GROUND WATER REPORT NO. 26

STATE OF OREGON

WATER RESOURCES DEPARTMENT

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Director

GROUND WATER CONDITIONS ON THE HARBOR BENCH, SOUTHWESTERN CURRY COUNTY, OREGON

By
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SALEM, OREGON
MARCH 1977

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DEFINITIONS OF SELECTED GROUND WATER AND GEOLOGIC TERMS

1. Alluvium - detrital deposits of sand, silt, gravel, and/or clay laid down in river beds, flood plains, and fans at the foot of mountain slopes.

2. Aquifer - a formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

3. Detrital - pertaining to material produced by the disintegration and weathering of rock and moved from its site of origin.

4. Eugeosyncline - a large generally linear marine trough receiving and accummulating a thick succession of stratified sediments and abundant extrusive igneous rocks.

5. Facies - a stratigraphic body as distinguished from other stratigraphic bodies of different appearance or composition.

6. Fluvial - pertaining to rivers or creeks.

7. Formation - a unit formed under essentially uniform conditions or under an alternation of conditions, and assumed to be limited in horizontal extent.

8. Greenstone - a term applied to altered basic igneous rock.

9. Lithology - the composition and texture of a rock.

10. Littoral - that part of the marine environment at and near shore.

11. Mélange - a broken, sheared, chaotic assemblage of rock units.

12. Pelagic - belonging to the deep sea.

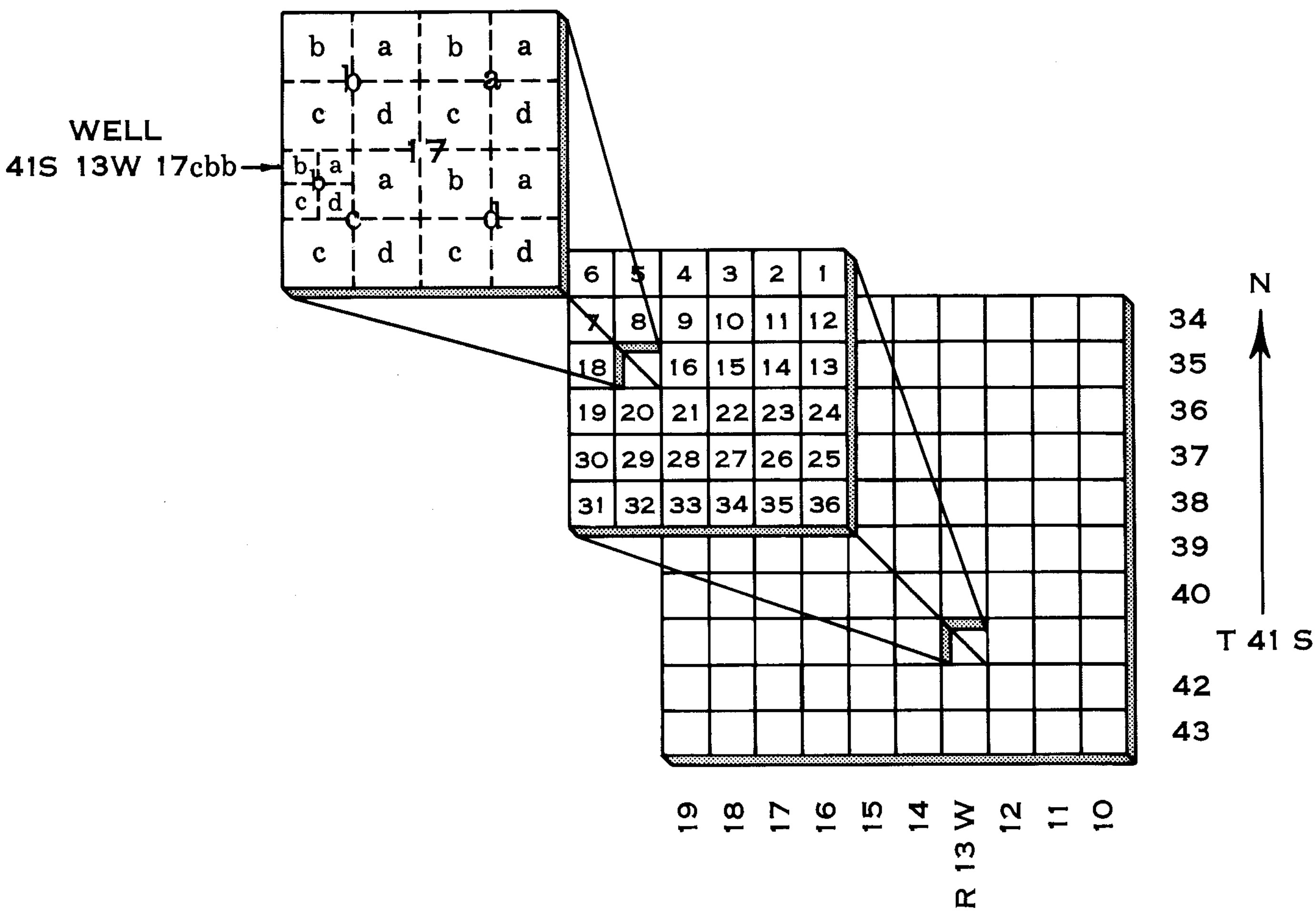
13. Phenocryst - a relatively large, well formed, and conspicuous crystal "suspended" in a finer-grained ground mass in an igneous rock.

14. Radiolaria - free floating, 1-celled, marine organisms characterized by minute silica shells.

15. Regolith - the loose incohesive rock material at and near the land surface derived from weathering of the bedrock.

WELL LOCATION AND NUMBERING SYSTEM

The well numbering system used in Oregon is based on the retangular system used for subdivision of public land. Each well number indicates the geographic location of the well and describes the township, range, and section. For example, the well number 41S/13W-17cbb indicates a well located within Township 41 South, Range 13 West, and Section 17. The letters indicate the well location within the section as shown in figure 1. The first letter (c) represents the quarter section (160 acres), the second letter (b) the quarter-quarter section (40 acres), the third letter (b) the quarter-quarter-quarter section (10 acres), etc.



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INTRODUCTION

Purpose of Study

Ground water is a major source of irrigation water on the Harbor Bench as well as a minor source of domestic and stock water. Lily bulbs and hydrangeas are the predominant crops on the bench and are grown for nation-wide distribution.

Until recently, all of the domestic water needs outside of the communities of Harbor and Brookings have been supplied by the ground water resource. However, this use has now been greatly curtailed as a result of the installation of a community water system which is intended to supply all of the domestic needs on the bench. The capacity of this system is not adequate to provide irrigation water, which, along with probably all the stock needs, is supplied by surface and ground water sources. Because the supply of surface water in the creeks which cross the bench is largely dependent upon precipitation, flows in the creeks are greatly diminished from mid-summer to mid-fall. To obtain the steadily increasing supply of irrigation water demanded as agriculture on the bench has expanded, farmers have increasingly turned to ground water as a source of irrigation water. This, in turn, has produced fears of real and/or anticipated ground water shortages.

In response to this concern, the Oregon State Engineer's Office established a net of observation wells (see Plate 1) late in 1966 to begin monitoring ground water level changes on a monthly basis. Since that time, some of the original wells have been deleted from the net and others added to provide better coverage.

The data obtained from these monthly measurements is incorporated herein to accomplish the two-fold objectives of this study: 1) to determine if there is an excessive ground water level decline beneath the Harbor Bench by authority of ORS 537.730, and 2) to comply with the requirements of ORS 537.685 to determine the boundaries of the aquifer, the location, extent, and quality of ground water, and the lowest permissible water table, and to describe the wells now tapping the aquifer.

Location

The study area on the Harbor Bench consists of a strip of land varying from approximately ¼ mile to nearly 1 mile wide and approximately 3½ miles long. On the southeast end the area is bordered by the Winchuck River and on the northwest end by Tuttle Creek. The Pacific Ocean forms the southwest boundary and the western foothills of the Klamath Mountains border the area along the the northeast edge. The entire area falls within Township 41 South, Range 13 West approximately 1½ miles southeast of Brookings and ½ mile southeast of Harbor, Oregon.

Previous Study

Widmier (1962) studied the structural and stratigraphic relationships of a large part of the southern Oregon coast including the area of this study. He assigned the name Chetco formation to the predominant surface formation in this southern coastal area and subdivided the Chetco formation into the Macklyn and Winchuck members. Dott (1971), in a more comprehensive study of the southwestern Oregon coast, recognized this same Chetco formation as being the Dothan formation of Diller (1907). However, he retained the Macklyn and Winchuck subdivisions of the formation.

Ramp (1975) studied the upper Chetco drainage area east of the Harbor Bench. He mapped extensive areas of Dothan formation, but made no attempt to divide the formation into members.

Beaulieu and Hughes (1976) studied western Curry county including the Harbor area to assess the geologic hazards to growth and development in the area.

Acknowledgements

The author greatfully acknowledges the assistance and cooperation of the local residents in completing this study. General background information obtained in conversations with them was extremely valuable in piecing together the developmental history of the bench. Particular thanks and appreciation are due to Mr. Robert Hastings on whose land many of the seismic lines were run, and to Mr. Norman Yock who made his irrigation wells available to us to perform an aquifer test.

The assistance and suggestions of Ed Olmsted and Fred Gelderman of the Soil Conservation Service are also greatly appreciated.

GEOLOGY

Climate

High precipitation, moderate temperatures, and moderate to high winds characterize the climate of the Harbor Bench.

Winds are variable depending upon the season, and are frequently quite strong. Summer winds typically blow from the north or northwest, but winter winds typically blow from the south or southwest striking the northwest-southeast trending coast line much more directly. Because of the coastal trend, summer winds are of little consequence geologically. However, onshore winter winds produce considerable wave activity which concentrates it's energy directly on the shoreline and may cause considerable erosion of both the beach and sea cliff.

Air temperatures on the Harbor Bench are moderated considerably by the proximity of the ocean. Although temperatures above 90 degrees and below freezing do occasionally occur, the monthly mean temperature in Brookings approximately two miles northwest of the study area does not exceed 60 degrees fahrenheit during the summer months nor fall below 47 degrees fahrenheit in the winter months.

Precipitation is the single most important climatic factor bearing upon this study. Figure 1 graphically represents the precipitation as recorded in Brookings from 1914 through 1975. The average annual precipitation during that 61 year period amounts to 77.4 inches, most of which falls from mid-October through mid-April. However, as the cumulative departure curve which is a part of that figure demonstrates, the annual precipitation during that 61 year period has not been constant. A 14 year period of abnormally low rainfall beginning in 1916 and continuing until 1930 produced a dramatic drop in the cumulative departure curve. Near average rainfall over the following 6 years was followed by a long period of abnormally heavy annual precipitation beginning in 1937 and continuing through 1958. From 1958 to 1971 precipitation, though varying considerably from year to year, remained near average. From 1971 to the present, precipitation has been slightly below average. 1976 precipitation figures are not available at the time of this writing, however,

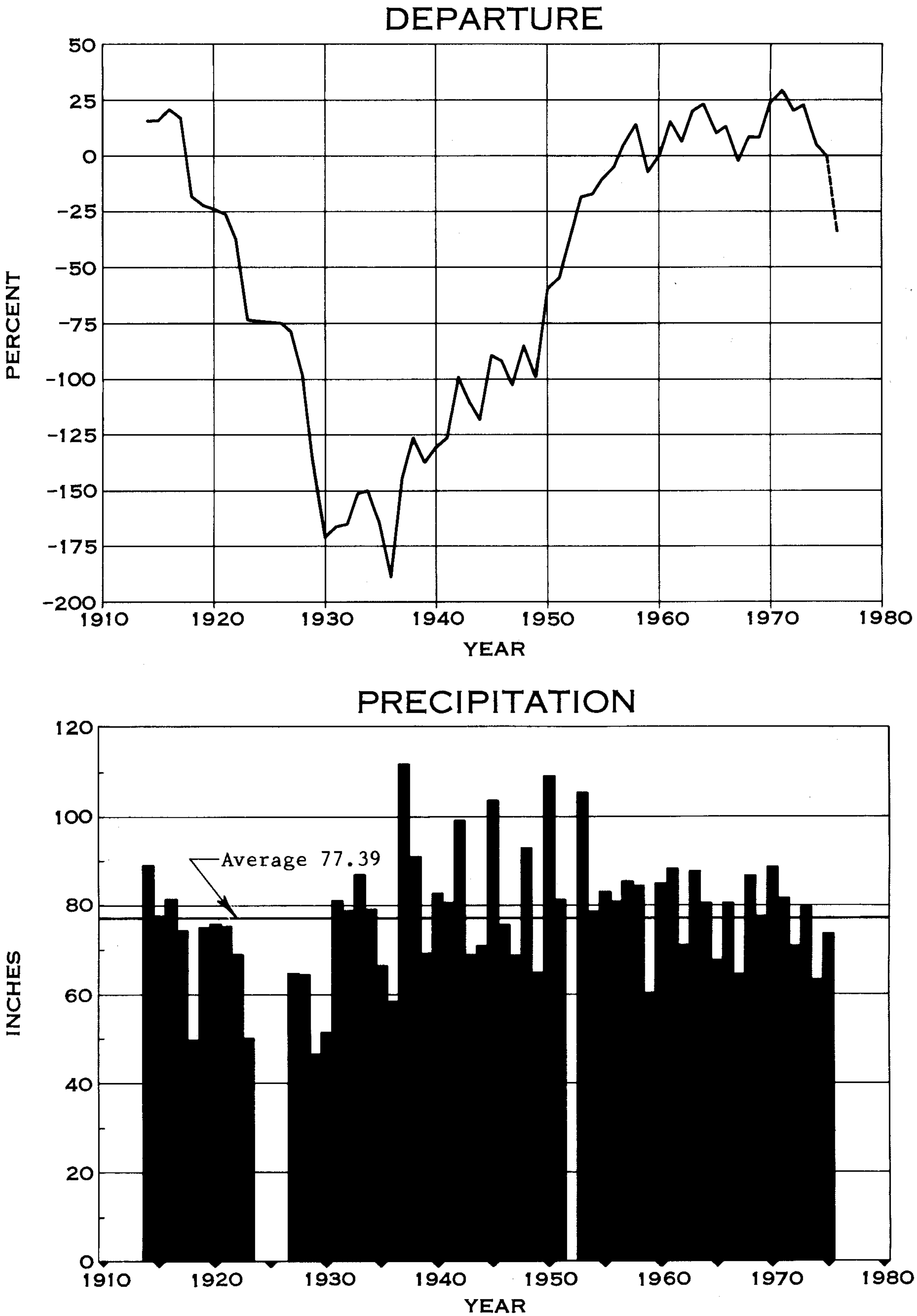


FIGURE 1. 1914-1975 Precipitation Data

the projected precipitation based upon figures for the first 10 months of the year is shown in figure 1 and indicates a significant deficiency in precipitation for the year.

Most of the precipitation on the Harbor Bench occurs as rainfall. Snow is rare but does occur occasionally in accumulations of a few inches. Because of the moderate climate, soils do not freeze and snow fall quickly melts.

Physiography

The topographic map of the Harbor Bench, Plate 1, is a composite of two topographic maps drawn by the Oregon State Highway Division prior to rebuilding Highway 101. The highway has been rebuilt and straightened since completion of the map. Topographic contours were not completed all the way to the ocean on the southwest, but approximately 75 percent of the bench is mapped topographically on a 5 foot contour interval. The study area limits are marked by the Winchuck River on the south, Tuttle Creek on the northwest, and the Pacific Ocean on the southwest. Trending subparallel to the coast northeast of the study area are the western foothills of the Klamath Mountains. The northeast boundary of the study area has been chosen approximately at the break in slope at the base of these hills. This boundary marks the farthest inland extent of the littoral zone aquifer which is the subject of this study. Highway 101 is constructed at the base of these hills in the south part of the area, but in the north part of the area, it is separated from the break in slope by gently rolling terrain typical of the bench.

From Tuttle Creek southeastward to Cooley Creek, land surface slopes gently oceanward. Southeast of Cooley Creek, land surface tilts more southerly and surface elevations drop much nearer sea level.

Land surface gradients are gentle throughout the entire bench, but are slightly greater near the foothills. Slopes are typically 4 to 6 percent and locally greater near Highway 101 and diminish to 3 percent or less near the ocean.

The coast line is marked by a prominent sea cliff which descends from more than 70 feet high at the northwest corner of the study area to approximately 35 feet near the mouth of Cooley Creek. From Cooley Creek southeastward the sea cliff diminishes rapidly in height, descending nearly to sea level in several hundred yards and persisting as only a slight rise above the beach along the remaining coast line to the Winchuck River.

Natural drainage on the bench is accomplished by approximately nine perennial or intermittent streams. Three of these, Johnson, McVay and Cooley Creeks, are deeply incised. These flow the year round, probably receiving much of their summer flow from ground water discharge directly into their channels. Parts or all of the remaining creeks dry up in late summer and early fall.

Topography on the bench must be considered in the early stages of youth having broad, relatively flat expanses of undisected land surface between creeks. Because of the high annual precipitation in the Harbor area, much of the land on these broad, nearly flat divides is naturally boggy. Soil development, erosion and deposition, and nature of the underlying terrace deposits also contribute to this condition. Most of these wet areas have been drained and the land claimed for agricultural purposes.

The surface of the bench between the drainages is typified by flat to gently rolling terrain. In the southeast half of the area the land surface is interrupted by at least four bedrock projections: McVay Rock located between Johnson Creek and McVay Creek, Hastings Rock located just south of Hastings Creek, the third one, herein called Freeman Rock, approximately 2,000 feet southeast of Cooley Creek, and a fourth one approximately 600 feet south of Freeman Rock. McVay Rock, which has been entirely removed for highway construction, is only partially shown on the topographic map and the fourth rock has been entirely omitted from the topographic map. These rocks represent sea stacks which would have been present during deposition of the terrace deposits on the Harbor Bench.

Surface irregularities on the bench may be attributed to a variety of causes. The manner of deposition of the terrace deposits results in a non-homogeneous layering of cobbles, gravels, sand, and silt which would have resulted in a surface with some initial relief. This relief has probably been further augmented by differential compaction. Mass movement of soils and regolith from the foothills to the northeast down onto the bench, erosion and some fan deposition, and warping and/or faulting of the underlying wave cut bench account for the remainder of the surface irregularities.

Stratigraphy

Dothan Formation - Diller (1907) first recognized and described the Dothan formation. Wells and Walker (1953) defined a fourfold subdivision of the Dothan formation while mapping in the Galice Quadrangle. The subdivisions were based on the relative abundance of the various lithologies that make up the Dothan formation. Widmier (1962) described in detail the sedimentary formation in the sea cliff and underlying the terrace deposits in the vicinity of Brookings and assigned the name Chetco formation to these rocks. However, the name "Chetco formation" has not been accepted, and this complex assemblage of sediments is now recognized as part of the Dothan formation.

Widmier (1962) divided the formation into two separate units, the Macklyn member whose type locality is Macklyn Cove southwest of Brookings, and the Winchuck member for which no type locality was chosen, but which is well exposed in stream channels and road cuts in the Winchuck River drainage basin. The contact between the Winchuck and Macklyn members is a gradational one and has been placed well east of the study area. As a result, this report will be concerned only with the Macklyn member of the Dothan formation.

Age dating the Macklyn member has been difficult because of a lack of both macro - and microfossils. Dott (1971) reports finding only carbonized plant fragments and two probable "worm tubes". Widmier (1962) reports carbonized plant fragments, but no other fossils. He does assign a relative age to the Macklyn member by sighting stratigraphic and structural relationships which tend to indicate that the Macklyn underlies the Winchuck farther east, and hence is older, but he is quick to point out that this conclusion is based on somewhat tenuous evidence. However, Ramp (1969) reports finding a fossil clam, Buchia Piochii (Gabb) which is uppermost Jurassic in age. These were identified in boulders of limey argillite tentatively identified as part of the Dothan formation well east of the study area in terrain mapped by Widmier (1962) as Winchuck member. If they are in fact part of the Dothan formation, and if the Dothan formation in fact becomes younger eastward, the Macklyn member should be considered upper Jurassic in age.

Dothan sediments are eugeosynclinal in nature. Widmier (1962) reports that graywacke comprises approximately 50 percent of the formation, mudstone and siltstone 40 percent, volcanics 10 percent, while bedded chert and conglomerates each make up less than 1 percent.

Graywackes of the Macklyn member are gray to gray-green on a fresh exposure while the weathered surface is a tan color. Beds range from thin to massive and are largely structurless except for grading which is occasionally observed. Poorly developed groove and flute casts and channel sections are also observed occasionally. The graywackes typically contain elongate granule and pebble-sized mudstone clasts and are typically hard, thoroughly indurated, and relatively undeformed in marked contrast to the siltstone and mudstone strata with which they are interbedded.

Mudstone and siltstone interbedded with the graywackes may be massive or contorted and sheared. Cross lamination is not uncommon. The mudstones consist of an argillaceous matrix surrounding quartz and feldspar and including much carbonaceous debris. The siltstones contain slightly more quartz and feldspar, chert, and igneous fragments and less carbonaceous material resulting in a slightly lighter gray coloration than is present in the mudstone.

Dott (1971) describes the environment of deposition of the Dothan formation as being moderately deep water typified by pelagic muds and radiolarian oozes. Turbidity currents periodically introduce sands and gravels into this environment. Turbidity flows would also account for the shale clasts observed within the graywackes.

