary. The river-channel deposits fill a shallow channel incised in the Lompoc Plain and their surface ranges from about the level of the plain at the ocean to as much as 45 feet below the Plain at the Narrows. The deposits occur only within the channel and do not pass beneath the Lompoc Plain. Their thickness ranges from a feather edge to an estimated maximum in the order of 30 feet.

As inferred from their surface features, these deposits consist primarily of lenses of cross-bedded coarse sand and gravel. The material is somewhat coarser in the Santa Rita Canyon and the eastern part of the Lompoc Plain, where it is almost all gravel. Near the ocean the material is mainly sand. Thus, the river-channel deposits doubtless transmit water freely. Within the area of the Lompoc Plain they are not tapped by known used wells. Nevertheless, they constitute the most extensive single member of the so-called shallow water-bearing zone, which is defined and described beyond.

Younger alluvium

The younger alluvium underlies and forms the surface of the Lompoc Plain, which comprises the extensive central level plain and marginal alluvial fans. The formation also underlies certain low depositional terraces that are continuous with the Lompoc Plain, but extend beyond it as narrow tongues along the Santa Ynez River and tributary streams.

The younger alluvium occupies and partly fills a system of valleys previously eroded in the underlying older alluvium, Careaga sand, and undivided Tertiary rocks. Certain existing canyons - Santa Rita Canyon, San Miguelito Canyon, Lompoc Canyon, and others - are visible upper portions of this former valley system. The formation consists of three members: a lower member of gravel, a middle member of tough clay, loose clay and silt, and an upper member of clay, silt, and sand with a few small bodies of pebble gravel. It is thickest, about 200 feet, below the central and northern parts of the Lompoc Plain (pl. 2); to the north and south it laps upon and abuts against the hills and terraces composed of older formations. Tongues of the formations extend several miles eastward from the plain, into and possibly through the Santa Rita Canyon; also northward and southward into the canyons of tributary streams.

The lower member of the younger alluvium is nowhere exposed but from reports by drillers, from the large yield of some wells that tap the zone, and from well-rounded cobbles as much as 3 inches in diameter obtained in drilling wells 7/34-19J1[1] and 7/34-19L1[1], it is inferred to consist of

1/ The symbol used to designate a well shows the location of that well according to the rectangular system for subdivision of public land. Thus, the part of the symbol that precedes the hyphen indicates the township and range (T.7 N., R.34 W.). The one digit or two digits following the hyphen indicate the section (sec. 19), and the letter indicates the 40-acre subdivision of the section as shown in the accompanying diagram.

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

Within each 40-acre tract the wells are numbered serially as indicated by the final digit of the symbol. Thus, well 19J1 is the first well to be listed in the NE¼ SE¼ of sec. 19. As virtually all of Santa Barbara County is in the northwest quadrant of the San Bernardino Meridian and Base line, the foregoing abbreviation is specific for the County. Some parts of the County have never been public land; for these the rectangular system of subdivision has been projected.

lenses of coarse gravel containing cobbles and boulders, doubtless some sand, but relatively little silt or clay. This member underlies nearly the full length of the Lompoc Plain and there appears to be fairly uniform in composition; it does not occur beneath the extreme eastern end of the plain north of the western terminus of the Santa Rita Hills, nor beneath the southernmost part of the plain in a discontinuous band from 1 mile to 1½ miles wide. It yields water more copiously than other water-bearing strata of the area, and is the chief source of water for most of the irrigation wells on the plain. Therefore, this member, together with certain discontinuous permeable strata at the base of the middle member, is designated as the main water-bearing zone of the area. (See pl. 2.)

This main water-bearing zone, essentially the lower member of the younger alluvium, occupies the lower part of the former valley in which the younger alluvium was deposited. Plate 4 shows the extent and

Plate 4. - Map of the Lompoc Plain showing tentative contours on the top and base of the main and secondary water-bearing zones.

thickness of the zone beneath the Lompoc Plain. It extends upstream for several miles through the Narrows and into the Santa Rita Canyon. Lateral tongues may extend into the former tributary valleys beneath the south edge of the Lompoc Plain, but the existence of such tongues is not clearly demonstrated by records of wells now available. The thickness of the zone ranges from a feather edge to at least 120 feet (pl.4), although the greatest thickness in the extreme western part of the area is not known and may exceed 120 feet. As computed from the contour lines on plate 4, the volume of the main water-bearing zone is approximately 425,000 acre-feet.

The middle member of the younger alluvium is a wedge-shaped body intervening between the lower and upper members beneath the central and western parts of the Lompoc Plain. Like the lower member, it is known only from well records. These show that the member is composed largely of tough clay and sandy clay or silt, which occur in extensive lenses from 10 feet to about 60 feet thick. (See pls. 2 and 3.) The record of well 7/35-25P1, one exception, shows sand and gravel through most of the upper part of the younger alluvium. However, because this well was drilled by the rotary method its anomalous record may not indicate the true nature of the materials penetrated. The lenses of clay and silt are thickest beneath the central and western parts of the Lompoc Plain and form an essentially continuous blanket as much as 100 feet thick at places, which rests on and almost entirely covers the lower gravel member. More specifically, this blanket is inferred to be essentially continuous beneath the northern two-thirds of the Lompoc Plain from the ocean eastward to about the line between secs. 26 and 27, T.7 N., R.34 W. - that is, over nearly the full extent of the lower member. The approximate outline of the blanket is shown on plate 1 by a dashed line, which marks a zone of transition rather than a sharp boundary. Beyond this boundary, the younger alluvium is represented chiefly by the upper member.

Silt transmits water very slowly under hydraulic gradients of ordinary magnitude, and compact tough clay transmits essentially no water. Therefore, the fine-grained materials that compose the middle member of the younger alluvium are essentially non-water-bearing. They do not yield water to wells and intercept water moving downward from the land surface. Instead, below most of the Lompoc Plain the extensive blanket of these materials already described confines water under pressure head in the lower member of the younger alluvium.

Lenses of gravel at the base of the middle member of the younger alluvium yield appreciable quantities of water. These are continuous with the lower member of the formation and for convenience are included in the main water-bearing zone.

The upper member of the younger alluvium consists mainly of fine-grained materials, but not so fine nor compact as those of the middle member. The upper member is about 80 feet in maximum thickness, of which about the upper 45 feet are exposed in places in the banks of the Santa Ynez River channel. These beds are of unstratified or indistinctly stratified clay, silt, and fine sand with enclosed stringers of pebbles at a few places. They are thus generally fine-grained, but are loose, and hence probably capable of transmitting water slowly.

Although largely fine-grained, the upper member of the younger alluvium contains some coarse-grained strata. According to drillers' records, bodies of coarse sand and gravel are widespread in the upper 50 to 60 feet of the upper member, but ordinarily are overlain by "soil", "sandy soil" or "sand", - that is, by materials similar to those exposed along the river channel. Along the margins of the Lompoc Plain, particularly near the mouths of foothill canyons, the fine-grained beds of the upper member finger into coarse-grained materials. For example, wells 6/34-2A1 and 7/34-35E1, in and near the Narrows, penetrate thick beds of sand and gravel but only thin beds of clay (see pl. 2). Thus, in the Santa Rita Canyon the river-channel deposits seem to rest directly on coarse materials that are part of or are vertically continuous with the lower member of the younger alluvium. (See pls. 2, 3.)

Certain of the lenses of permeable material in the upper 50 to 60 feet of the central part of the upper member probably are connected with each other and with the river-channel deposits. With the river-channel deposits they appear to contain a common ground-water body. The materials to which this water body is common are here considered to constitute a single water-bearing zone, designated as the shallow zone.

In continuity and water-yielding capacity this shallow water-bearing zone is decidedly inferior to the main water-bearing zone (pp. 8 and 9) and the secondary zone to be described (p. 13). The channel deposits that form a part of the shallow zone are not tapped by known used wells, but the adjacent parts of the zone beneath the Lompoc Plain are tapped by many wells for small domestic and stock supplies. Because after about 20 years of intensive agricultural development on the Lompoc Plain no irrigation wells tap the shallow zone, it is inferred that this zone is incapable of yielding supplies adequate for irrigation.

The volume of the shallow water-bearing zone was not computed, but is estimated to be in the order of 81,500 acre-feet, as the zone apparently underlies nearly all 16,300 acres of the Lompoc Plain, and is assumed to be 5 feet thick on the average.

Older alluvium

The older alluvium is a body of sand and gravel which crops out in certain terraces and foothills bordering the Lompoc Plain and which is as much as 300 feet thick. In most of these outcrops the strata of the older alluvium dip toward the plain; several lobes of the formation extend beneath the younger alluvium which forms the plain. (See pls. 2, 3, 4.)

The older alluvium is tapped by a moderate number of wells, nearly all where it is overlain by the younger alluvium. There, as shown by records of wells (pls. 2,3), the older alluvium consists largely of sand and clay, or clayey sand, but also contains beds of gravel. These beds are believed to constitute a basal gravel member. In general, the older alluvium is unconsolidated, but its predominant fine-grained beds contain sufficient clay and silt that their pore spaces are small and do not yield water readily to wells. On the other hand, the basal gravel member is relatively coarse-grained and yields large quantities of water to some irrigation wells. This member is less permeable, thinner, and less continuous than the main water-bearing zone of the younger alluvium, but nevertheless is the principal source of water in the easternmost and south-central parts of the Lompoc Plain, where the main zone is absent.

The basal gravel member of the older alluvium, just described, is therefore designated as the secondary water-bearing zone. Its extent and thickness are shown on plate 4; its volume is computed as about 105,000 acre-feet.

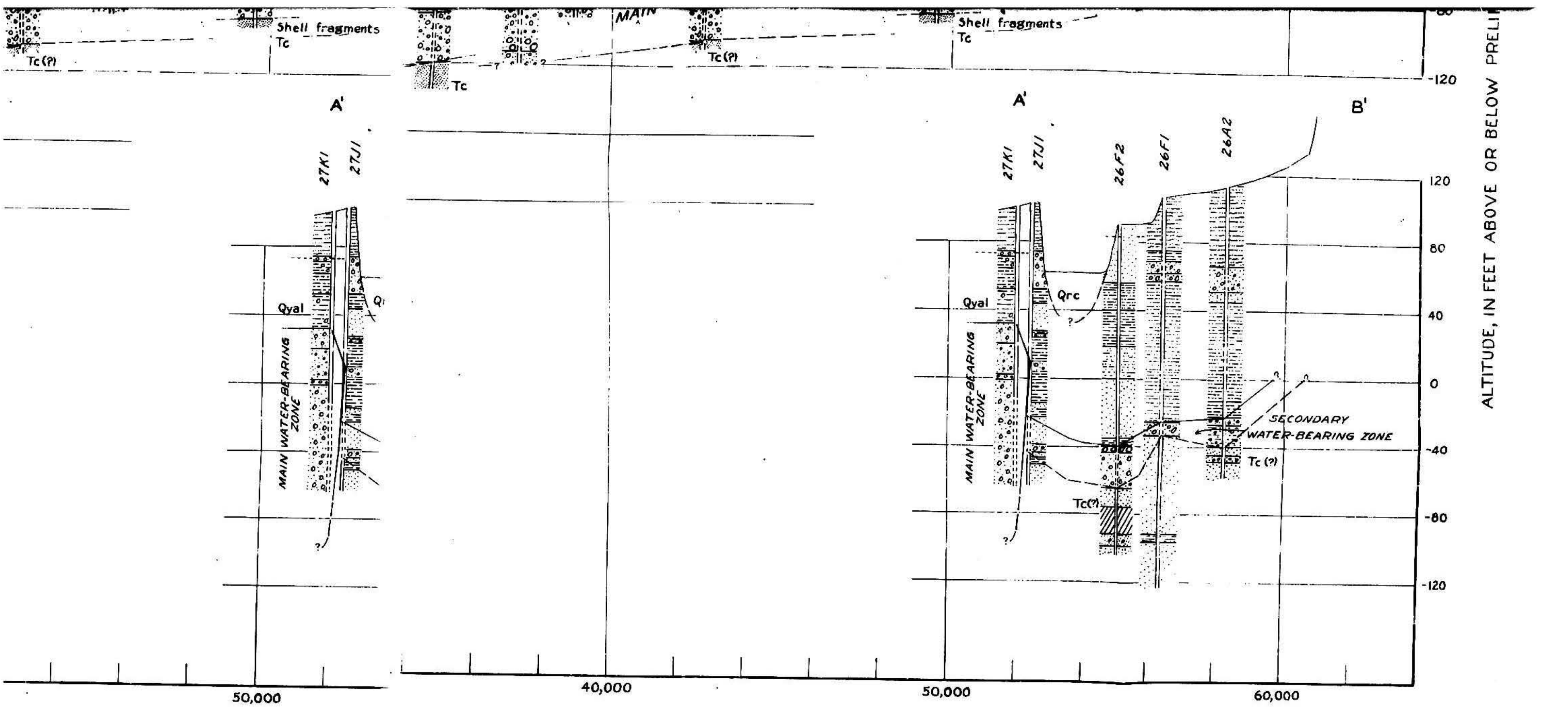
Careaga sand

The so-called Careaga sand of local petroleum geologists is the basal formation of the unconsolidated deposits, and lies on the consolidated Tertiary rocks. This formation is dominantly of sand, fine to coarse in size of grain, but locally it contains scattered pebbles, pebbly stringers, shell fragments, and some gravelly zones that contain numerous fossil shells. The formation crops out in outlying foothill areas and underlies parts of the Lompoc Plain. Beneath the plain, it lies directly beneath the older alluvium at some places; beneath the younger alluvium at other places.

At the land surface, the Careaga sand is somewhat consolidated, but as encountered in wells beneath the Lompoc Plain is loose and saturated with water. So far as known it does not yield water directly to existing deep wells most of which are cemented shut at the top of the formation. However, the formation is in direct contact with both the main and secondary water-bearing zones of the overlying alluvial deposits and the water that it contains may help to sustain the draft from those overlying zones.

Volume of water-bearing deposits

As computed from their form, shown in large part on plate 4, all the unconsolidated deposits beneath the Lompoc Plain and above the Careaga sand - in other words, the materials generally penetrated by wells - have an aggregate volume of about 2,051,000 acre-feet. The main and secondary water-bearing zones, which supply nearly all the water derived from wells on the plain together have a volume of about 530,000 acre-feet, or about 26 percent of the total volume of the unconsolidated deposits; all three water-bearing zones considered in this report, including the shallow zone, have about 30 percent of the total. In other words, the material which transmits water readily, and therefore which may receive and store surface water, constitute not more than about 30 percent of the unconsolidated deposits beneath the Lompoc Plain.



