United States
Department of the Interior
Geological Survey

Ground Water Resources of the Ṣurmān Area, Tripolitania, United Kingdom of Libya

Prepared in cooperation with the Government of Libya
under the auspices of
the United States Agency for International Development
Mission to Libya

Open File Report

Ground Water Resources of the Surmān Area, Tripolitania, United Kingdom of Libya

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November 1962

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Ground-Water Resources of the Şurmān Area, Tripolitania, United Kingdom of Libya

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Abstract

A study of the ground-water resources of the Şurmān area, Tripolitania, shows that water levels are declining in the area and that contamination of aquifers by salt-water encroachment is a current (1962) threat.

The area studied comprises about 200 sq. km. along the southern coast of the Mediterranean Sea. The land surface of the area slopes generally northward to the sea, which is bordered by consolidated coastal sand dunes. Between the coastal dunes and a belt of semi-active dunes along the southern border of the area, is a zone of flatter land about 5 km wide interspersed with stabilized dunes. Because of the widespread presence of dune features and low runoff, no coherent stream pattern exists in the area. Water from rain collects in depressions between the dune ridges and percolates into the ground and some of that which escapes the dunes and does not evaporate collects in a large sebkha (salt flat and dry lake) northwest of Şurmān. The climate is semiarid and is characterized by low precipitation (215 mm per year at Şurmān), high evaporation, and wide temperature range.

Most present farming in this agricultural area is restricted to the flat-land zone between the coastal dunes and those farther inland. Agricultural development depends largely upon ground water for irrigation, although some dry-land farming is practiced.

The Ṣurmān area is underlain by northward dipping Quaternary and Miocene limestone, sand, and clay which presumably overlie Mesozoic rocks. Quaternary sand and limestone aquifers yield most of the ground water currently used in the area.

Ground water occurs under unconfined to semi-artesian conditions throughout the area. The water-table slopes generally northward to the sea but is interrupted by a ground-water depression in the vicinity of the sebkha that extends slightly below sea level. Dug wells tap the shallow ground water in the Quaternary deposits at depths generally less than 10 meters. Most of the bored wells tap a deeper aquifer in the Quaternary but few attain depths greater than 60 meters. The water generally has fair to good chemical quality and is suitable for agriculture and domestic use. Artesian water is also probably available from deep Miocene and Mesozoic aquifers but these have not been explored in the report area. Poor chemical quality, however, may preclude use of water from such aquifers for most purposes.

Recharge to the Quaternary aquifers is both by infiltration from local precipitation and by underflow from the south. The deeper Miocene aquifers, however, are probably recharged by underflow alone. Withdrawals by pumps of about 12 million cubic meters annually together with the natural discharge exceed the recharge, at least in the developed area; consequently, the water level in the developed area is declining currently (1962) at about 0.2 meters per year. Salt-water encroachment is imminent near the sea and in the vicinity of the sebkha.

The southern part of the area is suggested as most suitable for new development of the shallow ground water in the Quaternary deposits. Exploration for deeper aquifers, especially in the middle and lower Miocene rocks, is also recommended. The trend toward overdevelopment of the shallow ground water near the coast needs to be monitored by observation wells for water levels and chemical quality. Also pumping tests to evaluate hydraulic characteristics of the aquifers are needed.

Introduction

Purpose and scope

This report summarizes the results of an investigation of the ground water resources of the Ṣurmān 1/ area, Tripolitania. It is one of a number of reports on areal investigations made as examples of methods and techniques of hydrologic studies; also the areas have been selected so as to provide data for development planning.

1/ Transliteration of most of the geographic names used in this report conforms to the system adopted by the U.S. Board on Geographic Names, BGN/PCGN system. (U.S. Dept. of Interior, 1958). Some familiar names are left in their conventional forms.

The United Kingdom of Libya is currently undergoing a period of rapid economic development following the discovery of fairly large petroleum reserves. Much of the anticipated revenue from the exploitation of this important resource is to be used for further development of agricultural lands and water resources. However, informed individuals in Libya realize that water is among the chief limiting factors in the economic growth of the country.

The demand for additional water for agricultural use, industry and public supplies has resulted in an alarming decline of water levels in many of the developed areas. Much of the additional demand for water has arisen from the increasingly efficient pumps, increased availability of electric power, and improved markets for agricultural products. Also concern over the decline of water levels in a number of developed areas is now becoming widespread.

The present report is based on field work carried on intermittently by the writers and technical personnel of the Government of Libya during 1959-62. The report illustrates the application of established methods of field inventory of wells and of other hydrologic features and the compilation and interpretation of the resulting data. Information is given on depth to water, changes in water levels, depths of wells, chemical quality of water, and other pertinent hydrologic phenomena. Test drilling, geophysical studies, and pumping tests to determine hydraulic characteristics of aquifers, however, were not a part of the work.

Location of the area

The area discussed in detail in this report comprises about 200 sq km (square kilometers) in the vicinity of the town of Ṣurmān, in the Province of Tripolitania (Wilāyat Ṭarābulus), Libya. Reference is made, however, to geologic and hydrologic conditions in the adjoining region that pertain also to the Ṣurmān area. The area lies between 12°30' and 12°40' east longitude and is bounded on the north by the Mediterranean Sea and on the south by 32°40' north latitude. The town of Ṣurmān, which is centrally located in the area, is about 58 km (kilometers) west of Tripoli (Ṭarābulus) along the coastal highway to Tunisia (fig. 1).

Figure 1.--Map of Mediterranean region showing location of area of study.

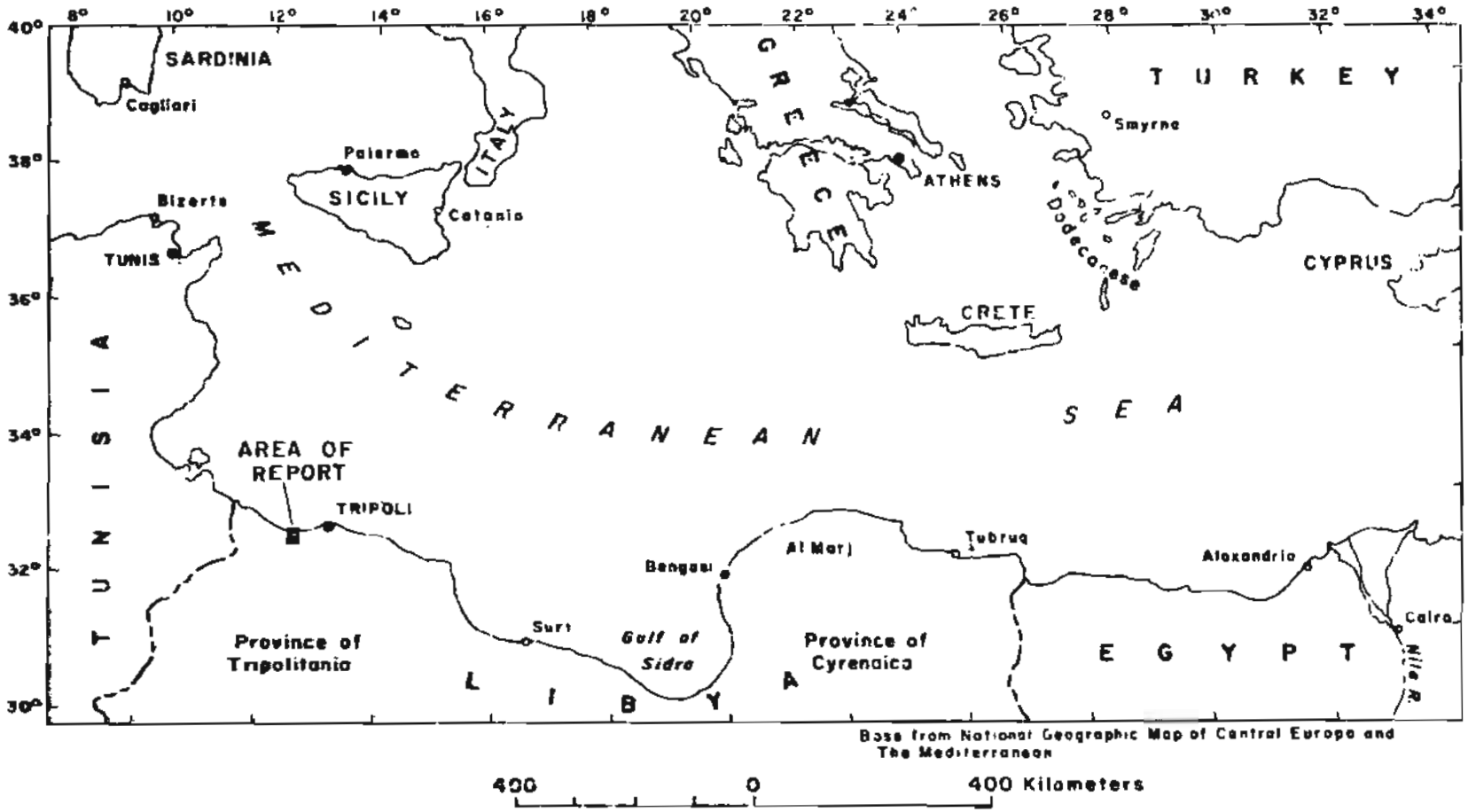

Figure 1.--Map of Mediterranean region showing the location of the area of study.

Description of well-numbering system

The wells described in this report are assigned identification numbers based on the latitude and longitude of the well site. All of Libya is situated in north latitude and east longitude. Each well number describes the location of the well within rectangles of 1 minute or 5 minutes of latitude and longitude. The first unit of four numbers describes north latitude, and the second unit, separated by a hyphen, describes east longitude. This number is the latitude and longitude of the southwest corner of a rectangle that contains the well. This rectangle has dimensions of either 1 minute by 1 minute or 5 minutes by 5 minutes. The 5-minute rectangle is designated by the addition of the numeral 5 separated from the other units by a hyphen. The last number, also separated by a hyphen, represents the serial number of the well within the rectangle. For example, well 3244-1232-1 is the first well described in a rectangle 1 minute on a side and bounded by 32°44' and 32°45' north latitude and 12°32' and 12°33' east longitude (fig. 2).

Figure 2.--Map of Ṣurmān area showing location of water wells.

Other well-numbering systems have been used in the past by the Italians and others. Many of these previously assigned numbers have been cross-indexed and are on file in the ground-water investigations offices of the Government of Libya.

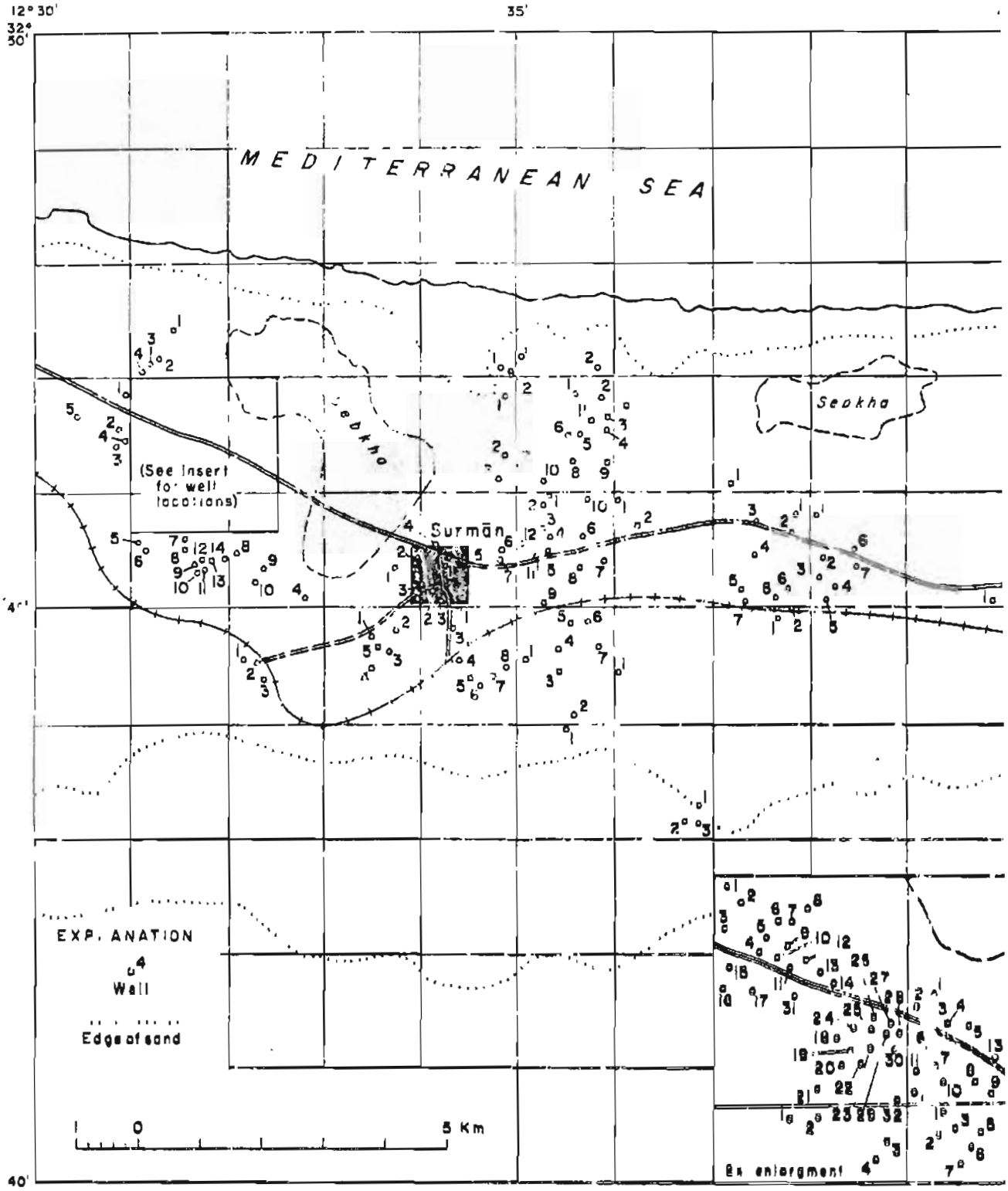

Figure 2.--Map of Ṣurmān area showing location of water wells.