Dott (1971) suggests that the many bedding plain slips and small folds observed in the Dothan, particularly in the mud- and siltstones, may indicate that the Dothan is a mélange much as discussed by Hsu (1968) relative to the Franciscan in northern California. It has been suggested that the Otter Point formation to the north, with which the Dothan appears to be contemporaneous, is also a mélange. In any event, the many intra-formational movements indicated by the deformed mud- and siltstones make any estimate of the total thickness of the Macklyn member, or of the Dothan formation, extremely tenuous. Wells and Walker (1953) measured the total thickness of the Dothan formation including repeated beds at 40,000 feet and estimated that the true stratigraphic thickness of the formation may be between 10,000 and 18,000 feet or more. Widmier (1962) estimates the Macklyn member to be approximately 6,000 feet thick, but was unable to find a definite top or bottom of the member to measure between and was unable to adequately eliminate the effect of bed repetition on his estimate.

A variety of volcanic rock types exist in the Macklyn including andesite, dacite porphyry, trachyte porphyry and rhyolite porphyry. Interstratified volcanic flows, flow breccias, agglomerates, and pyroclastics are scattered throughout the Macklyn member, many of which have been altered to greenstone. In addition, pillow basalts are reported by Beaulieu and Hughes (1976). The flows are predominantly massive and green in color and unless there are phenocrysts present, their fine-grained texture may impart a cherty appearance in outcrop.

Associated with the volcanics are conglomerates and bedded cherts. Granule and fine-pebble conglomerates are gradational with the finer grained pebbly graywackes and also with the coarser conglomerates. They typically crop out as lenticular bodies and may represent concentrations in channels. As is the case with all the lithologies within the Dothan, the conglomerates are thoroughly indurated.

Multicolored, bedded, radiolarian cherts make up the final lithology in the Macklyn member. Chert makes up less than one percent of the Macklyn member, but where present it is conspicuous as large lenses up to several scores of feet thick and several hundred feet in length and ending abruptly. Individual laminae within the chert range from approximately 1 inch to 1 foot in thickness and are separated by fine shale partings. Rainbow Rock 2 miles north of Brookings is an excellent exposure of Macklyn member chert.

The predominant difference between the Macklyn member and the Winchuck member of the Dothan formation is the volcanics which are absent in the Winchuck member. In addition, the quantity of conglomerate and chert is greatly reduced in the Winchuck member.

Upon weathering of the Dothan formation the more resistant lithologies, i.e. graywacke, chert, and volcanics, stand out in high relief.

Terrace Deposits - Quarternary marine terrace deposits overlie the Macklyn member with angular unconformity in the study area. These deposits are littoral-zone sediments and serve as the only aquifer in the study area. Terrace deposits extend from the Chetco River approximately one mile northwest of the study area to the Winchuck River and from the sea cliff to the base of the Klamath Mountain foothills. Total thickness of these sediments is variable ranging from a feather edge where older rocks protrude upward through the sediments, and at the contact with the Dothan formation at the base of the foothills, to 70 feet or more as indicated by the Hastings well in Section 22 (appendix 1). Average thickness of the terrace deposits calculated from the individual thicknesses represented on 111 well logs scattered throughout the study area is approximately 35 feet. The variation in thickness is indicated on the isopach map, Plate 2. In the north part of the area, the deposits seem to be thinner near the sea cliff and thicken inland before pinching out against the foothills. Dahlia, Johnson, and Cooley Creeks flow over areas underlain by generally thick terrace deposits and Hastings Rock appears to be located within a thick section of terrace deposits as well. Total thickness of the terrace deposits is somewhat greater on the southern part of the bench. These littoral deposits, of course, thin over buried sea stacks both inland and at numerous locations in the sea cliff. There are doubtless many more sea stacks buried beneath the terrace deposits than are shown on the map, but which cannot be detected due to the wide spacing of control points.

The seismic lines represented on the map indicate an extremely variable thickness to the terrace deposits. This variability caused by irregularities on the underlying wave cut bench should be present throughout the entire study area; however, the lack of closely spaced control points precludes the accurate mapping of these irregularities. These irregularities may have significant influence on ground water movement particularly during the dry months when the water table is low. This possibility will be discussed further in the hydrogeology section.

The average thickness of the terrace deposits is approximately 35 feet while the gravels average only about 16 feet in thickness. Like the remainder of the terrace deposits, the gravels are very loosely cemented if at all. The gravels are typically basal lying unconformably upon the Macklyn member. Sorting in the gravel layer is extremely poor, the larger interstices being filled with pebbles, smaller interstices being filled with sand, and still smaller interstices being filled with silt. Figure 2 shows the texture of these gravels where they crop out near the mouth of Tuttle Creek Canyon. However, these may not be typical of the remainder of the gravels on the bench; they occur at land surface and may or may not lie directly on the Macklyn member, and their proximity to Tuttle Creek suggests that they may be partially fluvial in origin. Figure

FIGURE 2. Terrace gravels near the mouth of Tuttle Creek Canyon.

3 shows basal gravels within the terrace deposits unconformably overlying Macklyn member graywacke sandstones, siltstones, and mudstones.

Well logs and well yields both indicate a textural change to finer grained materials in the southern end of the study area. This conclusion is further supported by figure 4 which shows an outcrop of terrace materials in a roadcut in the entrance to a parking area immediately north of the Winchuck River. Stratigraphic position of this exposure is not known with certainty; however, it is approximately 20 feet above the wave cut bench which should place it at or near the top of the gravel layer. As the figure shows, individual grain size does not exceed granule or fine pebble size.

An average of 18 to 19 feet of finer grained materials overlie the basal gravels. However, examination of appendix I discloses that the thickness of this overburden is quite variable, ranging from 0 to

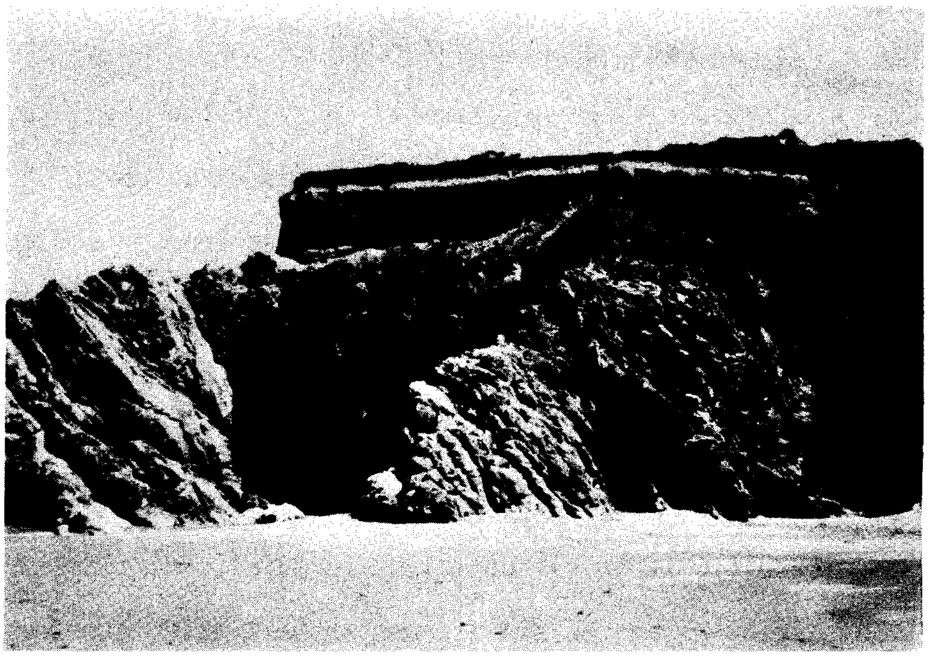


FIGURE 3. Terrace deposits with basal gravels lying unconformably upon the wave-cut bench carved in the Macklyn member of the Dothan formation.

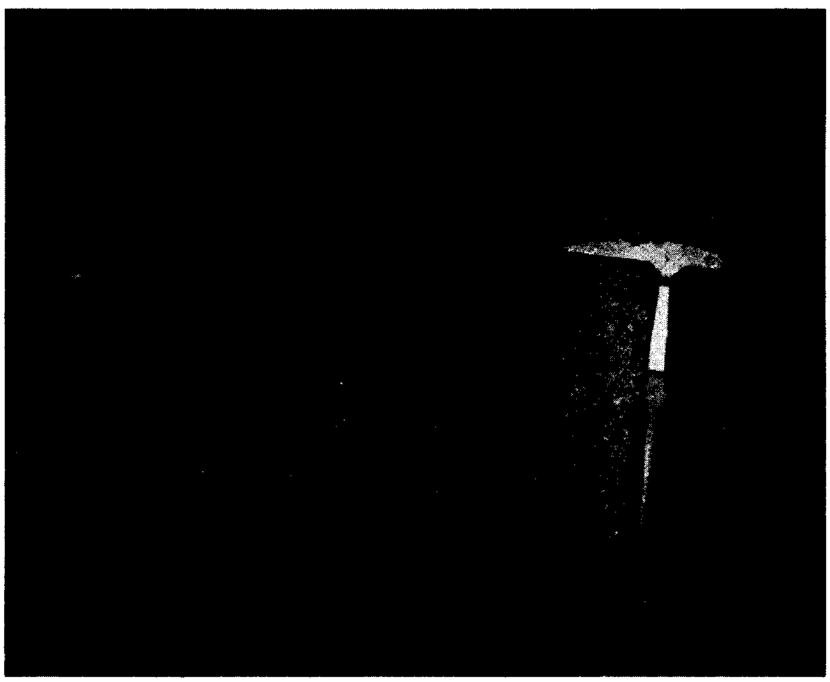


FIGURE 4. Terrace sands and gravels immediately north of the Winchuck River.

49 feet. Most of the driller's logs from the area indicate the presence of from 0 to 5 feet of soil, usually described as loam, overlying a thick column of clay overlying the gravels. Many of the logs also make mention of relatively minor amounts of "sandrock", "shale", "clay and gravel", etc. within this interval. This upper zone of sediments between the gravels and soil is composed of a clay and/or silt matrix surrounding sand lenses of perhaps fluvial origin and lenses of mud and rock debris resulting from mass wasting on the foothills.

Induration of the entire column of terrace sediments is slight, but according to Dicken (1961) it is sufficient to permit jointing in these deposits. This jointing may be significant in permitting aquifer recharge since vertical permeability along joint plains should be markedly greater than the vertical permeability of the fine-grained upper stratum of sediments.

Beach and Dune Sands - A very narrow beach borders the study area on the ocean side. At several locations along the beach, head lands project far enough seaward that they come under direct wave attack and at high tide it is impossible to walk around them. In other places, notably at the north and south ends of the study area, the beach widens to 100 feet or more, but the average width is probably between 30 and 40 feet. The absence of stabilized sand dunes, except for a short distance near the mid-point of the beach, indicates that the entire width of the beach, except for that short stretch, is subject to reworking during severe storms.

Kulm and others (1968) examined the mineralogy of several beaches and most of the coastal rivers of Oregon. However, their investigation did not include the Chetco River nor the beaches near its mouth. Dicken

(1961) reports the presence of igneous detrital fragments as well as quartz, dark minerals, and small quantities of gravel and cobbles in the beach deposits.

The only textural data available is also from Dicken's report. The median diameter of sand samples near the south jetty of the Chetco River was 0.222 millimeters; individual grains were angular to subangular in shape.

Greenstone - Widmier (1962) observed the presence of greenstone outcrops in, and east of, the study area. His investigation apparently did not include a detailed examination of every greenstone body he discovered, but all the ones which were studied in detail were attributed to metamorphosis of volcanics. Widmier attributed the alignment of McVay Rock, a greenstone outcrop at the base of the foothills, and a topographic ridge extending northeastward to a bed or sill of metavolcanics as shown on Plate 3. Dott's (1971) interpretation was similar.

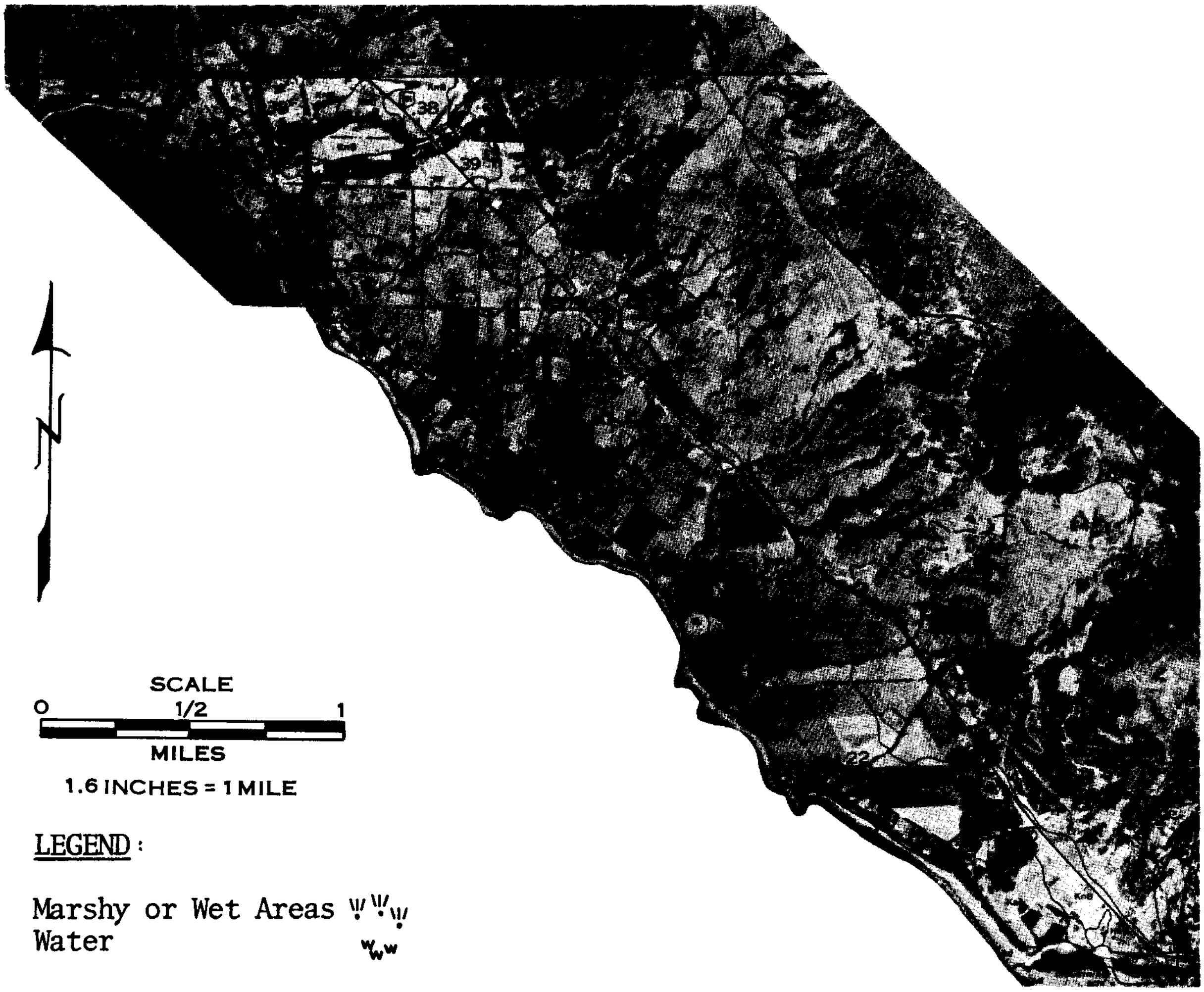
Beaulieu and Hughes (1976) identify these same outcrops (McVay Rock, Hastings Rock, etc.) as blueschist and point out that "exotics" such as blueschist do not occur in the Dothan formation. Then, because of the similarities in lithology, and presence of blueschist bodies, and abundant evidence of shearing, they suggest that the bedrock in the study area may, in fact, be Otter Point formation.

This writer has not petrographically examined samples of these outcrops and does not wish to support one interpretation over the other. It is sufficient for the purposes of this study to indicate that metamorphics are present within, and do protrude above, the wave cut bench. Many more such protrusions probably exist than have been mapped, but because they do not extend all the way to land surface or have not been encountered in water wells, their number and location are unknown. Plate 3 identifies these metamorphic outcrops as greenstone and more closely resembles the Widmier-Dott interpretation.

Soils - Five different soil types as mapped by Buzzard and Bowlsby (1970) have developed on the Harbor Bench and are extremely important in this study because of their influence on ground water recharge. Figure 5 is a soils map of the bench and surrounding area prepared by the U. S. Soil Conservation Service on a photographic base.

Hebo (HeB) soils are poorly drained and occupy slopes ranging from 0 to 7 percent. They form in mixed silty and clayey sediments washed from up-slope soils developed on sedimentary and igneous rocks. Hebo soils are very dark brown to very dark grey silty clay loams at the surface. At approximately 15 inches, the texture changes to a silty clay which is strongly mottled and which persists downward to approximately 58 inches where the texture changes to sandy clay. Runoff from the Hebo soils is slow, often resulting in ponding; the erosion hazard is slight; and the permeability of the soil is very slow (less than 0.06 inches per hour). Because of the very low permeability of the subsoil, and because of the heavy annual precipitation, Hebo soils contain a perched ground water body with a perched water table ranging from 0 to 1 foot below land surface from the months of November through June (U.S.D.A. Soil Conservation Service).

Knappa (KnB) soils form on alluvium derived from sedimentary and igneous rocks. Typically the surface layer which is approximately 14 inches thick consists of silt loam or silty clay loam overlying approximately 54 inches of silty clay loam. Knappa soils in general are very deep and well drained; runoff is slow; and permeability is moderate



LEGEND:

Marshy or Wet Areas
Water

Hebo Soils	Silty clay loam	HeB	0 to 7% Slopes
Knappa Soils	Silty clay loam	KnB	2 to 7% Slopes
	Clay loam, dark surface variant	KaA	0 to 3% Slopes
		KaC	3 to 12% Slopes
	Silty clay loam, heavy variant	KpC	0 to 12% Slopes
Orford Soils	Silty clay loam	OrE	12 to 30% Slopes
		OrG	30 to 70% Slopes
Winchuck Soils	Silt loam	WcE	12 to 30% Slopes
Winema Soils	Silty clay loam	WnE	12 to 30% Slopes
		WnG	30 to 70% Slopes
Nehalem Soils	Silt loam, overflow (on flood plain)	No	
Active Dune Sand		Ad	
Rock Outcrops		Ro, v	

FIGURE 5. Harbor Bench Soils Map

(0.6 to 2.0 inches per hour). In the study area, Knappa (KnB) soil occupies slopes ranging from 2 to 7 percent.

Two variants of the Knappa soil also exist in the study area. The dark surface variant (KaA, KaC) consists of approximately 20 inches of clay loam overlying approximately 28 inches of clay loam or silt loam which in turn overlies 6 or more inches of gravelly clay loam which has a moderate (0.6 to 2.0 inches per hour) permeability. Knappa dark surface (KaA) occupies fairly flat and level terrain with slopes ranging from 0 to 3 percent some distance from the foothills, while Knappa dark surface (KaC) occupies gentle slopes ranging from 3 to 12 percent near the foothills where the terraces come in contact with alluvial fans and the foothills themselves. As the figure 5 indicates, much of the dark surface variant is boggy or marshy. This may be due to the lower permeability of the clay loam which overlies the gravelly clay loam, or, more likely, to small inclusions of Hebo soil in minor depressions within the Knappa dark surface variant.

Knappa heavy variant (KpC) consists of approximately 5 inches of silty clay loam overlying approximately 55 inches of silty clay with a slow (0.06 to 0.2 inches per hour) permeability. Like the other Knappa soils, the heavy variant forms on alluvium derived from sedimentary and igneous sources and typically developes on alluvial fans and foot slopes ranging in slope from 0 to 12 percent. The heavy variant is moderately well drained; surface runoff is medium which results in a moderate erosion hazard.

Orford (OrE, OrG) soils form on steep slopes ranging from 12 to 70 percent over siltstone and sandstone. Orford soils are very friable silty clay loams. Because of the steep slopes, runoff is rapid; permeability of the subsoil is moderately slow (0.2 to 0.6 inches per hour); and the erosion hazard is severe. Orford soils are relatively thick, but below approximately 59 inches, they become gravelly silty clay loam in texture because of the inclusion of fragments of unconsolidated weathered parent material, i.e. Dothan graywackes and siltstones.

Winchuck (WcE) soils are deep and well drained, and form on sediments derived chiefly from siltstones and sandstones. Winchuck soils in the study area occur on slopes of from 12 to 30 percent. Winchuck soils are fairly deep consisting of a surface layer of very friable silt loam approximately 8 inches thick overlying approximately 10 inches of silty clay loam overlying approximately 16 inches of silty clay overlying approximately 12 inches of heavy silty clay loam overlying 12 or more inches of gravelly sandy clay loam whose coarser texture results from the alluvial deposits below.

Runoff on the Winchuck (WcE) is medium to rapid, and the erosion hazard is severe.

The total area of Winchuck soils in the study area is small and Winchuck soils are of little importance therefore.

Relatively insignificant amounts of Winema (WnE, WnG) soils are present on the foothills on slopes ranging from 12 to 70 percent. Winema soils are typically deep and well drained, and develop on sandstones and siltstones. The surface layer consists of approximately 14 inches of silty clay loam which overlies the subsoil consisting of 10 inches of silty clay loam overlying 16 inches of silty clay overlying 14 inches of silty clay loam. Below this depth are fine-grained, soft siltstones and sandstones deficient in quartz. Runoff is medium to very rapid and the erosion hazard, is, correspondingly, moderate to very severe. Permeability of the subsoil is moderately slow (0.2 to 0.6 inches per hour).

Other units indicated on the soil map figure 5 include active dune sand (Ad) and rock outcrops (Ro, v), which have been discussed above, and Nehalem silt loam, overflow (No). The Nehalem silt loam occurs on the Winchuck River flood plain and is unimportant to this study.