THE LOMPOC PLAIN

UNPUBLISHED RECORDS
SUBJECT TO REVISION

Effectiveness of the several water-bearing zones in detaining flood run-off of the Santa Ynez River

As has been indicated, the coarse-grained members of the deposits beneath the Lompoc Plain, which transmit water readily, and which sustain nearly all the water wells drilled on the plain, comprise three water-bearing zones. In order of relative productiveness of water to wells, these zones are: (1) a main water-bearing zone, which comprises the lower member of the younger alluvium and adjoining lenses of gravel at the base of the upper member, (2) a secondary zone, which is the basal gravel member of the older alluvium, and (3) a shallow zone which comprises the river-channel deposits and lenses of permeable material in the uppermost member of the younger alluvium.

Under natural conditions the water in these three zones is in constant motion through the zones to natural outlets and to points of artificial discharge at wells. The water so discharged from the zones is replenished in part from the Santa Ynez River, in part from tributary streams that enter the Lompoc Plain, in part from rainfall on the plain, and probably in part from certain underground sources. Thus all three zones contain water derived in considerable part from the streams.

It has been suggested that the capacity of these three zones to hold water be utilized to lessen flood discharge in the lower Santa Ynez River. To accomplish this purpose it is obviously necessary that during the period of flood discharge there exist in one or more of the zones, below the profile of the river, unwatered permeable material in a volume sufficient to store the flood water desired to be detained. Also, that the water so stored be discharged before the next flood. These general requirements hold whether or not the rate and duration of the flood run-off at the Narrows is regulated by flood-control works upstream. The extent to which the withdrawal of water from wells unwaters permeable materials prior to flood run-off depends on the mode of occurrence of water in the several water-bearing zones and on the manner of their replenishment. These hydrologic features are discussed in the ensuing paragraphs.

Main water-bearing zone

Occurrence of water. - With respect to the occurrence of ground water, the main water-bearing zone may be considered in three distinct parts: (1) a principal segment in which the zone is overlain by a continuous blanket of impermeable materials and which extends beneath nearly the full length of the Lompoc Plain (see pls. 1, 4); (2) a secondary segment or tongue that extends southeastward through the Narrows into the Santa Rita Canyon; and (3) several subsidiary tongues or lobes that are inferred to extend toward San Miguelito, San Pascual, Rodeo, and Lompoc Canyons along the south margin of the zone.

In the principal segment water is effectively confined by the clay and silt of the overlying middle member of the younger alluvium. In the eastern part of the plain the water of this segment rises in wells to within 35 to 40 feet of the land surface, or about 80 feet above the bottom of the confining member; in the western part, as in well 7/35-18J1, to within 2 to 5 feet of the land surface or about 120 feet above the bottom of the confining member. (See pls. 2, 3.)

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In most parts of the segment that extends as a tongue into the Santa Rita Canyon, water is unconfined. Except as modified by draft from wells, the head of water in this segment of the main zone tends to adjust itself to the stage of the Santa Ynez River close at hand. Locally, however, the water is confined beneath relatively impermeable beds in the terrace deposits along the river channel within the Santa Rita Canyon.

In the discontinuous lobes inferred to exist along the south margin of the main water-bearing zone, ground water is probably confined as in the principal segment; but in the southward extensions of these lobes, beneath the headward portions of the marginal alluvial fans, the water is probably unconfined and its head tends to adjust itself to the stage of the respective intermittent streams.

Replenishment of the zone. - The main water-bearing zone acts essentially as a conduit through which water moves, generally westward according to the hydraulic gradient, and is discharged through natural submarine outlets off the mouth of the Santa Ynez River, also artificially through wells. Water so transmitted through the zone is belived to be replaced from three principal sources: (1) from the Santa Ynez River and the shallow water-bearing zone, by percolation downward through and from the river-channel deposits in the Santa Rita Canyon and at the extreme southeastern end of the Lompoc Plain; (2) from tributary streams, by percolation through and from permeable deposits at the mouths of the several canyons along the south margin of the Lompoc Plain, and (3) from contiguous parts of the older alluvium and of the Careaga sand by transfer of water under ground.

There are two lines of evidence that replenishment from the Santa Ynez River can take place only in the easternmost part of the area. These lines of evidence are based on the physical character of the unconsolidated materials and on the heads of the several water bodies.

The blanket of impermeable material that overlies and confines the water in the principal segment of the main water-bearing zone essentially prevents vertical downward percolation of water from the river or from ~~the~~ the shallow water-bearing zone. Likewise, beyond the limit of the deeper-lying impermeable blanket (pl. 1), moderately permeable materials in the uppermost part of the younger alluvium that forms terraces along the river channel within the Santa Rita Canyon, the Narrows, and in a small contiguous part of the Lompoc Plain, permit only slow passage of water from the land surface to the main zone. Thus, it appears that water can percolate vertically downward to the main water-bearing zone chiefly from the Santa Ynez River through the river-channel deposits and from that source essentially only where the channel deposits and the main zone are not separated by extensive impermeable beds. As indicated on plate 4, such conditions are inferred to exist only within the Santa Rita Canyon, through the Narrows, and downstream along the river to a point about 3,000 feet beyond Robinson Bridge. In the area between this point and the edge of the impermeable blanket, some water may percolate slowly to the main water-bearing zone from the shallow zone. However, such percolation is small in amount, and is subject to the existance of a favorable head differential between the shallow and deep water. This relationship is discussed in the next paragraph.

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Preliminary data on the head of the ground water, as indicated by water levels in wells, show that under natural conditions the head of water in the main water-bearing zone has been and is higher than the river over all the principal segment of the main zone, and higher than the head of unconfined water in the shallow water-bearing zone over that segment except in a small area off the mouth of San Miguelito Canyon. Over nearly all the principal segment of the main zone, therefore, the head differential favors vertical movement of water upward from the zone rather than downward to the zone. The decline in head that accompanies draft from wells is insufficient to reverse the differential in most of this area. On the other hand, the head of water in the main water-bearing zone has been equal to or less than that in the shallow water-bearing zone and lower than the river in the area that begins about a mile below Robinson Bridge and extends upstream into the Santa Rita Canyon. In this area the difference in head favors percolation from the river and from the shallow water-bearing zone to the main water-bearing zone. Obviously, the downstream extent of this area will vary according to the stage of the river and the ~~seasonal~~ fluctuations of head in the main zone. The extent will increase with higher river stages and greater withdrawals from wells. However, except during floods of extreme stage, it does not seem likely ever to extend more than a few miles below Robinson Bridge. Also, as is developed in the next paragraph, replenishment of the main water-bearing zone from the Santa Ynez River is proportional to the difference in head between the river and the main zone.

Water is enabled to percolate downward from the river channel to the main water-bearing zone probably throughout the Santa Rita Canyon and in the small area within the Lompoc Plain already described and shown on plate 4, in which the river-channel deposits lie directly above the main water-bearing zone. To reach the principal or confined segment of the zone, water must be transmitted through the nearly horizontal pipe-like tongue of the zone that extends northwestward for about 1½ miles below Robinson Bridge, and there must pass beneath the feather edge of the impermeable confining blanket. At this feather edge, therefore, the water enters the principal segment of the zone through an intake orifice which in vertical section is shaped roughly like an inverted triangle and whose sides are formed of impermeable Tertiary rocks or the slightly permeable older alluvium. The top of the orifice is of course the confining blanket. As the cross-sectional area of this orifice is constant, the quantity of water transmitted through it is determined chiefly by the hydraulic gradient. The magnitude of this hydraulic gradient would tend to increase with rise of river stage in the reach near Robinson Bridge, also with declining head in the confined segment of the main water-bearing zone. It can be controlled artificially only to the extent that river stage is regulated and that head of the confined water is varied by withdrawals through wells. On pages 25 to 29, this last principle is applied to the suggestion that the unconsolidated materials beneath the Lompoc Plain be utilized to detain artificially a greater part of the run-off of the Santa Ynez River.

The main water-bearing zone probably is replenished in part by small streams tributary to the Lompoc Plain - chiefly by the streams in San Miguelito, San Pascual, Rodeo, and Lompoc Canyons, along the south edge of the plain. Unlike those from the north, these tributary streams from the south drain moderately extensive areas of foothill and mountainous terrane which receive comparatively heavy rainfall. They flow perennially about to the mouths of their canyons and there lose part of their flow by percolation into alluvial-fan deposits which are marginal parts of the younger alluvium. Most of the water so lost probably percolates to the shallow and secondary water-bearing zones. However, depending on local hydraulic gradients, some probably passes down buried extensions of the canyons to the main water-bearing zone (see pl. 4). For example, fluctuations of water level in well 7/35-27C1, which is off the mouth of Lompoc Canyon and which penetrates the confined main water-bearing zone, suggest that runoff from the Lompoc Canyon drainage area passes directly and rather quickly into the zone.

Under favorable conditions the secondary zone may afford considerable replenishment to the main zone where the two zones are contiguous. (See pls. 2, 3, 4.) For example, beneath the easternmost part of the Lompoc Plain the head of water in the secondary zone appears to be higher than in the main water-bearing zone (see pl. 2, section A' - B'). This head differential, though small, tends to induce movement of water into the main zone. There is doubtless a similar head differential along part of the north border of the Lompoc Plain between water in the main zone and that in the extensive portion of the secondary zone that is inferred to lie at the base of the older alluvium beneath the terraced terrane east of Burton Mesa (see pl. 1). The head differential and the velocity of movement are small, but, because the area of the contact surface across which water can move is extensive, the total quantity of water transmitted may be large. As is discussed beyond, this portion of the secondary zone receives water by infiltration of rain and thus may constitute a sizeable independent source of replenishment to the main zone. Especially during drought periods, when flow in the Santa Ynez River is small, and when withdrawals of water from the main zone are heavy and prolonged, the head of water in the main zone may be so lowered as to induce relatively rapid transfer of water from the secondary zone.

Also, the natural rate of movement may be accelerated locally owing to the effects of pumping from the main zone. For example, wells 7/34-19J1 and 7/34-20K1 draw water from the main zone close to the edge of the secondary zone. When these wells are pumped their cones of depression doubtless extend into the secondary water-bearing zone so that some of the pumped water is drawn directly from that zone.

Thus, although it is believed that the greater part of the water withdrawn from the main water-bearing zone probably is replenished from the Santa Ynez River, an unmeasured but doubtless considerable part is replenished from other sources.

Detention of flood run-off of the Santa Ynez River. - Owing to the conditions of water occurrence that have been described, withdrawals through wells from the main water-bearing zone beneath the Lompoc Plain do not unwater permeable material in any part of that zone. Therefore, the main zone does not afford space in which Santa Ynez River water may be stored at will. However, the manner of replenishment from the river is such that regulation of stream flow by flood-control works may increase somewhat the rate of replenishment of the main water-bearing zone during periods of drought and so increase its perennial safe yield.

Because the water in the main zone is confined beneath most of the Lompoc Plain, decline of water levels in irrigation wells which tap the zone does not indicate a commensurate general unwatering of shallow permeable material. Withdrawals for irrigation on the Lompoc Plain cause the water-levels in wells to decline only a few feet. This is shown on plates 2 and 3 by profiles of the head of the confined water as of May 15, and September 30, 1941, before extensive withdrawals for irrigation began and near the end of the irrigation season, respectively. All these levels are far above the top of the zone, which is, therefore, completely saturated even when the head is lowest. Even during pumping, the drawdown is not sufficient to unwater any part of the confined segment of the main zone. Further, the decline of water levels in these wells does not indicate that the unconfined shallow water-bearing zone is unwatered commensurately, because wells are not perforated in and do not draw water from the shallow zone. However, a small volume of permeable materials is probably unwatered in that portion of the shallow zone in which the water level coincides with the head of the deeper water (p. 21). Thus, fluctuations of water level in the irrigation wells indicate chiefly fluctuations of head. Reduction in head tends to steepen the hydraulic gradient at the intake orifice of the principal segment of the main zone (p. 22) and so to increase the rate at which water is transmitted through that orifice.

As discussed by Meinzer [2] and later elaborated by Theis [3] water

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[2] Meinzer, O. E., Compressibility and elasticity of artesian aquifers: Econ. Geology, vol. 23, no. 3, pp. 263-291, 1928.
[3] Theis, C. V., The significance and nature of the cone of depression in ground-water bodies: Econ. Geology, vol. 33, no. 8, pp. 889-902, 1938.

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withdrawn from a confined aquifer, or water-bearing zone, is derived initially through release of water from storage by compression and compaction of the aquifer itself, and by compaction of fine-grained strata enclosing the aquifer, and occurring as lenses in it. Theis [4] has shown

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[4] Idem. p. 893.

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for unconfined and confined aquifers alike that water is drawn from storage until, owing to continuing withdrawal, the cone of depression of the water table or other piezometric surface spreads either to the recharge area or to the discharge area of the aquifer. Then, and only then, is water, in excess of that entering the aquifer under the natural gradient, drawn into the confined aquifer to replenish that withdrawn artificially. Whereas the rate of spread of the cone of depression in nonartesian aquifers is exceedingly slow, it may be 100 to as much as 1000 [5] times as fast in artesian aquifers. In the Lompoc area, no

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[5] Idem. p. 898

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part of the confined segment of the main water-bearing zone is more than 12 miles distant from the area of recharge from the Santa Ynez River; irrigation wells are scattered widely over the plain, and some wells are in or very near the recharge area itself. Thus, it seems likely that the cone of depression produced by general sustained withdrawals of water from the main zone reaches the recharge area during a single pumping season. Thereupon, the hydraulic gradient at the intake orifice ~~would~~ is ~~be~~ steepened and more water ~~would be~~ is drawn into the zone from the river and from the river-channel deposits. At the same time a small volume of permeable material ~~would be~~ is unwatered in the recharge area. (See p. 33.)