Previous investigations

Information on the ground-water hydrology of Libya is not extensive, however, many significant contributions bearing on ground-water conditions were made by Italian geologists prior to 1940. The description of the geology of Tripolitania by Bernet (1912) was probably the first of these contributions. Parona (1915) discussed the formations exposed along the Tripolitanian coast in "Geomorphic Notes on the Gefara." Zacagna (1915) published a general report on geohydrologic studies in western Tripolitania and in 1919 published some measured sections along the Jabal escarpment. Desio (1939) compiled a geologic map of Libya. Floridia (1939) published measured sections and geologic map of the Homs (Al Khums) area.

In a more recent study, Borgognoni (1946) gave a generalized discussion of the ground water of Tripolitania. In 1955 Christie published on the geology of the Garian area. Hill (1960) published a paper on the ground-water resources of the Gefara. Cederstrom (1960) prepared a ground-water report on the Tripoli area that contains much information applicable to the Ṣurmān area. Stuart (1960) presented the results of pumping tests conducted in various parts of the Gefara. Vorhis (written communication) provided a good compilation and review of the geologic history of northern Tripolitania.

Acknowledgements

The study at Ṣurmān was made with the help and cooperation of the Nazir of Agriculture of Tripolitania, other Provincial and local government officials, and farmers. The work was undertaken as part of the joint program of the Government of Libya and the United States Agency for International Development Mission to Libya (USAID/L). Most of the field work was done by trained Libyan technicians under the guidance of U.S. ground-water advisors.

Geography

The Ṣurmān area lies within the physiographic unit known as the Gefara, which is a coastal plain sloping gently northward from the escarpment of Jabal Nafūsah to the Mediterranean Sea. The Gefara, which is relatively flat land interspersed with sand dunes, extends along the coast from southern Tunisia eastward to Al Khums (Homs) where it pinches out between the sea and the Jabal Nafūsah. A chain of oases extends along the coast from Zuwarah to Al Khums in a narrow belt about 5 to 10 km wide. These oases lie between fossil dunes along the present coast and an active sand dune belt, several kilometers wide, that begins about 5 to 10 km south of the coastline. The Jabal Nafūsah forms the southern boundary of the Gefara. The Jabal, an erosional scarp which rises some 400 m (meters) above the Gefara, consists principally of interbedded limestone, sandstone, and gypsum.

In the northern part of the Ṣurmān area a long chain of fossil dunes, which rises about 15 to 25 m above sea level, parallels the coast. South of these dunes is a sebkha about 2 km wide and 4 km long that lies northwest of the town of Ṣurmān. The sebkha is low-lying tract with little or no vegetation that holds a shallow ephemeral lake during the rainy season but becomes a salt flat during the dry season. A belt of irrigated land about 5 km wide lies inland and parallel to the coastal dunes. South of this belt is a zone of semi-active sand dunes about 4 km wide which is gradually being put into cultivation by dune-stabilization methods.

Climate

The climate of the Ṣurmān area is characterized by low percipitation, high evaporation, and a wide range in daily and annual temperature. The average annual rainfall for Ṣurmān for the period of record, from 1929 to 1939 and 1950 to 1961, is 215.5 mm (millimeters) (table 1). During these years the measured annual rainfall ranged from 58 mm in 1935 to 350 mm in 1957. The period of record, however, is too short to evaluate any long-term trends or cyclic effects that may be present.

Rainfall in the Ṣurmān area, as in most of coastal Tripolitania, is seasonal with the maximum precipitation in the winter months and little or no rain during the summer. Monthly averages, which range from 51 mm in December to 0.02 mm in July, tend to give a false impression of the temporal distribution, as the actual rainfall is quite erratic. For example, recorded rainfall for December has ranged from 0.0 mm in 1935 to 147.8 mm in 1956.

The Ṣurmān area lies within the limited farming zone described by J. H. Stewart (1960, p. 30) (fig. 3). Only crops with low moisture requirements, such as barley and olives, can be successfully grown in the area without supplemental irrigation. During the period of record, the annual rainfall was below 200 mm for 11 of 23 years indicating that the area is marginal or unreliable for extensive dry-land farming.

Figure 3.--Map of northern Tripolitania showing average annual rainfall, in millimeters.

Table 1.--Rainfall at Şurmăn, 1929-39 and 1950-61, in millimeters

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
1929	100.9	22.8	13.9	0.1	0.0	0.0	0.0	0.0	20.0	0.7	14.1	2.5	175.0
1930	20.0	35.6	9.7	0.0	2.4	0.0	0.0	0.0	0.0	14.2	44.2	22.4	148.5
1931	31.8	36.6	0.0	0.0	14.3	0.0	0.0	0.0	57.3	6.3	10.0	32.9	189.7
1932	115.0	14.0	9.0	0.0	0.0	0.0	0.0	0.0	2.7	26.2	26.0	26.0	218.9
1933	37.7	43.0	115.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	58.1	259.3
1934	75.0	28.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	31.0	(51.0)	187.1
1935	12.2	0.0	0.0	0.3	0.0	0.0	0.0	0.0	12.5	1.0	32.0	0.0	58.0
1936	9.0	0.0	0.0	19.0	0.0	0.0	0.0	0.0	0.0	43.6	73.0	185.6	330.2
1937	43.0	20.7	3.2	0.0	0.0	0.0	0.0	0.0	9.4	14.8	1.2	33.6	125.9
1938	75.0	58.0	12.5	53.8	0.0	0.0	0.0	0.0	0.0	0.0	24.8	69.8	239.9
1939	63.0	70.5	13.3	35.8	0.0	0.0	0.0	0.0	0.0	0.0	50.6	20.5	253.7
1950	57.0	35.1	73.1	4.5	12.0	0.0	0.0	0.0	0.0	5.1	62.6	37.3	286.7
1951	44.7	1.5	2.0	0.0	8.7	0.0	0.4	0.0	7.7	13.6	28.2	96.0	202.8
1952	52.1	103.6	0.0	12.8	0.4	0.0	0.0	0.0	11.2	3.2	24.5	30.3	238.1
1953	80.5	4.3	16.4	1.3	12.1	0.2	0.0	1.9	0.0	20.5	96.1	93.2	326.5
1954	2.5	7.4	9.9	3.8	0.8	11.0	0.0	0.0	0.0	49.8	29.7	21.6	136.5
1955	1.1	16.0	0.0	53.9	0.0	0.5	0.0	0.0	0.0	47.4	10.4	29.0	158.3
1956	3.2	9.2	27.8	0.0	0.0	0.0	0.0	0.0	6.7	24.5	4.0	147.8	223.2
1957	112.3	0.2	5.2	47.7	24.0	1.8	0.0	0.0	0.0	72.5	35.5	51.0	350.2
1958	9.2	11.3	24.2	0.0	0.0	0.0	0.0	0.0	1.0	22.0	75.7	34.1	177.5
1959	10.6	49.2	8.4	5.8	1.2	0.0	0.0	0.0	0.0	17.6	8.4	13.2	114.4
1960	6.1	6.5	0.0	38.6	0.0	0.0	0.0	0.0	73.0	0.0	108.3	103.9	336.4
1961	45.4	6.0	42.0	15.9	16.0	0.0	0.0	1.0	13.0	14.4	0.0	13.0	166.7
Average	43.8	25.2	16.6	12.8	4.0	0.6	0.0	0.1	9.3	17.4	34.7	51.0	215.5

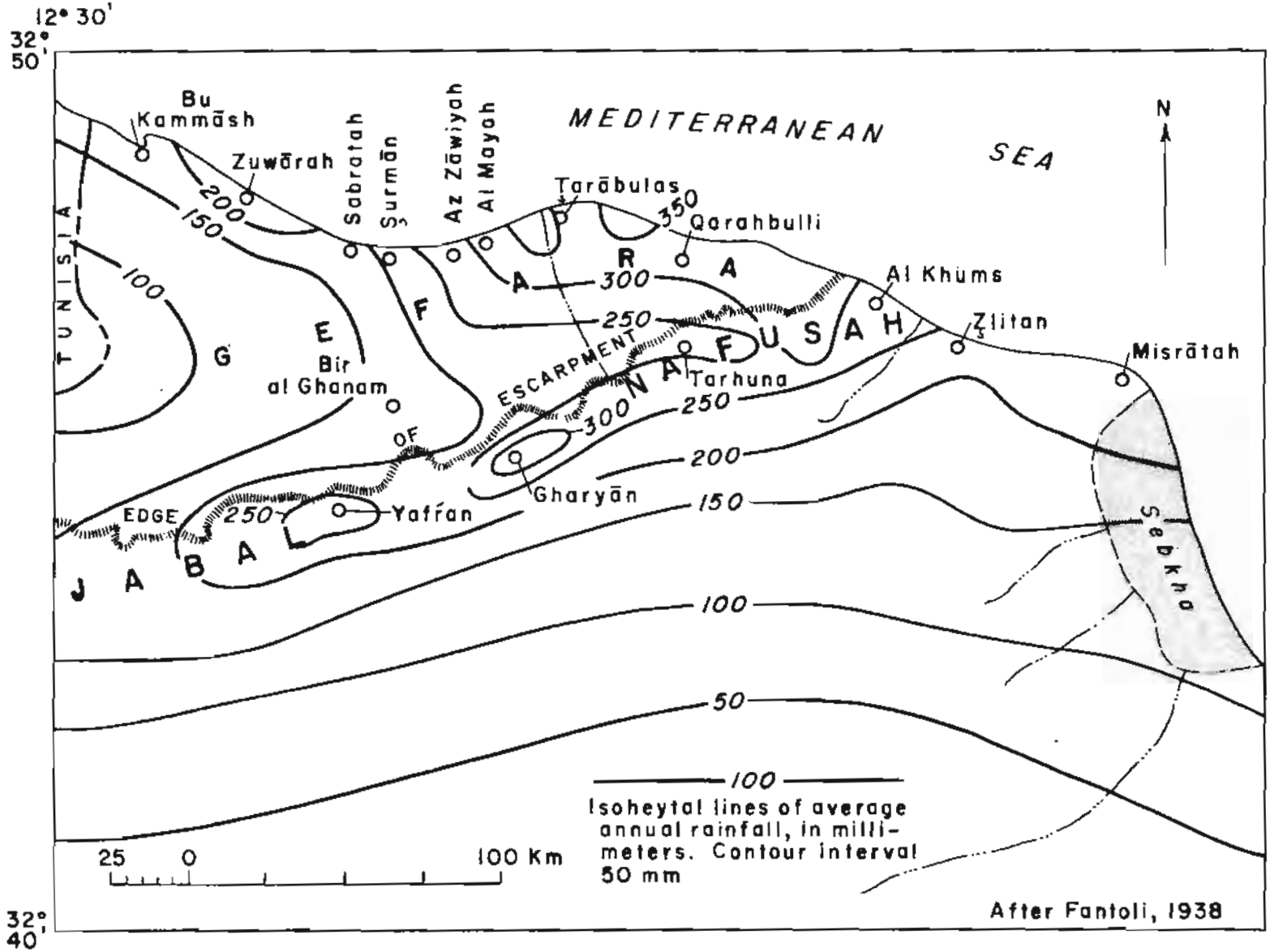

Figure 3.--Map of northern Tripolitania showing average annual rainfall, in millimeters.

The frequency as well as the amount and distribution of rains is a very important factor in the pattern of cultivation in this area. Optimum conditions for growth of barley and other cereals require a sequence of moderate rains beginning in late October and extending through March with few extended dry periods. Variations from these conditions greatly affect the yield of the winter cereals and the grazing conditions that are especially important to the semi-nomadic inhabitants of the southern part of the Ṣurmān area.

Agricultural development

Farming in Tripolitania and the Ṣurmān area was originally centered near the oases that lie near the coast. In these oases where the water table is generally shallow, extensive groves of date palms have been cultivated for many centuries. Probably many of the ancient groves were originally subirrigated from a high water table and the palms were essentially phreatophytes. More recently in the oases, date culture has been supplemented by subsistence-type gardens irrigated from water lifted by animal power and mechanical pumps from dug and bored wells. As has been the case since time immemorial the southern part of the Ṣurmān area is inhabited by semi-nomads who follow their herds most of the year but carry on some dry-land cultivation of cereals dependent on the winter rains.

The economy of the Ṣurmān area, as of much of Libya, is based largely on agriculture. Most agricultural production in the area comes from the narrow belt about 5 kilometers wide near the sea. The principal crops are peanuts, alfalfa and other fodder crops, barley, wheat, maize, dates, olives, potatoes, tomatoes, and other vegetables. South of the coastal belt the principal crop is barley and grazing of livestock is important. The 1960 census of agricultural statistics lists 271 hectares of peanuts planted with a yield of 2,750 quintals (qtls.); 184 hectares of alfalfa and other fodder crops yielding 14,690 qtls; 10,938 hectares of cereals with a yield of 4,124 qtls. Production figures are not available for dates, olives and citrus fruits, however, these crops contribute substantially to the commercial exports of the area. In addition to crops listed above, some 26,800 head of livestock and poultry were grazed, which yielded for human consumption and use 790 gallons of milk, 350 qtls. of wool, and 223,600 eggs. Agricultural development in the Ṣurmān area is largely based upon ground-water irrigation, but dry-land cultivation of barley, grapes, and olives also is practiced.

Stratigraphy

Rocks exposed in northern Tripolitania range in age from Triassic to Recent (table 2). Existing (1962) drilled wells in the Ṣurmān area have not actually penetrated formations older than Quaternary, however, drilling in neighboring areas has given considerable information on the pre-Quaternary rocks. The older formations are described herein because they may be explored and developed for water in the future.