Generally speaking, Hebo soils occupy a lower position on the terrace than the Knappa soils. In addition, many of the Knappa soils are developed on alluvial fans. Artifical diversion of the stream channels and construction of Highway 101 have largely terminated the advance of fan deposits. However, it is possible that in the past, alluvial fans have covered preexisting soils as they spread and advance downslope. As mentioned above, Hebo soils occupy a lower position on the bench than the Knappa soils and form from a mixture of silt and clay washed from the up-gradient, i.e. Knappa, soils. If this has occurred to any great extent on the Harbor Bench, a significant area of Knappa soils, particularly on and near the toe of alluvial fans, may be underlain by less permeable Hebo soils resulting in perched ground water bodies, seep and spring discharge, and inefficient ground water recharge. However, the existence of the buried soils is speculative at this time.

Structure

The wave cut bench on which the terrace deposits lie was formed on Dothan rocks in Pleistocene time just as the wave cut bench currently along the coast in the Brookings area has formed. Similarly, just as beach sands and gravels are distributed on the current wave cut bench by wave activity, sands and gravels were spread on top of the Pleistocene wave cut bench. The sands and gravels, which make up the terrace deposits, were spread oceanward from the foothills which, in Pleistocene time, were the sea cliff. Subsequent to deposition of the terrace sands and gravels, either sea level lowered or the land surface in the Brookings area raised, or a combination of the two occurred to produce the present landscape.

Plate 4 is a map of the upper surface of the Dothan formation beneath the terrace deposits. As the map indicates, this surface slopes gently seaward throughout most of the study area. The slope is somewhat steeper along the northeast edge of the study area where the bench rises to meet the Pleistocene sea cliff, and nearly level with some surface irregularities near the current sea cliff. Seismic lines and bedrock exposures in the sea cliff both indicate that the upper surface of the wave cut bench is quite complex. These complexities, as previously discussed, are attributed to sandstone ridges, buried sea stacks, dikes or sills as indicated by Widmier (1962) and Dott (1971) and shown on the geologic map, Plate 3, and buried channels and eroded fracture systems. No attempt has been made to contour these irregularities except where seismic lines and sea cliff exposures identify their presence.

As previously stated, Dothan rocks are upper Jurassic in age. Some time after their formation in a eugeosynclinal environment, these Dothan strata were folded and faulted and moved into their present location. For this reason, several joint systems have developed in the Macklyn member of the Dothan formation. These joints are particularly evident in the type locality of the Macklyn member, i.e. Macklyn Cove.

The forces that emplaced the Macklyn member were also responsible for much shearing particularly within the more incompetent beds. The formation is no longer flat lying as at the time of deposition, but currently has a strike ranging from several degrees west to several degrees east of north and an easterly dip ranging from approximately 28 degrees to more than 70 degrees. Grading within some of the graywacke sandstones indicates that some of these beds are overturned, and Dott and Widmier both map an overturned anticline and syncline based on these lines of evidence with axes trending a few degrees east of north.

There is no direct evidence of faulting within the boundaries of the study area; however, Macklyn member rocks make a rise to the north near the mouth of Cooley Creek. This rise may be attributed either to faulting or slumping at that location, or to the presence of a monoclinal fold. Bedrock exposures in the vicinity are not adequate to make a determination.

HYDROGEOLOGY

Aquifers

Two sedimentary units exist in the study area which may produce some ground water. The first of these is the Macklyn member of the Dothan formation which, as described above, consists of hard, dense, thoroughly cemented graywackes, siltstones, and shales. Any primary porosity which may have existed in these sediments at the time of deposition was lost during the induration process. Some secondary porosity has developed in the form of fractures, joints, and shear zones; however, many of these have been closed by deposition of secondary calcite. Several shear zones noted in the sea cliff along the Harbor Bench discharge minor amounts of ground water, perhaps a gallon per minute in mid-summer, but the unpredictable landward extention of the shear zones and their relatively low permeability make the prospects of obtaining even a marginal domestic supply of water from them via water wells very poor.

In general terms, the Macklyn member lithologies have extremely small hydraulic conductivities and storage coefficients and are of no value as aquifers. The fractures, joints, and shear zones developed within the Macklyn member may have sufficiently large storage coefficients and hydraulic conductivities to obtain a marginal domestic supply, but the likelihood of encountering such zones during drilling operations is small. The Macklyn member holds no potential for producing irrigation supplies of water.

Domestic and limited irrigation supplies of water can be obtained from the terrace deposits overlying the Macklyn member. These terrace deposits, which constitute the only aquifer on the Harbor Bench, are described in the stratigraphy section. Water is produced from the basal sands and gravels which are overlain by approximately 19 feet of fine-grained overburden. Because of the overburden, the gravel behaves as a partially confined aquifer when filled. However, at some point during the irrigation season static water levels drop below the top of the gravels and the aquifer begins to behave more like an unconfined aquifer.

Facies changes occur within the aquifer with the result that the gravels are not of uniform thickness over the entire bench and, in fact, are absent in some locations. Plates 5 and 6 are high and low water table maps respectively drawn on the basis of static water level measurements. There are an insufficient number of control points south of Johnson Creek to complete the maps, but closely spaced contours would be necessitated by the sparse data that are available in that area. Close spacing is indicative of a low hydraulic conductivity which dictates a steep gradient in order to induce ground water flow. The low hydraulic conductivity suggests the general absence of permeable gravel in this area. This line of reasoning also supports a similar conclusion for the area up-gradient of the Yoshida-Yock-Strahm-Rigdon wells in Sections 9dd, 15bb, and 16aa. Sparse data again prevent accurate mapping of the water table near the sea cliff; however, the relatively slow ground water discharge observed in the sea cliff suggests that a low permeability zone exists landward of the sea cliff.

Conversely, the widely spaced contours present down-gradient from the Yock wells and in a band through the jog in Pedioli Lane indicate a relatively high hydraulic conductivity. This, in turn, suggests the presence of gravels and coarse sands in these areas, and may represent a buried shoreline where regression of the sea was halted long enough to distribute gravels by long shore drift and to winnow out the finer grained sediments. It is probable that small gravel bodies exist south of Johnson Creek which could provide limited supplies of water, but which have heretofore not been discovered by well construction.

As the above discussion points out, the aquifer is not continuous because of facies changes. In addition, the major drainages which cross the Harbor Bench also cause the aquifer to be at least partially discontinuous. Tuttle Creek and parts of Johnson, McVay, and Cooley Creeks are so deeply incised that their channels intercept the water table and receive ground water discharge. This condition will be discussed more completely below.

An aquifer test of limited duration was conducted by pumping Yock's well No. 6 and observing the water level fluctuations in the state observation well (see Plate 1). Test results on the basal gravel indicate a transmissivity of 12,600 gallons per day per foot, storage coefficient of 0.032, and hydraulic conductivity of 125 feet per day. A storage coefficient of 0.032 is very small for a water table aquifer, but large for an artesian aquifer. Two explanations present themselves for this observation. First, the aquifer is at least partially confined. This is indicated by 1) a good correlation between barometric pressure changes and irregularities in the drawdown curve, 2) the presence of a cohensive and consolidated clay and silt horizon overlying the gravel, and 3) the presence of a slight artesian head in the observation well at the time the test began, although the pumping well had a static water level below the top of the gravel layer. The second, and probably more important, reason for the small storage coefficient is the fact that the gravel is very poorly sorted which tends to greatly reduce the porosity and increase the specific retention.

Terrace deposits extend from the town of Harbor, approximately one mile northwest of Tuttle Creek, southeastward to and beyond the California border. However, the deeply incised Tuttle Creek on the northwest and the Winchuck River on the southeast form hydrologic boundaries for the aquifer in the study area. The northeastern boundary of the aquifer occurs at the base of the foothills where the terrace deposits pinch out, and the southwest boundary of the aquifer occurs at the sea cliff. The lower boundary of the aquifer is the underlying Macklyn member of the Dothan formation whose surface is represented on Plate 4. The basal gravels which comprise the aquifer vary greatly in thickness, but average approximately 16 feet and in general directly overlie the Macklyn member. The position of the upper surface of the gravel layer is again quite variable but averages approximately 19 feet below land surface. Thickness of the entire column of terrace deposits is presented on Plate 2, but no attempt has been made to isopach the gravel member.

Surface Water

Because the ground water body is shallow and because of the limited areal extent of the aquifer, surface water has a direct effect upon the ground water body. Ground water recharge is dependent upon runoff from the foothills percolating downward into the ground water reservoir at the base of the hills and incident precipitation percolating directly downward to the aquifer. Surface water is also important because of its effect upon the natural drainages on the bench. Any erosional deepening of the drainage channels below the water table will increase the ground water discharge to the creeks.

Several of the local farmers have drained marshy Hebo and Knappa soils in order to expand their crop production capability. The drain tiles now carry precipitation to surface streams quickly during and immediately after rain storms, whereas this water used to pond on the surface and run off very slowly. The result is that less recharge occurs to the aquifer because the water is channeled away, and the streams continue to downcut because of the increased peak discharge.

Urbanization has also had an effect on surface water runoff. The construction of parking lots, driveways, buildings and streets and roads and their associated drainage ditches has had the same two effects as draining the Hebo soils; namely, 1) they have eliminated recharge to the ground water body through the land they occupy, and 2) they cause rapid diversion of surface runoff to the natural drainages where the increased discharge causes increased down-cutting in the creek beds.

The construction of U. S. Highway 101 at the base of the foothills has also had a disruptive effect on ground water recharge and storage. Highway construction and subsequent widening in 1970 have eliminated land from recharge and increased the amounts of runoff water entering the surface drainages. In addition, much water which used to move downslope off the foothills and spread onto the alluvial fans and gentle slopes of the terrace and gradually be absorbed is now channeled laterally adjacent to the highway to culverts which concentrate the flow and discharge it to surface streams increasing the peak flows and causing the streams to cut deeper.

Even if much of the water involved in the above examples was unable to percolate downward to the ground water body because of the soil and sediment textures prior to these cultural changes, it was at least forced to percolate relatively slowly through the soils to discharge gradually into the surface streams. This would have resulted in a slower, more gradual runoff resulting in smaller peak discharges in the surface streams which, in turn, would have resulted in less downcutting.

Although the consensus of residents and knowledgeable parties interviewed is that peak stream discharges and downcutting have both increased in the recent past, some disagreement exists as to how much downcutting has occurred and which creeks have been affected. In 1973, the district office of the Soil Conservation Service in Gold Beach indicated that increased runoff caused by urbanization had resulted in higher peak flows in the creeks and that some of the creeks were cutting through the terrace deposits at an average rate of 1 foot per year.

Ten to twelve feet of downcutting is thought to have occurred in Cooley Creek since 1971. However, both Cooley and McVay Creeks are in that area of the bench which is not underlain by coarse gravels, and, although those creeks could be receiving ground water discharge from the terrace deposits, the results of that discharge are not severe because of 1) the relatively low hydraulic conductivity of these finer materials and 2) ground water is not generally relied upon as a water source in this area.

Johnson Creek is deeply incised into the terrace deposits and, in fact, is reported to have cut into the basal gravels in its lower reaches. Downcutting in Johnson Creek in recent years is not thought to have been more than a few feet.

An artificial base level of degradation has been established for each creek by construction of Ocean View Drive near the sea cliff. Each creek crossing has been accomplished by means of an earth fill with a culvert at the bottom. As a result, the creeks are not able to downcut below the level of the culvert unless severe flooding washes out the fills. Gradients along the streams, particularly in their upper reaches, are fairly steep which, combined with the increased peak discharges, will permit considerable downcutting to continue until the stream profiles have reached an equilibrium between the peak discharges and the artificial base level of degradation. Such downcutting could conceivably erode completely through the basal gravels some distance upgradient from Ocean View Drive.

Ground Water

Flow System - Virtually all of the ground water available on the Harbor Bench is present within a perched ground water body contained in the terrace deposits overlying the Macklyn member of the Dothan formation. It is contained within a local flow system which receives recharge at and near the base of the foothills to the northeast where precipitation runoff velocities decrease because of the decreased land surface gradient, and over the entire surface of the Harbor Bench as a result of incident precipitation.

Soils have a significant influence on recharge. Since the basal gravels are overlain by a relatively thick column of fine-grained material, percolation from land surface down to the water table is relatively slow except where this fine-grained overburden may be jointed. If it were not for a combination of the overlying soils and vegetation, runoff from the land surface would likely be so rapid that very little recharge would occur. The mantle of soils provides a medium that slows the movement of precipitation runoff and keeps it in contact with the fine-grained sediments overlying the aquifer long enough to permit recharge. This beneficial aspect of the soil cover is, unfortunately, counteracted by the urbanization which is proceeding on the Harbor Bench. Increases in the land surface area covered by roof tops, parking lots, and streets and roads is gradually diminishing the area in which recharge can take place.

However, soils are not universally beneficial to the recharge process. Some of the soils on the Harbor Bench, specifically the Hebo soils, are a hindrance to recharge. Large areas of Hebo soils with very slow permeabilities tend to pond water instead of allowing it to percolate downward. This ponded water then runs off very slowly through natural channels or as sheet wash, or is drained off rapidly by means of field tile to permit use of the land for agriculture. The latter is especially damaging to recharge efficiency within Sections 9 and 16, see figure 5.

The dark surface variant of the Knappa soils contains a gravelly subsoil 6 or more inches in thickness at its base. Precipitation falling on this soil may percolate downward to the gravelly layer and then flow down-gradient to emerge at land surface as a seep or spring at the down-gradient edge of the soil body. This has apparently happened at several places on the Harbor Bench where the down-gradient soil is a member of the Hebo series as in Section 16. The result is additional ponded water which is drained naturally, or more often artificially, and lost as recharge.

From these examples, it can be seen that the soils cover is not universally beneficial to the recharge process.

The ground water gradient in the transition zone between the foothills and the sea cliff is generally quite shallow as indicated on Plates 5 and 6. Down-gradient movement of ground water is generally towards the sea cliff except in the vicinity of the deeper drainages where some of the flow will be diverted and discharged into the streams. Data currently available does not permit mapping this diversion with any accuracy.

Beaulieu and Hughes (1976) indicate that this stretch of the Oregon Coast is highly susceptible to erosion resulting from wave action. As the sea cliff retreats landward, the hydraulic gradient will increase resulting in more rapid ground water discharge, and consequently less water available for irrigation purposes. However, this phenomenon should be of no concern for many generations.

It will be noted that the static water level contours on Plates 5 and 6 indicate a depressed water table in the vicinity of the Yock property in Sections 15 and 16. In addition, table 1 indicates that in general the wells in this area recharge later in the year than other wells monitored on the bench, i.e. late March or early April as opposed to January or early February. This is probably the result of at least two factors, 1) low hydraulic conductivity up-gradient as indicated by the close spacing of the contours on Plates 5 and 6 resulting in slower ground water movement into this area from the up-gradient recharge area, and 2) low permeability of the overlying Hebo soils (see figure 5) at least part of which is artificially drained.

A number of natural barriers to ground water movement exist within the aquifer unit itself. Creeks receiving ground water discharge control lateral movement of ground water on the bench. This control becomes less dominant as the water table drops. However, there are numerous other barriers which become progressively more significant as the water table drops. These include buried sea stacks, sandstone ridges, and any channels developed on the wavecut bench as well as the bed or sill of metamorphosed volcanics hypothesized by Widmier (1962) and Dott (1971) if it protrudes above the wavecut bench. By comparison to the terrace deposits, these rocks can be considered impermeable and, therefore, capable of diverting ground water. They have more effect on ground water movement in the lower levels of the aquifer.

Natural ground water discharge occurs on the sea cliff at and immediately above the contact between the terrace deposits and the underlying Macklyn member of the Dothan formation where numerous springs and seeps are evident. Natural discharge also occurs in the stream beds which cross the Harbor Bench whenever the water table stands high enough to come in contact with the individual stream beds. The amount of ground water discharge into stream beds has increased, and will continue to increase, as the creeks incise themselves more deeply into the terrace deposits as a result of increased surface flows.

Artificial ground water discharge includes water withdrawn for domestic, stock, industrial, and irrigation purposes by means of wells and sumps. By far the largest single use for ground water on the Harbor Bench is irrigation. At the present time there are approximately 350 acres under irrigation, but there is no way of estimating the amount of ground water actually used for this purpose annually.

Annual Variations - Table 1 is a summary of the data obtained from water level measurements in the 14 observation wells on the Harbor Bench

TABLE 1 HYDROGRAPH ANALYSES

NAME	NORMAL TIME OF HIGH WATER TABLE	APPROXIMATE LOW WATER TABLE SATURATED COLUMN IN FEET*	APPROXIMATE HIGH WATER TABLE SATURATED COLUMN IN FEET*	AQUIFER THICKNESS IN FEET	APPROXIMATE AMOUNT OF OVER-FILL AT HIGH WATER LEVEL IN FEET**	APPROXIMATE AVERAGE ANNUAL WATER TABLE FLUCTUATION IN FEET	YEARS OF RECORD	AVERAGE ANNUAL WATER TABLE DECLINE IN FEET [A]	AVERAGE ANNUAL WATER TABLE RECOVERY IN FEET [B]	AVERAGE ANNUAL DEFICIT (SURPLUS) RECHARGE EXPRESSED AS FEET OF SATURATED COLUMN [A - B]
Clendenin, M.	Mid Jan.	14.0	30.6	22	8.6	16.7	8½	16.5	16.9	(0.4)
Edwards, E. R.	Mid Jan.	17.3	30.6	10	20.6	13.6	4½	13.8	13.4	0.4
Penter, G.	Mid Jan.		No Log Available			16.7	9½	16.6	16.9	(0.3)
Quier, H. D.	Early Jan.	13.0	22.9	7	16.9	11.3	4½	11.1	11.6	(0.5)
Rigdon, E. L.	Mid Feb.	14.5	21.5	18	3.5	7.0	4½	6.8	7.1	(0.3)
Strahm, G.	Mid Mar.	16.0	21.8	11	10.8	5.8	4½	5.8	5.5	0.3
Swan, R.	Late Jan.	16.4	30.3	15	15.3	14.2	8	14.3	14.1	0.2
Yock, N. #2	Early Apr.	7.1	12.2	14	-1.8	5.7	4½	5.8	5.5	0.3
Yock, N. #3	Mid Mar.	11.9	17.0	15	2.0	5.3	4½	5.6	5.0	0.6
Yock, N. #4	Mid Apr.	12.9	17.3	16	1.3	4.6	4½	4.8	4.3	0.5
Yock, N. #5	Mid Mar.	13.0	19.7	23	-3.3	6.5	4	6.7	6.3	0.4
Yock, N. #6	Mid Apr.	14.3	20.2	15	5.2	5.6	4	6.0	5.2	0.8
Yock, N. #7	Early Feb.	14.8	29.3	20	9.3	13.7	4	14.3	12.9	1.4
Yoshida (Watt)	Mid Apr.	11.3	15.0	14	1.0	3.8	4½	4.0	3.7	0.3
AVERAGE		13.6	22.3	15.4	6.9	9.3				0.38

*Saturated Column Above Base of Aquifer
**Saturated Column Above Top of Aquifer

over a period of years. Hydrographs of the individual observation wells are presented in appendix II.

The thickness of the saturated column above the base of the aquifer at low water table (late September) is presented in column 3 of table 1. These values vary greatly ranging from 7.1 feet to 17.3 feet with an average of 13.6 feet (aquifer thickness is approximately 16 feet). As column 4 indicates, when the water table is high, the saturated column above the base of the aquifer is also quite variable ranging from 12.2 to 30.6 feet and averaging 22.3 feet. Since the aquifer thickness is approximately 16 feet, the saturated column extends approximately 6.3 feet above the top of the aquifer. The average annual fluctuation of the water table (column 7) is 9.3 feet.

A slight annual water table decline (column 11, table 1) is indicated by the data. The decline amounts to approximately 4.6 inches per year which is equal to 1.7 percent of the high water table saturated column or 2.8 percent of the low water table saturated column. The wells which have been measured for the longest period of time, 8 to 9 years, indicate an increase in the water table elevation as opposed to those wells which have been measured for only 4 to 5 years -- 0.2 foot increase per year as opposed to 0.4 foot decline per year. The implication is that the decline has occurred in the last 4 to 5 years. This is coincident with a general decline in annual precipitation over the last 4 years as indicated in figure 1. Ground water in the terrace deposits results solely from precipitation and the decline in precipitation over the last 4 years is probably the single most important factor in the water table decline. Other possible causes for the decline include excessive pumping from the aquifer, cultural changes which reduce the area through which recharge may occur and increase surface runoff, and downcutting of the creeks as a result of these cultural changes which permits more rapid ground water discharge to the creeks. In all likelihood a return to average precipitation will stabilize or increase the water table elevation. However, as figure 1 illustrates, long periods of below average precipitation do occur as was the case from 1916 through 1936.

At the time of this writing, it is too early to determine whether another long period of below average precipitation has begun. If it has, careful management of the ground water resource on the Harbor Bench will be vital to the economic survival of the local agricultural interests. Prevention of ground water losses due to discharge into surface streams could make a significant difference in the ground water supply. The possibility of constructing a series of water control structures in the creeks was briefly discussed with Fred Gelderman of the Soil Conservation Service. Purpose of these structures would be twofold; 1) to raise the water table in the vicinity of the creeks to decrease or prevent ground water discharge to the creeks, and 2) to terminate downcutting and erosion in the creek beds which not only threatens the ground water supply but also valuable crop land.

Lowest Permissible Water Table

The sole consideration in determining the lowest permissible water table on the Harbor Bench is that of maintaining an adequate supply for irrigation purposes since salt water intrusion is no threat on the bench. The lowest permissible water table must depend upon recharge (which in turn is dependent upon precipitation as discussed above) giving consideration to 1) maintaining sufficient storage to insure adequate ground water supplies during years of less than average precipitation, and 2) maintaining a sufficient saturated column such that the product of the specific capacity of the wells and the thickness of the saturated column is equal to or greater than the permitted rate of production at the point of withdrawal.