Of the water that enters the Santa Rita Canyon, part runs off as surface flow of the Santa Ynez River and part enters the river-channel deposits and the tongue-like unconfined segment of the main water-bearing zone as underflow. This underflow moves slowly down the canyon. Upon reaching the intake orifice that has been described a portion of this underflow is drawn into the confined segment of the main water-bearing zone, in proportion to the hydraulic gradient across the orifice. The remaining underflow passes beyond the orifice through the river-channel deposits; virtually none of it thereafter reaches the main water-bearing zone. Throughout the irrigation seasons of 1941 and 1942, and apparently also in other years of average rainfall and run-off, the quantity of water available in the recharge area along the Santa Ynez River near Robinson Bridge was greater than the transmission capacity of the intake orifice under the prevailing hydraulic gradients. In other words, replenishment of the main water-bearing zone from the Santa Ynez River appears ordinarily to have been as great as was potentially possible. However, unusually heavy or prolonged withdrawals may have lowered the pressure head excessively in the confined segment of the zone before the hydraulic gradient at the intake orifice became sufficiently steep to cause water to pass through the orifice in a quantity commensurate with the withdrawal. Heavy draft coincident with very low river flow, as has been ordinary during protracted droughts, may have involved withdrawals greater than the flow of the river in the recharge area.

Year-round regulation of the flow in the Santa Ynez River upstream from Santa Rita Canyon would maintain summer river stages slightly higher than under natural unregulated flow in the Lompoc area. With river stage so heightened, but withdrawals from the main water-bearing zone neither greater nor more prolonged than has been ordinary, the rate of replenishment to the main zone would be increased little if at all. However, if withdrawals were unusually heavy or prolonged, and river stages were heightened, the hydraulic gradient at the intake orifice of the confined segment of the main water-bearing zone probably would be steepened appreciably and transmission to the confined segment would be slightly increased. Thus, the perennial yield of the main water-bearing zone would be increased slightly.

Secondary water-bearing zone

Occurrence of water. - Like that in the main zone, water in the secondary water-bearing zone is confined under sufficient head to rise in wells to within a few feet or tens of feet of the land surface. As with the main water-bearing zone, also, withdrawals from the secondary water-bearing zone do not cause general unwatering of pervious materials in the zone or in the overlying deposits, except to a small extent in the areas of recharge.

Replenishment of water. - Water discharged or withdrawn from the secondary zone is replenished mainly from sources other than the Santa Ynes River - largely from minor streams and by infiltration from rainfall. The parts of the zone that underlie the southern part of the Lompoc Plain probably derive water indirectly from the minor streams which lose water by percolation into the headward portions of the alluvial fans along the margin of the overlying younger alluvium. Some of this percolate passes entirely through the several alluvial-fan deposits and reaches the secondary water-bearing zone. Recharge by infiltration from rainfall is widespread. Thus, the lobe of the secondary zone between Lompoc and Rodeo Canyons in the southwestern part of the area, the lobe east of the river and north of the Narrows, and the portion of the zone below the north border of the Lompoc Plain, are contained in bodies of older alluvium that crop out beyond and above the plain. In these outlying outcrop areas rain water doubtless percolates slowly downward to the water-bearing zone through the fine-grained somewhat permeable materials that form the upper part of the older alluvium, and reaches the basal gravel member that is an extension of the secondary water-bearing zone. Thence the water so derived percolates laterally to those parts of the zone that lie beneath the Lompoc Plain. In the area immediately northwest of the Narrows some water may enter the secondary zone from the pipe-like tongue of the main zone where the two zones are in contact (see pl. 4); however, hydrologic data at hand do not indicate that the amount of water so derived is large.

Thus, essentially all water in the secondary zone beneath the Lompoc Plain apparently is derived from minor streams and from rainfall - that is, from sources other than the Santa Ynez River. Accordingly, the zone affords no storage space in which flood run-off in the Santa Ynez River can be detained artificially.

Shallow water-bearing zone

Occurrence of water. - The shallow water-bearing zone is unconfined at most places although locally its water is confined under slight head by lenses of impermeable material. The water-levels in wells that tap the zone, therefore, represent the water table. Over most of the Lompoc Plain, beyond the river-channel deposits, this water table is from 1 foot to 35 feet below the land surface. In the river-channel deposits, the water table is adjusted to river stage and commonly ranges from about 5 feet below the land surface while the river is low to several feet or even tens of feet above the land surface while the river is in flood. As discussed on page 21, the head of the water in the shallow zone is lower than that of the water in the main zone throughout most of the Lompoc Plain. However, in the vicinity of the Narrows, and upstream in the Santa Rita Canyon, the water table in the shallow zone essentially coincides with the static level of the main zone.

Because the water is unconfined, withdrawals from wells in and natural discharge from the shallow zone unwater part of the material composing the zone. Water levels in wells tapping the shallow zone declined from 1 foot to 4 feet between May 15 and October 1, 1941: not more than 2 feet in wells near the river channel and as much as 4 feet only in wells near the margin of the Lompoc Plain. Assuming that the average decline in wells was 2 feet and the extent of the shallow water-bearing zone is 16,300 acres (see p. 12) the indicated volume of material unwatered would be 32,600 acre-feet. Taking the specific yield of the material as probably not more than 15 percent,[6] the corresponding volume of water withdrawn from shallow wells and naturally discharged would be not more than about 5,000 acre-feet. These computed volumes probably are somewhat too large, as most of the wells in which the water-table recession was measured are used. Much of the material in the shallow water-bearing zone is fine-grained and transmits water slowly, so that the effect of pumping may not extend far from individual wells. Accordingly, the average recession of the water table probably was less than the average decline of water level as measured in the wells. A small part of this unwatering is probably the result of withdrawals from the main and secondary water-bearing zones. Such withdrawals, however, affect the shallow zone only in the recharge areas where the water table essentially coincides with the static level of water in the main and secondary zones. (See pp. 26, 28, and 30.) As these areas are a very small proportion of the Lompoc Plain, the volume of material unwatered is a very small fraction of the total 32,600 acre-feet.

[6] Piper, A. M., and others, Geology and ground-water hydrology of the Mokelumne area, California: U. S. Geol. Survey Water-Supply Paper 780, pp. 101-122, 1939.

Replenishment of water. - Because the water table of the shallow zone is not far below the land surface and because moderately permeable materials intervene between the land surface and the water table, the zone doubtless derives its water by infiltration of rain, seepage from streams, and probably also by infiltration of water applied to the land for irrigation. A considerable part of the water derived from streams probably originates in the tributary streams that enter the south side of the Lompoc Plain, and which, as has been stated, are intermittent in their reaches on the plain. It is believed that most of the water naturally stored in the shallow ~~permeable~~ water-bearing zone is derived from sources other than the Santa Ynez River.

Preliminary contour maps showing the configuration of the water table as of May 15 and October 1, 1941,[7] indicate that during this period, water in the shallow zone moved northward from the tributary canyons, especially from San Miguelito and Lompoc Canyons. These maps also show that in both spring and autumn the shallow ground water nearly everywhere percolated toward the Santa Ynez River. However, some water in the shallow water-bearing zone apparently left the river-channel deposits near Robinson Bridge, moved directly northwestward and re-entered the river below the "H"-Street Bridge due north of Lompoc. A part of the shallow ground water moving through this reach probably was derived from the river but was also returned to the river. Thus, it is concluded that during periods of low or moderate stream flow, even in years of average or excessive

7/ La Rocque, G. A., Jr., Material in preparation for report on County-wide inventory of water resources.

wetness, water previously stored in the shallow water-bearing zone drains into the river-channel deposits and is discharged from the area by surface flow or by underflow in those deposits. Accordingly, during periods of low or moderate stream flow the Santa Ynez River gains water from the shallow water-bearing zone.

While the river is in flood or at stages above the average, on the other hand, the water-table gradient in the river-channel deposits and contiguous parts of the shallow water-bearing zone is reversed and slopes away from the river. As long as this condition exists, river water percolates into the river-channel deposits and outlying parts of the shallow zone. Such recharge to the zone probably moves outward from the river as a ground-water wave, but even in years of excessive wetness probably does not travel across the full width of the Lompoc Plain because the materials that comprise most of the shallow water-bearing zone have only small transmission capacity. Subsequently, as the river stage declines, the ground-water wave subsides, and water in the shallow zone again drains into the river and river-channel deposits. Thus, in general, only a small proportion of the water naturally stored in the shallow water-bearing zone is derived from the Santa Ynez River.

Detention of flood run-off of the Santa Ynez River. - With complete regulation of the Santa Ynez River for purposes of flood control and water conservation, the quantity of river water entering the shallow water-bearing zone would not be materially increased over that entering under natural conditions. Under regulation, excessively high stages would no longer occur in the reach below the Santa Rita Canyon, and waves of ground-water replenishment in the shallow zone would no longer be so high as they were in past years of excessive wetness. However, if water were not diverted from the river in large amounts for use upstream, river stages moderately higher than the average of past years might be maintained for relatively long periods. These moderately high stages might continue well into the summer, long after the unregulated river would have fallen to a low stage. Under such conditions, yearly waves of replenishment in the shallow water-bearing zone would be induced in only moderate height, but would be longer sustained. Under natural conditions, even in periods of excessive wetness, each successive wave of ground-water replenishment moving outward from the river probably has added no more than a few thousand acre-feet of water to storage in the shallow zone; also, most of this storage has been temporary and has been depleted by drainage within the succeeding summer. With the stream regulated, the corresponding additions to storage probably would be little greater, if greater at all, and the ensuing drainage would be nearly as rapid.

As the net effect, the average height of the water table, and hence general storage, throughout the shallow water-bearing zone probably would be somewhat greater for years of average or excessive wetness. Also, depletion of storage would be delayed and slowed. However, during protracted droughts, storage might be depleted quite as much as under natural conditions. Increased storage in the shallow zone would decrease the pumping lift in wells such as are now used for small domestic and stock supplies. It would not increase storage in the main water-bearing zone from which most irrigation supplies are and must be drawn. By loading the intervening confining beds, however, increased storage in the shallow zone might increase somewhat the [illegible] head of confined water in the main zone, and hence slightly decrease the pumping lift in the irrigation wells, but the perennial yield of the main zone would not be greatly increased.

Summary and conclusions

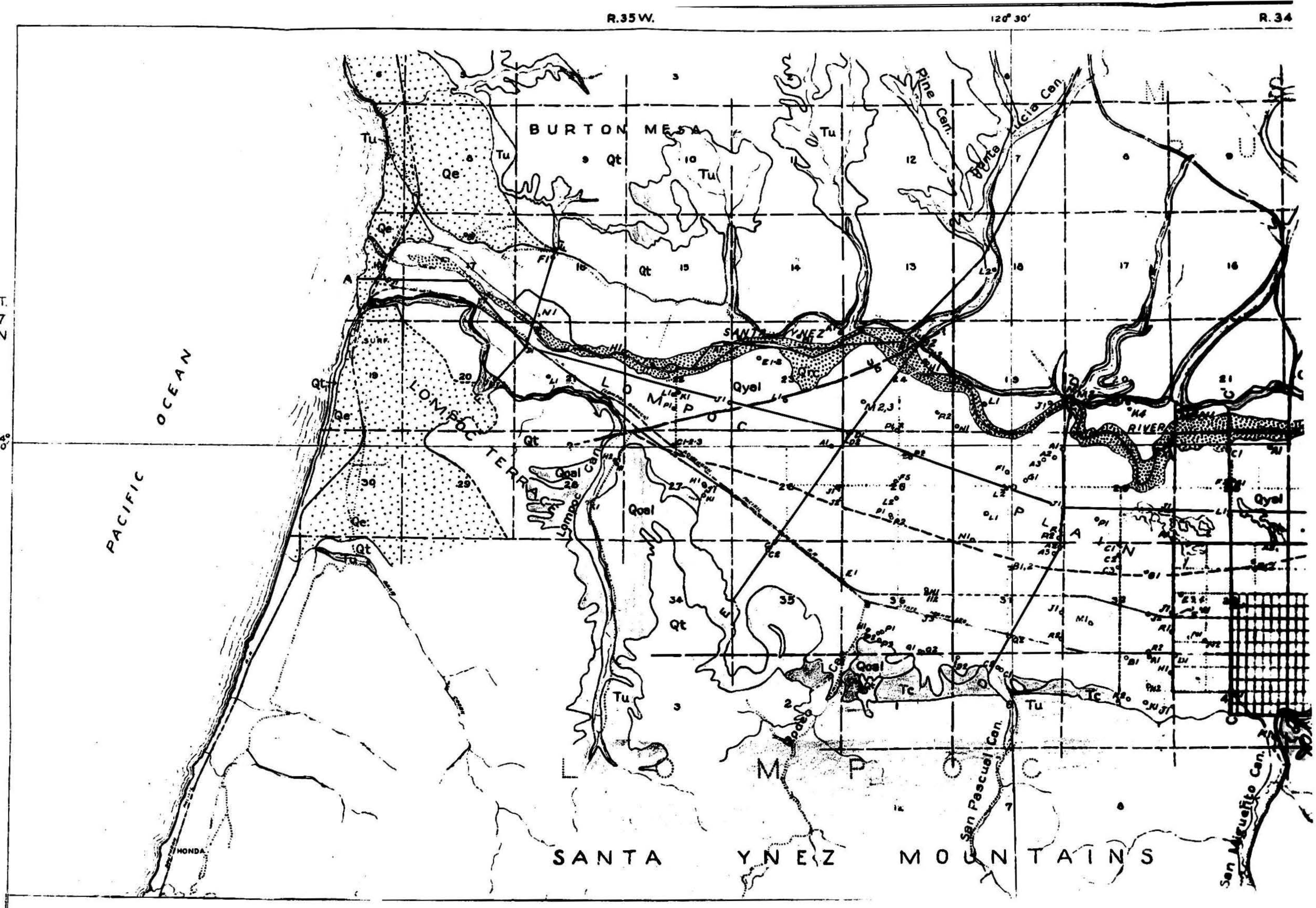
Water for irrigation in the Lompoc Plain is derived from wells that tap one of two bodies of water-bearing material - the main and secondary water-bearing zones. A third zone, called the shallow water-bearing zone, affords small yields for domestic and stock wells, but is incapable of yielding water in quantities adequate for irrigation. These three zone together constitute about 30 percent of the total volume of unconsolidated deposits beneath the plain. The remaining 70 percent of the deposits is largely so fine-grained that it does not yield water readily, if at all, to wells.