The rocks of the region consist of a sequence of sedimentary formations that dip gently and thicken gradually toward the sea from near the foot of the Jabal Nafūsah; thus they are not only thicker toward the sea but also lie at greater depth than inland. The process of deposition did not occur evenly, as some formations at places were either eroded away prior to burial by younger beds or were not deposited. Post-depositional faulting and folding also affects some of the beds.

Mesozoic rocks

The oldest formation exposed in northern Tripolitania is the Ras Hamia Formation of Middle Triassic age (Burollet, 1960, p. 44). The type section exposed near Al Azīzīyah consists of some 74 m of dark-red, fine-grained, micaceous sandstone, red and green silty clay and claystone, and vari-colored siltstone. Only the uppermost part of the formation is exposed at the type locality and the total thickness may be several hundred meters.

Table 2.--Generalized section of the geologic formations of northwestern Tripolitania.

(After Christie, 1955)

System	Series	Group or Formation	Thickness (meters)	Lithologic Description	Water-bearing Character
Quaternary	Recent			Loess, wind-blown sand	
	Pleistocene	Garagaresc calcarenite	0-30+	Loosely cemented coquinoid calcareous sandstone	Yields some potable water locally but quality soon deteriorates with use owing to proximity to sea
		Gefarico silt with intercalations of marine deposits	50+	Calcrete, silty sand, loosely cemented sandstone, limestone and clay	Upper strata yield small to moderate amounts of water wells. Lower strata yield moderate to large amounts. Principal aquifers of the area
		?	?		
Tertiary	Pliocene	Unconformity	?	May be present but not identified in subsurface	
	Miocene		560±	Marine limestone, sandstone, and clay found in subsurface in northern part of Gefara	Middle sandstone strata yield moderately saline water, but little known about quality and quantity. Basal sandstone strata yield large quantities of brackish water
Cretaceous	Upper (Cenomanian to Turonian)	Gasr Tigrinna Formation	87	Limestone, dolomite, marl, sandstone, clay and conglomerate that are exposed on the front of Jabal Nafusah and may also underlie the Miocene near the coast	Yields small to large amounts of potable water. Many springs flow from the Ain Tobi and Chicla Formations
		Garian dolomite	55		
		Nafusa Group Jefren Marl Ain Tobi Limestone	79		
	Lower (Wealden)	Chicla Formation	0-65		
Jurassic		Bir el Ghnem Group	100±	Gypsum and limestone with beds of clay and sandstone. Not identified in the subsurface near the coast	Not considered a source of potable water
		?			
		Bu Scebs Formation			Yields moderate amounts of slightly, saline water to wells. Supplies water for irrigation near Bir al Ghanam
Triassic	Upper (Kueper)		165±	Sandstone, conglomerate, clay, and some gypsum	
	Middle (Muschelkalk)	Az zia Limestone	110	Limestone and chert, exposed near Azizia	Not considered a source of water
		Ras Hamia Formation	800±	Micaceous sandstone, silty clay, claystone	Reported to yield large amounts of water for irrigation near Al Aziziyah

The Azizia Limestone overlies the Ras Hamia Formation (Christie, 1955, p. 4-6). In the type section at Al Azīzīyah 61 m of [illegible] to dark-grey compact fossiliferous limestone with bands and nodules of chert is exposed. The Azizia is used as road metal and as an ornamental building stone.

The Bu Sceba Formation (Christie, 1955, p. 15-16; Burollet, 1960, p. 10) has been described as Late Triassic to Early Jurassic in age. The formation comprises about 165 m of red to brown sandstone, pebble conglomerate, white sandstone, red and green [illegible] and minor amounts of gypsum.

The Bi'r el Ghnem Group of Jurassic age consists of about 100 meters of gypsum and limestone with thin beds of clay and sandstone.

Five stratigraphic units of Cretaceous age have been identified (Christie, 1955, p. 17-20) from their exposures in the Jabal Nafūsah escarpment. They consist of limestone, dolomite, marl, clay, sandstone and conglomerate.

Rocks of Mesozoic age have not been reached by borings in the report area, although they probably underlie it at depths of several hundred meters. Sedimentary rocks older than Miocene were penetrated from 412 to 750 m in a test hole at Umm al Hashshān, about 30 km east of Ṣurmān. Although the age of these rocks was not definitely established, they probably are of Cretaceous age.

Tertiary rocks

Miocene rocks consisting chiefly of limestone, clay, marl, quartz sand and sandstone overlie the Mesozoic rocks. The Miocene attains a thickness of approximately 560 meters in the coastal Gefara according to Desio (1940) and 500 meters or more near the Ṣurmān area. The Miocene strata dip northwesterly at about 15 m per kilometer.

Quaternary deposits

Quaternary deposits most of which are unconsolidated form the surface rocks of the Ṣurmān area and adjacent parts of the Gefara. These deposits are of eolian and marine origin and range in thickness from 40 meters near Tripoli to 130 meters at Ṣabratah. In the vicinity of Ṣurmān the deposits are probably about 110 meters thick.

The lower part of the deposits consists of loosely cemented silty sand, some limestone, and clay, whose overall permeability appears to be much greater than that of overlying beds. The upper part of the deposits consist of unconsolidated eolian sand, loess, calcrete and some loosely cemented sand.

The Gargaresc calcarenite, a coquinod fragmental calcareous sandstone, is exposed in a series of loess-covered cemented dunes extending from Tripoli westward along the coast at least as far as the Tunisian frontier. The calcarenite deposits are limited to the coast and have not been found inland. They are used extensively for building stone.

Ground water

Source and occurrence

The source of most fresh water on the earth is precipitation. The process of evaporation, condensation, and precipitation known as the hydrologic cycle, (Fig. 4) is continuous and has no beginning or end.

Figure 4.--The hydrologic cycle.

Water evaporated from the land and water surfaces, is borne as vapor into the atmosphere where it condenses and falls back to the earth as rain. Some of the precipitation sinks into the ground, some runs off into streams, and some is evaporated back into the atmosphere. The water that sinks into the ground flows underground and reappears at the surface as springs or enters the ocean directly. The water in the streams flows to the ocean where it is again evaporated into the atmosphere thus completing the hydrologic cycle.

Water, which occurs naturally as rain, falls on the surface of the ground and percolates downward through the pore spaces of the soil and forms the zone of saturation. The upper surface of the zone of saturation is known as the water table. The water in the zone of saturation, sometimes referred to as "phreatic water", moves by gravity flow towards areas of discharge.

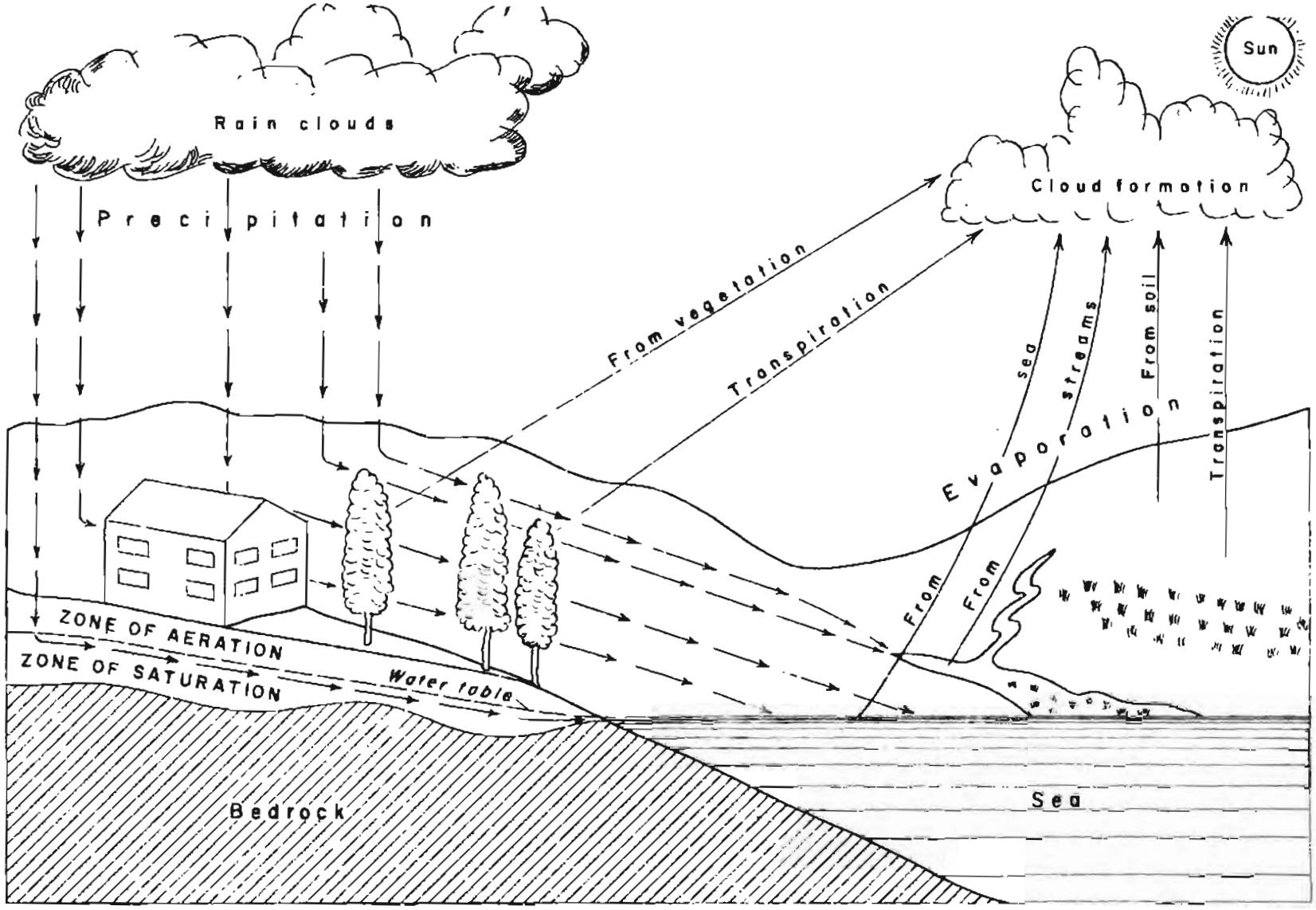

Figure 4.--The hydrologic cycle.

Ground water also occurs as confined or artesian water. A gross over-simplification of the origin of an artesian aquifer is described below. As water moves through a formation by gravity flow the water-bearing strata commonly pass beneath overlying impermeable beds which restrict vertical flow. If the bed beneath the water-bearing formation is also impermeable, the water-bearing formation is said to be confined or artesian. As the water continues to flow through this confined formation it acquires a hydrostatic pressure proportional to the vertical distance between the elevation of the point of confinement and the top of the confined bed at any point.

Ground water is stored in the earth in the pore spaces of the different types of rocks in which it is found. All granular material in the earth contains openings between the grains or particles, but the openings differ in number, size, and shape. In materials such as clay and silt, the open spaces are very small, and therefore, do not readily yield water to wells. Sand, gravel, and fractured massive rocks may have large interconnected spaces through which water can flow freely. The size and amount of the voids or open spaces of the water-bearing formation affect the ability of the formation to transmit and store water.

Water-bearing formations

Mesozoic rocks

The oldest water-bearing formations known in northern Tripolitania are the Ras Hamia, Azizia and Bu Sceba of Triassic to Jurassic age. Usable water in these aquifers is tapped at depths ranging from 100 to 325 m near Bi'r al Ghanam and Al Azīzīyah. For example, a test hole drilled 2 km south of Al Azīzīyah encountered a very permeable aquifer in the Ras Hamia at a depth of 324 m. A few wells of low yield also tap water-bearing zones in the Azizia near the type locality. Permeable beds in the Bu Sceba yield water rather freely to wells at Bi'r al Ghanam. Potable water is also obtained from springs issuing from the Cretaceous rocks, notably the Ain Tobi Limestone, of the Jabal Nafūsah to the south of the report area. Presumably, all these formations underlie the Ṣurmān area but probably at considerable depth. The water contained in these formations, however, probably would be salty or brackish beneath the report area.

Tertiary rocks

Rocks of Miocene age attain a thickness of 500 meters or more in the coastal zone adjacent to the Ṣurmān area. Exploratory wells put down at points adjacent to the Ṣurmān area have penetrated to the basal Miocene and each has encountered several water-bearing zones in the Miocene. Also each well has encountered three fresh-water aquifers in the middle Miocene section. For example, in well 3247-1248-4 (OPDL well no. 21) at Jud Dā'im, aquifers in the Miocene were penetrated at depths of 140, 239, 254, 280, 344, 426, 437, and 496 m. Unfortunately, the water from the wells was not checked systematically for quality or quantity, for interest at the time the wells were put down was solely in flowing artesian water. In well 3247-1256-2 (OPDL well no. 16) at Al Mayah, the first aquifer was encountered at 141 meters, the second at 191 meters, and the third at 223 meters. The reported chemical quality of water from the aquifer at 223 meters suggests that the water, though slightly brackish, could be used for irrigation. Water of similar quality was also obtained from an aquifer at 254 meters in well 3247-1248-4. These aquifers were also encountered in a test hole, well 3243-1255-2, at Umm al Hashshān drilled by the predecessor US AID in 1956. The Miocene aquifers thus may contain a potential source of water for future utilization in the Ṣurmān area that could be used to supplement the declining supply from Quaternary aquifers in the present agriculturally developed tracts. Test holes, however, need be drilled to determine the extent and thickness of these aquifers in the Ṣurmān area. The test holes should be properly logged and the quality and quantity of water should be determined by analyses and pumping tests.

Sandstone aquifers in the basal Miocene yield flowing water to wells along the coast from Ṣabratah to near Al Khums. The water, however, is both hot and highly mineralized and contains hydrogen sulphide (H_2S) gas. The water from these wells generally has proved unsatisfactory for irrigation. Analyses of water from wells penetrating the basal Miocene strata suggest that the quality of the water improves inland or up dip. If this conclusion is correct, it may be possible to obtain water of quality suitable for irrigation in the southern part of the Ṣurmān area from aquifers in the basal Miocene and at depths which become progressively less to the south.