The specific capacity of a well is defined (Lohman, 1972) as "the rate of discharge of water from the well divided by the drawdown of water level within the well". Specific capacity is greatly influenced by well design and development. Specific capacities of wells on the Harbor Bench as calculated from data in appendix I range from less than 0.01 gallons per minute per foot (Gerlach well, Section 15, ¼ gallon per minute, 41 feet drawdown) to perhaps 100 gallons per minute per foot or more (Yock well No. 4, Section 15, 50 gallons per minute, assumed 6 inches drawdown) with an average of 7 gallons per minute per foot of drawdown. An aquifer test conducted using the Yock No. 6 well indicated a specific capacity of approximately 12 gallons per minute per foot which is probably a reasonable figure for irrigation wells on the bench. Most irrigation projects on the bench are very small, the average being slightly less than 10 acres. After adjudication proceedings are complete, ground water production rate for all irrigation purposes will probably be limited to 1/80 cubic foot per second per acre. The average irrigation project, i.e. 10 acres, will thus be permitted to withdraw ground water at a rate of 1/8 cubic foot per second, or slightly less than 60 gallons per minute.

Using 60 gallons per minute as the average production rate and dividing that figure by a specific capacity of 12 gallons per minute per foot indicates an anticipated average drawdown of 5 feet. This figure, for the purposes of this discussion, is taken as the absolute minimum allowable saturated column above the bottom of the aquifer if 1) the average amount of precipitation falls each year, and if 2) no increases occur in the amount of natural ground water discharge either in the stream channels or in the sea cliff.

However, it is not reasonable to assume that the "average" amount of precipitation will occur each year. Therefore, 50 percent of the average annual recovery from column 7, table 1, or approximately 5 feet, is arbitrarily chosen as a reasonable safety factor for dry years. Adding this to the 5 feet of drawdown expected during irrigation of typical acreages gives 10 feet as an approximate and arbitrary minimum saturated column above the bottom of the aquifer. As indicated in table 1, the annual low water table currently leaves 13.6 feet of saturated column above the base of the aquifer which is 3.6 feet in excess of the minimum herein prescribed. This figure may increase or decrease with time dependent upon precipitation, changes in ground water use, and management of all factors affecting runoff and erosion.

Serviceable Methods of Withdrawal

As discussed above, ground water in the terrace deposits is perched on top of the Macklyn member of the Dothan formation and is contained within the basal gravels of the terrace deposits. These basal gravels are overlain by silts and clays with relatively low hydraulic conductivities and which themselves are overlain by a variety of soils. Hebo soils in particular have a very slow permeability and therefore tend to pond water. This ponding is augmented if a gravelly subsoil is present up-gradient. These conditions combine to produce smaller ground water bodies perched above the main aquifer which lies some 19 feet below land surface. Several irrigation projects are supplied with water from sumps excavated where these conditions prevail.

However, on much of the bench, sumps cannot provide an adequate water supply for irrigation needs. In these areas, drilled wells are necessary to tap the ground water resources. Even then, proper design including perforated casing or preferably well screens, filter packs, and proper well development is necessary to produce an adequate irrigation supply.

Sand points may be capable of producing water in very limited quantity in a few locations on the bench, but without a filter pack and proper development, excessive drawdowns will prevent production of an adequate irrigation supply.

Hand dug wells, though capable of producing adequate amounts of water, are to be discouraged because of the high potential for contamination of the ground water body through them by the highly toxic pesticides and herbicides commonly in use on the bench, and by onsite domestic sewage disposal.

Water Quality

Ground water quality on the Harbor Bench is generally very good, though the potential for contamination by onsite domestic sewage disposal is increasing with the change of land use from agricultural to suburban and urban development. Tables 2A and 2B present the chemical analyses of water samples from the Yock well No. 1 (Section 16) and conductivity measurements on water from the Yock well No. 6 and from several surface streams. Chemical analyses show the water to be soft; its pH is nearly neutral; and the total dissolved solids are low having decreased from 160 in 1968 to approximately 70 in 1974. A cursory water quality test made with a conductivity cell on water from the Yock well No. 6 on November 3rd, 1976, indicated a salinity of 0 and a conductivity of 99 micromhos per centimeter (total dissolved solids approximately equals 70 parts per million). Similar tests of several water samples taken from the surface drainages also indicated very high water quality: 0 salinity, and conductivity ranging from 61 to 85 micromhos per centimeter.

TABLE 2A

Chemical Analyses

Sample Location Sample Date	Yock #1 September 1968	Yock #1 August 1974
Cation Concentration in ppm		
Calcium (Ca)	10.0	6.0
Magnesium (Mg)	5.0	5.0
Sodium (Na)	14.5	11.0
Boron (B)		0.06
Anion Concentration in ppm		
Chlorine (Cl)	24.9	16.0
Sulfate (SO_4)	6.0	
Carbonate CO_3)	0	
Bicarbonate (HCO_3)	23.8	15.0
Nitrate (NO_3)		13.0
Conductivity in μmhos/cm	190.2	100
Total Dissolved Solids	160	70*
Sodium Adsorption Ration (S.A.R.)	0.93	0.17
pH	7.25	7.5
Analysing Lab	U. S. Dept. of Agriculture Stillwater, Oklahoma	Soil & Plant Lab, Inc. Bellevue, Washington

*Estimated

TABLE 2B

Conductivity Cell Measurements

Sample Location	Water Temperature	Salinity (‰)	Conductivity (μmhos/cm)	Approximate Total Dissolved Solids (ppm)
Yock #6	15°C	0	99 ± 6	70
Dahlia Creek 100' S.W. of Hwy. 101	14°C	0	85 ± 5	60
Johnson Creek 300' from shore line	13°C	0	78 ± 5	55
Cooley Creek 400 ' from shore line	14°C	0	70 ± 4	49
Cooley Creek 500 ' upstream from Hwy. 101	14°C	0	61± 4	43

CONCLUSIONS

A slight water level decline amounting to an average of approximately 4.6 inches per year has occurred on the Harbor Bench during the last four or five years. This decline can probably be attributed entirely to a decline in average annual precipitation which has occurred over the same period of time. The decline is not considered to be excessive at this time, and it is anticipated that a return to average precipitation will reverse the static water level decline.

The aquifer which supplies ground water to the Harbor Bench consists of approximately 16 feet of basal sands and gravels within the Quaternary marine terrace deposits which overlie the Macklyn member of the Dothan formation. The terrace deposits which comprise the uppermost stratigraphic unit on the Harbor Bench are not uniform in thickness, but average approximately 35 feet. They are bounded on the northeast and southwest by the Klamath Mountain foothills and the current sea cliff respectively. Tuttle Creek and the Winchuck River constitute hydrologic boundaries on the northwest and southeast respectively. A lack of data precludes an accurate determination of the aerial extent of the basal gravels. However, they do seem to be limited to the area north of Johnson Creek.

Ground water is stored in and is transmitted by the basal gravels which average 16 feet in thickness. The average annual low static water level is approximately 21.4 feet below land surface leaving 13.6 feet of saturated column while the average annual high static water level rises well above the top of the gravel to approximately 12.7 feet below land surface giving 22.3 feet of saturated column.

Ground water exists within the terrace deposits generally throughout the entire areal extent of the Harbor Bench. However, in some areas, notably south of Johnson Creek, wells may be capable of only small production rates because of a thinning or complete absence of gravels.

Ground water quality on the Harbor Bench is generally very good. Great care must be exercised in water well construction, agricultural practices, and onsite sewage disposal to maintain the high quality in the future.

An arbitrary "lowest permissible water table" has been chosen to leave 10 feet of saturated column within the aquifer. This level on the average is 25 feet below land surface and provides a safety factor to buffer the effects of dry years as well as providing sufficient saturated column to produce modest irrigation needs at the rate of 1/80 cfs per acre. Total annual ground water use on the Harbor Bench is currently unknown.

Serviceable methods of ground water withdrawal on the Harbor Bench include drilled wells which must be properly constructed and developed to produce adequate water supplies from this aquifer, and sumps where the soil conditions are appropriate. Drive points are capable of producing some water but only at rates insufficent for irrigation purposes. Hand dug wells can be completed to supply large quantities of water, but the contamination potential resulting from construction of hand dug wells makes them extremely undesireable.

Various cultural changes have resulted in less efficient recharge to the aquifer and more efficient runoff of surface water. This in turn has resulted in down-cutting and erosion in the stream channels to the point that some of the surface drainages are receiving ground water discharge.

RECOMMENDATIONS

1) Continue monitoring the established observation well net and compare water table behavior with precipitation.

2) Require installation of water meters on all irrigation systems using ground water as a water supply. Make periodic readings of these meters to determine the actual amount of ground water used, and compare the ground water use with static water level fluctuations.

3) Prohibit construction of hand dug wells on the Harbor Bench.

4) Initiate a cooperative effort in conjunction with the Soil Conservation Service, Curry County, and the local growers to plan and construct a series of water control structures in one or more of the creek channels. Purpose of the structures would be twofold; 1) to stop further down-cutting and erosion in the channels, and 2) to raise the surface water level in a series of small impoundments upstream from each structure thereby preventing ground water discharge to the creek. In preliminary conversations on this subject with the Soil Conservation Service, that agency indicated a willingness to do at least some of the design work on such a project.

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APPENDIX I

WELL DESCRIPTIONS

THE FOLLOWING IS A LIST OF ALL WELLS WITHIN THE STUDY AREA WHOSE LOCATIONS COULD BE ESTABLISHED

WELL NUMBER 41S/13W-	OWNER	YEAR COMPLETED	DEPTH OF WELL (FEET)	DIAMETER OF WELL (IN.)	DEPTH OF CASING (FEET)	FINISH	WATER-BEARING ZONE(S) DEPTH TO TOP (FEET)	THICKNESS (FEET)	CHARACTER OF MATERIAL**	WATER LEVEL FEET BELOW DATUM	DATE	WELL PERFORMANCE YIELD (GPM)	DRAWDOWN (FEET)	USE*	REMARKS
9abb	Anderson, R. J.	1965	38	6	27	Prf. 21-27	3	27	S, C	19	9/9/65	5	14	D	
9adc(2)	Anderson, Vick	1958	38	8	36	Prf. 12-36	3	33	S, G	10	10/24/58	3	31	D	
9adc(1)	Anderson, Vick	1958	61	8	54	Prf. 44½-54	26	19	Ss					T	
9dc	Christensen, G. P.	1969	33	6	33	Prf. 23-33	14	19	Ss, G	12	2/1/69	20	16	D	15 minute test
9dc	Christensen, G. P.	1966	34	6	34	Prf. 24-34	22	11	G	10	3/15/66	300	14	D	
9dc	Christensen, G. P.	1968	35	6	34	Prf. 23-33	19	16	S, G	13½	5/17/68	15	13½	D	
9dcbd	Clendenin, Minnie	1964	59	10	45	Prf. 19-25	20	22	C, G	23	7/2/64	15	0	I,O	
9ddbb	Edwards, E. R.	1965	42	6	42	Prf. 32-42	32	10+	G	28	9/1/65	4	35	D,O	
9	Edwards, Harold W.	1964	44	6	25	Prf. 19-25	0	19	G, C	16	10/14/64	½	26	D	
9dbd	Hamman, W. J.	1965	60	6	60	Prf. 50-60	38	20	G	45	7/24/65	12½	55	D	½ hour test
9dda	Hildenbrand, Gerald	1965	66	6	66	Prf. 56-66	38	28+	Ss	50	6/7/65	3	55	D	¼ hour test
9bbb	Horton, Don	1962	27	6	25	Prf. 18-25	3	22	C, S, G	12	4/25/62	10	4	D	
9cc	Hurt, Ed	1966	26	6	26	Prf. 20-26	14	12	S, G	10	3/3/66	30	18	D	¼ hour test
9dca	Kelley, Frank	1958	31	8	28	Prf. 19-28	10	19	S, C, G	24	10/10/58	2	30	D	
9cbb	Kreiger, Vernon H.	1964	40	6	30	Prf. 24-30	3	27	S, G	14	7/8/64	8	10	D	
9bda	Larson, Jay	1960	28	8	28	Prf. 10-16	12	4							
						Prf. 20-28	19	9	G	12	6/9/60			D	
9bdc	Magie, Maurice C.	1965	44	6	44	Prf. 34-44	28	14	G	26	10/9/65	10	33	D	½ hour test
9ccc	Marks, J. R.	1965	41	6	30	Prf. 26-30	3	16	C, B	10	5/3/65	12	4½	D	
9acc	Oliver, Roger	1966	30	8	30	Prf. 20-30	20	10+	S, G	14	10/31/66	14	25	I	¼ hour test
9	Penter, Gerald (Anderson Bulb Co.)	1970	33	8	33	Scr. 22-32 3/16" Slot	18	14	Ss, S, G	18	6/20/70	10	22	I	
9dcbb	Penter, G.	1954	69	8	69					40	6/54			I,O	
9cd	Roberts, Viona	1957	34	8	33					10	1/30/60	50		I	No well log
9bad	Stafford, May	1958	55	8	50	Prf. 32-50	35	2	G, S	34	10/22/58	½ Total		D	
9bad	Stafford, May	1958	48	8	43	Prf. 30-48	25	5	G, S	25	10/26/58	3 Total		D	
							43	2	G, S						
9cca	Stanley, J. B.	1964	36	6	33	Prf. 25-32	10	14	S, G	17	10/21/64	15	10	D	
9bab	Swigert, Darrell N., & May, Robert H.	1964	45	6	39	Prf. 12-17 & 31-39	12	13	S, G	12	10/5/64	6	31	D	
9ba	Taylor, Ken	1964	60	6	58	Prf.	49	4	G	42	6/8/64	5	10	D	
9bdc	Vanduhouf, Cuffard R.	1965	52	6	46	Prf. 40-46	3	40	C, G	21	4/17/65	15	13	D	
9	Yock, Norman (Oregon Propagating Co.)	1969	36	8	35	Prf. 20-35	25	10	S, G	14	4/12/69	14	18	A	¼ hour test
9ddb	Zumpfe, Joseph	1954	52			Prf. 0-20	20	12	G	4				I	
9dca	Zumpfe, Joseph	1948	59	10	20	Prf. 0-20	12	30	G	30		30	25	I	low yield test-dry season
												80	10		high yield test-wet season
9dca	Zumpfe, Joseph	1954	34	8	28	Prf. 0-28	20	14	G	20		15	34	I	

WELL NUMBER 41S/13W-	OWNER	YEAR COMPLETED	DEPTH OF WELL (FEET)	DIAMETER OF WELL (IN.)	DEPTH OF CASING (FEET)	FINISH	WATER-BEARING ZONE(S) DEPTH TO TOP (FEET)	THICKNESS (FEET)	CHARACTER OF MATERIAL **	WATER LEVEL FEET BELOW DATUM	DATE	WELL PERFORMANCE YIELD (GPM)	DRAWDOWN (FEET)	USE*	REMARKS
15cba	Colegrove, Gene	1957	41	6	31	Prf. 21-31	4	8	G, S	26	9/27/57	2	Total	D	½ hour test
15dba	Gerlach, Byron	1975	60	6	50	Prf. 30-49	4	18	C	9	1/12/75	¼	41	D	¼ hour test
15bcd	Hastings, A. K.	1955	50	8	50	Prf. 20-50	20	30+	C, S, G	30	7/?/55	80		I, O	
15cdd	Hastings, Robert	1965	52	6	52	Prf. 40-52	28	24	G, S	27	8/17/65	20	18	Ind.	
15acc	Horton, Donald	1966	29	6	29	Prf. 19-29	24	5	G	22	9/14/66	4	24	D	½ hour test
15bcb	Rigdon, E. L.	1969	35	8	35	Prf. 20-34	16	18	S, G	14	4/29/69	60	26	I,O	
15bcbb(1)	Ridgon, E. L.	1951	40	8	40	Prf.				20		75	40	I	
15bcbb(2)	Ridgon, E. L.	1976	34½	8	34	Prf. 21½-33½	16	15½	S, G	17	6/15/76	40	3	I	
15dbc	Waldron, Charles	1967	25	6	25	Prf. 19-25	17	2	G	12	10/9/67	10	14	D	
15bbcab	Watt, Cecil (Yoshida)	1948	44	12	44		30	14+	G, S	30		100	10	I,O	
15bbcba	Yock, Norman	1969	38	8	38	Prf. 27-38	20	18	S, G	33½	8/29/69	50	0	O	Yock No. 4
	(Oregon Propagating Co.)														
15bbcba	Yock, Norman	1975	39	8	39	Prf. 26½-37¼	21	17 2/3	S, G	24	7/28/75	30	2	I	Yock No. 4
	(Oregon Propagating Co.)														Reconstructed
15bbcca	Yock, Norman	1969	33	8	32	Prf. 21-32	20	12	S, G	16	9/5/69	50	0	O	¼ hour test
	(Oregon Propagating Co.)														Yock No. 7
15bbcca	Yock, Norman	1976	42½	8	42	Scr. 28½-39¼	19	20	S, G	24	6/23/76			I	Yock No. 7
	(Oregon Propagating Co.)														Reconstructed
15bbcab	Yoshida - See Watt														
16abd	Atwood, C. W.	1962	33	6	31	Prf. 25-30	20	5	Ss	14	11/3/62	8	10	D	
16aca	Esselstrom, A. L.	1963	17	18	17	Prf. 13-17	13	4+	G	12	9/8/63	4	4		
16acb	Grayshel, Charles	1965	34	6	34	Prf. 24-34	20	12	G	24	7/30/65	4	22	D	¼ hour test
16adad	Hastings, R. K.	1959	24	6	22½	Prf. 10-22	10	12	S, G	12	5/14/59	10	19	D,O	½ hour test
16abd	Quier, H. D.	1964	27	8	27	Prf. 20-26	8	12	G	14	6/30/64	8	10	D,O	½ hour test
16acd	Reeser, Ray	1960	22	8	22	Prf. 14-22	13	9+	G	14	4/18/60			D	
16aba	Rose, A. G.	1944	26				24	2+	S, G	12		110	25	I,O	Dug well
	(Woodriff, Alvin)														
16abb	Smith, Lyle O.	1948	35				0	12	G	10		40	12	I	Dug well
							24	11+	G						
16acb	South Coast Lumber Co.	1960	20	8	20	Prf. 12-20	9	11+	G	11	4/29/60			D	
16ada	Strahm, G. G.	1969	32	6	32	Prf. 20-32	20	11	G, S	14	7/31/69	30	16	D,O	
	(Kelso, H. E.)														
16dcc	Swan, Robert	1952	30							16		100	10	I,O	
16baa	Swan, Robert	1952	30							16		100	10	I	No well log
16aba	Woodriff - See Rose														
16aadaa	Yock, Norman	1965	39	8	39	Prf. 25-38	19	20+	G	22	6/23/65	50	1	A	Yock No. 1
	(Oregon Propagating Co.)														

WELL NUMBER 41S/13W-	OWNER	YEAR COMPLETED	DEPTH OF WELL (FEET)	DIAMETER OF WELL (IN.)	DEPTH OF CASING (FEET)	FINISH	WATER-BEARING ZONE(S) DEPTH TO TOP (FEET)	THICKNESS (FEET)	CHARACTER OF MATERIAL**	WATER LEVEL FEET BELOW DATUM	DATE	WELL PERFORMANCE YIELD (GPM)	DRAWDOWN (FEET)	USE*	REMARKS
16aadaa	Yock, Norman (Oregon Propagating Co.)	1976	42	8	42	Scr. 27½-39	19	19½	S, G	25	6/22/76			I	Yock No. 1 Reconstructed
16aaadc	Yock, Norman (Oregon Propagating Co.)	1969	32	8	31	Prf. 21-31	16	14	S, G	15	8/7/69	55	17	I,O	¼ hour test Yock No. 2
16aaddb	Yock, Norman (Oregon Propagating Co.)	1975	31	8	31	Scr. 19¼-30	13	15½	G	15	8/6/75	30	3	I	Yock No. 3
16aadda	Yock, Norman (Oregon Propagating Co.)	1970	33	8	32	Scr. 22-32	18	14	S, G	16	7/23/70	40	12	O	¼ hour test Yock No. 5
16aadda	Yock, Norman (Oregon Propagating Co.)	1975	35	8	35	Scr. 23½-34¼	10	23	S, G	18	8/1/75	30	5	D,I	Yock No. 5 Reconstructed
16aadac	Yock, Norman (Oregon Propagating Co.)	1970	31	8	30	Scr. 20-30	18	12	S, G	19½	7/16/70	40	14	A	¼ hour test Yock No. 6
16aadac	Yock, Norman (Oregon Propagating Co.)	1976	38	8	38	Scr. 24-35	19	15	S, G	19	6/23/76			I,O	Yock No. 6 Reconstructed
16aadac	Yock, Norman (Oregon Propagating Co.)	1970	32	6	32	Prf. 22-32	22	10+	S, G	22	7/8/70	20	28	T,O	¼ hour test Used as water level monitoring well only.
16acb	Yost, Howard W.	1964	30	6	30	Prf. 24-30	4	21	S, G	13	7/4/64	4	14	D	
22aca(1)	Cain, F. J.	1956	53	6	53	Prf. 43-53	30	23+	S, G, C	10	10/24/56	15	2	D	
22bab(1)	Clinkingbeard, Karl	1963	28											A	All gravels cemented
22bab(2)	Grimmer, Louis	1963	27	18	27	Prf. 22-27	20	7+	G	22	10/9/63	3	2	D	
22abca	Hastings, Robert	1966	72	8	72	Prf. 55-72	25	45	S	39	7/29/66	12	11	I	¼ hour test
22ad	Horton, Donald	1966	50	6	50	Prf. 40-50	38	12	S	37	7/26/66	7	3	D	
22aca(2)	Linder, Jas	1969	49	8	48	Prf. 38-48	35	13	S, G	40	4/19/69	5	42	D	
22aca(3)	Manley, Clive	1967	44	6	44	Prf. 34-44	38	5	G, S	30	6/13/67	3	34	D	¼ hour test
22aca(4)	West, J. V.	1963	56	6	49	Prf. 44-49	4	46	C, G, B	36	7/20/63	4	25	D	
23cb(1)	Bieberdorf, Otto	1956	20	8	20	Prf. 15-20	10	5	G	10	3/27/56	20	0	D	
23cbd(1)	French, F. M.	1962	18	18	18		15	3+	B, S, G	12	11/4/62	20	4	D	
23cb(2)	Horton, Donald	1965	29	6	28	Prf. 20-28	22	5	C, S, G	10	11/11/65	10	15	D	¼ hour test
23cbd(2)	McGugin, Robert	1963	26	6	23	Prf. 19-23	14	9	S, G	16	9/17/63	7	5	D	
23cd	Reeser, Ray	1963	30	6	27	Prf. 19-27	5	21	B, C	18	10/21/63	3	10	D	
23cba	Soule, Eva	1964	25	6	24	Prf. 16-24	6	14	C, S, G	12	8/3/64	8	8	D	
23cada	Trimmer, Hazel A.	1964	30	6	30	Prf. 0-20	25	5+	G, S	25	8/13/64	8	2	D	½ hour test
23cadc	Trimmer, Hazel A.	1966	29	8	29	Prf. 22-29	22	7	S, G	19	2/10/66	5	6	D	

*A = Abandoned
D = Domestic
I = Irrigation
Ind = Industrial
O = Observation
T = Test

**B = Boulders
C = Clay
G = Gravel
S = Sand
Ss = Sandstone

APPENDIX II

RECORDS OF IRRIGATION AND OBSERVATION WELLS

Records of Wells — State Well Number 41/13W-9cd

Owner: Viona Roberts — Location SE¼ SW¼, Sec. 9, T. 41 S., R. 13 W.