Withdrawals of water from the main water-bearing zone unwater none of the permeable beds of that zone, and only a relatively small volume of permeable deposits in the shallow zone in the intake area of the main zone. Whereas this volume doubtless varies with intensity of withdrawals, the volume of material unwatered even by heavy and prolonged pumping would be insignificant in comparison with the volume of flood discharge, although it probably would be appreciable in comparison with the pumpage. Accordingly, such withdrawals create relatively little space in which flood run-off of the Santa Ynez River could be stored.

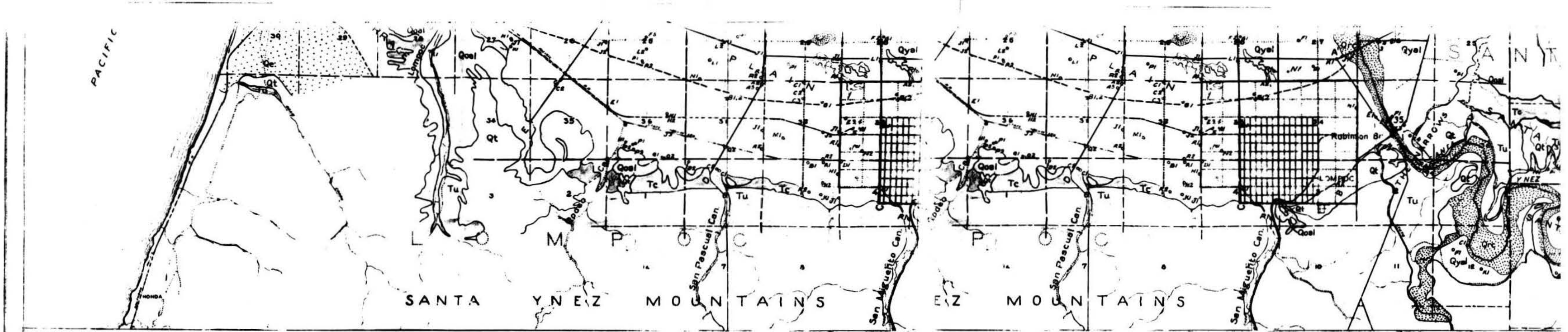
Withdrawals of water from the secondary water-bearing zone similarly unwater only very small volumes of permeable material. Even if a large volume were unwatered, none of it would be available for storage of Santa Ynez River water, as the zone is entirely replenished from other sources.

Probably the greatest volume of unwatered space each year occurs in the shallow water-bearing zone, but even this is small compared to the volumes of flood discharge. Also, the infiltration capacity of most unconsolidated materials along the river is so small that comparatively little of the flood run-off would be detained even if sufficient unwatered space existed.

On the other hand, if flood control should be accomplished by stabilization of river flow upstream from the Narrows, in such a way that summer river stages were raised somewhat, the rate of replenishment to the main zone, especially during periods of heavy withdrawals, would be slightly increased, thus slightly increasing the perennial yield of the zone.



R.35W.
120° 30'
R. 34
T. 7 N
34° 40'
PACIFIC OCEAN
BURTON MESA
LOMPOC TERRACE
LOMPOC PLAIN
SANTA YNEZ RIVER
Pine Can.
Santa Lucia Can.
Lompoc Can.
San Pascual Can.
San Miguelito Can.
LOMPOC
SANTA YNEZ MOUNTAINS
HONDA
SURF
Qe
Qt
Tu
Qyel
Qoal
Qrc
Tc



EXPLANATION

QUATERNARY

Recent — Pleistocene

Qe — Eolian deposits (Active dune and blown sand near the coast)

Qrc — River channel deposits (Sand and gravel, generally coarse-grained and unconsolidated)

Qyal — Younger alluvium (Unconsolidated clay, sand, and gravel, beneath the Lompoc Plain. Locally includes Recent beach deposits. A lower member of gravel contains water under pressure head and yields water copiously to wells)

Qt — Terrace deposits (Unconsolidated clay, sand, and gravel capping terraces bordering the Lompoc Plain. Not tapped by wells)

Qoal — Older alluvium (Mainly unconsolidated sand, some gravel and clay. Locally may include part of the Careaga sand. Except for a lower gravel member which yields water freely to wells, generally not highly permeable)

TERTIARY

Tc — Careaga sand (Dominantly sand, loose to semi-consolidated. Generally permeable but does not yield water directly to wells)

Qoal — Older alluvium (Mainly unconsolidated sand, some gravel and clay. Locally may include part of the Careaga sand. Except for a lower gravel member which yields water freely to wells, generally not highly permeable)

Tc — Careaga sand (Dominantly sand, loose to semi-consolidated. Generally permeable but does not yield water directly to wells)

Tu — Tertiary rocks undivided (Mainly consolidated shale and sandstone which are not water-bearing. Includes rocks of Monterey, Sisquoc, and Foxen epochs)

Concealed fault

Approximate outline of impervious blanket over ... of younger alluvium

Water well (Numbering ... referred to in text)

Line of section (See plates 2...)

R. 35 W. — 120° 30′ — R. 3 — 120° 30′ — R. 34 W.

Base by G. A. La Rocque, Jr. from photoplanimetric map by Fairchild Aerial Surveys, Inc. Broken land lines projected; for reference only.

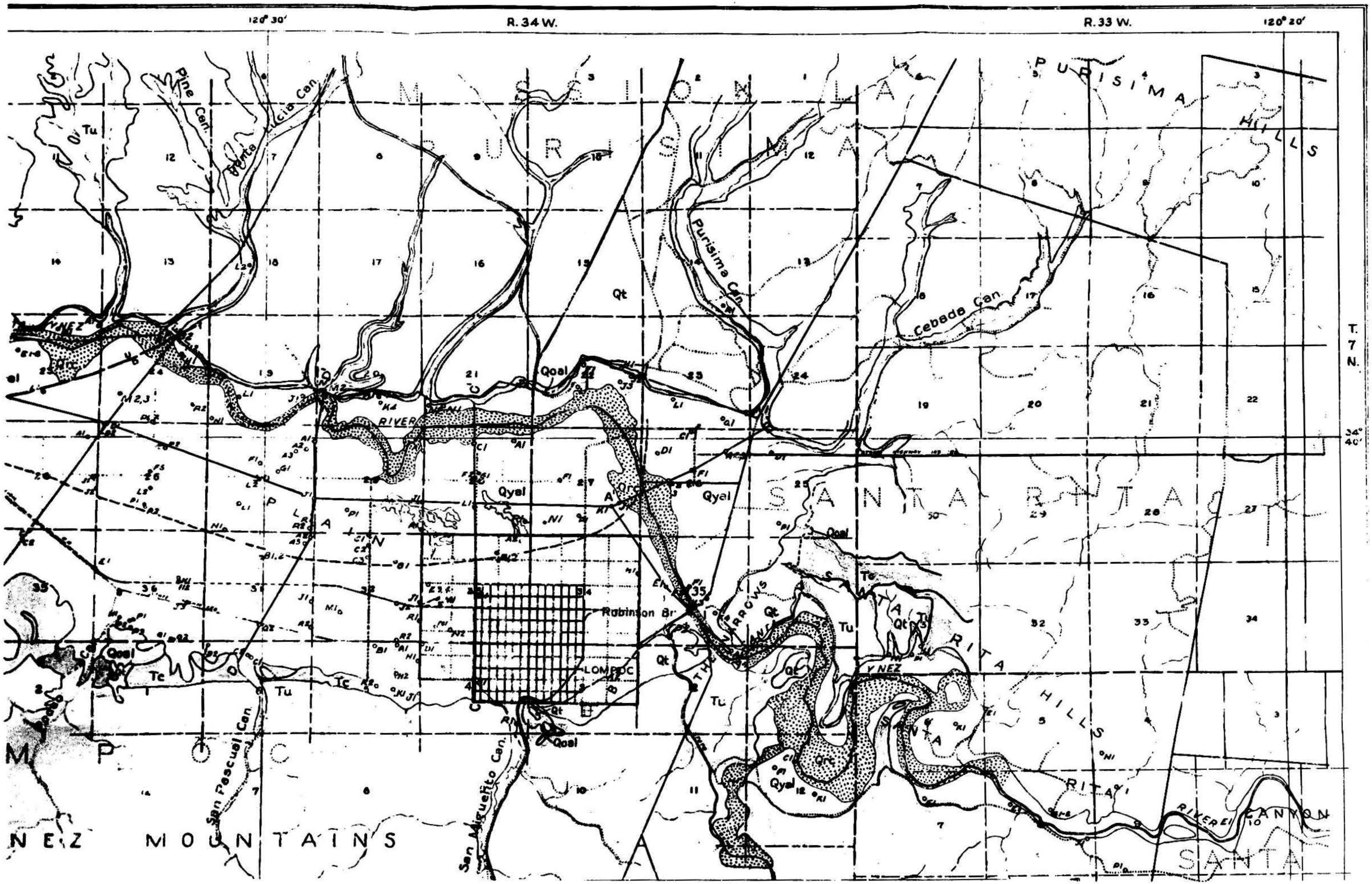
PLATE 1.—PRELIMINARY GEOLOGIC MAP OF THE LOMPOC BASIN, SANT... IC MAP OF THE LOMPOC BASIN, SANTA BARBARA COUNTY, CALIFORN...

1 0 1 2 3 Miles

The map is a little hard to read because colors do not contrast & fault, boundary of impv. blanket & lines of sections too weak. Why not give the river channel deposits a good contrasting color?

Contrast improved ...

...


120° 30'
R. 34 W.
R. 33 W.
120° 20'
T. 7 N.
34° 40'
PURISIMA HILLS
Pine Can.
Santa Lucia Can.
Purisima Can.
Cebada Can.
RIVER
Qt
Qoal
Qyal
Qrc
Tu
Tc
Robinson Br.
LOMPOC
THE NARROWS
SANTA RITA HILLS
San Pascual Can.
San Miguelito Can.
NEZ MOUNTAINS
RIVER CANYON
SANTA

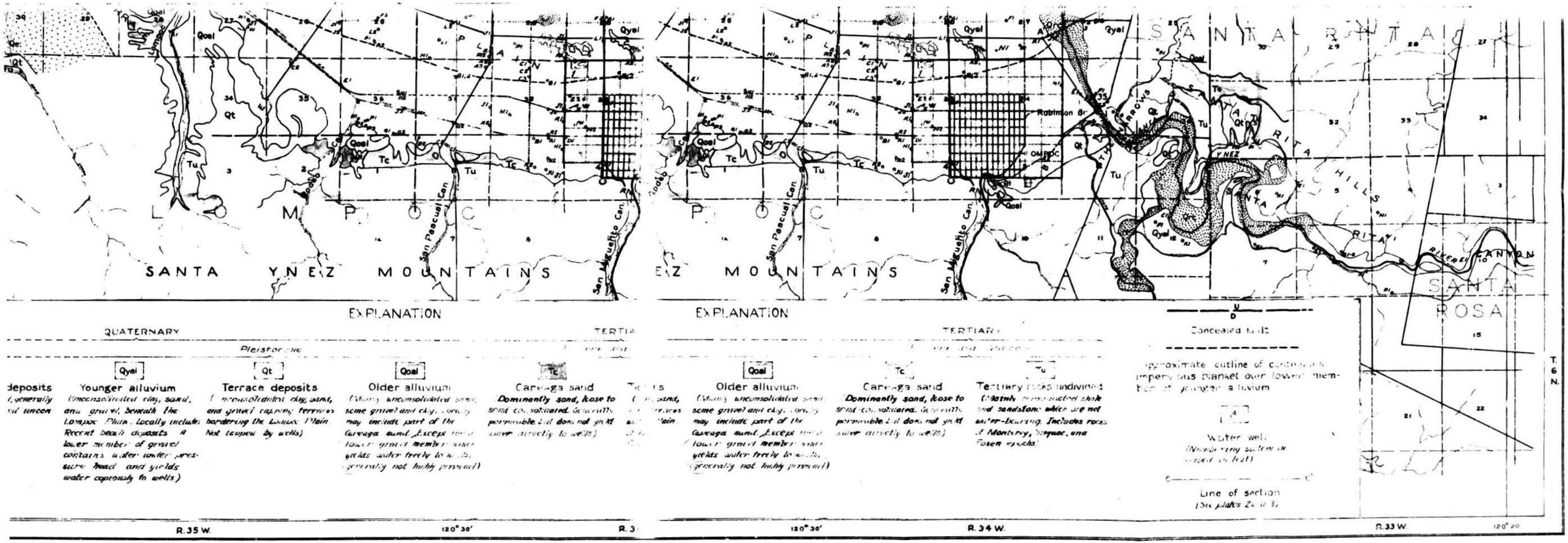
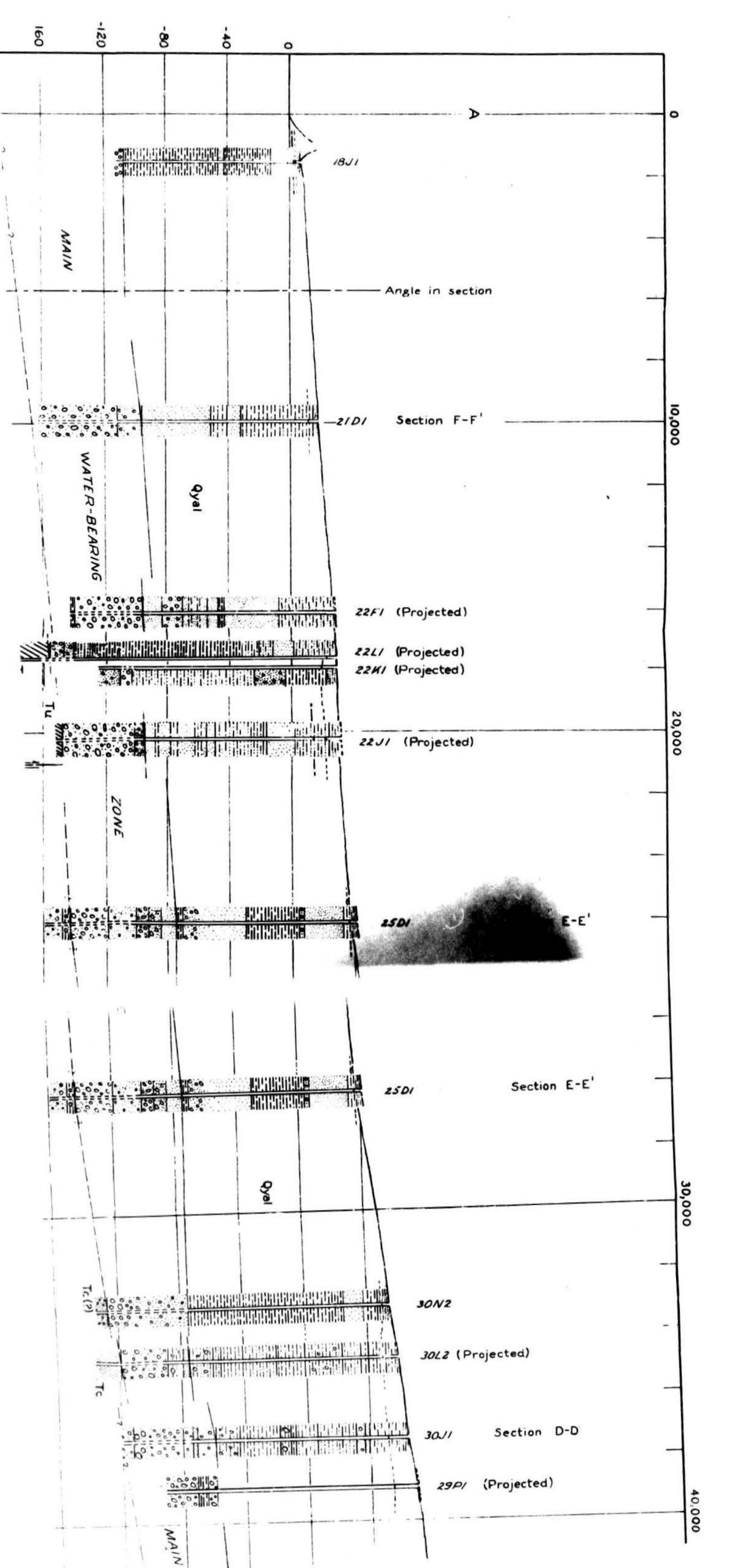