Quaternary deposits

Quaternary deposits overlying the Miocene contain the principal aquifer in the Gefara of Tripolitania. The deposits range from unconsolidated sand to loosely cemented sandstone and limestone. The thickness ranges from 40 meters near Tripoli to 130 meters at Ṣabratah and is probably about 110 meters near Ṣurmān.

The lower beds in the Quaternary deposits, locally referred to as the second aquifer, furnish most of the water for irrigation and public supply in coastal Tripolitania as well as in the Ṣurmān area. The water-bearing materials are loosely cemented permeable sandstone and limestone intercalated with impermeable layers of clay. The aquifer is considered to be semi-artesian, that is, it is hydraulically continuous over a large region but locally, vertical movement of water may be impeded by less permeable beds. Consequently, when the lower beds are penetrated by a well, the water will rise in the well to the level of the water table. The permeable beds in the second aquifer are highly lenticular and any particular bed may lens out in a relatively short distance. The overall permeability of the lower beds appears to be considerably greater than that of the upper beds which constitute the first or water-table aquifer. The average depth of the wells penetrating the second aquifer in the lower beds of the Quaternary is about 60 meters, increasing somewhat to the west.

In the Ṣurmān area, the first and second aquifers in the Quaternary deposits appear to be directly interconnected in many places. Consequently the shallow dug wells tapping the first aquifer may go dry shortly after nearby deeper drilled wells begin pumping. Since 1959 a large number of dug wells have been deepened or replaced with drilled wells.

The calcarenite deposits are extremely permeable and locally yield small supplies of potable water. Owing to their proximity to the sea, however, they are subject to salt-water contamination.

Hydraulic characteristics

Under natural conditions and over a long period of time, the hydraulic system in a water-bearing formation is essentially in balance, that is, the natural discharge is equal to the recharge. Water in transit between the area of recharge and the discharge area is said to be in storage. When this natural balance is upset by a withdrawal of water, as from an irrigation well, an adjustment takes place which results in a decline in the water level. When water is withdrawn from a well that penetrates an aquifer, the direction of flow of the water in the vicinity of the well is changed. The withdrawal causes a lowering of the water level around the well in the form of an inverted cone, the well being at the center. As the cone expands and deepens, water flows to the well from all directions. (Fig. 5). The rate of decline of the water level and the outward spread

Figure 5.--Diagram showing movement of ground water around a cone of depression of a pumped well near sea level.

of the cone depend on the hydraulic characteristics of the formation as well as the rate of pumping. The magnitude of the decline in water level varies directly as the rate of withdrawal of water, and increases with the logarithm of time that has elapsed since withdrawals began.

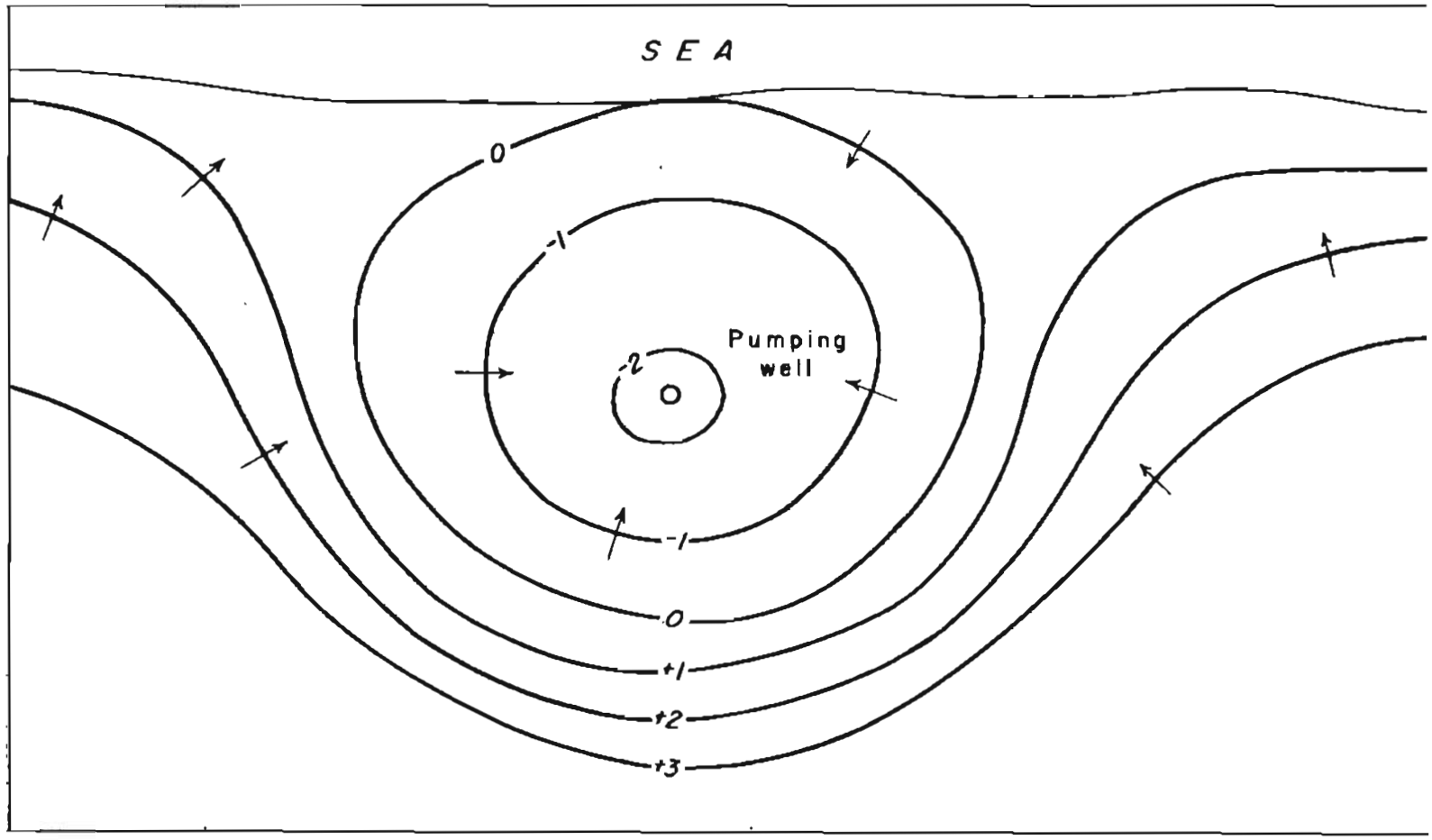

Figure 5.--Diagram showing movement of ground-water around a cone of depression of a pumped well near sea level.

Two of the hydraulic characteristics of water-bearing formations which affect the rate of decline of water levels in wells are the ability of the formation to transmit water, and the capacity of the formation to yield water from storage. These are known as the coefficient of transmissibility and the coefficient of storage. The coefficient of transmissibility is defined as the rate of flow of water, in gallons per day, through a vertical strip of the aquifer one foot wide, extending the full saturated thickness of the aquifer under a hydraulic gradient of one foot drop in head in one foot of flow distance. The coefficient of storage is defined as the volume of water an aquifer releases or takes into storage per unit surface area of the aquifer per unit change in the component of head normal to that surface.

The hydraulic coefficients of storage and transmissibility of the aquifers in the Ṣurmān area are not available owing to the lack of pumping tests. Tests were conducted however, in the Azzahra (ex-Bianchi) area by W. T. Stuart (1960). The aquifers at Azzahra are believed to be sufficiently like those at Ṣurmān that their hydraulic characteristics are comparable. In the Azzahra tests the coefficient of transmissibility was determined to be 37 cubic meters per hour per meter (68,000 U.S. gallons per day per foot) and the coefficient of storage was found to be 0.0016.

The figures obtained in the Azzahra tests indicated a moderate ability of the water-bearing formations to transmit water to wells. The figures may have been low owing to lack of complete penetration by the pumped wells of the water-bearing formations.

Recharge and discharge

Recharge to the aquifers in the Şurmān area is either from direct infiltration of water from precipitation or from the runoff in ephemeral streams of the region. Much of the recharge comes from local rainfall that percolates down into the ground-water reservoir, however, it is difficult to predict how much recharge will occur in any one year. During drought years the recharge may be small or nil, but during periods of heavy rainfall a high per cent of the precipitation may enter the ground-water reservoir as recharge. Information is not available to evaluate the rate of recharge that occurs in relation to the amount of rainfall. Correlation of rainfall and recharge would be difficult to determine because water is being withdrawn continuously for irrigation causing an overall decline in the water level that masks the effects of ground-water fluctuations due to natural causes. Detailed recharge studies therefore, were beyond the scope of this report.

Recharge also moves into the Ṣurmān area from the south as shown in figure 6. The contour lines in figure 6 are drawn through points

Figure 6.--Map showing configuration of the water table in a part of the central Gefara, 1959-60. (After Vorhis).

of equal altitude on the water table and were constructed from water levels in wells measured during 1959-60. The map shows that the water table slopes northerly toward the sea. A ground-water mound marked by the 95-meter contour in the Bi'r al Ghanam area and another south of An Nāṣiriyah marked by the closed 90-meter contour suggest that these two areas may be primary recharge zones. This tends to substantiate the conclusion that much of the recharge for the aquifers of the Gefara comes from the runoff of ephemeral streams draining seaward from the Jabal Nafūsah. During periods of heavy rainfall on the Jabal, the runoff is high. The water flows northward from the steep wadis of the Jabal front and disappears into the ground along the wadi channels in the southern Gefara. Generally, very little runoff originating in the Jabal reaches the sea. Recharge from local direct infiltration of rainfall on the southern part of the Gafara also occurs but diminishes southward with decreasing rainfall.

There also may be interformational recharge in the Ṣurmān area and other areas along the coast, but this has not been evaluated.

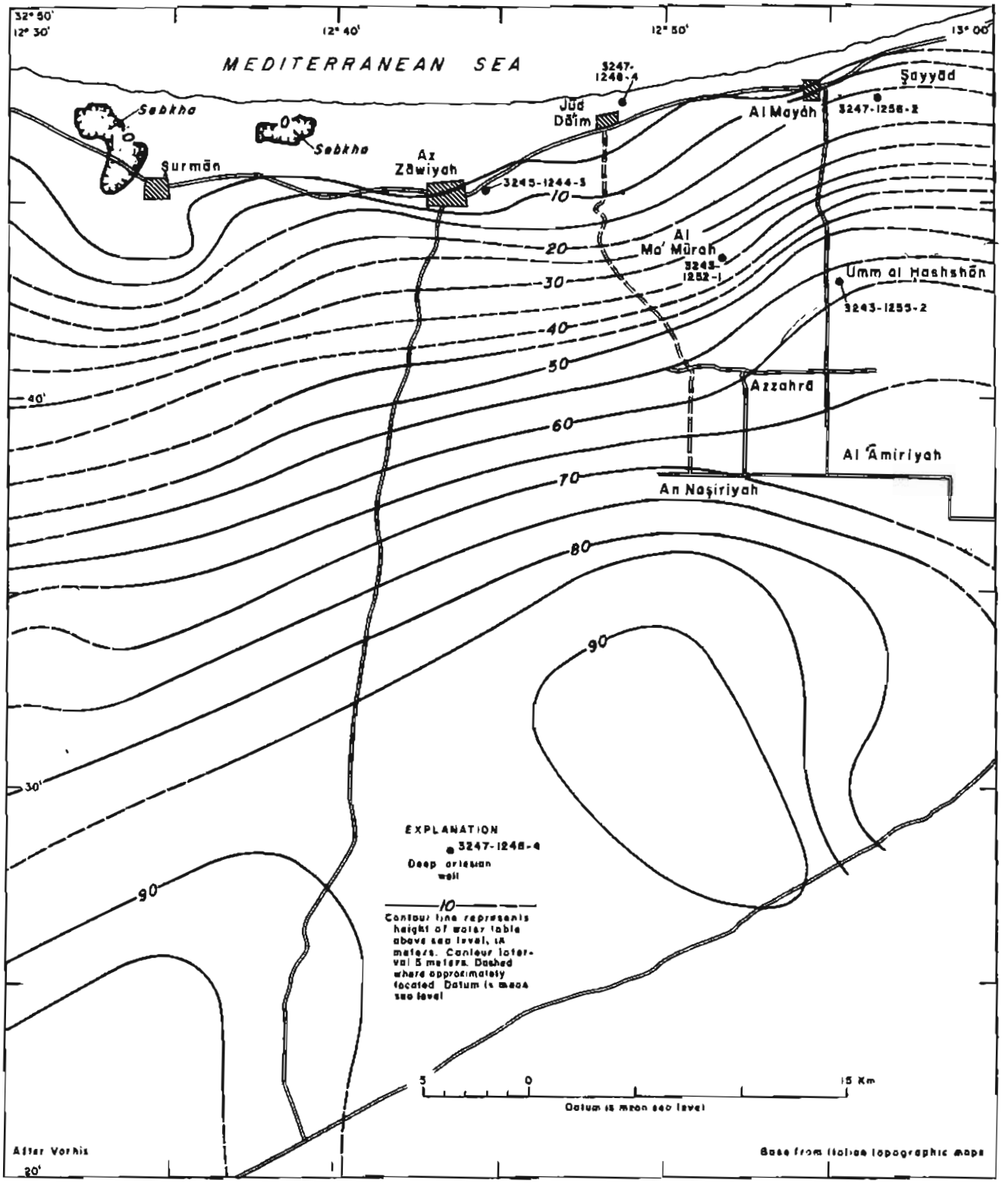

Figure 6.--Map showing configuration of the water table in a part of the central Gefara, 1959-60. (After Vorhis).

Ground-water discharge in the Ṣurmān area occurs both by natural and artificial means. Water is discharged naturally from ground-water reservoir by submarine outflow, spring flow, and evapotranspiration. Submarine outflow below sea level may form an important part of the natural discharge in the Ṣurmān area. Discharge by evapotranspiration is substantial near the sea and the sebkha where the water table is near the surface.