Depth: 33 feet. Diameter: 8 inches. Depth cased: 33 feet.

Approximate altitude of land surface at well: 92. Year constructed: 1957

Yield: 50 gpm. Drawdown ?. Test duration ? hr. Test date 3/57

Remarks: Irrigation well

Generalized Log:

Not available

Records of Wells — State Well Number 41/13W-9db

Owner: V. E. Anderson — Location NW¼ SE¼, Sec. 9, T. 41 S., R. 13 W.

Depth: 57 feet. Diameter: 10 inches. Depth cased: - feet.

Approximate altitude of land surface at well: ______. Year constructed: 1951

Yield: - gpm. Drawdown -. Test duration - hr. Test date -

Remarks: Irrigation well

Generalized Log:

Not available

Records of Wells — State Well Number 41/13W-9dcbb

Owner: Gerald Penter — Location SW¼ SE¼, Sec. 9, T. 41 S., R. 13 W.

Depth: 69 feet. Diameter: 8 inches. Depth cased: 69 feet.

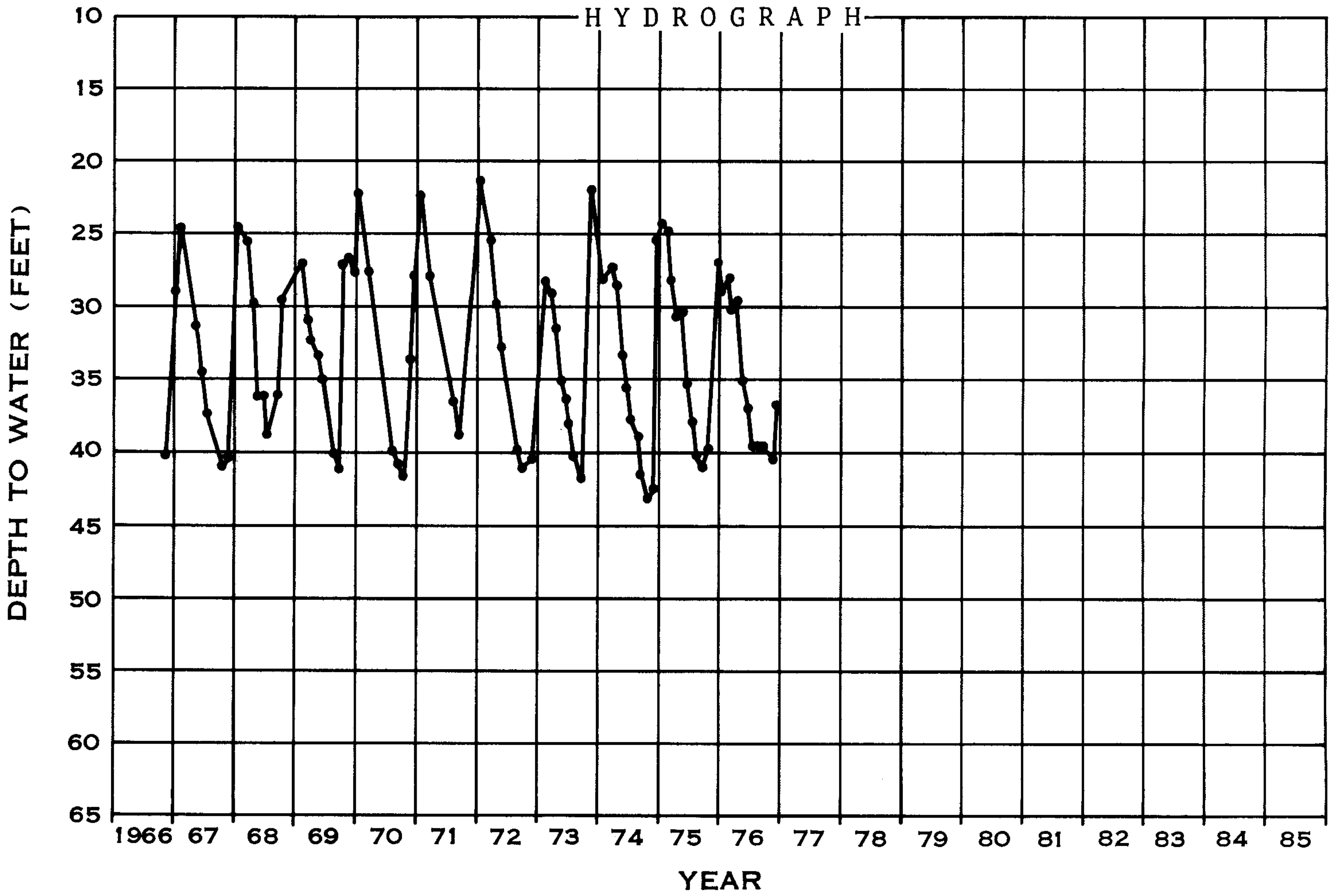
Approximate altitude of land surface at well: 115. Year constructed: 1954

Yield: - gpm. Drawdown -. Test duration - hr. Test date -

Remarks: Irrigation and observation

Generalized Log:

Not available



Records of Wells

State Well Number 41/13W-9dcbd

Owner: Minnie Clendenin Location SW¼ SE¼, Sec. 9, T. 41 S., R. 13 W.

Depth: 59 feet. Diameter: 10 inches. Depth cased: 45 feet.

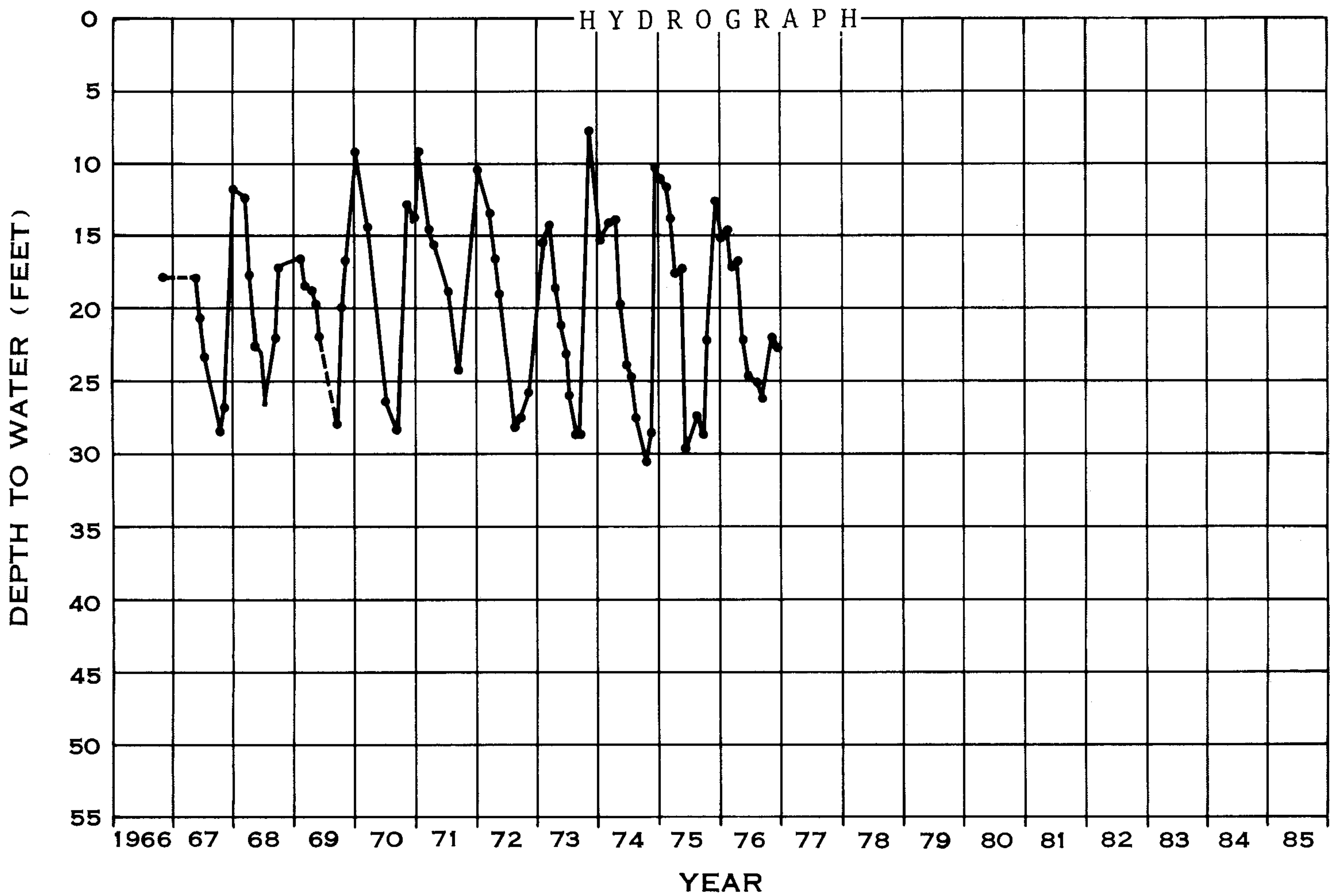
Approximate altitude of land surface at well: 101. Year constructed: 1964

Yield: 15 gpm. Drawdown 0. Test duration 1 hr. Test date 7/2/64

Remarks: Irrigation and observation

Generalized Log:

Black top soil	0 - 4 feet
Brown clay	4 - 20 feet
Coarse gravel with clay cement	20 - 42 feet
Brown sandstone	42 - 59 feet



Records of Wells State Well Number 41/13W-9dd

Owner: Victor Anderson Location SE¼ SE¼, Sec. 9, T. 41 S., R. 13 W.

Depth: ? feet. Diameter: 8 inches. Depth cased: ? feet.

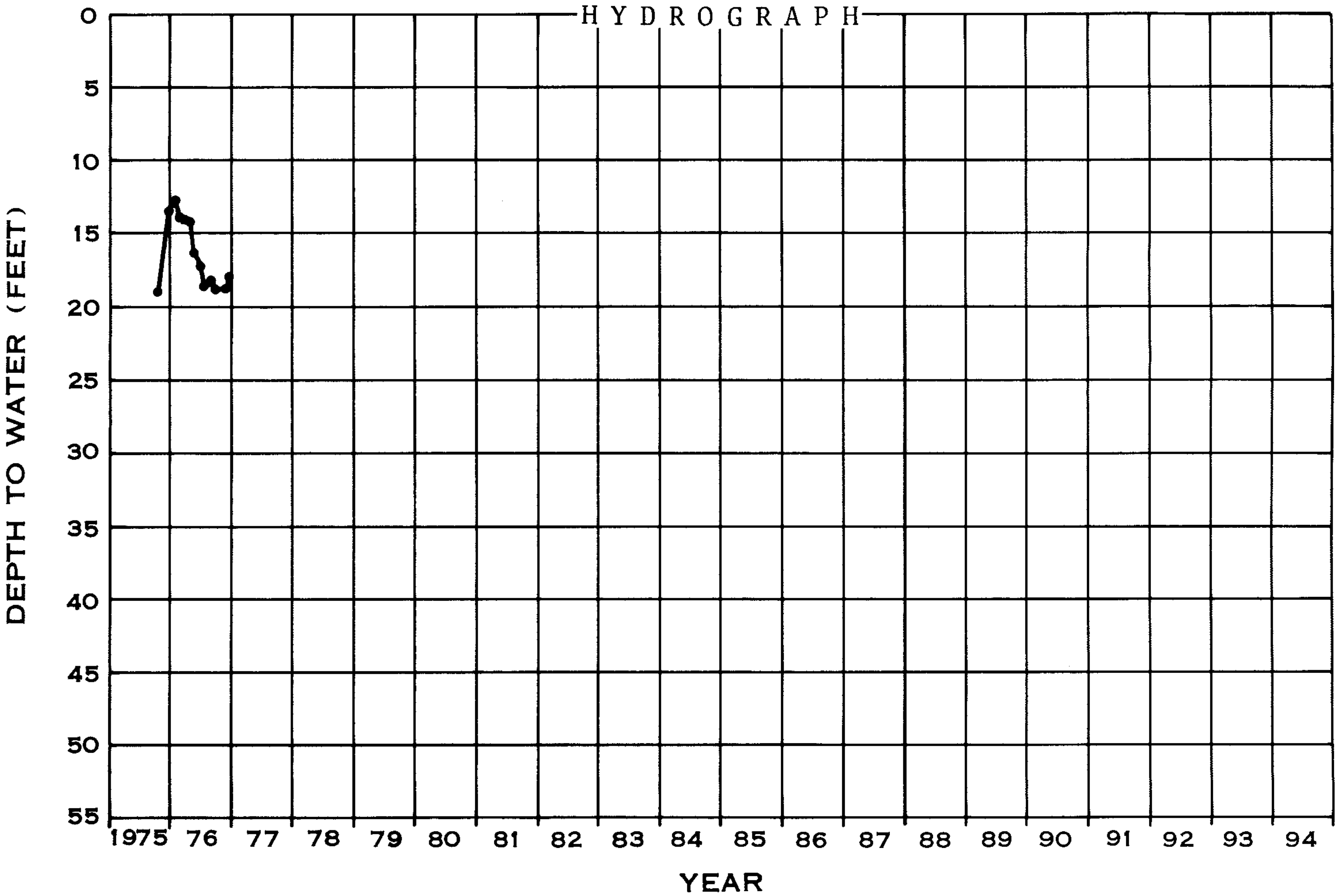
Approximate altitude of land surface at well: 108. Year constructed: ?

Yield: ? gpm. Drawdown ?. Test duration - hr. Test date -

Remarks: Used for observation only

Generalized Log:

Not available



Records of Wells State Well Number 41/13W-9ddbb

Owner: E. R. Edwards Location SE¼ SE¼, Sec. 9, T. 41 S., R. 13 W.

Depth: 42 feet. Diameter: 6 inches. Depth cased: 42 feet.

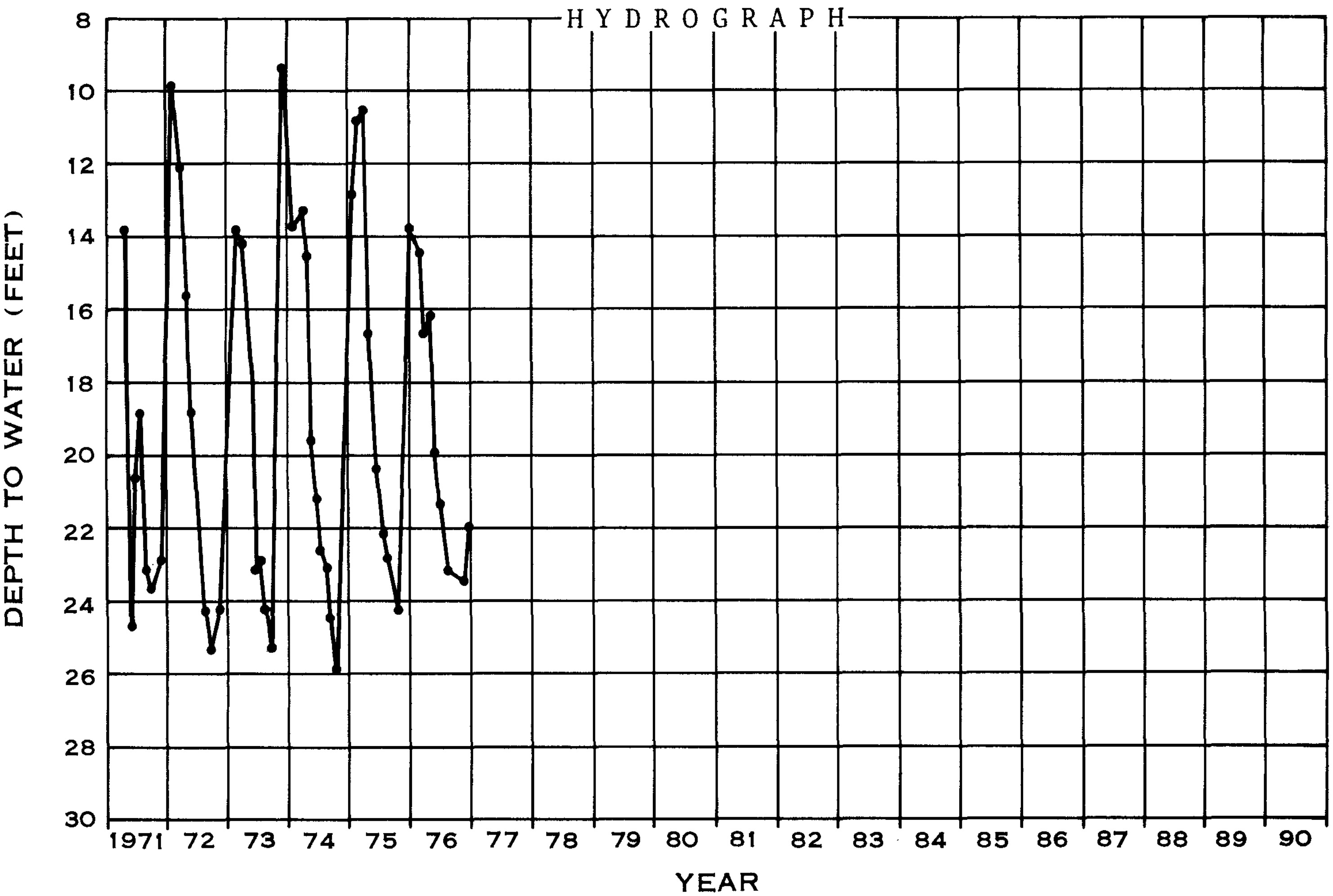
Approximate altitude of land surface at well: 110. Year constructed: 1965

Yield: 4 gpm. Drawdown 35. Test duration 1/2 hr. Test date 9/1/65

Remarks: Domestic and observation well

Generalized Log:

Black loam	0 - 4 feet
Clay	4 - 32 feet
Gravel	32 - 42 feet



Records of Wells — State Well Number 41/13W-15bb

Owner: Walter I. Saylor — Location NW¼ NW¼, Sec. 15, T. 41 S., R. 13 W.

Depth: 43 feet. Diameter: 6 inches. Depth cased: 43 feet.

Approximate altitude of land surface at well: 110. Year constructed: ?

Yield: ? gpm. Drawdown -. Test duration - hr. Test date -

Remarks: Irrigation well

Generalized Log:

Not available

Records of Wells — State Well Number 41/13W-15bbcba

Owner: Norman Yock #4 — Location NW¼ NW¼, Sec. 15, T. 41 S., R. 13 W.

Depth: 39 feet. Diameter: 8 inches. Depth cased: 39 feet.

Approximate altitude of land surface at well: 88 ft. Year constructed: 1975

Yield: 30 gpm. Drawdown 2. Test duration 3½ hr. Test date 7/28/75

Remarks: Irrigation well

Generalized Log:

Brown clay soil	0 - 1 foot
Brown clay	1 - 9 feet
Sandy brown clay	9 - 16 feet
Brown clay and gravel	16 - 20 feet
Sand and gravel	20 - 36 feet
Serpentine	36 - 39 feet

Records of Wells

State Well Number 41/13W-15bbcab

Owner: Yoshida (Watt) Location NW¼ NW¼, Sec. 15, T. 41 S., R. 13 W.

Depth: 44 feet. Diameter: 12 inches. Depth cased: ? feet.