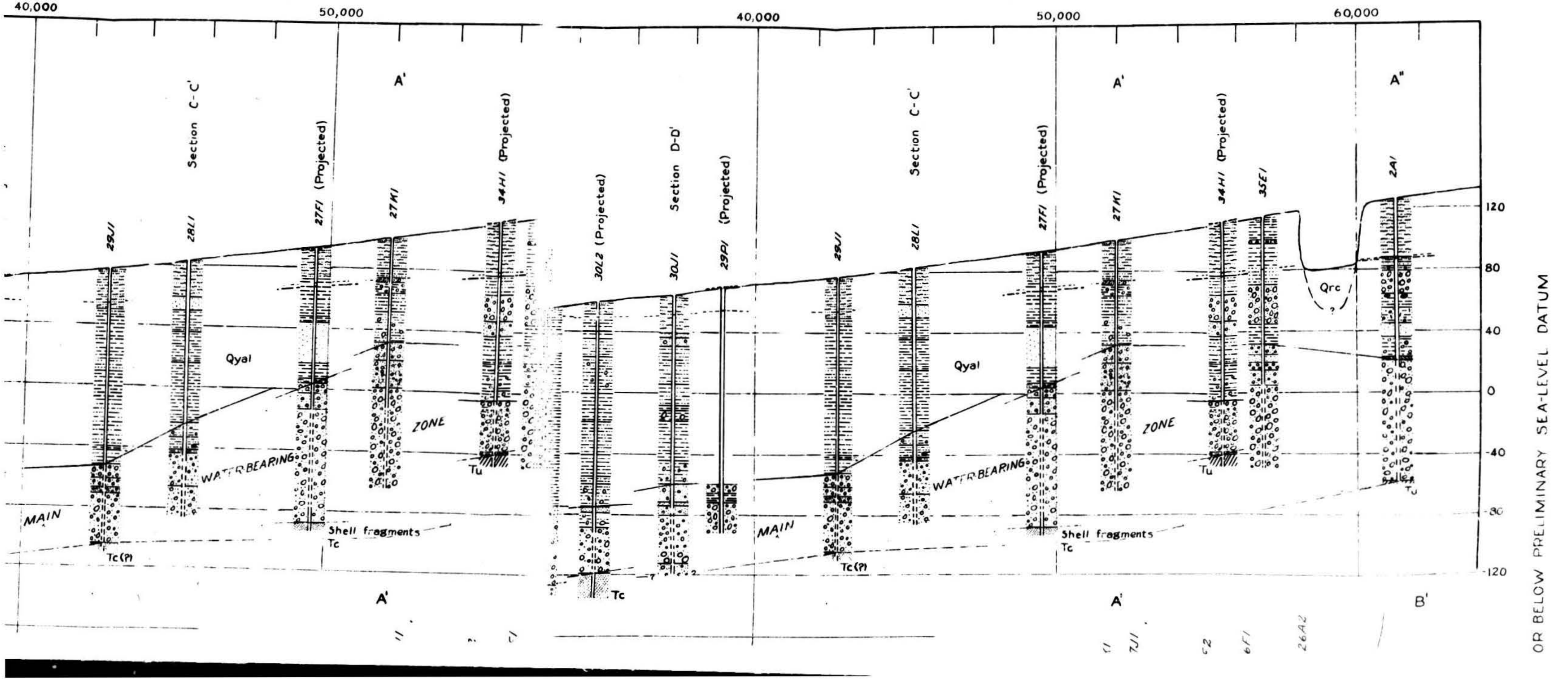
PLATE I.—PRELIMINARY GEOLOGIC MAP OF THE LOMPOC BASIN, SANT[…]IC MAP OF THE LOMPOC BASIN, SANTA BARBARA COUNTY, CALIFORNIA

1 0 1 2 3 Miles

UNPUBLISHED RECORDS SUBJECT TO REVISION



160
-120
-80
-40
0
A
0
10,000
20,000
30,000
40,000
18J1
MAIN
Angle in section
21D1
Section F-F'
WATER-BEARING
Qyal
22F1 (Projected)
22L1 (Projected)
22K1 (Projected)
Tu
22J1 (Projected)
ZONE
25D1
E-E'
25D1
Section E-E'
Qyal
Tc(?)
30N2
30L2 (Projected)
Tc
30J1
Section D-D
29P1 (Projected)
MAIN


40,000
50,000
40,000
50,000
60,000
A'
A'
A"
Section C-C'
27F1 (Projected)
27K1
34H1 (Projected)
30L2 (Projected)
Section D-D'
29P1 (Projected)
Section C-C'
27F1 (Projected)
27K1
34H1 (Projected)
35E1
2A1
29J1
28L1
30J1
29J1
28L1
Qyal
Qyal
Qrc
ZONE
ZONE
WATER BEARING
WATER BEARING
MAIN
MAIN
Tu
Tu
Tu
Shell fragments
Shell fragments
Tc (?)
Tc
Tc
Tc (?)
Tc
A'
A'
B'
120
80
40
0
-40
-80
-120
OR BELOW PRELIMINARY SEA-LEVEL DATUM
26A2

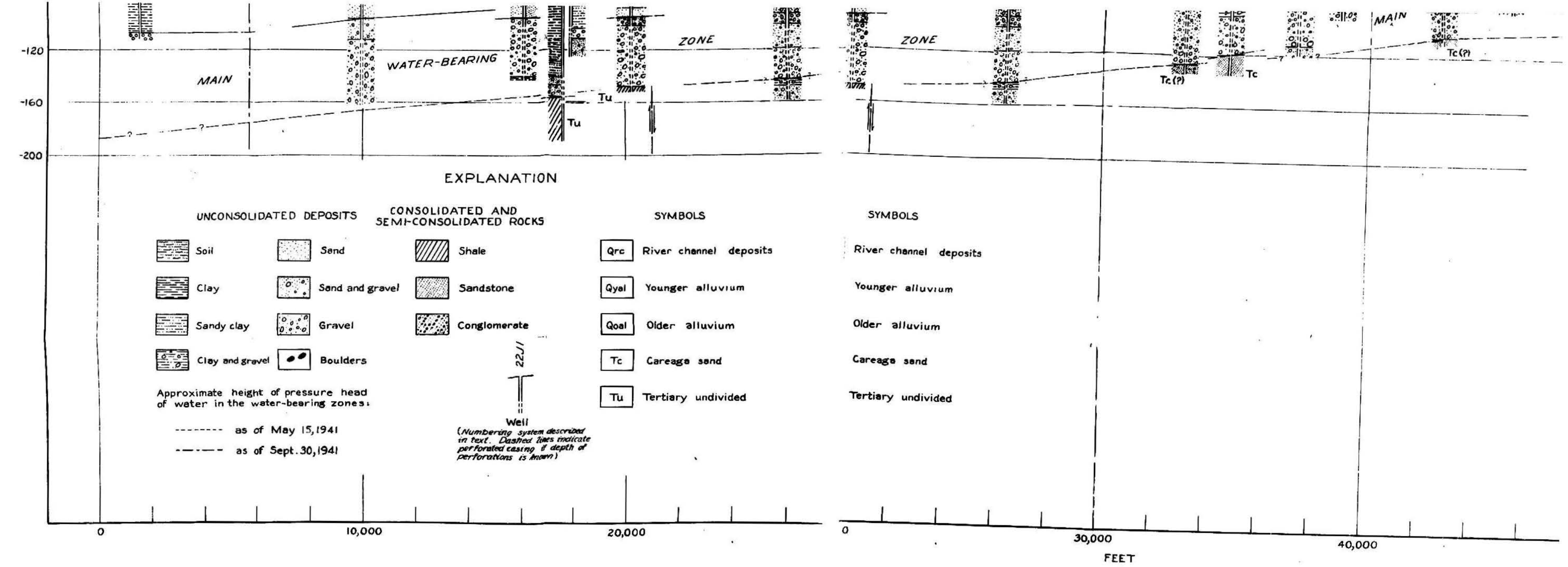
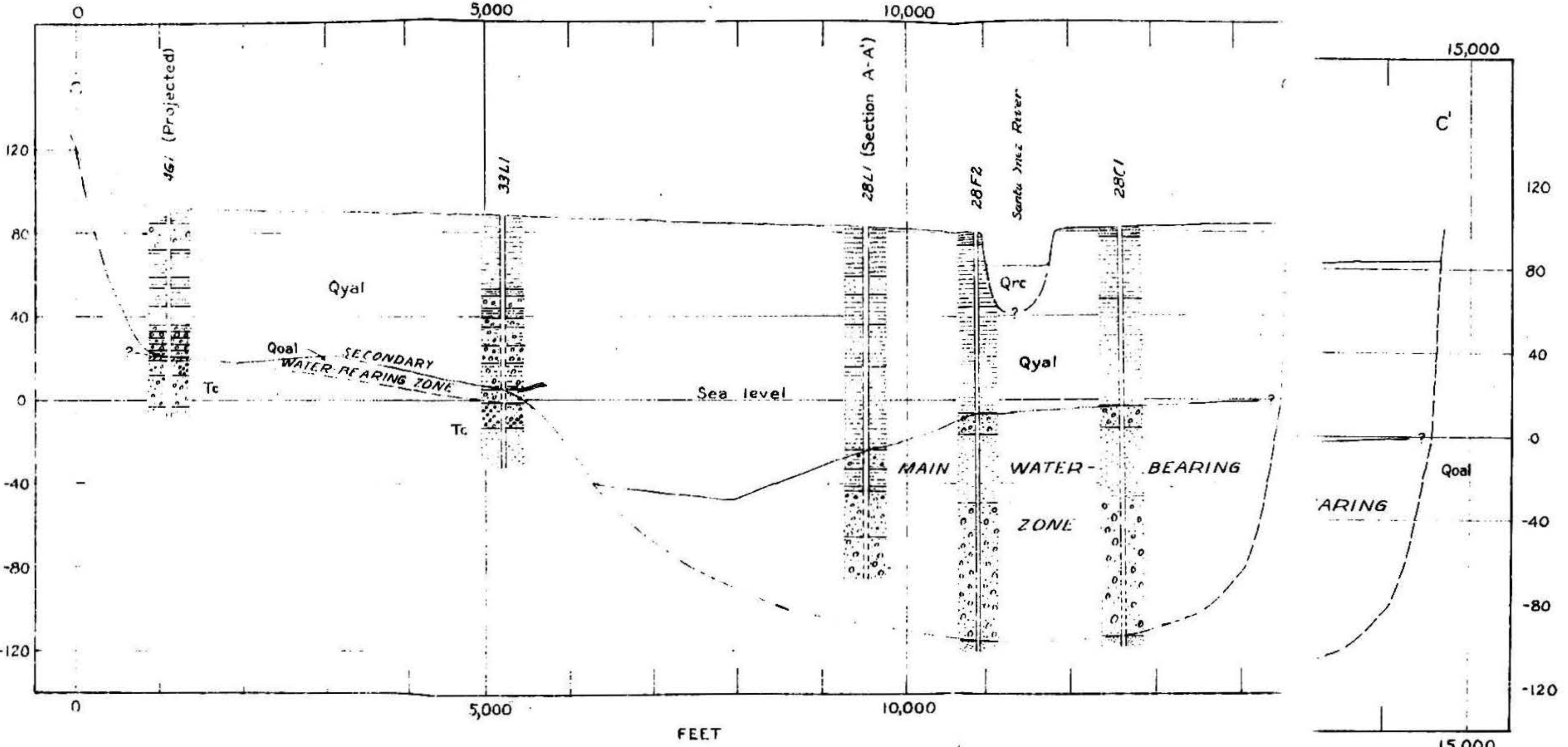