Most of the ground-water discharge in the Ṣurmān area is through wells used for irrigation and domestic supply. The total annual withdrawal from wells in the Ṣurmān area was computed by estimation methods. The data were supplied in part by the owners and the rest was acquired from other sources. Table 3, lists the reported yield, crops, and number of hectares irrigated. Irrigation requirements given by Casadio (Lewis, p. 55, 1954) and by Fred M. Tileston (1961, written communication) were used to estimate the annual withdrawal from those wells for which the crops and hectares irrigated were available.

In order to obtain a more precise base for estimates of withdrawals from wells, an inventory in the Ṣurmān area was made in 1958-59. The inventory of wells, listed in table 3, was not complete, however, but most of the deeper wells of substantial discharge were visited and described. Information received in 1961 from the Mudir of the Ṣurmān District listed 1,150 dug wells and 375 drilled wells. Most of the newer drilled wells were bored to deepen or replace old dalu-type dug wells and are equipped with small centrifugal pumps used to irrigate "Arab gardens" west and north of Ṣurmān.

Using the computed consumption from the inventoried wells plus an estimate for the newer reported wells, a total consumption of 12 million cubic meters per year was derived. Consumptive figures for domestic and stock use were not computed per se, however, the estimated figure for the reported dug wells includes water used for these purposes.

The total discharge figure is believed to be of the proper magnitude. Approximately 2,000 hectares were under irrigated cultivation in the Ṣurmān area in 1962, but a large percentage of the farms, which still grow palms, olives, figs and a few vegetables not requiring much water, are not intensively irrigated. The total discharge figure may be a little conservative for if only 6,000 cubic meters of water per year per hectare were used on 2,000 hectares of land, the total would be 12 million cubic meters.

Well yields

The yields of individual wells in the Ṣurmān area range from about 1 cubic meter per hour (m^3/hr) from an average dalu well to about 60 m^3/hour (250 gpm) in a drilled well. About 125 wells yield from 15 to 60 m^3/hour (67 to 250 gpm). An additional 250 wells may have a pumping capacity of 5 to 10 m^3/hour, however, they are pumped only for short periods of time to irrigate small Arab gardens. There are also about 1,150 dalu-type wells reported in the Ṣurmān area that individually yield about 1 m^3/hour.

Most of the drilled wells _/ in this area use centrifugal pumps set in an "avampozzo", which is a dry well dug to a point just above the water table. A minimum distance must be maintained between the pump and the dynamic water level, for the maximum effective lift of a centrifugal pump is about 8 meters (28 feet). The amount of water that a well can pump is controlled somewhat by the specific capacity of the well (the yield of the well per unit of drawdown). If the specific capacity of the well decreases or is low, the rate of discharge cannot necessarily be augmented by increasing the pumping rate or size of the pump.

The yields of many of the wells in this area could be increased if they were developed properly by modern water-well construction methods. Most of the drilled wells are not properly cased and screened and rarely are developed properly. Few of the wells completely penetrate the water-bearing formation. It is common practice to case only the upper part of the well and to leave the lower part of the well open. This practice subjects the well to failure by sanding.

_/ A drilled well in this area is one that has been put down mechanically including rotary and motor or hand-powered percussion methods.

Present and potential development

In the past, agricultural development in the report area has been concentrated to the east and west of the large sebkha just northwest of Ṣurmān. To the east and to the west of this concentration of small farms are several large farms, largely of olive groves. The shallow water-table aquifer has long been drawn upon by dug wells to irrigate farms in Arab-type gardens of 1 hectare or less, customarily by dalus _/. The use of motor-driven pumps in deeper wells on some of the larger farms has caused water levels to decline below the bottoms of many of the nearby dug wells. Therefore, owners of the dug wells have had to deepen their wells and install small centrifugal pumps. This trend has been accelerated since 1959. A further increase in ground-water withdrawals in this area will accelerate the rate of decline of the water table and the consequent encroachment of salt water from the sea and the sebkha. For this reason further development of irrigated agriculture in this area should be discouraged.

Some new farms have been developed south of Ṣurmān and the sebkha in recent years. The water table in this part of the area is 5 meters or more above sea level and rises gradually to the south (fig. 6). The position of the water table is thus sufficiently high to minimize the immediate hazard of salt-water intrusion from the sea. Therefore, even though the pumping lift increases to the south, new ground-water development preferably should be in this direction.

_/ A dalu is a skin, or commonly today rubber, bag which is raised from and lowered to water by rope, pulley with a camel or yoke of bullocks for power.

Additional problems in the southern part of the area are shifting sand that has to be controlled by dune-stabilization methods and the necessity for land leveling or sprinkler irrigation. These problems, moreover, apply to most of the Gefara.

Water levels in the Quaternary aquifer of the Ṣurmān area as well as in other parts of the Gefara have been declining steadily for the past 10 years or more. Eventually, if these declines continue the quality of the shallow ground water will be affected in the Ṣurmān area. Serious consideration needs to be given, therefore, to the possibility of utilizing water from deeper artesian water-bearing formations. Water-bearing middle Miocene strata were encountered at depths between 140 and 275 meters in test holes drilled by the OPDL and USAID at points adjacent to the report area. Water samples from wells at Az Zāwiyah and Al Mayah suggest that this water has quality suitable for irrigation. If these intermediate aquifers yield water of quality and quantity suitable for irrigation in the Ṣurmān area, they could be tapped to supplement the diminishing shallow-water supplies. Water from the basal Miocene sandstones may also be usable, as the chemical quality of the water may improve southward with proximity to the recharge area.

A government project for land development and resettlement in an area comprising about 55,000 hectares south of Az Zāwiyah and southeast of Ṣurmān is under consideration (1962). The project would be based on irrigation. Large withdrawals from the shallow aquifers of this area are certain to intercept a large part of the underflow that recharges the shallow aquifers of the developed agricultural belt nearer the coast. Too little is known, however, of the deeper aquifers to predict the magnitude of effects of pumping from them. Although the Ṣurmān area is not adjacent to the proposed project, it would probably in time be involved in a regional drawdown of water levels that would result from large-scale pumping.

Water levels

Water levels in wells are one of the most important indices used in evaluating the water supply of an area. Changes in water levels resulting from discharge of water are a measure of the overall effect of discharge upon the aquifer. If the static water level fails to return to its original level after cessation of extended pumping, then this fact suggests that the water is being withdrawn faster than it is being replenished. During the period of minimum withdrawal, in the winter months, the water levels are generally at their highest level. It is during this time that static water levels for year to year comparison and evaluation are usually measured.

The general configuration of the water table in the Ṣurmān area and adjoining areas to the south and east is shown in figure 6. As indicated, the water table slopes toward the north at an average of about 4 meters per kilometer. The water levels are only slightly above sea level near the shore line. Near Ṣurmān the water levels are generally from about 1 to 3 meters above sea level for a distance of about 4 kilometers inland from the sea. These areas are subject to salt-water encroachment from the sea if the ground-water reservoir is overpumped. The sebkha near Ṣurmān also presents another source of possible salt-water contamination of the ground-water reservoir. South of Ṣurmān, the altitude of the water table rises well above sea level, but the slope of the land surface is greater than that of the water table and consequently the depth to water increases southward as shown in figure 7.

Figure 7.--Map showing depth to water in the Ṣurmān area, 1961-62.

The depth to water is of great importance to farmers using ground water for irrigation, for as the depth to water becomes greater the cost of lifting water to the surface increases. If the farmer uses a dalu, he must pump water for a longer period or purchase a pump, or if a pump is already installed, he must use more power which will increase the cost of operation. However, the increase in pumping cost may be partly offset if expansion of the new power system in Tripoli makes electric power available.

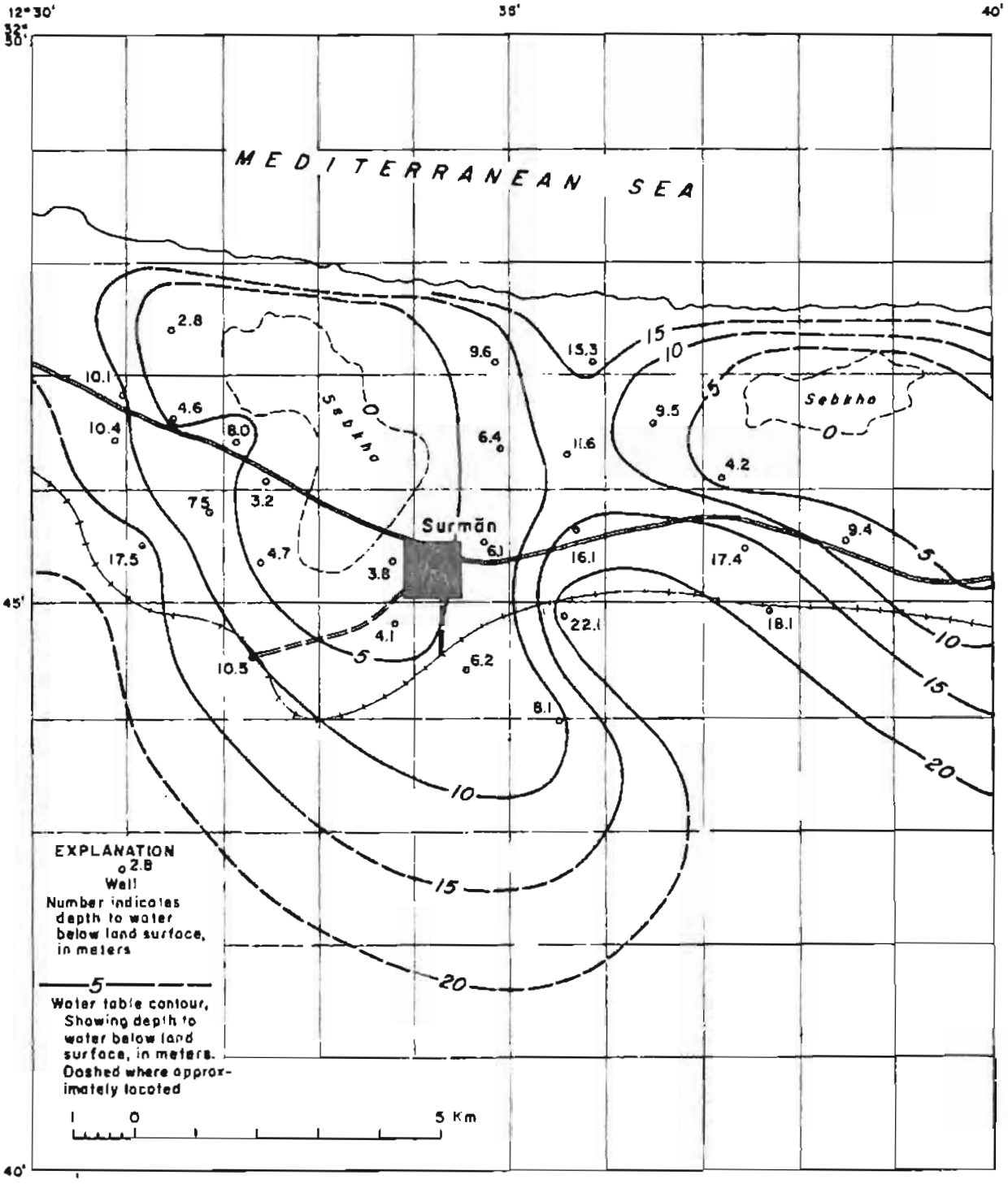

Figure 7.--Map showing the depth to water in the Surmān area, 1961-62.

Very few water-level measurements are available for the Ṣurmān area prior to 1957. Only three measurements are available for 1938 with which to compare the present water levels. In wells 3244-1232-2 and 3, south of the town of Ṣurmān, the water level declined 2.3 meters from 1938-60 (fig. 8). North of Ṣurmān where the water table is but slightly above

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Figure 8.--Map showing water level declines in Ṣurmān area.

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sea level and danger of salt-water infiltration is consequently great, water levels in two wells declined markedly. The decline in well 3246-1235-4 between 1938 and 1960 was 1.3 meters, and that in well 3245-1236-1 was 3.2 meters in the briefer period, 1952 to 1960.

Most of the comparative water level measurements in the Ṣurmān area were made between 1957 and 1959 (fig. 8). During this period the average decline was about 0.5 meters, equivalent to a rate of decline of about 0.2 meters per year. If the water levels continue to decline at this rate, wells near the sea and the sebkha may become salty within 10 years. The large number of pumps being installed in this area can only accelerate the rate of decline of the water level, and consequently, the rate of encroachment and contamination by sea water would also increase.