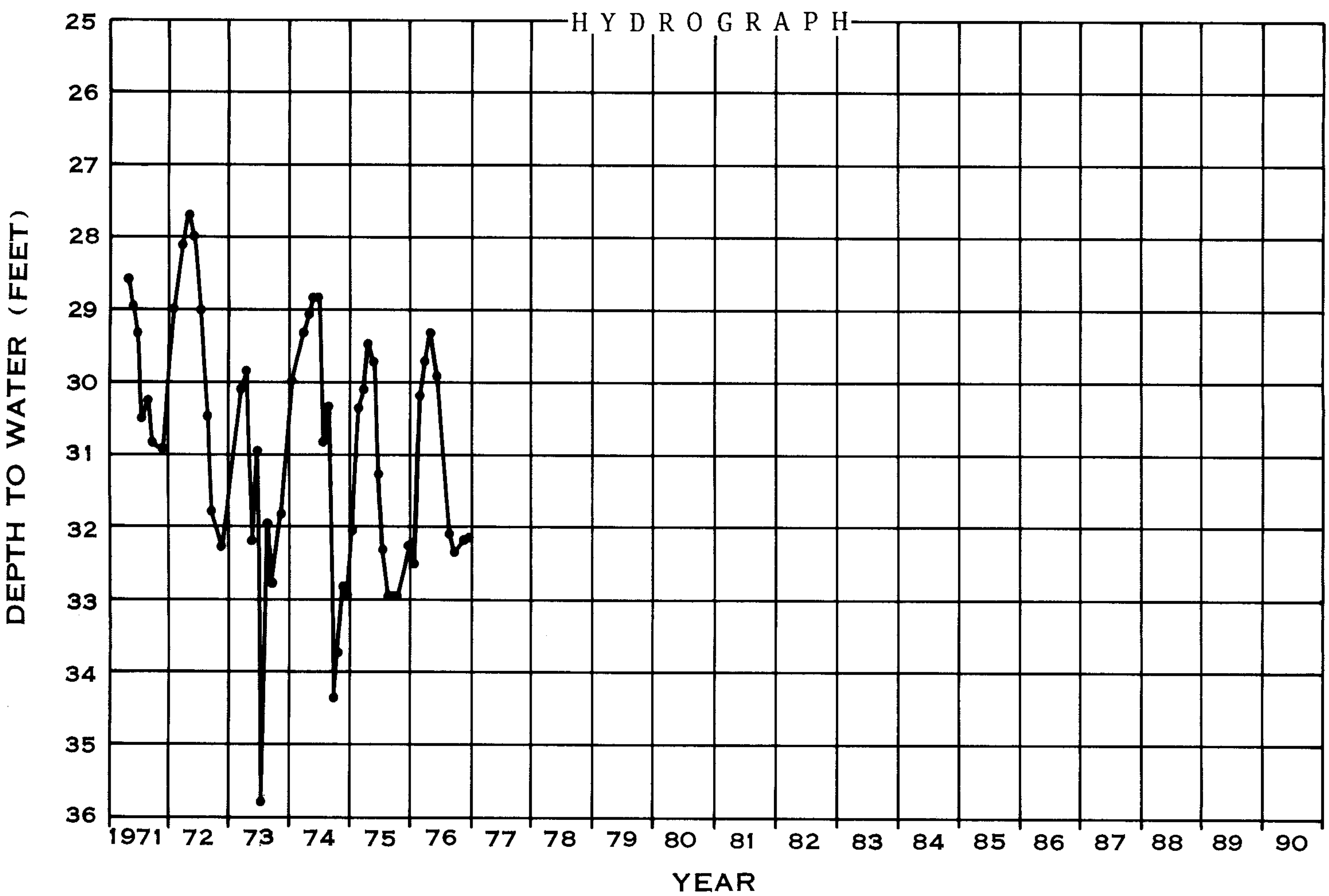
Approximate altitude of land surface at well: 95. Year constructed: 1948

Yield: 100 gpm. Drawdown 10. Test duration ? hr. Test date 5/48

Remarks: Irrigation and observation well

Generalized Log:

Silty gravelly clay	0 - 10 feet
Yellow clay	10 - 30 feet
Sand and gravel	30 - 44 feet



Records of Wells   State Well Number 41/13W-15bbcba

Owner: Norman Yock #4   Location NW¼ NW¼, Sec. 15, T. 41 S., R. 13 W.

Depth: 39 feet. Diameter: 8 inches. Depth cased: 38 feet.

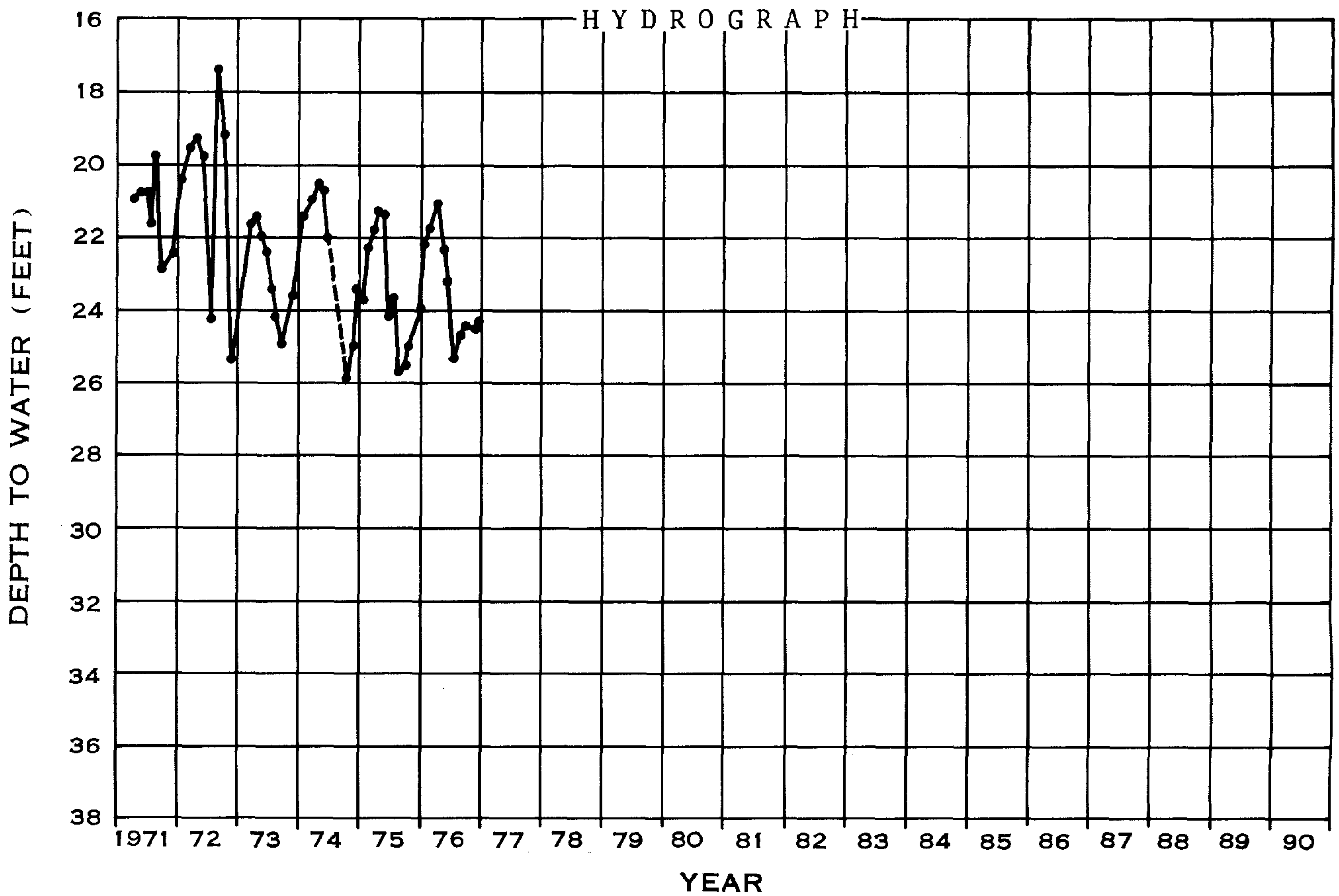
Approximate altitude of land surface at well: 88 ft. Year constructed: 1969

Yield: 50 gpm. Drawdown 0. Test duration 1/4 hr. Test date 8/29/69

Remarks: Observation well

Generalized Log:

Black loam	0 - 3 feet
Brown clay	3 - 20 feet
Gray sand	20 - 25 feet
Gravel	25 - 38 feet
Blue serpentine	38 - 39 feet



Records of Wells State Well Number 41/13W-15bbcca

Owner: Norman Yock #7 Location NW¼ NW¼, Sec. 15 , T. 41 S., R. 13 W.

Depth: 33 feet. Diameter: 8 inches. Depth cased: 32 feet.

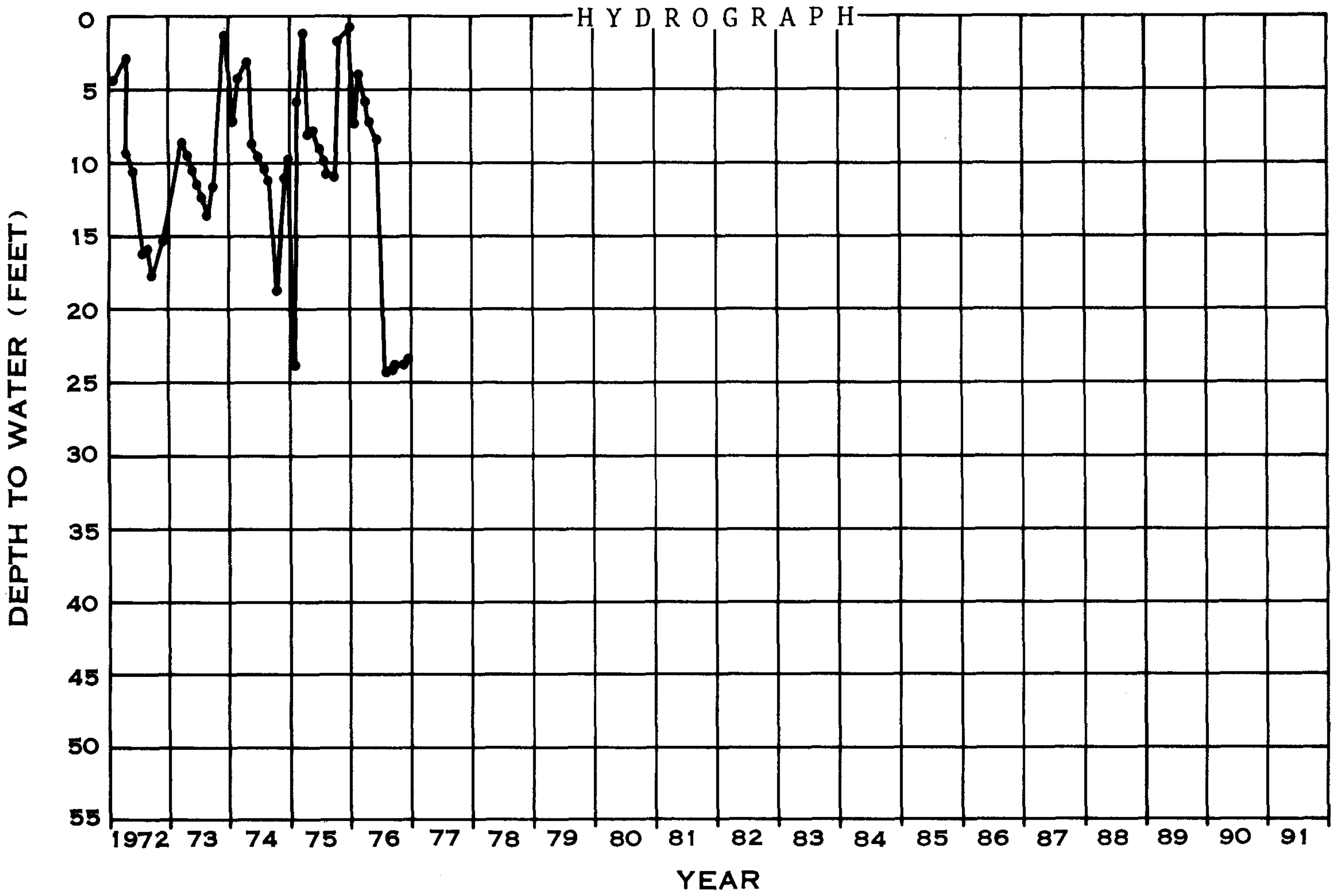
Approximate altitude of land surface at well: 85 ft. Year constructed: 1969

Yield: 50 gpm. Drawdown 0 . Test duration ¼ hr. Test date 9/5/69

Remarks: Old #7, observation only

Generalized Log:

Black loam	0 - 3 feet
Brown clay	3 - 20 feet
Gray sand	20 - 22 feet
Gravel	22 - 32 feet
Serpentine	32 - 33 feet



Records of Wells — State Well Number 41/13W-15bcbb(1)

Owner: E. L. Rigdon — Location SW¼ NW¼, Sec. 15, T. 41 S., R. 13 W.

Depth: 40 feet. Diameter: 8 inches. Depth cased: 40 feet.

Approximate altitude of land surface at well: 69 ft. Year constructed: 1951

Yield: 75 gpm. Drawdown 40. Test duration ? hr. Test date ?

Remarks: Irrigation well

Generalized Log:

Not available

Records of Wells — State Well Number 41/13W-15bcbb(2)

Owner: E. L. Rigdon — Location SW¼ NW¼, Sec. 15, T. 41 S., R. 13 W.

Depth: 35 feet. Diameter: 8 inches. Depth cased: 34 feet.

Approximate altitude of land surface at well: 76 ft. Year constructed: 1976

Yield: 40 gpm. Drawdown 3. Test duration 4 hr. Test date 6/15/76

Remarks: Irrigation well

Generalized Log:

Brown clay soil	0 - 5 feet
Brown clay	5 - 13 feet
Brown gravelly clay	13 - 16 feet
Sand and gravel	16 - 32 feet
Serpentine	32 - 35 feet

Records of Wells

State Well Number 41/13W-15bbcca

Owner: Norman Yock #7 Location NW¼ NW¼, Sec. 15, T. 41 S., R. 13 W.

Depth: 43 feet. Diameter: 8 inches. Depth cased: 42 feet.

Approximate altitude of land surface at well: 85 ft. Year constructed: 1976

Yield: ? gpm. Drawdown ?. Test duration - hr. Test date -

Remarks: Irrigation well

Generalized Log:

Brown clay	0 - 19 feet
Sand and gravel	19 - 39 feet
Serpentine	39 - 43 feet

Records of Wells   State Well Number 41/13W-15bcb

Owner: E. L. Rigdon   Location SW¼ NW¼, Sec. 15, T. 41 S., R. 13 W.

Depth: 35 feet. Diameter: 8 inches. Depth cased: 34 feet.

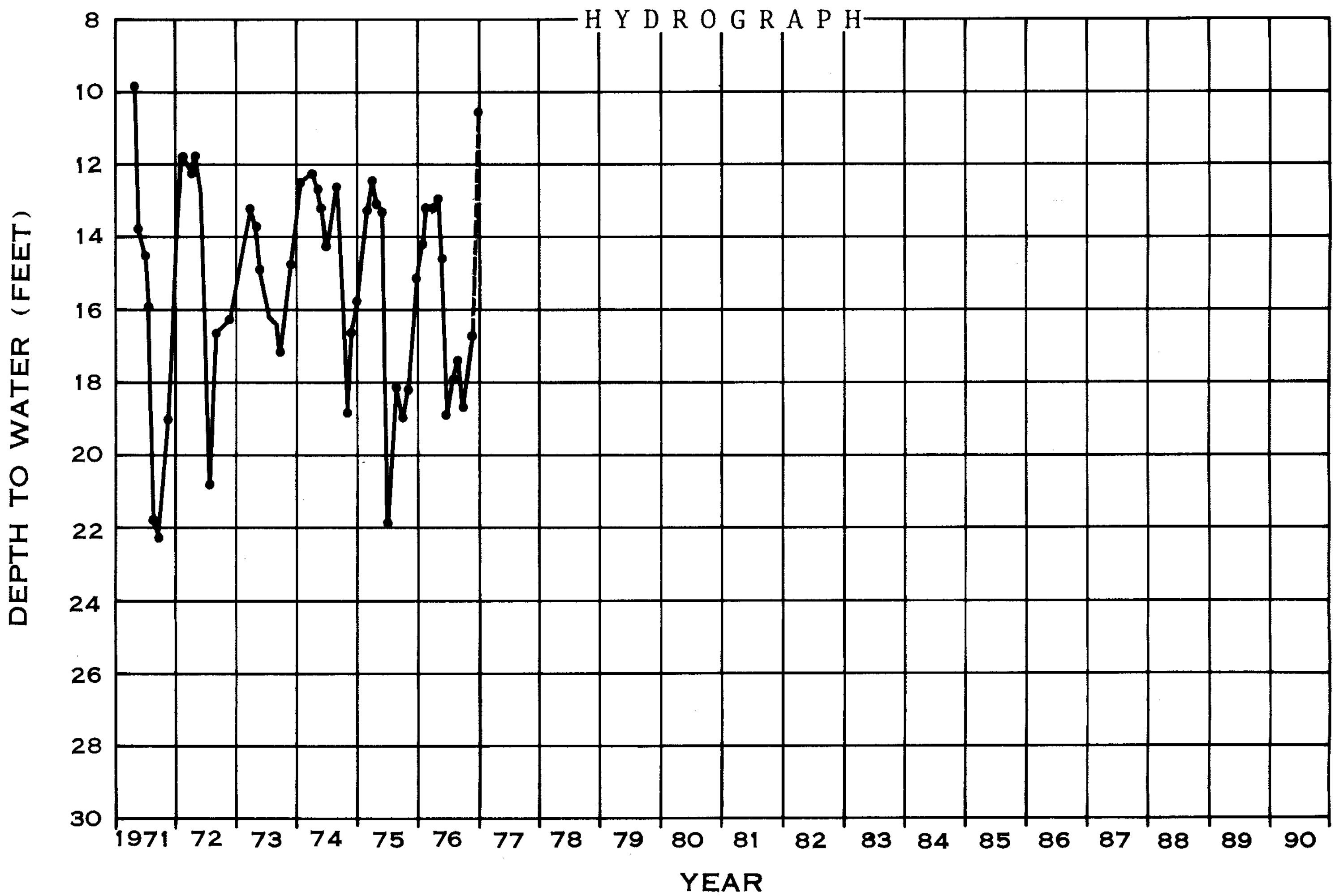
Approximate altitude of land surface at well: 76 ft. Year constructed: 1969

Yield: 60 gpm. Drawdown 26. Test duration 12 hr. Test date 4/29/69

Remarks: Irrigation and observation well

Generalized Log:

Loam	0 - 3 feet
Brown sandstone	3 - 16 feet
Brown sand	16 - 18 feet
Gravel	18 - 34 feet
Serpentine	34 - 35 feet



Records of Wells   State Well Number 41/13W-16aaadc

Owner: Norman Yock #2   Location NE¼ NE¼, Sec. 16, T. 41 S., R. 13 W.

Depth: 37 feet. Diameter: 8 inches. Depth cased: 37 feet.

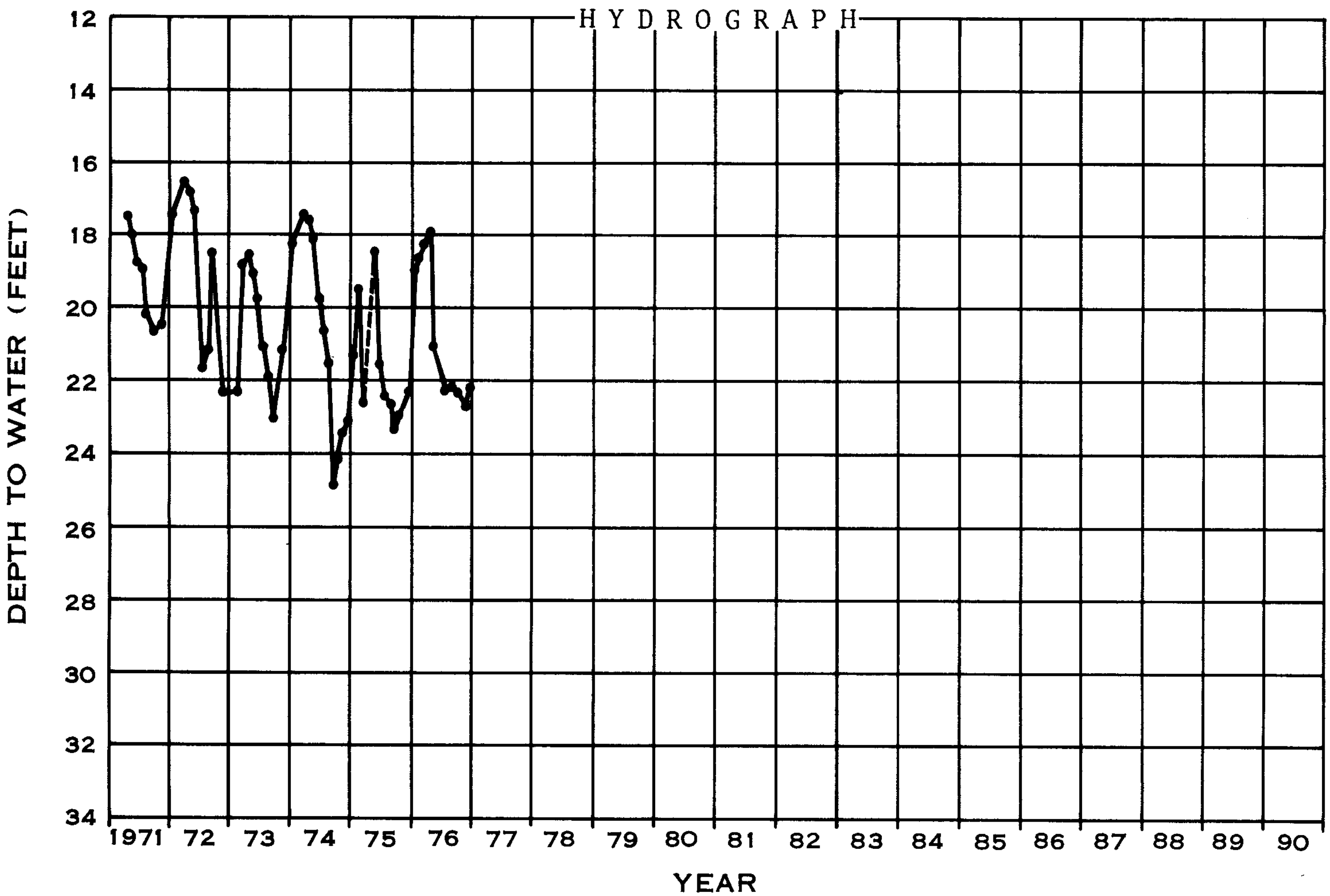
Approximate altitude of land surface at well: 89 ft. Year constructed: 1976

Yield: 40 gpm. Drawdown 5. Test duration 1 hr. Test date 6/21/76

Remarks: Irrigation and observation well

Generalized Log:

Black loam	0 - 2 feet
Brown clay	2 - 6 feet
Brown sandstone	6 - 18 feet
Gray sand and gravel	18 - 30 feet
Blue serpentine	30 - 32 feet
Clay and gravel	32 - 34 feet
Blue serpentine	34 - 37 feet



Records of Wells — State Well Number 41/13W-16aadaa

Owner: Norman Yock #1 — Location NE¼ NE¼, Sec. 16, T. 41 S., R. 13 W.