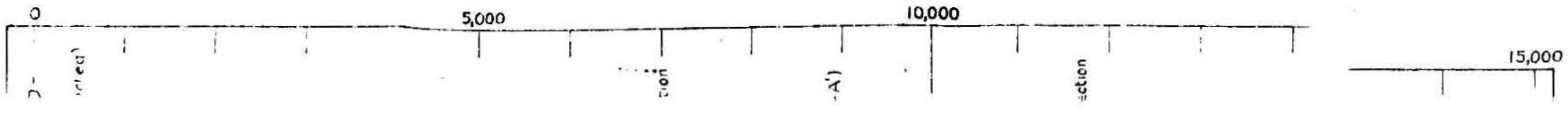
PLATE 2.- LONGITUD

PLATE 2.-LONGITUDINAL SECTIONS OF THE LOMPOC PLAIN

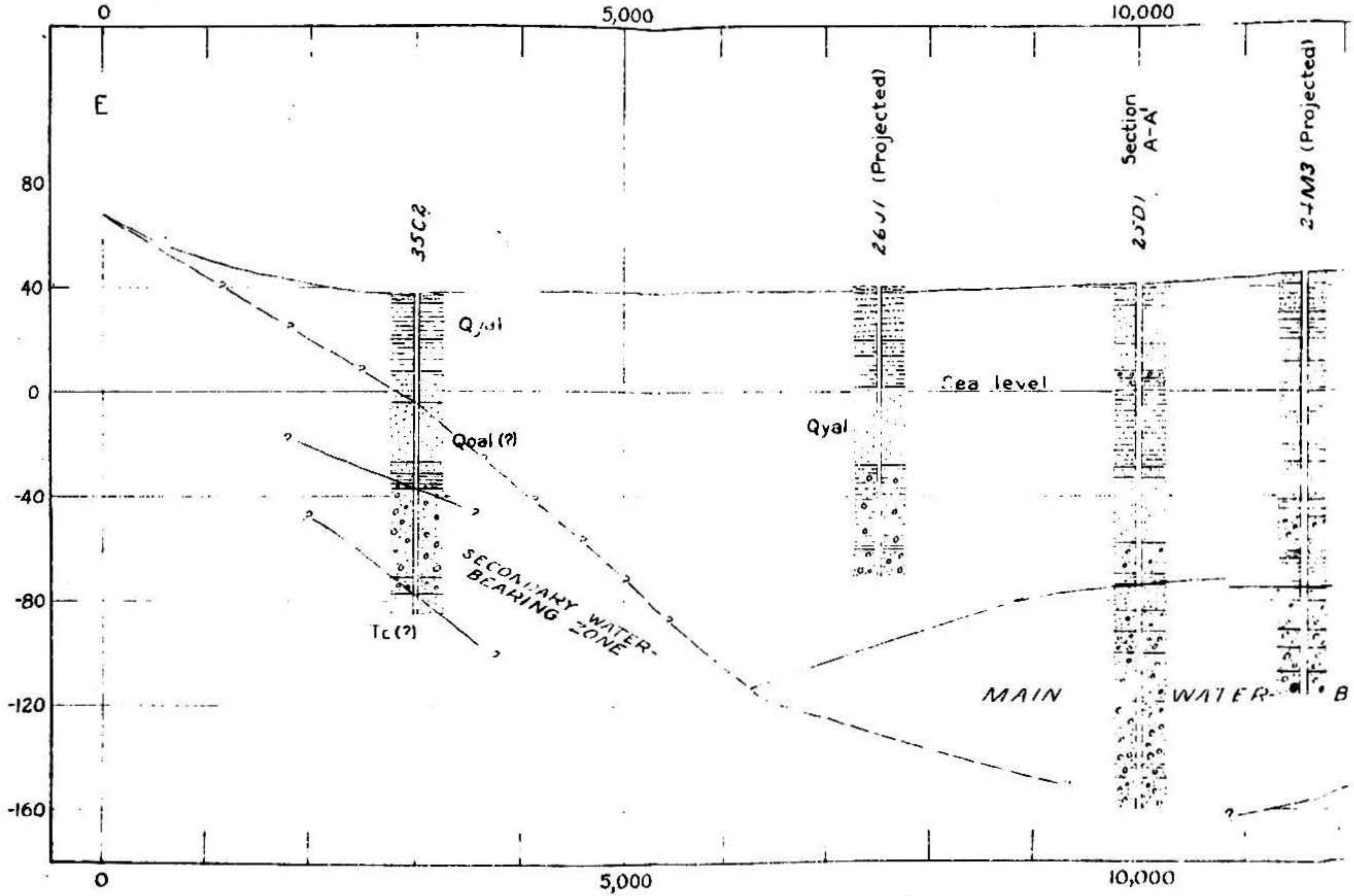


0
5,000
10,000
15,000
C'
4G1 (Projected)
33L1
28L1 (Section A-A')
28F2
Santa Ynez River
28C1
120
80
40
0
-40
-80
-120
Qyal
Qrc
Qoal
SECONDARY
WATER BEARING ZONE
Tc
Sea level
MAIN WATER-BEARING ZONE
ARING
FEET

SECTION C-C'



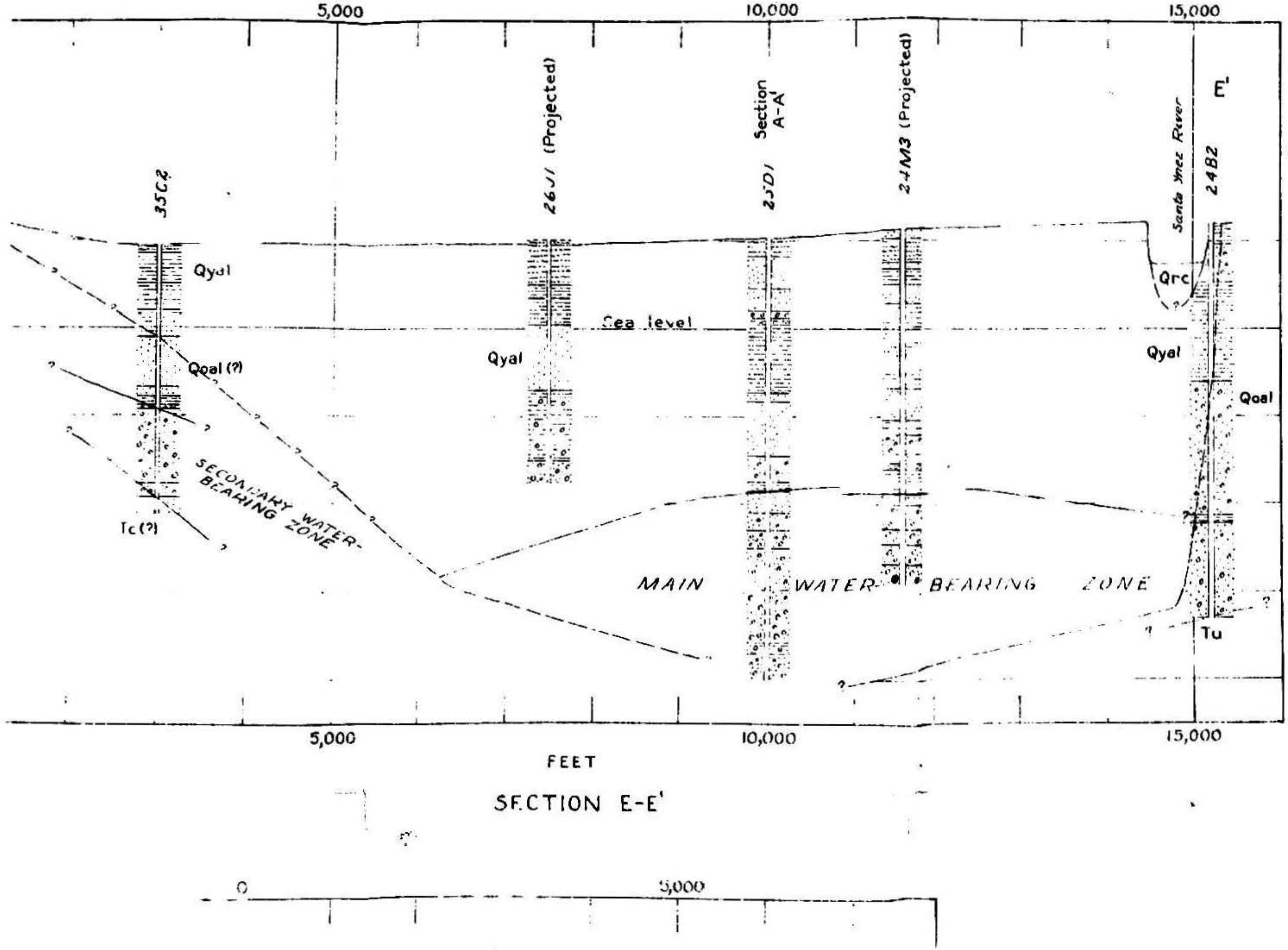
0
5,000
10,000
15,000



E
35C2
26J1 (Projected)
Section A-A'
25D1
24M3 (Projected)
Qyal
Sea level
Qoal (?)
Tc (?)
SECONDARY WATER-BEARING ZONE
MAIN WATER-B
80
40
0
-40
-80
-120
-160
0
5,000
10,000
FEET

SECTION E-E'

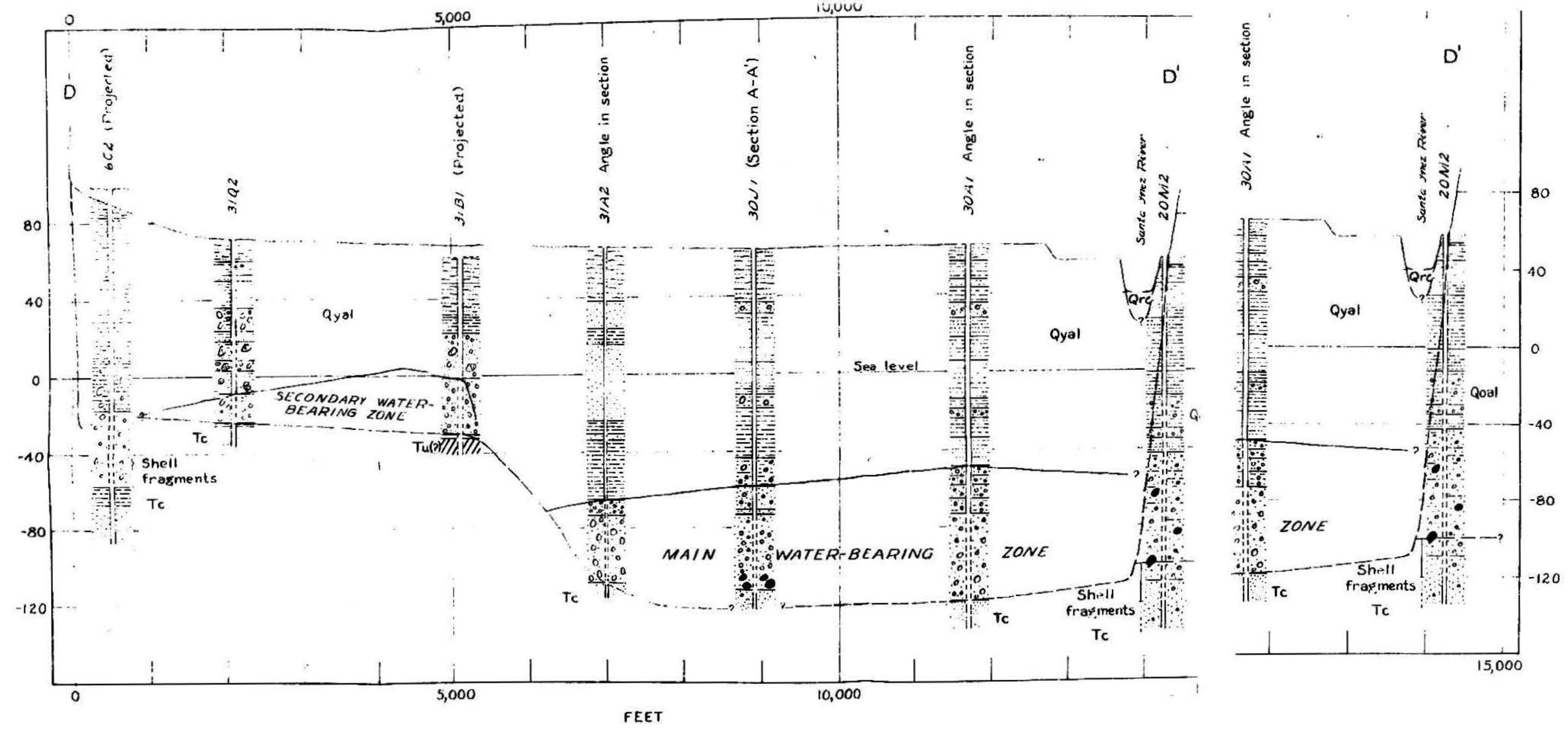
PLATE 3



SECTION E-E'

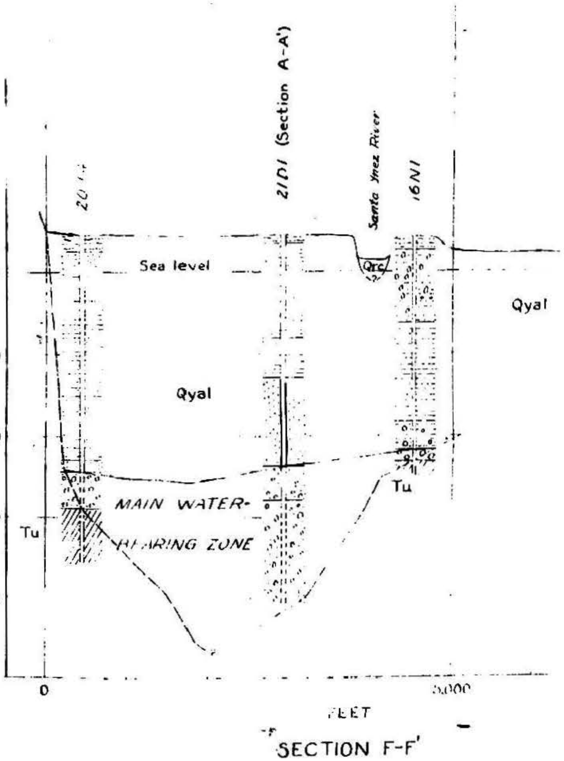
W PRELIMINARY SEA-LEVEL DATUM

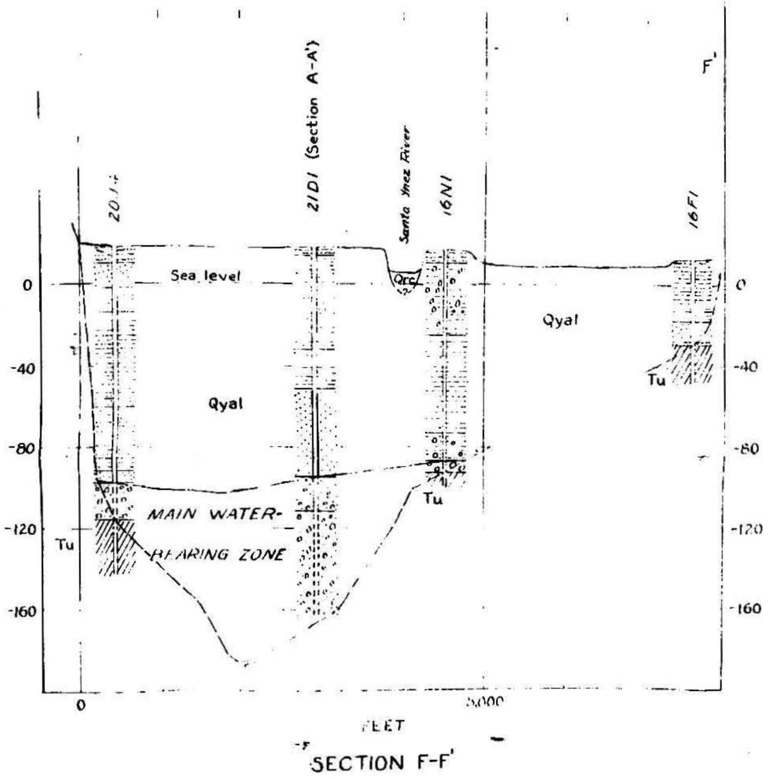
(Plate 1, lines A-A'-A" and A'-B')