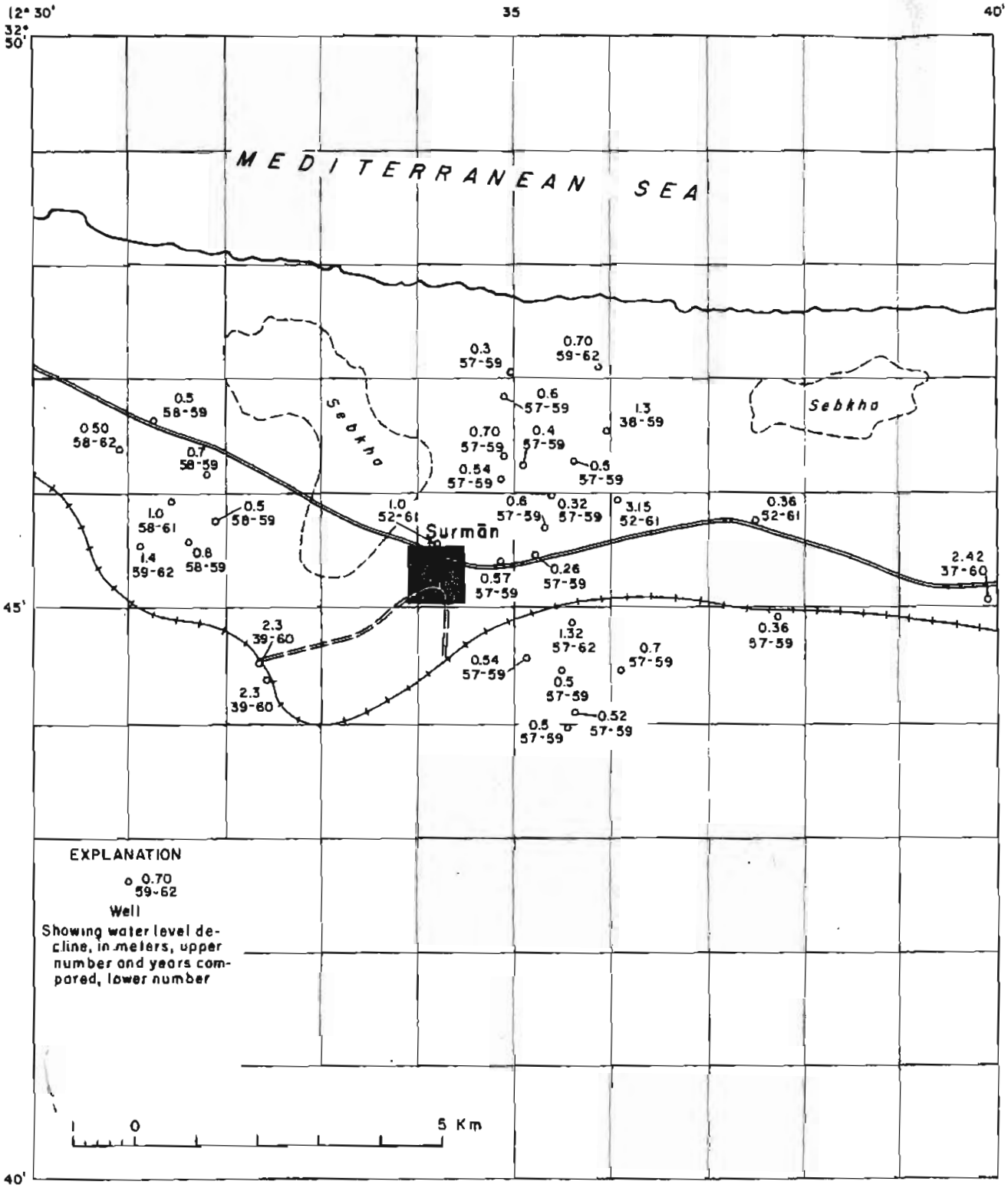

Figure 8.--Map showing water-level declines in the Surmān area.

In the vicinity of the sea and the sebkha, the fresh water of the ground-water reservoir is in contact with salt water along an interface or zone of diffusion. It is important that the hazard of salt-water contamination from the sea and from the sebkha be recognized and that the relationship between salt water and fresh water in the coastal zone be understood. This relationship, known as the Ghyben-Herzberg principle, results from the fact that the specific gravity of water increases with the amount of dissolved minerals in the water. Fresh water, containing less dissolved minerals, is lighter and will float on salt water. In the coastal zone, the depth to which fresh water occurs below sea level is determined by the head of the fresh ground water above sea level and the difference in specific gravities of the two waters. Under conditions of equilibrium, 1 meter of fresh-water head above sea level will balance approximately 40 meters of fresh water below sea level. This means that if 1 meter of fresh-water head is lowered by pumping or other means, the fresh water-salt water interface will rise approximately 40 meters. To avoid salt-water contamination, substantial withdrawals from wells should not be made adjacent to the coast and water levels in pumping wells should not be depressed below sea level for prolonged periods.

The water table in the Ṣurmān area, as in other parts of the Gefara, declines during the summer months and recovers during the winter when irrigation is at a minimum. As the water table approaches sea level the danger of salt water encroachment increases. If, during the summer, the water table, because of heavy pumping for irrigation, declines below sea level, the ground-water gradient or slope will be reversed and salty water can then move into the wells (fig. 5) and thus contaminate the water, making it useless for most purposes.

Quality of water

General features

All ground water contains dissolved minerals but the content varies through a wide range. Water from some wells may contain as little as 200 parts per million (ppm) of dissolved solids, whereas water from other wells may contain more than 20,000 ppm. Useful limits of water are difficult to determine, for although waters containing large amounts of dissolved solids are not considered to be potable, they may be useful for other purposes such as livestock or industry. As the mineral content increases, however, the usefulness of the water decreases markedly.

Quality of water determinations are generally expressed in concentrations of individual ions for those substances known to be dissociated in solution. Determinations commonly made in water analyses include cations, anions, and certain more general chemical and physical properties such as acidity (pH), hardness, specific conductance, and dissolved solids. The number of chemical determinations of an analysis is usually governed by the nature of the investigation.

Dissolved solids is a measure of the total quantity of matter carried in solution by the water. Dissolved solids have a direct relationship to the specific conductance (conductivity) of the water and can be easily estimated from the conductivity. Specific conductance, an electrical property, which is used as an index of the total salinity of the water, can be measured easily and accurately in the laboratory and in the field.

The cations ordinarily present in significant concentrations in ground-water are calcium, magnesium, sodium, and potassium. Calcium, magnesium and potassium are essential plant foods; however, although sodium is used by many plants it is not as essential as the other nutrients and may be toxic to some plants.

The more important anions in irrigation water include carbonate, bi-carbonate, sulfate, chloride and nitrate. Sulfate and nitrate are essential nutrients in optimum concentrations. Chloride in high concentrations is toxic to many plants.

The precipitation of sodium carbonate, resulting from evaporation of irrigation waters containing high bicarbonate ion concentrations, forms a "black alkali" deposit which has a deleterious effect upon soil structures. This condition is not prevalent in the report area because the bicarbonate ion concentrations of the waters are relatively low and the soil has good drainage.

Ground water in the area of study is used principally for domestic supply, irrigation, and livestock. The quality of water for these purposes can vary through a wide range. The preferred upper limits, in parts per million, for total dissolved solids and other common chemical constituents in drinking water as prescribed by the United States Public Health Service (1961) is shown in the table below. Water which contains much higher concentrations, however, is used in many parts of the United States as well as other parts of the world.

Chloride	250	Dissolved solids	1,000
Sulfate	250	Nitrate	44
Magnesium	125	Flouride	1.5

Most of the common constituents in drinking water are objectionable only when the concentrations are high enough to be noticeable to the taste. Because of differences between individuals, objectionable concentrations are difficult to state. Water containing 400-600 ppm chloride is salty to the taste of the average person. People can become accustomed to an objectionable taste if no other source of water is available.

The nitrate content of water from well 3245-1238-1 of 110 ppm and of 115 ppm from well 3244-1233-5 are far above the limits suggested by the U.S. Public Health Standards. Because both of these wells are shallow it is possible that the excess nitrate may be the result of surface pollution from fertilizer on irrigated farms or from local cesspools. Detrimental effects from drinking water with high nitrate content have been reported in the United States. High concentrations of nitrates in drinking water are believed to cause methemeglobinemia or cyanosis in infants (Comly, 1945).

The quality limitations in water for livestock are not as stringent as for human consumption. The upper limits of dissolved solid concentrations in stock waters are reported to range from 5,000 to 15,000 ppm. If the animals are accustomed to highly mineralized water, upper limits of 10,000 to 12,000 ppm dissolved solids can be used as shown in the table below. For the best growth and development of the animals, however, water of quality better than the upper limits indicated is desirable.

Poultry	2,860	Cattle (Dairy)	7,150
Pigs	4,290	Cattle (Beef)	10,000
Horses	6,430	Adult Sheep	12,900

It is common belief that camels have higher tolerance for salts than do most animals.

The concentration and composition of dissolved constituents in a water determine its quality for irrigation use. Quality of water is an important consideration in any appraisal of salinity or alkaline conditions of the soil in an irrigated area.

The characteristics of an irrigation water that appear to be most important in determining its quality are: (1) total concentration of soluble salts; (2) relative proportion of sodium to other cations; (3) concentration of boron or other elements that may be toxic; and (4) under some conditions, the bicarbonate concentration as related to the concentration of calcium plus magnesium.

The total concentration of soluble salts in irrigation waters can be adequately expressed for purposes of evaluation and classification in terms of electrical conductivity (specific conductance). The conductivity is useful because it can be readily and precisely determined. In the classification of irrigation water, conductivity is the measure of the salinity hazard.

In determining the salinity hazard, the waters are divided into four groups with respect to conductivity. The limits or dividing points of the classes were determined to be at 250, 750, and 2,250 micromhos/cm (fig. 9). These class limits were selected in accordance with the

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Figure 9.--Diagram for the classification of irrigation waters. (U. S. Salinity Laboratory, 1954).

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relationship between the conductivity of irrigation waters and the saturated extract of the soil. Most waters used for successful irrigation have conductivity values of less than 2,250 micromhos/cm, however, water of higher conductivity can be used in some instances where the soil is well drained and a large percentage of gypsum is present in the soil.

It has been shown that the water-transmission and drainage properties of the soil and the salt tolerance of the crop to be grown are important factors in appraising irrigation waters with respect to total salt concentration.

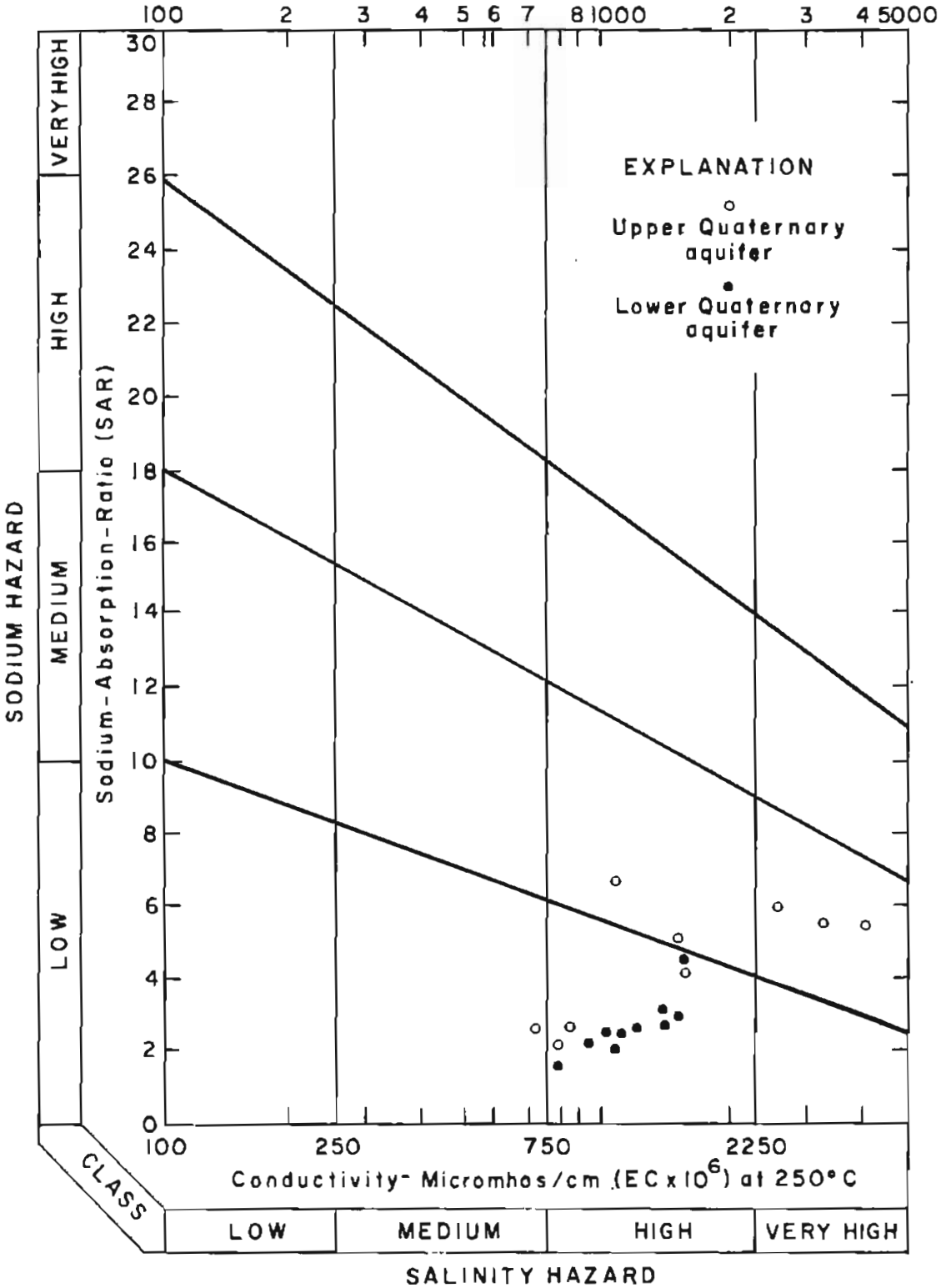

Figure 9.--Diagram for classification of irrigation waters.

(U.S. Salinity Laboratory, 1954).

The soluble inorganic constituents of irrigation waters react with soils as ions. The alkali hazard involved in the use of a water for irrigation is determined by the absolute and relative concentrations of the cations. The sodium-adsorption-ratio (SAR) of a soil solution is related to the adsorption of the sodium by the soil. This ratio is used as an index of the sodium or alkali hazard of the water. The ratio is defined by the empirical equation:

$$SAR = \frac{Na^{++}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

where sodium (Na^{++}), calcium (Ca^{++}), and magnesium (Mg^{++}) represent the concentrations in milliequivalents per liter of the respective ions.

The significance and interpretation of the quality-class ratings on the diagram for the classification of irrigation waters (fig. 9) are summarized below:

Conductivity

Low-salinity water	- can be used for irrigation with most crops on most soils, with little likelihood that a salinity problem will develop. Some leaching is required, but this occurs under normal irrigation practices except in soils of extremely low permeability.
Medium-salinity water	- can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most instances without special practices for salinity control.
High-salinity water	- cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required, and plants with good salt tolerance should be selected.
Very-high salinity water	- is not suitable for irrigation under ordinary conditions but may be used occasionally under very special circumstances. The soils must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching, and very salt-tolerant crops should be selected.