Depth: 42 feet. Diameter: 8 inches. Depth cased: 42 feet.

Approximate altitude of land surface at well: 87 ft. Year constructed: 1976

Yield: ? gpm. Drawdown ?. Test duration - hr. Test date -

Remarks: Irrigation well

Generalized Log:

Brown clay	0 - 19 feet
Brown sand and gravel	19 - 39 feet
Serpentine	39 - 42 feet

Records of Wells — State Well Number 41/13W-16aadac

Owner: Norman Yock — Location NE¼ NE¼, Sec. 16, T. 41 S., R. 13W.

Depth: 32 feet. Diameter: 6 inches. Depth cased: 32 feet.

Approximate altitude of land surface at well: 78 ft. Year constructed: 1970

Yield: 20 gpm. Drawdown 28. Test duration ¼ hr. Test date 7/13/70

Remarks: State monitor well - continuous water level recorder in operation since 9/27/76

Generalized Log:

Brown clay	0 - 8 feet
Brown sandstone	8 - 22 feet
Sand and gravel	22 - 32 feet

Records of Wells   State Well Number 41/13W-16aadac

Owner: Norman Yock #6   Location NE¼ NE¼, Sec. 16, T. 41S., R. 13 W.

Depth: 38 feet. Diameter: 8 inches. Depth cased: 38 feet.

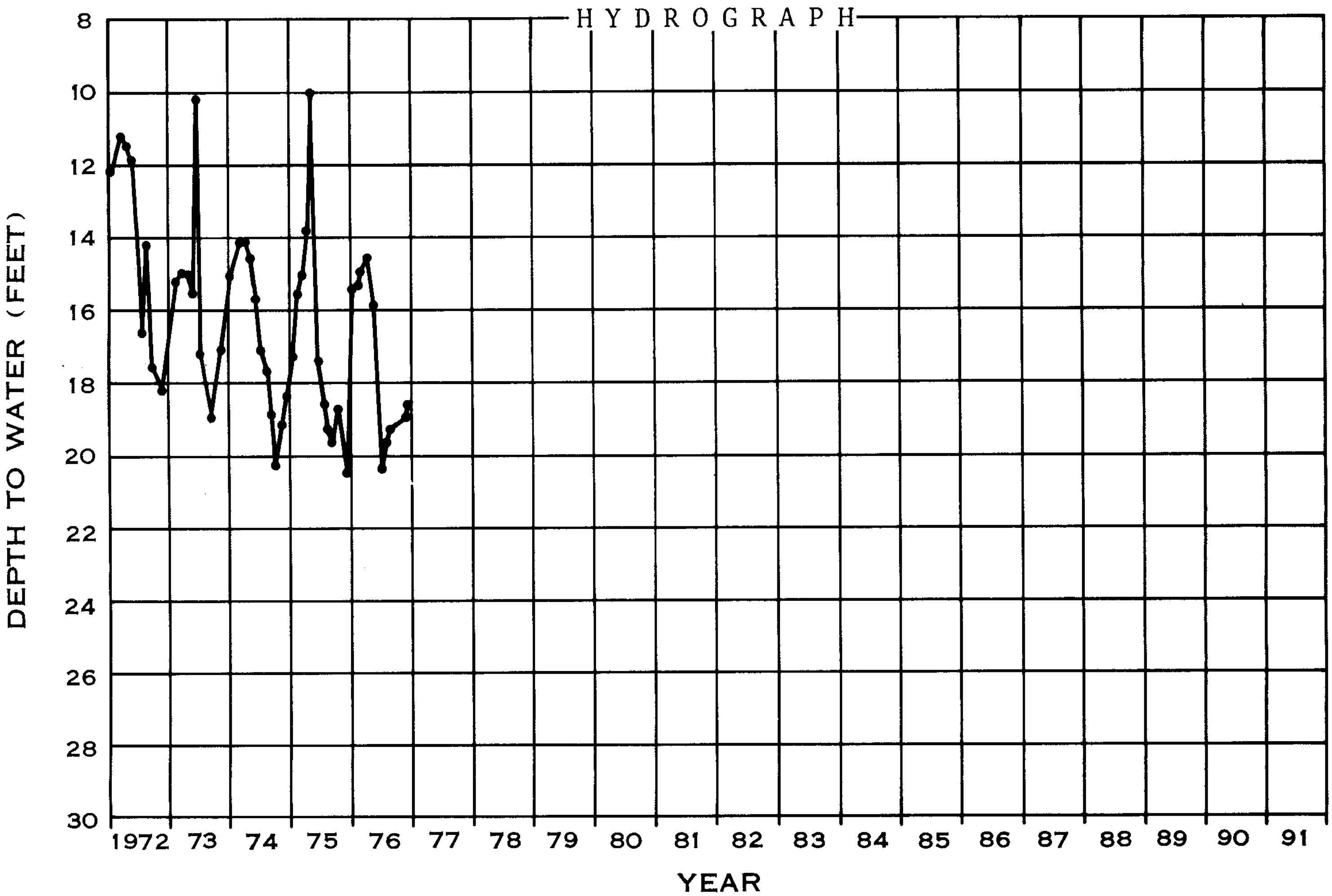
Approximate altitude of land surface at well: 80 ft. Year constructed: 1976

Yield: 12 gpm. Drawdown 1. Test duration 24 hr. Test date 11/3/76

Remarks: Irrigation and observation well

Generalized Log:

Brown clay	0 - 19 feet
Sand and gravel	19 - 34 feet
Serpentine	34 - 38 feet



Records of Wells

State Well Number 41/13W-16aadda

Owner: Norman Yock #5 Location NE¼ NE¼, Sec. 16, T. 41 S., R. 13W.

Depth: 32 feet. Diameter: 8 inches. Depth cased: 32 feet.

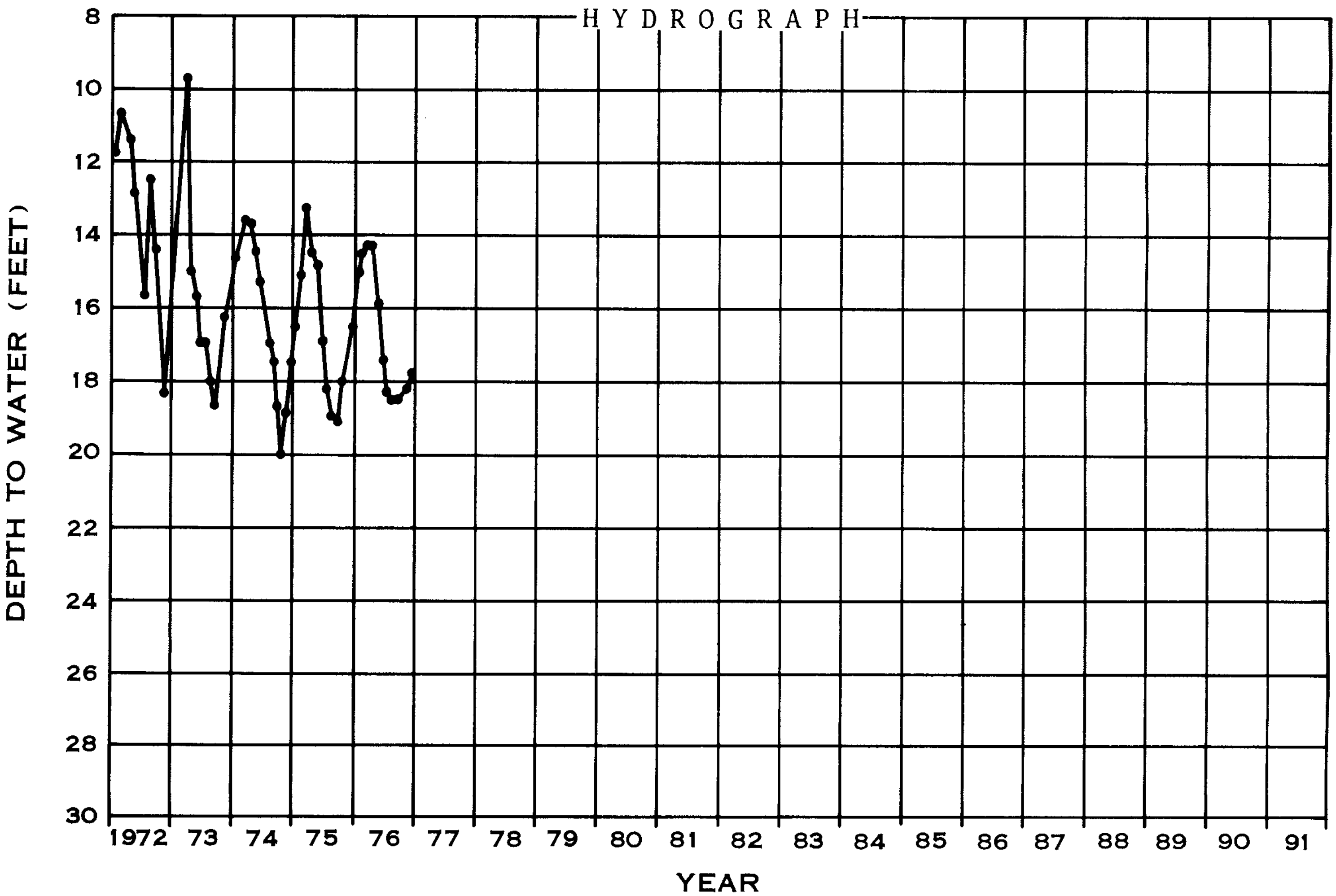
Approximate altitude of land surface at well: 77 ft. Year constructed: 1970

Yield: 40 gpm. Drawdown 12. Test duration ¼ hr. Test date 7/24/70

Remarks: Observation well

Generalized Log:

Black loam	0 - 3 feet
Brown clay	3 - 16 feet
Gray conglomerate sandstone	16 - 18 feet
Gray sand and gravel	18 - 32 feet
Serpentine	32 feet



Records of Wells — State Well Number 41/13W-16aadda

Owner: Norman Yock #5 — Location NE¼ NE¼, Sec. 16, T. 41 S., R. 13 W.

Depth: 36 feet. Diameter: 8 inches. Depth cased: 36 feet.

Approximate altitude of land surface at well: 77 ft. Year constructed: 1975

Yield: 30 gpm. Drawdown 5. Test duration 4 hr. Test date 7/31/75

Remarks: Domestic and irrigation well

Generalized Log:

Brown clay soil	0 - 3 feet
Brown clay	3 - 8 feet
Gravel and boulders	8 - 17 feet
Gravel and sand	17 - 26 feet
Gravelly sand	26 - 31 feet
Blue serpentine	31 - 36 feet

Records of Wells — State Well Number 41/13W-16aaddb

Owner: Norman Yock #3 — Location NE¼ NE¼, Sec. 16, T. 41 S., R. 13 W.

Depth: 31 feet. Diameter: 8 inches. Depth cased: 31 feet.

Approximate altitude of land surface at well: 71 ft. Year constructed: 1975

Yield: 30 gpm. Drawdown 3. Test duration 3½ hr. Test date 1975

Remarks: Irrigation well

Generalized Log:

Brown clay	0 - 2 feet
Gravelly clay	2 - 11 feet
Brown gravel	11 - 27 feet
Serpentine	27 - 31 feet

Records of Wells State Well Number 41/13W-16aba

Owner: A. G. Rose (Woodriff, A.) Location NW¼ NE¼, Sec. 16, T. 41S., R. 13 W.

Depth: 26 feet. Diameter: ? inches. Depth cased: ? feet.

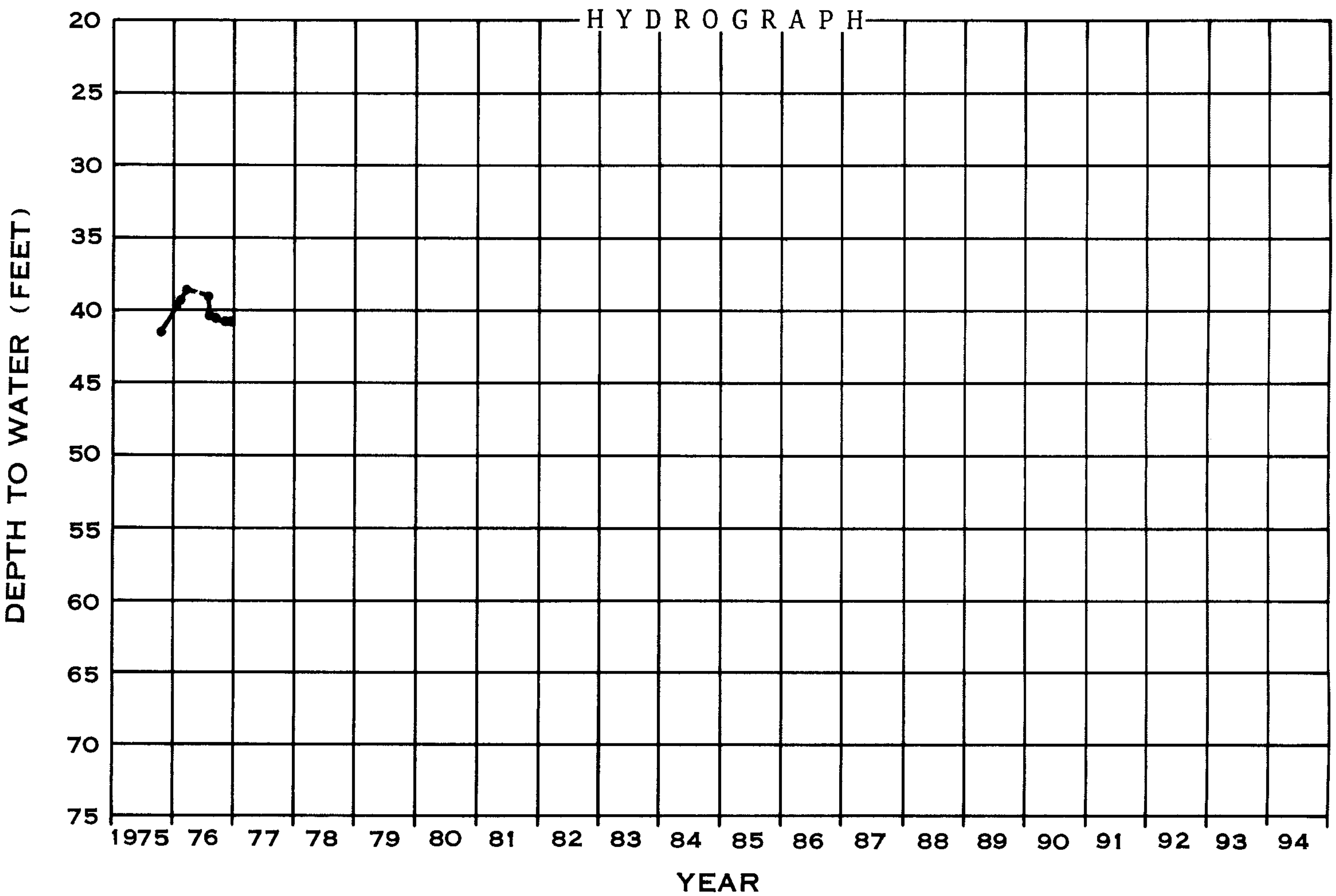
Approximate altitude of land surface at well: 82 ft. Year constructed: 1944

Yield: 110 gpm. Drawdown 25. Test duration ? hr. Test date ?

Remarks: Irrigation and observation well, hand dug

Generalized Log:

Top soil	0 - 3 feet
Clay	3 - 24 feet
Gravel and sand	24 - 26 feet



Records of Wells

State Well Number 41/13W-16abd

Owner: H. D. Quier Location NW¼ NE¼, Sec. 16, T. 41 S., R. 13 W.

Depth: 27 feet. Diameter: 8 inches. Depth cased: 27 feet.

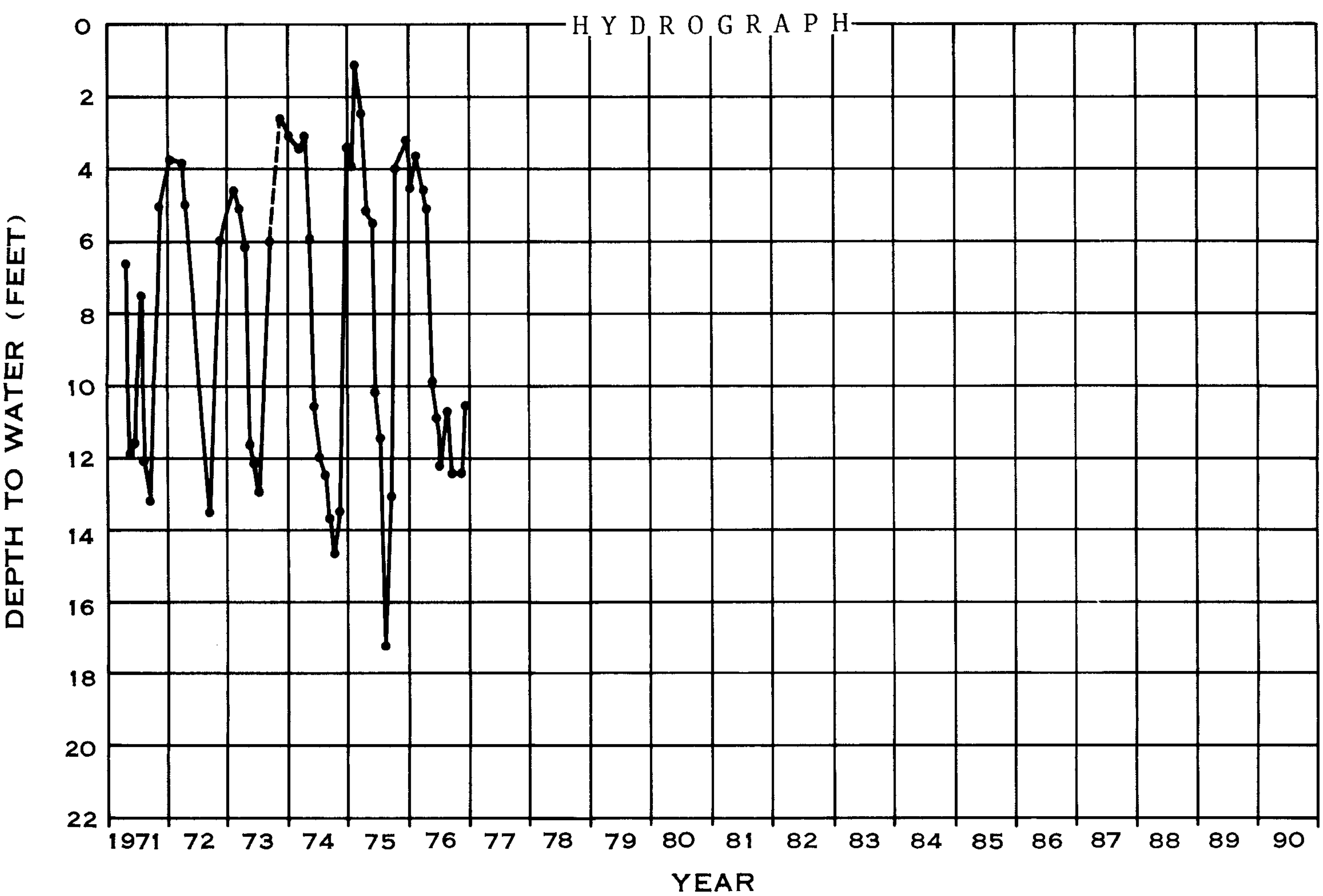
Approximate altitude of land surface at well: 65 ft. Year constructed: 1964

Yield: 10 gpm. Drawdown 10 . Test duration ½ hr. Test date 6/30/64

Remarks: Used for observation only

Generalized Log:

Loam	0 - 8 feet
Brown gravelly clay	8 - 20 feet
Cemented gravel	20 - 27 feet



Records of Wells State Well Number 41/13W-16ada

Owner: G. G. Strahm (Kelso) Location SE¼ NE¼, Sec. 16, T. 41 S., R. 13 W.

Depth: 32 feet. Diameter: 6 inches. Depth cased: 32 feet.