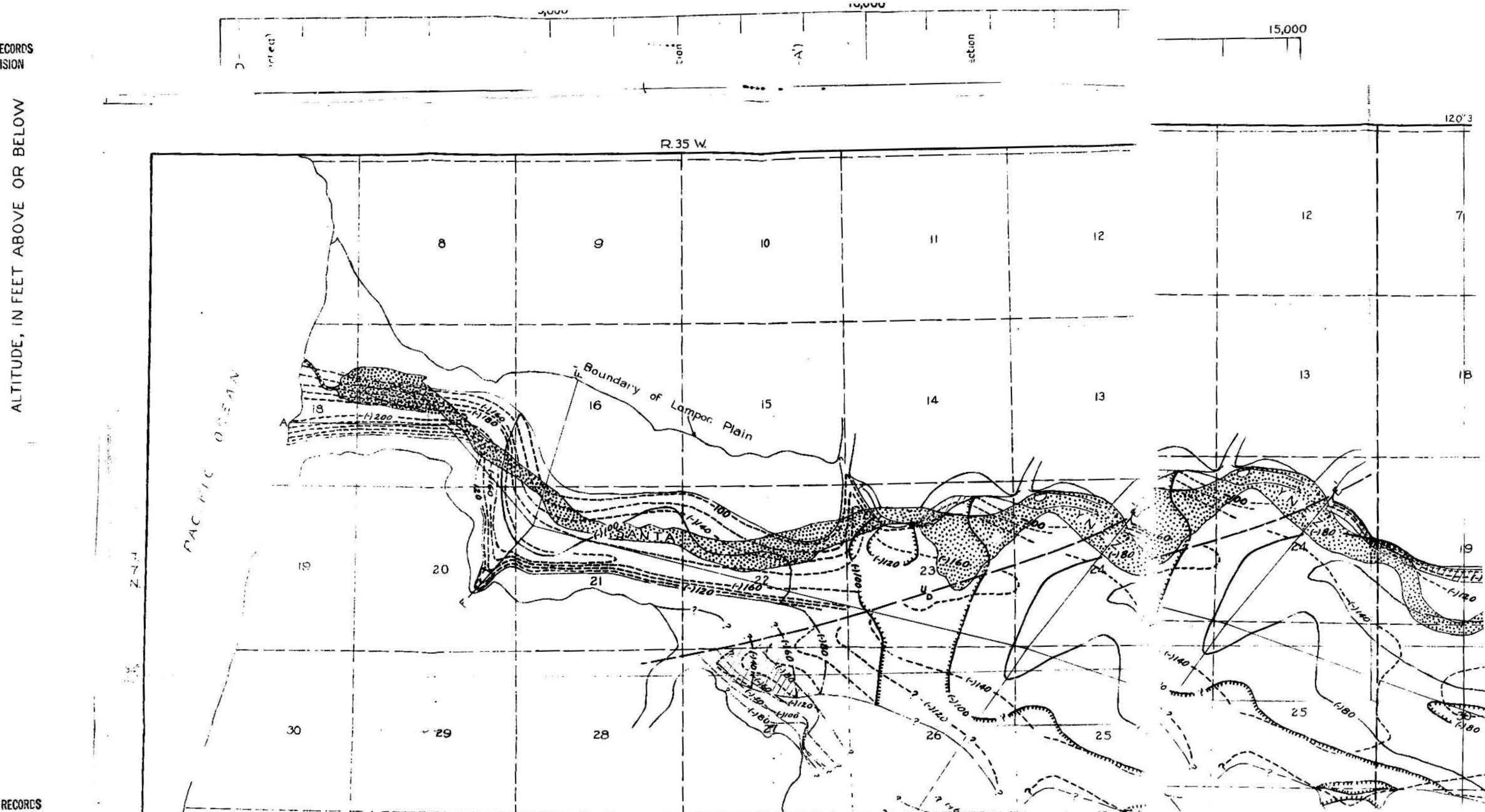


SECTION D-D'

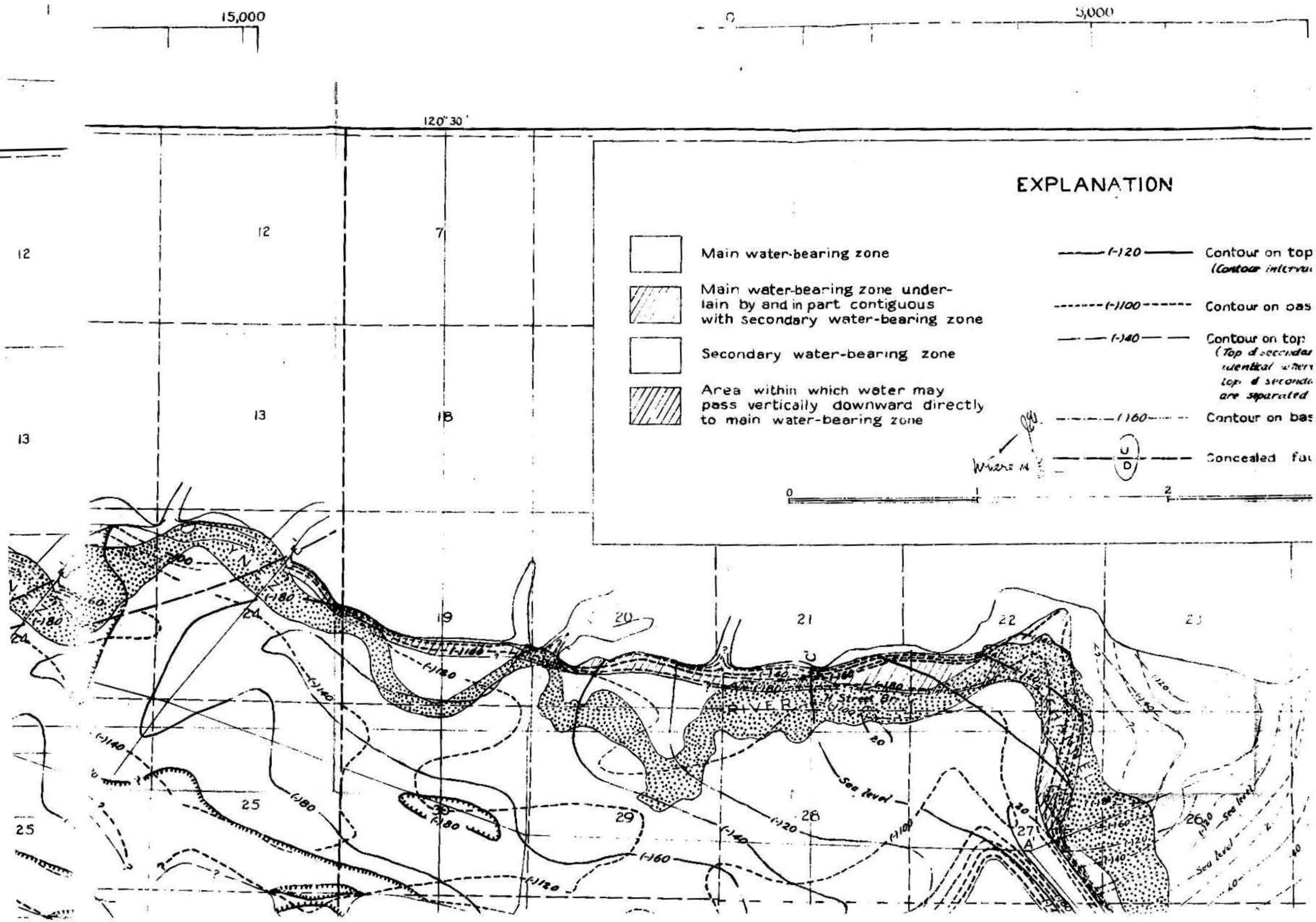
: PLAIN


21D1 (Section A-A')
Santa Ynez River
16N1
Sea level
Qrc
Qyal
Qyal
0
-40
-80
-120
-160
Tu
Tu
MAIN WATER-
BEARING ZONE
0
5,000
FEET
SECTION F-F'

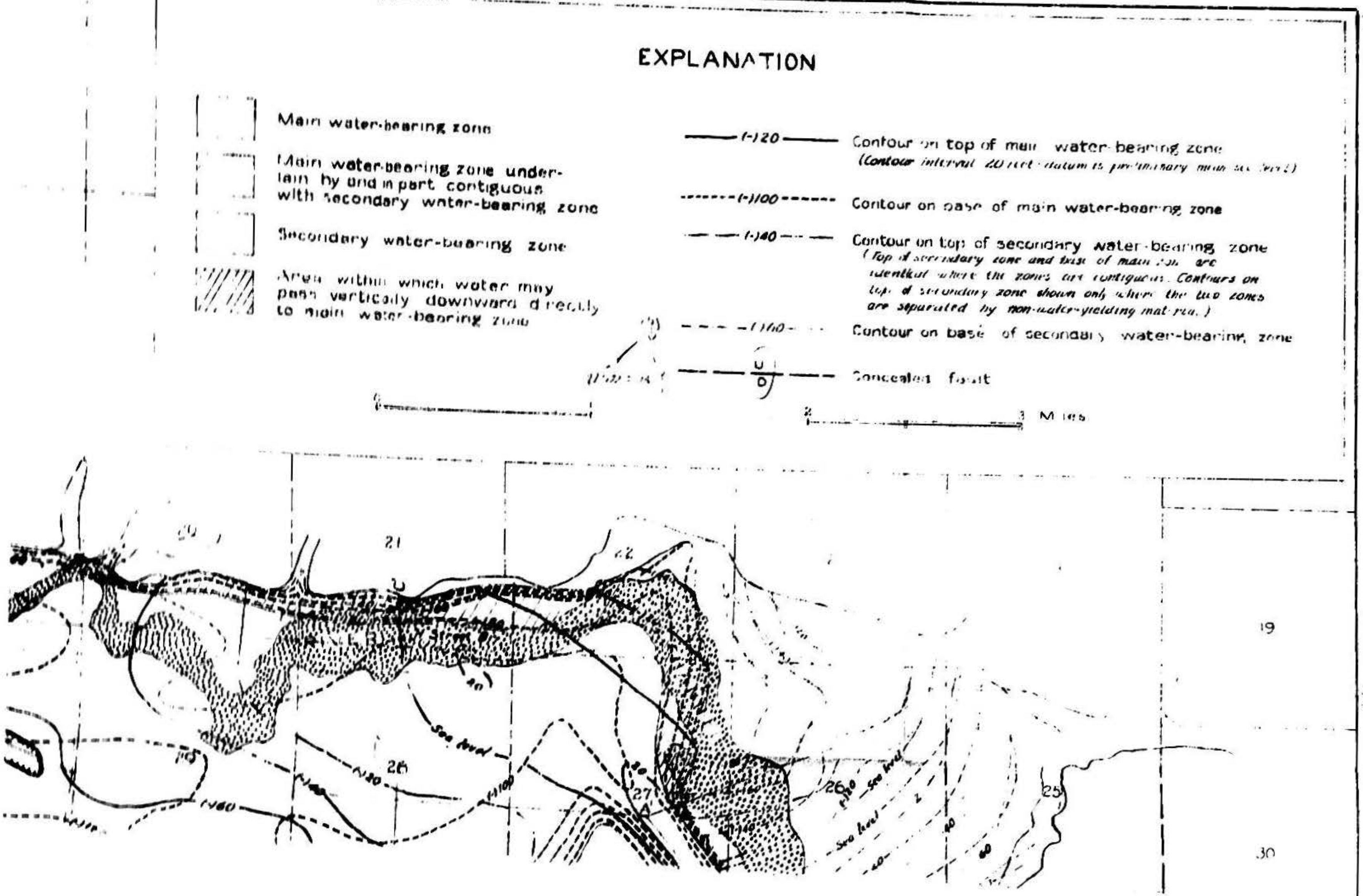

21D1 (Section A-A')
Santa Ynez River
16N1
16F1
F'
Sea level
Qrc
Qyal
Qyal
0
-40
-80
-120
-160
Tu
Tu
Tu
MAIN WATER-
BEARING ZONE
0
5,000
FEET
SECTION F-F'
ALTITUDE, IN FEET ABOVE OR BELOW



UNPUBLISHED RECORDS
SUBJECT TO REVISION



15,000
0
5,000
120°30'
EXPLANATION
Main water-bearing zone
Main water-bearing zone underlain by and in part contiguous with secondary water-bearing zone
Secondary water-bearing zone
Area within which water may pass vertically downward directly to main water-bearing zone
(-)120 Contour on top
(Contour interva
(-)100 Contour on bas
(-)140 Contour on top
(Top of secondar
identical where
top of second
are separated
(-)160 Contour on bas
U D Concealed fa
0
1
2
RIVER
Street Br.
Sea level