The classification of irrigation waters with respect to SAR is based primarily on the effect of exchangeable sodium on the physical condition of the soil. Sodium-sensitive plants may, however, suffer injury as a result of sodium accumulation in plant tissue when exchangeable sodium values are lower than those effective in causing deterioration of the physical condition of the soil.

Low-sodium water	- can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium. However, sodium-sensitive crops, such as stone-fruit trees and avocados, may accumulate injurious concentrations of sodium.
Medium-sodium water	- will present an appreciable sodium hazard in fine textured soils of high cation-exchange-capacity, especially under low-leaching conditions, unless gypsum is present in the soil. This water may be used on coarse-textured or organic soils that have good permeability.
High-sodium water	- may produce harmful levels of exchangeable sodium in most soils and will require special soil management--good drainage, high leaching, and additions or organic matter. Gypsiferous soils may not develop harmful levels of exchangeable sodium from such waters. Chemical amendments may be required for replacement of exchangeable sodium, except that amendments may not be feasible with waters of very high salinity.
Very-high sodium water	- is generally unsatisfactory for irrigation purposes except at low and perhaps medium salinity where the solution of calcium from the soil or use of gypsum or other amendments may make the use of these waters feasible.

Soils may become saline from use of irrigation waters if the drainage is inadequate or water is applied too sparingly. Plant roots take in water but absorb very little salt and evaporation removes the soil water and leaves the salt, consequently an excess amount of salt may accumulate near the base of the root zone and the growth of crops may be curtailed.

This may be controlled by leaching of the soil by the use of excessive irrigation water if the soil drainage is good.

The control of increased exchangeable sodium, or alkali, resulting from irrigation with waters high in sodium content may require special management practices. As the proportion of exchangeable sodium increases, the physical and chemical conditions of the soil become detrimental to the growth of plants. This can be prevented in some instances by the addition of gypsum ($CaSO_4$-$2H_2O$) to the water or to the soil. If the soils are highly calcareous or gypsiferous the irrigation water may dissolve sufficient calcium from the soil to decrease and control the sodium hazard.

Evaluation of water analyses

Chemical analyses of water from typical wells in the Ṣurmān area are given in table 4. As indicated the water is generally hard and slightly alkaline with 30 per cent of the samples containing more than 1,000 ppm of total dissolved solids. Chemical data from the water analyses when plotted on the SAR diagram (fig. 9) indicate that the salinity hazard of most of the water is high but that the sodium hazard is low. Six of the analyses when plotted indicated a medium sodium hazard and high to very high salinity hazard. The poorest quality water in this area was obtained from the very shallow dug wells near the sebkha.

Most of the water used in the Ṣurmān area has a relatively low sodium content; therefore, the danger of toxic effects on plants and permanent damage to the soil structure is small. The higher sodium-hazard waters found in the shallow wells may be offset by the gypsum content that is reported in the soils of Tripolitania. If the amount of gypsum in the soil is not sufficient then additional amounts may be added to the water or the soil.

Table 4.--Chemical analyses, in parts per million, of water from typical wells in the Şurmān area.

Well No.	Depth of Aquifer (meters)	Date of Collection	pH	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Specific conductance (micromhoms at 25°C.)	Dissolved solids at 180°C.	Hardness as $CaCO_3$	Sodium absorption Ratio SAR)
3243-1235-1	39	June 7, 1961	7.7	82	27	100	6	185	159	139	30	1076	632	312	2.46
3244-1232-1	14.8	May 20, 1961	8.5	40	21	79	5	78	100	125	25	765	522	186	2.52
3244-1232-3	39	do	7.6	95	34	108	6	189	115	227	55	1225	804	37[illegible]	2.42
3244-1233-2	9.7	do	7.3	218	179	442	16	260	830	808	55	4040	2930	1280	5.38
3244-1233-5	3	do	7.4	317	342	907	30	377	1660	1450	115	6790	5290	2200	8.38
3245-1232-3	33	June 12, 1961	7.7	97	28	12[illegible]	6	16[illegible]	114	252	34	1470	792	361	2.89
3245-1232-11	5	Apr 2, 1957	-	183	97	-	-	239	317	780	-	3330	2500	857	5.56
3245-1235-9	45	June 7, 1961	7.7	79	34	109	5	142	129	212	35	1170	670	335	2.60
3245-1237-1	4[illegible].5	May 18, 1961	7.6	74	3[illegible]	89	10	1[illegible]3	94	177	[illegible]3	1110	634	339	2.07
3245-1237-7	41.3	June 12, 1961	7.9	6[illegible]	19	77	9	197	47	139	32	920	512	[illegible]	2.14
3245-1238-	6.9	May 18, 1961	7.5	124	86	348	19	253	351	557	110	2630	1750	606	5.90
3245-1238-6	11.8	May 18, 1961	7.4	49	26	72	4	232	33	106	18	784	1230	228	2.04
324[illegible]-1239-2	2[illegible].9	May 20 1961	7.5	62	32	6[illegible]	6	250	69	89	32	784	482	285	1.55
324[illegible]-1231-1	30	May 2[illegible], 1961	5.6	90	42	204	9	213	158	347	35	1640	1038	395	4.76
3246-1231-15	15	May 2[illegible], 1961	7.5	40	19	175	15	241	108	182	15	1110	687	180	5.70
3246-1232-6	32	June 12, 1961	7.9	105	35	139	8	189	141	284	21	1610	919	407	3.0
3246-1232-10	9	June 12, 1961	7.9	84	33	183	11	272	120	283	5	1650	904	338	4.28
3246-12[illegible]-1	6.4	May 18, 1961	[illegible]	64	49	287	4	372	111	270	23	1610	931	364	4.74
3247-1234-2	50	June 7, 1961	7.5	82	40	135	8	261	76	234	36	1460	741	368	3.05
3247-1235-1	12	June 7, 1961	[illegible].8	44	32	87	6	211	69	125	18	878	468	239	2.42

The soils in the Ṣurmān area, as in most of the Gefara, are predominately sandy and thus provide good drainage of the soil. Under these conditions control of salinity can be readily attained by leaching of the soil with additional irrigation water. Some of the crops grown in this area are sensitive to both sodium and salinity. Stone-fruit trees, such as peaches, are reported to be sodium-sensitive. Citrus fruit, almonds and potatoes have a low salinity tolerance, whereas figs, grapes, olives, alfalfa, barley, peanuts, and tomatoes have a moderate to high salinity tolerance. Date palms and tobacco have a high salinity tolerance. Most of the crops grown in this area appear to have a moderate to high tolerance to salinity. The irrigation waters, except in the very shallow wells, do not present problems that cannot be ameliorated by judicious irrigation management and leaching procedures.

Few, if any, wells in this area tap deeper artesian formations that might contribute highly mineralized water to the shallow aquifers. Such contamination, however, takes place in many other parts of the Gefara. Near the coast and along the edges of the sebkha, west of Ṣurmān, many of the shallow wells penetrating the first aquifer in the upper beds of the Quaternary are reportedly becoming salty. This suggests the possibility of salt-water encroachment from the sea and the sebkha. The increased salinity, however, may be due in some cases to contamination of the shallow ground water by irrigation return from the land surface.

Conclusions and recommendations

Ground water has been used for irrigation in the Ṣurmān area, probably for many centuries. During much of this stretch of time the ground-water reservoir was probably in an approximate state of equilibrium, that is, the recharge was equal to discharge. Date culture was supplemented by cultivation of figs, olives, peppers, and other crops with low water requirements. With the introduction of crops of large water requirement, such as peanuts, alfalfa, potatoes and tomatoes during the past 25 years the draft on the ground-water reservoir has increased substantially, Installation of power pumps and cultivation of additional land also have materially increased withdrawals. Consequently, water levels have declined and salinity of water has increased at some places.

The chemical quality of the ground water in the area is generally satisfactory for domestic use and irrigation. A few shallow wells show relatively high mineral content, but this is believed due to contamination from irrigation return or possibly from the sea or the sebkha.

Water-level measurements in the Ṣurmān area show that the water level at some places has declined more than 3 meters between 1938 and 1960. Measurements available for 1938 are so few that the areal extent of this decline is not known. Water-level measurements from 1957 to 1959, however, show a decline of more than 0.5 meters. This decline of the water table is general in most of the developed area (fig. 8).

North and west of Ṣurmān, near the sebkha and the sea, the altitude of the water table is generally from 1 to 3 meters above sea level (fig. 6). These areas are subject to salt-water contamination from the sea if the ground-water reservoir is overpumped. If the water levels continue to decline at 0.2 meters per year, wells near the sebkha and the sea may become salty within 10 years.

Artesian water was encountered in middle Miocene strata at depths of 150 to 300 meters in many O.P.D.L. test holes drilled in the Gefara. Moderate to large yields of water of acceptable chemical quality also may be obtained in wells tapping these aquifers in the Ṣurmān area.

With these conclusions in view the following recommendations are made.

New large withdrawals of water, such as for irrigation or industrial use from the Quaternary aquifers should be restricted to the area south of the town of Ṣurmān and the sebkha where the altitude of the water table is 5 meters or more above sea level.

Ground-water withdrawals should be kept at a minimum, and further agricultural expansion should be discouraged in the northern part of the Ṣurmān area to lessen the danger of contamination from the sea and sebkha.

Representative wells should be selected and periodic observations made of changes in water levels and chemical quality of the water. It may be necessary to drill wells for the specific purpose of observing fluctuations in water levels if suitable unpumped wells cannot be found. Fluctuations of water levels are used to evaluate the effects of pumping and to appraise the long-term availability of water. Data from the observation wells will also show whether the danger of salt-water contamination is increasing and the location of the susceptible areas.

The Miocene aquifers should be drilled and tested to determine if they can produce water of suitable quality and quantity to supplement or replace the diminishing supply in the Quaternary aquifers of the coastal belt.

Several pumping tests should be made to measure the hydraulic characteristics of the various aquifers. Such information, together with data on pumpage and water levels, is necessary for quantitative evaluations and of the ground-water supply of the area. With such data valid estimates of the amount of water taken from storage and of recharge can be made.

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Notes to accompany Table 3.

1/ The spellings of the cabilas and owners' names follow those of the field notes.

2/ Dr, drilled. All drilled wells in this report are put down in dug wells that extend to a short distance above the water table.

3/ Chemical analyses are given in table 4. Conductivity = specific conductance in micromhos at 25°C.

4/ See bottom of page.

5/ Aquifer, upper (1) or lower (2) Quaternary deposits tapped by well.

6/ Irr, irrigation; Dom, Domestic or public supply; S, stock.

Table 3.--Records of typical wells in the Şurmān area.

WELL NUMBER	LOCATION AND OWNER 1/	ELEVATION ABOVE SEA LEVEL (meters)	DEPTH (meters)	TYPE OF WELL 2/	YEAR CONSTRUCTED	AQUIFER 5/	DEPTH TO WATER BELOW LAND SURFACE (meters)	DATE OF MEASUREMENT	REPORTED YIELD (m^3/hr)	HECTARES IRRIGATED	CROPS IRRIGATED 4/	USE 6/	ANNUAL DISCHARGE (m^3)	REMARKS 3/
3243-1235-1	Surman-Cabila Ulad Ahmed Shek Mohamed Sweay		39	Dr.	1952	2	6.14 6.72 7.27	11 Dec 57 21 Oct 59 21 Mar 62	38	10	Pe,Pp,To	irr.	119,400	Chemical analysis.
3243-1236-1	Surman-Cabila Has El Hamra Ali Ben Said Shauish		4.9	Dug		1	3.58	11 Dec 57		1½	Po,Pe,Ol, Ds	irr.	15,000	
3243-1236-2	Surman-Cabila Has El Hamra Ali Ben Said Shauish		5.8	Dug		1	4.26	11 Dec 57		1½	Po,Pe	irr.	15,000	
3243-1236-3	Surman-Cabila Has El Hamra Ali Ben Said Shauish		40.4	Dr.		2	3.72	11 Dec 57				irr.	25,000	
3244-1232-1	Surman-Cabila Ulad Ammara Mobruk Ben Abdulgader		14.76	Dug	1961		14.38	20 May 61						Chemical analysis.
3244-1232-2	Surman Massaud Buggeleda		45	Dr.	1938	2	8.32 10.64	15 June 39 13 May 60	30	9	Pe,Or,Po Al,Ba,On	irr.	99,500	
3244-1232-3	Surman-Lot 72 Well 2 Eredi Massaioli		59.6	Dr.	1938	2	11.73 14.02	19 Dec 38 13 May 60	50	22	Or,Pe,Me, Al,Ba,On	irr.	99,000	
3244-1233-1	Surman-Cabila Ulad Hammad Ali Ben Mabruk		6.5	Dug	1950	1	3.52	25 July 59		½	To,Pp	irr.	2,800	
3244-1233-2	Surman-Cabila Hreiza Belgasem Ali & Smeda Said		8.9	Dr.	1956		4.25 4.10	20 Oct 59 19 Mar 62	35	4	Pe,Co,Pp	irr.	40,000	Chemical analysis.
3244-1233-3	Surman-Cabila Hreiza Amor Ben Ali		10.2	Dr.	1959		4.53 4.56	25 July 59 20 Oct 59	42	2	Pe,To	irr.	26,000	
3244-1233-4	Surman-Cabila Hreiza Milud Ben Ali		5	Dug		1	3.47	25 July 59				unused		
3244-1233-5	Surman-Cabila Hreiza Smeda Ben Said		3	Dug		1	2.90	20 May 61				unused		Water reported salty.
3244-1234-1	Surman-Cabila Muhagib Ali Ben Ahmed		28.2	Dr.	1957		5.18 5.31	25 July 59 20 Oct 59	32	4	Pe,To,Al	irr.	52,000	
3244-1234-2	Surman-Cabila Grarda Mehemed Bumliana		25.4	Dr.	1955	2	3.00	27 July 59	30	3	Co,Pe,Ol Pp	irr.	30,000	
3244-1234-3	Surman-Cabila Grarda Abdulnabi Bumliana		6.9	Dug		1	3.68	27 July 59		1½	Pe,To,Pp, Ba,Al,On	irr.	23,000	

4/ * Pe - Peanuts; Po - Potatoes; Pp - Peppers; Be - Beans; Al - Alfalfa; Ol - Olives; Ds - Date Palm; Or - Oranges; On Onions; Ba - Barley; To - Tomatoes; Co - Corn; Me - Melons

Table 3 Cont'd.