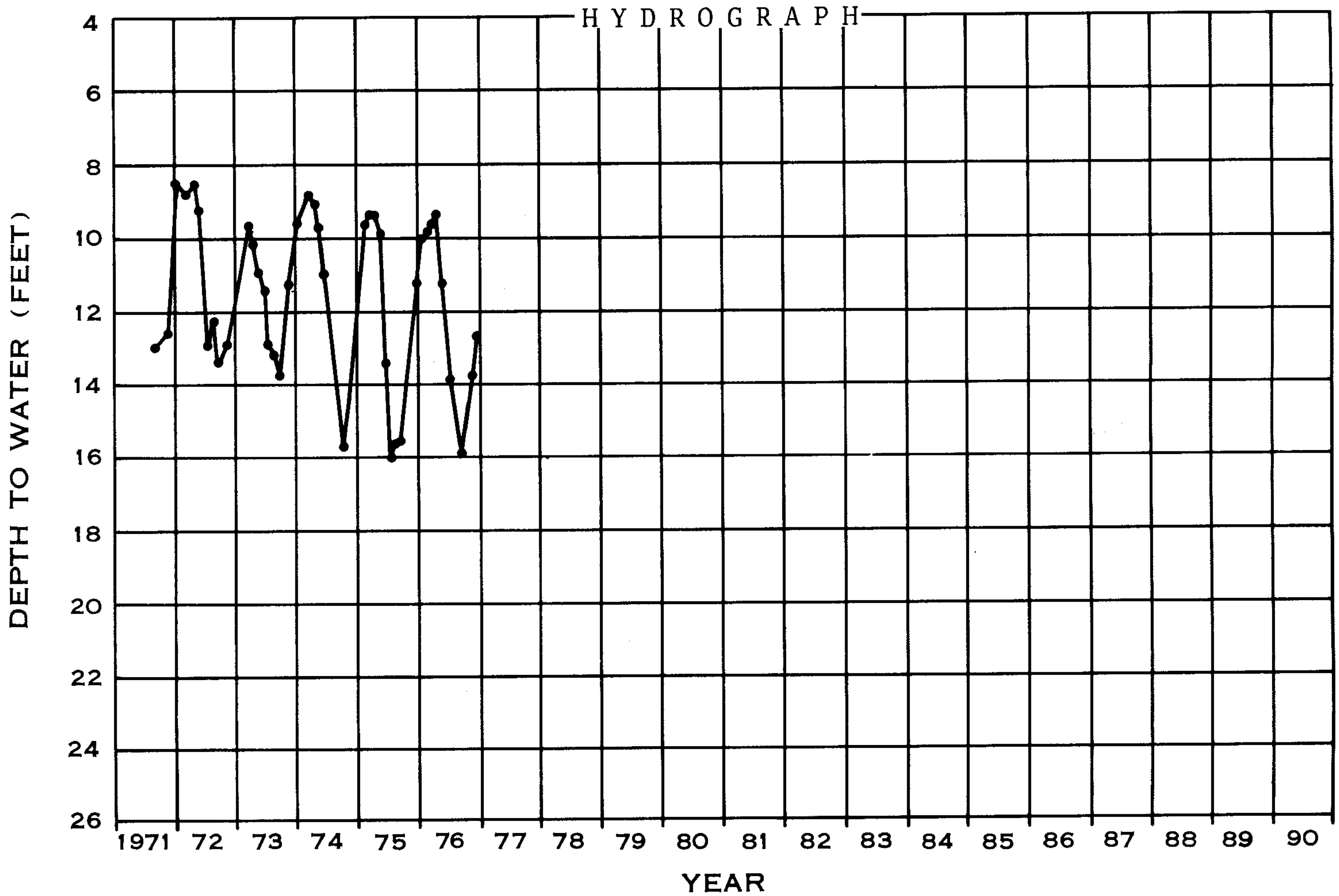
Approximate altitude of land surface at well: 72 ft. Year constructed: 1969

Yield: 30 gpm. Drawdown 16. Test duration 2 hr. Test date 7/31/69

Remarks: Irrigation and observation well

Generalized Log:

Black loam	0 - 3 feet
Brown clay	3 - 20 feet
Gravel and sand	20 - 31 feet
Serpentine	31 - 32 feet



Records of Wells State Well Number 41/13W-16adcd

Owner: R. K. Hastings #1 Location SE¼ NE¼, Sec. 16, T. 41S., R. 13 W.

Depth: 24 feet. Diameter: 6 inches. Depth cased: 23 feet.

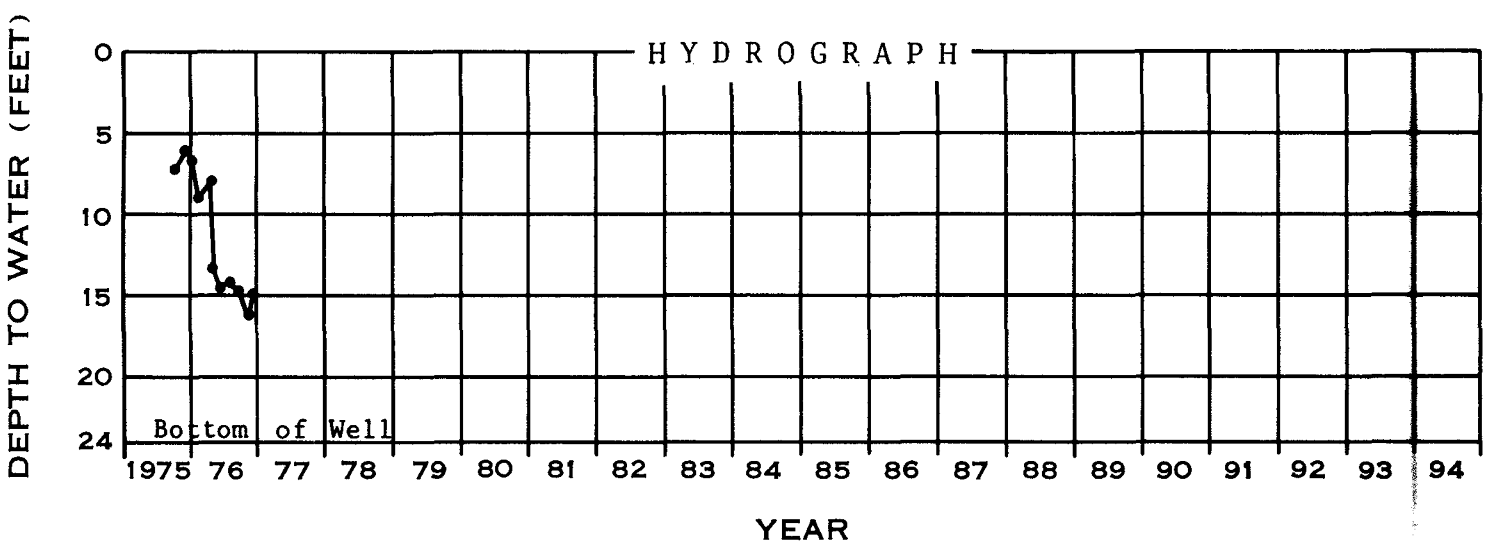
Approximate altitude of land surface at well: 58 ft. Year constructed: 1959

Yield: 10 gpm. Drawdown 19. Test duration ½ hr. Test date 5/15/59

Remarks: Domestic and observation well

Generalized Log:

Brown top soil	0 - 4 feet
Brown gravelly clay	4 - 10 feet
Sand and gravel	10 - 22 feet
Sandy clay	22 - 23 feet
Shale	23 - 24 feet



Records of Wells

State Well Number 41/13W-16addb

Owner: Norman Yock #3 Location NE¼ NE¼, Sec. 16, T. 41 S., R. 13 W.

Depth: 39? feet. Diameter: 8 inches. Depth cased: ? feet.

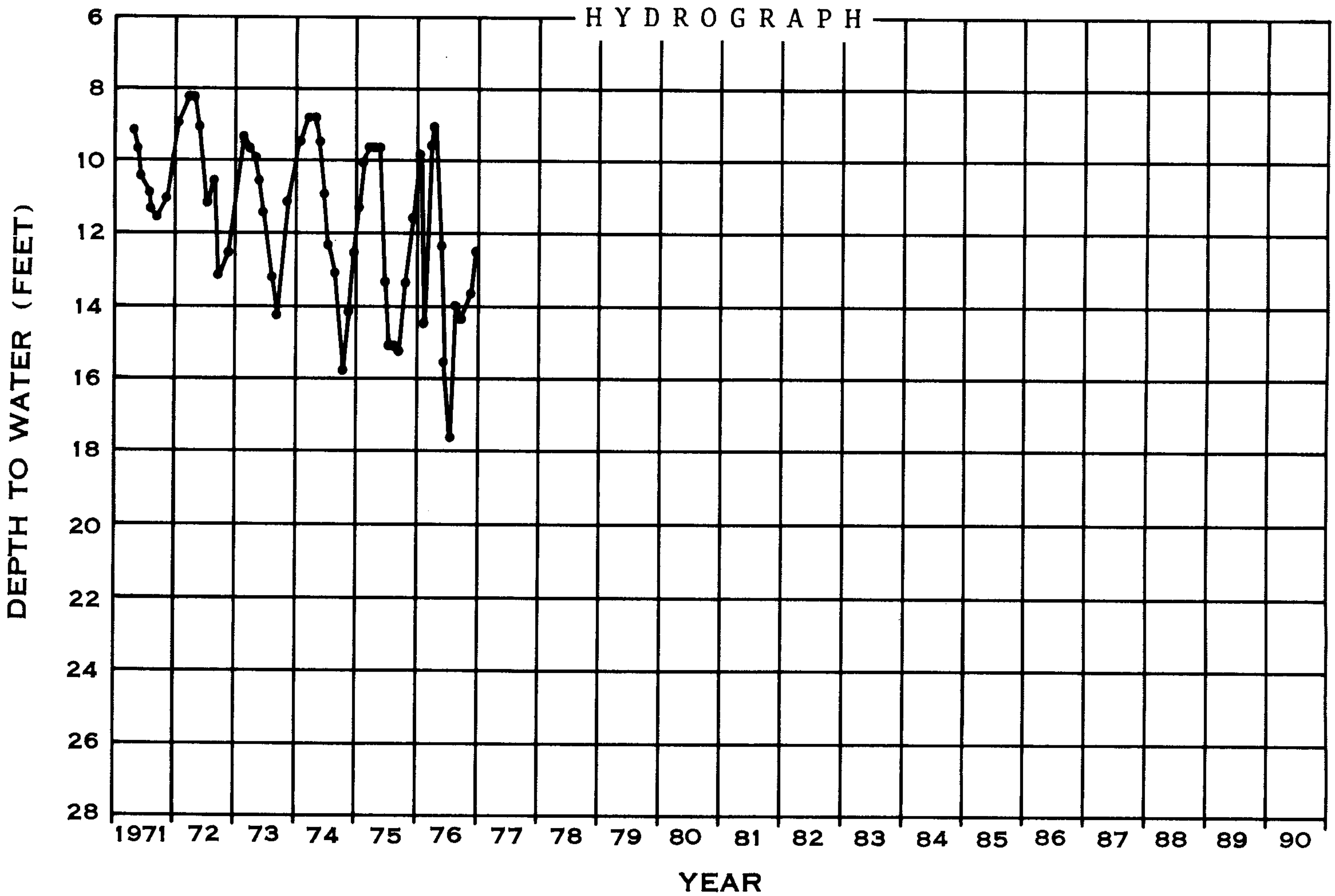
Approximate altitude of land surface at well: 71 ft. Year constructed: ?

Yield: ? gpm. Drawdown ?. Test duration - hr. Test date -

Remarks: Observation well

Generalized Log:

Not available



Records of Wells

State Well Number 41/13W-16baaa

Owner: Robert Swan Location NE¼ NW¼, Sec. 16, T. 41 S., R. 13 W.

Depth: 30 feet. Diameter: ? inches. Depth cased: ? feet.

Approximate altitude of land surface at well: 77 ft. Year constructed: 1952

Yield: 100 gpm. Drawdown 10. Test duration ? hr. Test date ?

Remarks: Irrigation

Generalized Log:

Not available

Records of Wells

State Well Number 41/13W-~~16~~ 15 bcd

Owner: R. K. Hastings #2 Location SW¼ NW¼, Sec. 15, T. 41 S., R. 13 W.

Depth: 50 feet. Diameter: 8 inches. Depth cased: 50 feet.

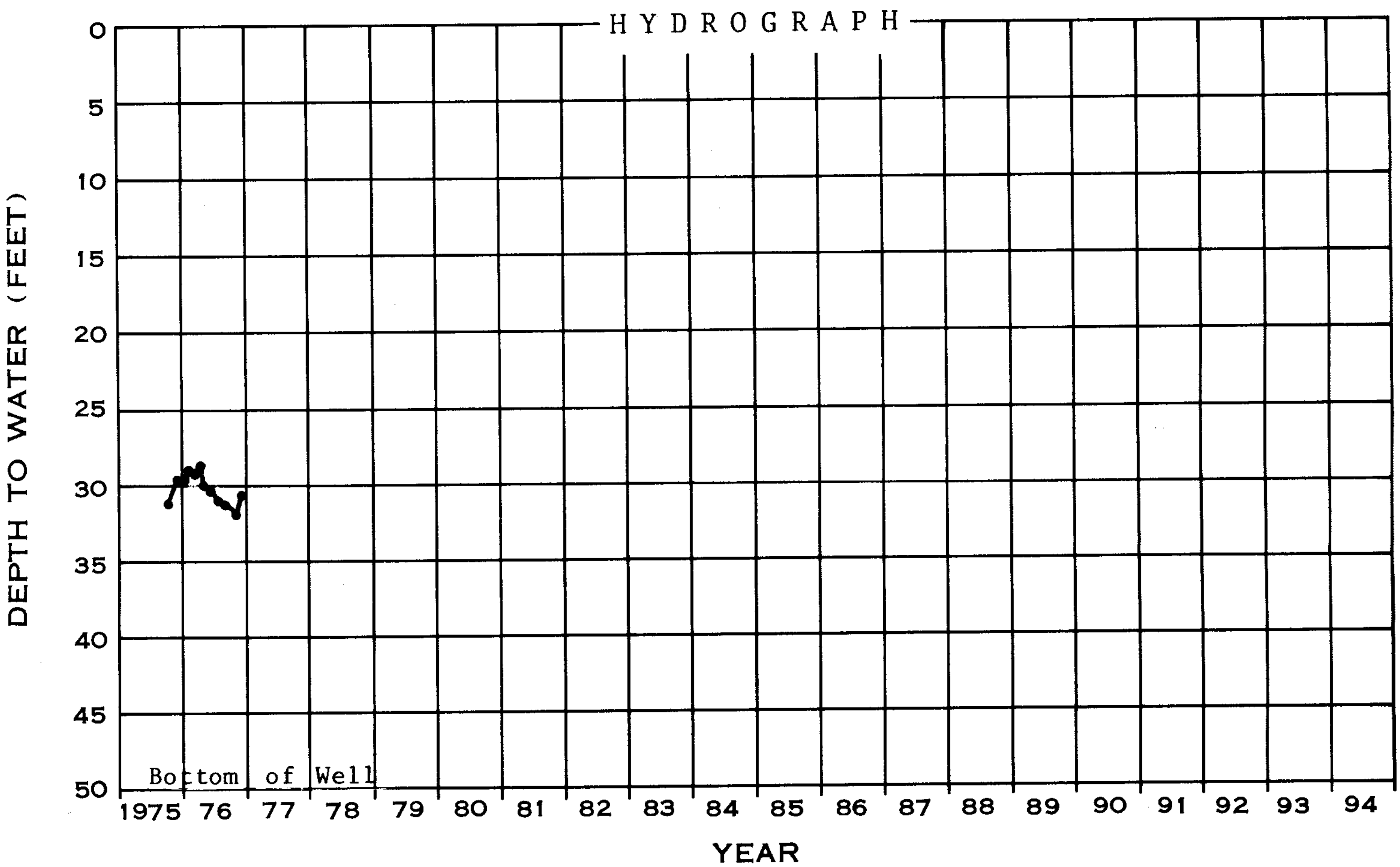
Approximate altitude of land surface at well: 92 ft. Year constructed: 1955

Yield: 80 gpm. Drawdown ?. Test duration ? hr. Test date ?

Remarks: Irrigation and observation well

Generalized Log:

Top soil	0 - 3 feet
Clay	3 - 20 feet
Clay, sand, and gravel	20 - 50 feet



Records of Wells

State Well Number 41/13W-16dcc

Owner: Robert Swan

Location SW¼ SE¼, Sec. 16, T. 41 S., R. 13 W.

Depth: 36 feet. Diameter: 12 inches. Depth cased: 36 feet.

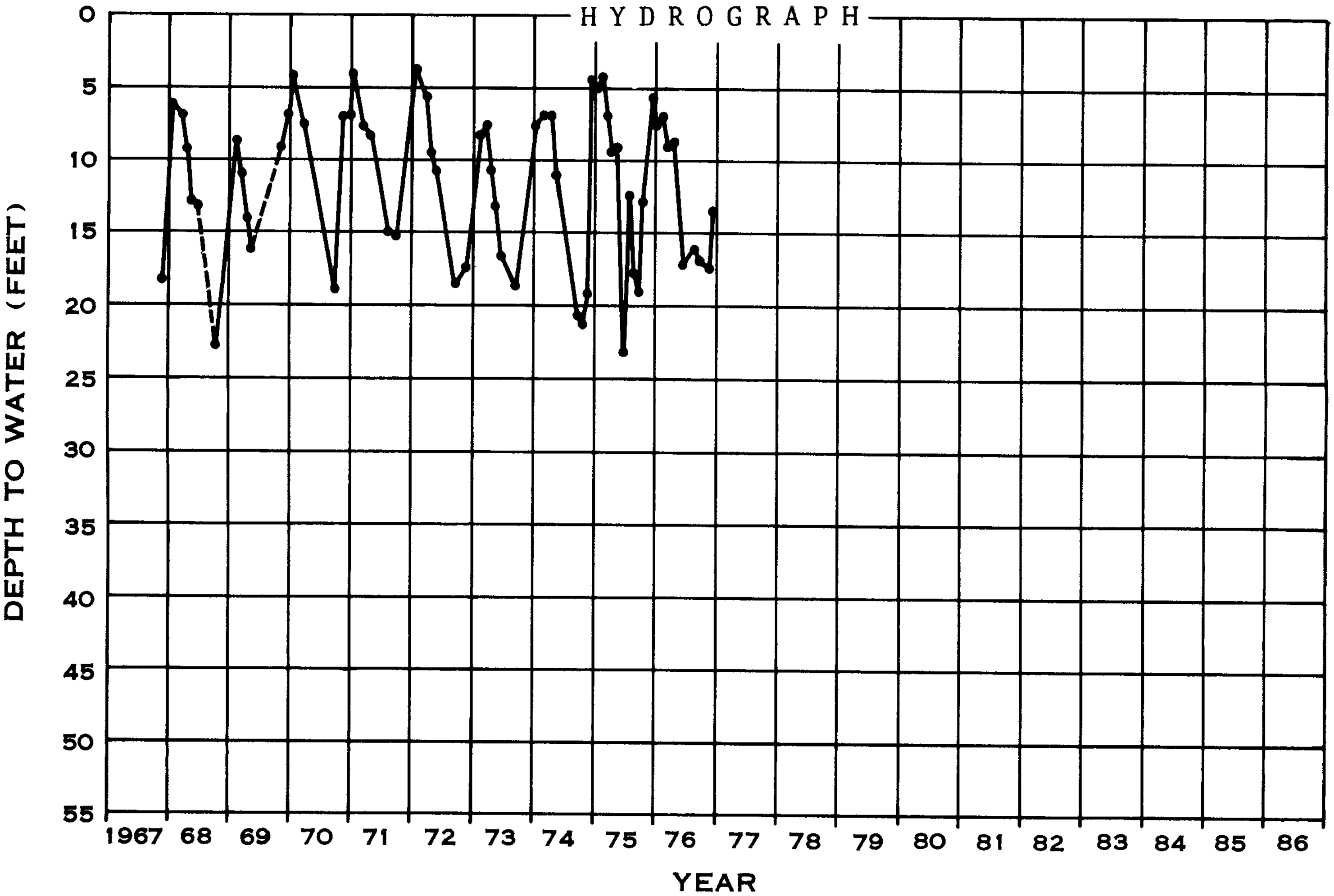
Approximate altitude of land surface at well: 88 ft. Year constructed: 1967

Yield: 60 gpm. Drawdown 0. Test duration ¼ hr. Test date 10/27/67

Remarks: Irrigation and observation well

Generalized Log:

Black loam	0 - 3 feet
Brown clay	3 - 18 feet
Greenstone or graywacke	18 - 21 feet
Sand and gravel	21 - 36 feet



Records of Wells　　State Well Number 41/13W-22abca

Owner: R. K. Hastings　Location NW¼ NE¼, Sec. 22, T. 41 S., R. 13W.

Depth: 72 feet. Diameter: 8 inches. Depth cased: 72 feet.

Approximate altitude of land surface at well: 66 ft. Year constructed: 1966

Yield: 12 gpm. Drawdown 50. Test duration ¼ hr. Test date 7/29/66

Remarks: Irrigation well

Generalized Log:

Black loam	0 - 4 feet
Clay	4 - 25 feet
Sand	25 - 70 feet
Clay	70 - 72 feet

PLATE 1

TOPOGRAPHIC MAP OF THE HARBOR BENCH

TUTTLE CREEK TO THE WINCHUCK RIVER

Topographic Mapping by Oregon State Highway Department
January 1966

PLATE 2

ISOPACH MAP OF THE MARINE TERRACE DEPOSITS

TUTTLE CREEK TO THE WINCHUCK RIVER

PLATE 3

GEOLOGIC MAP OF THE SOUTHERN OREGON COAST

TUTTLE CREEK TO THE WINCHUCK RIVER

PLATE 4

ELEVATION CONTOUR MAP OF THE UPPER SURFACE OF THE DOTHAN FORMATION
TUTTLE CREEK TO THE WINCHUCK RIVER

WRD 77

PLATE 5

WINTER–HIGH–WATER TABLE MAP ON THE HARBOR BENCH

PLATE 6

LATE SUMMER–LOW–WATER TABLE MAP
ON THE HARBOR BENCH