EXPLANATION
Main water-bearing zone
Main water-bearing zone underlain by and in part contiguous with secondary water-bearing zone
Secondary water-bearing zone
Area within which water may pass vertically downward directly to main water-bearing zone
(-)120 Contour on top of main water-bearing zone
(Contour interval 20 feet; datum is preliminary mean sea level)
(-)100 Contour on base of main water-bearing zone
(-)140 Contour on top of secondary water-bearing zone
(Top of secondary zone and base of main zone are identical where the zones are contiguous. Contours on top of secondary zone shown only where the two zones are separated by non-water-yielding material.)
(-)160 Contour on base of secondary water-bearing zone
U D Concealed fault
Miles
20
21
22
19
26
27
26
25
30
Sea level
40
60

SECTION D-D'

PLATE 3.- TRANSVE
(P

LATE 3.- TRANSVERSE SECTIONS OF THE LOMPOC PL
(Plate I, lines C-C', D-D', E-E', and F-F')
See Plate 2 for explanation

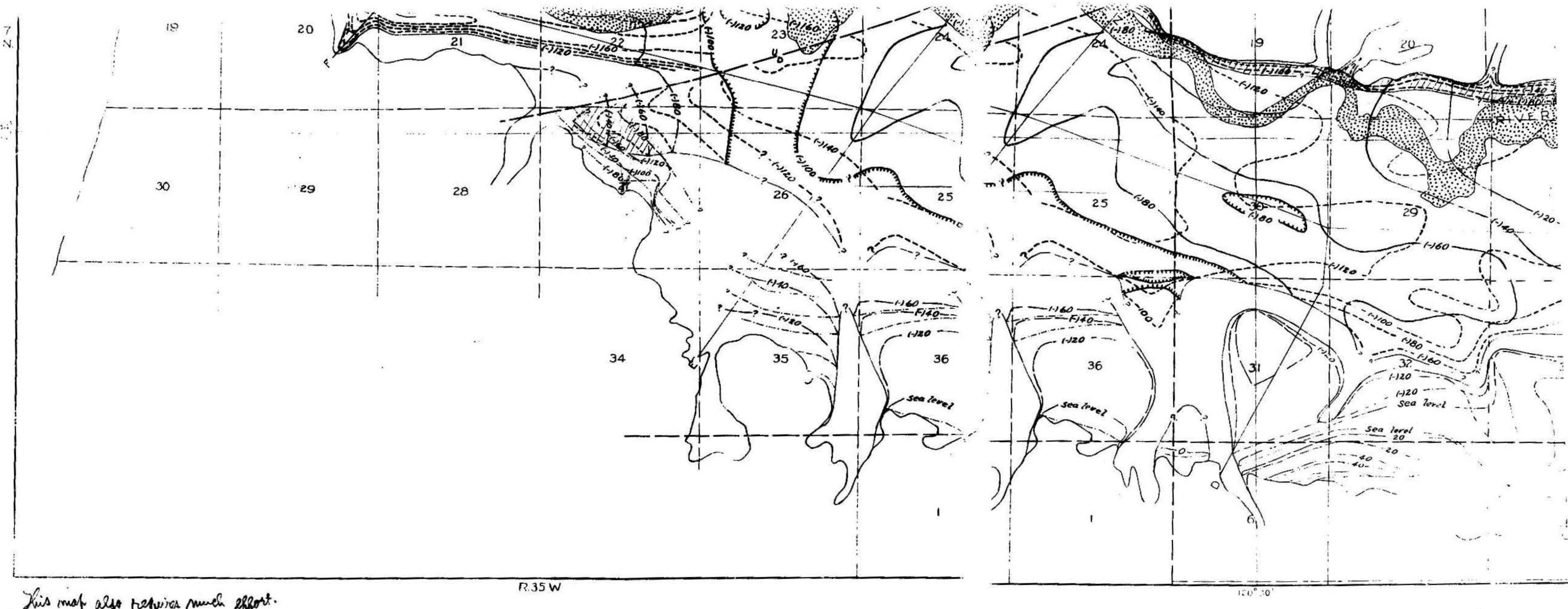


PLATE 4.- MAP OF THE LOMPOC PLAIN
OF THE MAIN AN

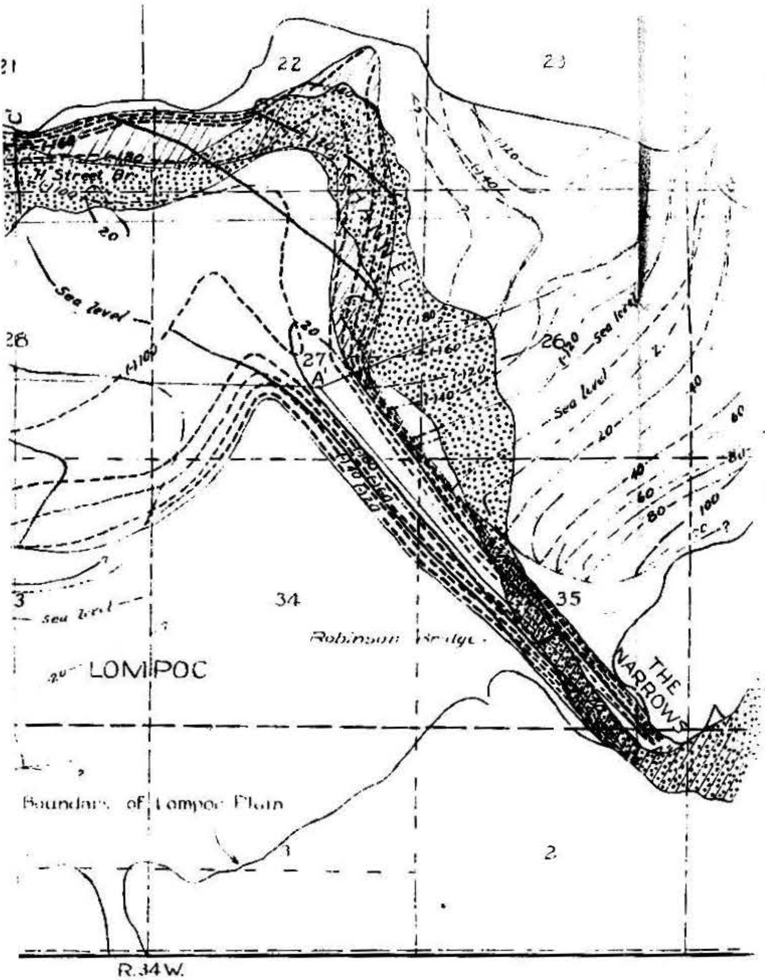
MPOC PLAIN SHOWING TENTATIVE CONTOURS ON THE
HE MAIN AND SECONDARY WATER-BEARING ZONES

This map also requires much effort.
It might help if the river channel were
shown more distinctly. Orm

JEU
Channel deposits stippled and
color contrast strengthened by J.E.U.

SECTION F-F'

AIN

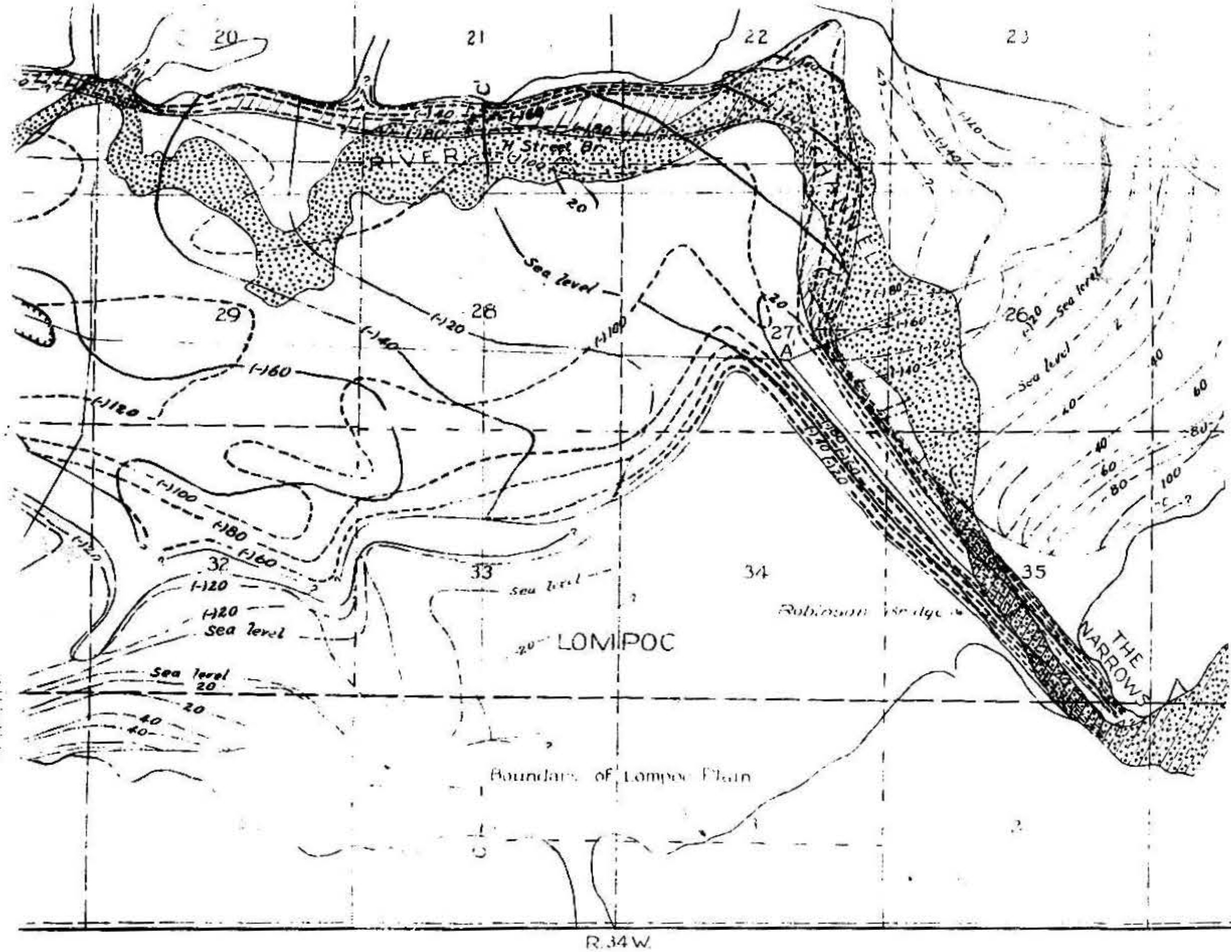


TOP AND BASE

FEET

SECTION F-F'

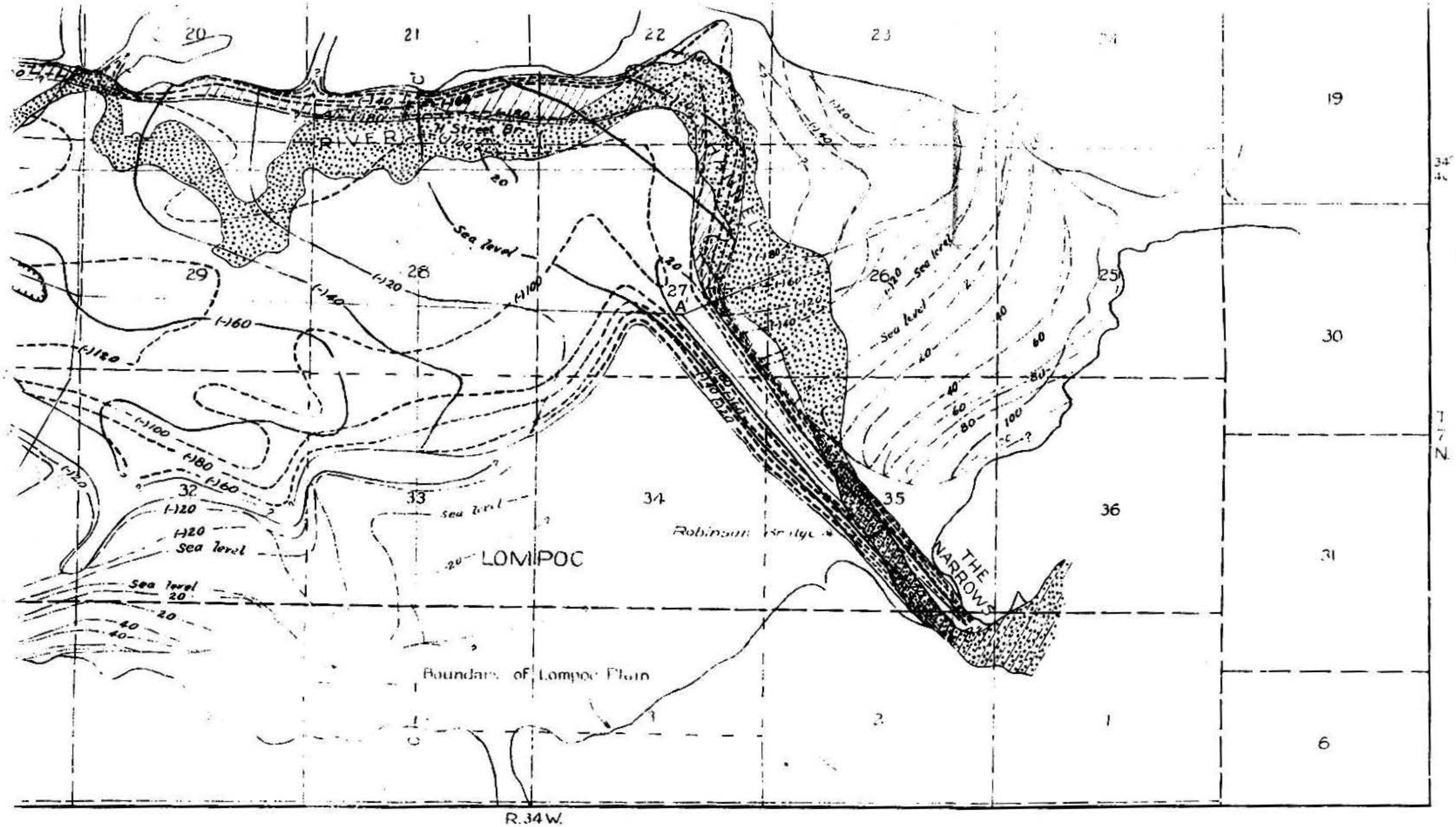
LOMPOC PLAIN



TATIVE CONTOURS ON THE TOP AND BASE
VATER-BEARING ZONES

SECTION F-F'

LOMPOC PLAIN



TATIVE CONTOURS ON THE TOP AND BASE
VATER-BEARING ZONES