WELL NUMBER	1/ LOCATION AND OWNER	ELEVATION ABOVE MSL LEVEL (meters)	DEPTH (meters)	2/ TYPE OF WELL	YEAR CONSTRUCTED	5/ AQUIFER	DEPTH TO WATER BELOW LAND SURFACE (meters)	DATE OF MEASUREMENT	(m^3/hr) REPORTED YIELD	HECTARES IRRIGATED	4/ CROPS IRRIGATED	6/ USE	ANNUAL DISCHARGE (m^3)	3/ REMARKS
3244-1234-4	Surman-Cabila Ulad Amara Ali Dabbar		30.8	Dr.	1956		5.03 5.2	27 July 59 20 Oct 59	25	4	Pe,To,Ol	irr.	52,000	
3244-1234-5	Surman-Cabila Grarda Hag Abdussalam Hassuad	10.602	27.6	Dr.	1958		5.78 6.22	28 July 59 21 Mar 62	20	2	Pe,To,Co, Al	irr.	26,000	
3244-1234-6	Surman-Cabila Grarda Mohamed Buagela		31.6	Dr.	1958		5.16	28 July 59	45	4	Pe,To,Pp	irr.	52,000	
3244-1234-7	Surman-Cabila Grarda Mohamed Macma		39.8	Dr.	1954		13.71	28 July 59	40	3	Pe,Co,To	irr.	39,000	
3244-1234-8	Surman-Cabila Grarda Hag Abdussalam Macma		39.7	Dr.	1952	2	14.87 15.3	28 July 59 20 Oct 59	30	2½	To, Pe, Po, Ol	irr.	33,000	
3244-1235-1	Surman-Cabila Mahgib Belgasem Elgelidy		43.9	Dr.	1957	2	18.94 19.48	3 Dec 57 20 Oct 59	40	10	Pe,Po,Ba	irr.	116,000	
3244-1235-2	Surman-Cabila Ulad Hamad Sbek Omar Bhusa		40.2	Dr.	1954	2	8.63 9.15	11 Dec 57 20 Oct 59	65	0	Pe, Ol, Pp, Be	irr.	116,000	
3244-1235-3	Surman-Cabila Mahgib Hasem Ben Ali Tir		27.8	Dr.	1956	2	19.00 19.50	3 Dec 57 21 Oct 59	50	8	Pe,Po,Ba	irr.	107,000	
3244-1235-4	Surman-Cabila Mahgib Amor Ben Ras		51.5	Dr.	1956	2	21.03 21.74	3 Dec 57 21 Oct 59	60	10	Pe,Po,Ol, Or, Al	irr.	130,800	
3244-1235-5	Surman-Cabila Ogba Taher Ogbi	28.465	56.7	Dr.	1955	2	20.76 21.36 22.11	26 Nov 57 21 Oct 59 7 Apr 62	70	24	Pe,Po,Pp, Ol,Al,Ba	irr.	280,000	
3244-1235-6	Surman-Cabila Ogba Taher Ogbi		48.3	Dr.	1955		4.51 4.67	26 Nov 59 21 Oct 59	105	45	Pe, Po, Al, Or	irr.	516,000	
3244-1235-7	Surman-Cabila Mahgib Taher Ogbi		52	Dr.			4.51 4.85	26 Nov 59 21 Oct 59	105	45	Pe, Po, Ol, Al	irr.	516,000	
3244-1236-1	Surman-Cabila Mahgib Taher Ogbi		56.7	Dr.	1955	2	20.76 21.06	26 Nov 57 21 Oct 59	80	24	Pe,Po,Ba, Ol, Al	irr.	280,000	
3244-1237-1	Surman-Cabila Bafina Giuseppe Mazabito		58	Dr.	1935	2			70	6	Or	irr.	60,000	
3244-1237-2	Surman-Cabila Bafina Giuseppe Mazabito		44.9	Dr.	1944	2	17.80 17.44	30 July 59 24 Mar 62	45	5	Or	irr.	50,000	

4/ Pe - Peanuts; Po - Potatoes; Pp - Peppers; Be - Beans; Al - Alfalfa; Ol - Olives; Da - Date Palm; Or - Oranges; On Onions ; Ba - Barley; To - Tomatoes; Co - Corn; Me - Melons

Table 3 Cont'd.

WELL NUMBER	LOCATION AND OWNER 1/	ELEVATION ABOVE SEA LEVEL (meters)	DEPTH (meters)	TYPE OF WELL 2/	YEAR CONSTRUCTED	AQUIFER 5/	DEPTH TO WATER BELOW LAND SURFACE (meters)	DATE OF MEASUREMENT	REPORTED YIELD (m^3/hr)	HECTARES IRRIGATED	CROPS IRRIGATED 4/	USE 6/	ANNUAL DISCHARGE (m^3)	REMARKS 3/
3245-1231-1	Surman-Cabila Ulad Yahya Mobruck Ziri		13.3	Dug	1948	1	12.8 13.2 13.8	8 July 58 10 Oct 59 16 Nov 61		1	Ol	irr.	2,000	
3245-1231-2	Surman-Cabila Ulad Yahya Mohamed Bukres		4.3	Dug		1	4.2	8 July 58				irr.	3,000	
3245-1231-3	Surman-Cabila Grablia Hag Mohamed Hadud		30.8	Dr.	1957	2			40	3	Pe, To	irr.	39,000	
3245-1231-4	Surman-Cabila Grablia Taieb Ben Mohamed		28	Dr.	1958	2	7.4 7.9 7.3	8 July 58 10 Oct 59 17 Mar 62	18	1		irr.	10,000	
3245-1231-5	Surman-Cabila Grablia Abdusselam Ben Mohamed	18.884	59	Dr.	1955	2	16.0 16.7 17.7 17.4	8 July 58 10 Oct 59 16 Nov 61 17 Mar 62	45	5	Pe, Co	irr.	60,000	Chemical analysis.
3245-1231-6	Surman-Cabila Grablia Belgasem Ben Salah		50	Dr.	1957	2	14.5 15.0	8 July 58 10 Oct 59	45	½	Pe,Co,Pp	irr.	6,500	
3245-1231-7	Surman-Cabila Grablia Kalifa Ben Ali		27	Dr.	1957	2	12.6 13.4	8 July 58 10 Oct 59	18	1	Pe	irr.	12,000	
3245-1231-8	Surman-Cabila Grablia Mohamed Ben Hussen		13	Dug	1928	1	11.6	22 July 58		¼	To, Po	irr.	3,500	
3245-1231-9	Surman-Cabila Zuaga Mohamed Ben Abdalla		15.9	Dug		1	15.5	22 July 58		1/5	Co	irr.	2,000	
3245-1231-10	Surman-Cabila Ftahlia Abdalla Ben Hassan		19.1	Dr.	1955	2			40	9	Pe,Co,Al	irr.	115,000	
3245-1231-11	Surman-Cabila Ftahlia Ibrahim Ben Mohamed		32.9	Dr.	1958	1 & 2	11.8	22 July 58	30	3	Pe,Co	irr.	51,000	Chemical analysis.
3245-1231-12	Surman-Cabila Zuaga Amor Ahmed Shakshak			Dr.	1956		12.1	22 July 58	50	10	Pe,Co,Ol	irr.	112,000	
3245-1231-13	Surman-Cabila Mahgib Mohamed Ben Ahmed		32	Dr.	1955	2	10.7	22 July 58	60	9	Pe,Ol	irr.	117,000	
3245-1231-14	Surman-Cabila Grablia Amer Ben Ali		8.5	Dug		1	7.5	22 July 58		3	Ol, Po	irr.	6,000	

4/ Pe - Peanuts; Po - Potatoes; Pp - Peppers; Be - Beans; Al - Alfalfa; Ol - Olives; Da - Date Palm; Or - Oranges; On Onions; Ba - Barley; To - Tomatoes; Co - Corn; Me - Melons

Table 3 Cont'd.

WELL NUMBER	LOCATION AND OWNER 1/	ELEVATION ABOVE SEA LEVEL (meters)	DEPTH (meters)	TYPE OF WELL 2/	YEAR CONSTRUCTED	AQUIFER 5/	DEPTH TO WATER BELOW LAND SURFACE (meters)	DATE OF MEASUREMENT	REPORTED YIELD (m^3/hr)	HECTARES IRRIGATED	CROPS IRRIGATED 4/	USE 6/	ANNUAL DISCHARGE (m^3)	REMARKS 3/
3245-1232-1	Surman-Cabila Ulad El Isy Mabruk Ben Mohamed		4.8	Dug		1	3.4	26 Aug 58		½	Pe,To,Co, Ol	irr.	3,000	Conductivity - 2700
3245-1232-2	Surman-Cabila Ulad Omar Abdessalam Ben Genen		5.2	Dug	1942	1	3.7	26 Aug 58		¼	Pe,Co,Ol	irr.	1,000	Conductivity - 1200
3245-1232-3	Surman-Cabila Ulad Amara Khalifa Mosuy		7.0	Dug	1949	1	5.7	26 Aug 58		1	Pe, Ol	irr.	4,000	Conductivity - 1900
3245-1232-4	Surman-Cabila Hemidat Ayyon Hamidi		4.9	Dug	1950	1	3.0	11 Dec 57		2 3/4	Pe,Al,Pp	irr.	33,000	
3245-1232-5	Surman-Cabila Bubraia Khalifi Ben Al. Khzirhiz		4.1	Dug		1	3.5	26 Aug 58				unused		Conductivity - 4200 Salty.
3245-1232-6	Surman-Cabila Bubraia Khalifi Ben Ali Khzirhiz		5.5	Dug		1	3.7	26 Aug 58		¼	Pp	irr.	1,500	Conductivity - 3000 Salty.
3245-1232-7	Surman-Cabila Grablia Mabruk Ben Ali		4.1	Dug	1956	1	2.4	26 Aug 58		1½	Pe, Co	irr.	14,000	Conductivity - 3000
3245-1232-8	Surman-Cabila Grablia Belgasem Ben Mohamed		31	Dr.	1950	2	4.6	22 July 58	30	3	Pe,To,Co, Pp	irr.	39,000	
3245-1232-9	Surman-Cabila Ulad Amara Ali El Kep		36.6	Dr.	1957	2	4.9 4.7	21 July 58 19 Mar 62	60	4	Co, Al	irr.	50,000	Conductivity - 1680
3245-1232-10	Surman-Cabila Ulad Amara Alin El Kep		8.8	Dug		1	8.1	21 July 58				irr.	3,000	
3245-1233-1	Surman-Cabila Rubaien Ali Kamory		12.7	Dr.	1957		4.62 3.8	27 July 59 19 Mar 62	35	2	Pe,Co,Al	irr.	24,000	Water reported salty.
3245-1233-2	Surman-Cabila Rubaien Sheik Abdessalam		5.7	Dug	1953	1	4.5	27 July 59		¼	Co	irr.	1,000	Water reported salty.
3245-1233-3	Surman-Cabila Rubaien Khalifa Ben Ahmed		5.9	Dug		1	3.6	27 July 59		½	Al, Pe	irr.	2,000	Water reported salty.
3245-1234-1	Surman-Cabila Tgurri Mohamed Zeglum		8.1	Dug		1	6.9	27 July 59		¼	Pe, To	irr.	1,500	Water reported salty.
3245-1234-2	Surman-Cabila Rubaien Ali Ben Salem Gala		6.1	Dug		1	3.3	27 July 59		1/5	Pe, Al	irr.	1,000	

4/ : Pe - Peanuts; Po - Potatoes; Pp - Peppers; Be - Beans; Al - Alfalfa; Ol - Olives; Da - Date Palm; Or - Oranges; On Onions ; Ba - Barley; To - Tomatoes; Co - Corn; Melons - Me

Table 3 Cont'd.

WELL NUMBER	LOCATION AND OWNER 1/	ELEVATION ABOVE SEA LEVEL (meters)	DEPTH (meters)	TYPE OF WELL 2/	YEAR CONSTRUCTED	AQUIFER 5/	DEPTH TO WATER BELOW LAND SURFACE (meters)	DATE OF MEASUREMENT	REPORTED YIELD (m^3/hr)	HECTARES IRRIGATED	CROPS IRRIGATED 4/	USE 6/	ANNUAL DISCHARGE (m^3)	REMARKS 3/
3245-1234-3	Surman-Cabila Rubaien Mohamed Ben Mohamed		4.3	Dug	1955	1	3.48	25 July 59		½	To	irr.	1,200	
3245-1234-4	Surman-Cabila Ulad Amera Sohi Ben Shibani	9.26	7.2	Dug Dr.	 1960	1 1 & 2	6.6 7.6	5 Dec 52 18 Feb 61				irr.	10,000	
3245-1234-5	Surman-Cabila Magora Hassen Ali Ettey		37.2	Dr.	1953	2	4.75 4.38 6.1	27 Jan 58 21 Oct 59 21 Mar 62	50	3	Al, Ol	irr.	36,000	
3245-1234-6	Surman-Cabila Magora Salem Mohamed Magora		37.2	Dr.	1957	2	7.00 7.53	27 Jan 57 20 Oct 59	30	4½	Pe,Al, Be,Ol	irr.	44,000	
3245-1234-7	Surman-Cabila Magora Hag Abdalla Said		35	Dr.	1956	2	3.90 4.47	27 Jan 58 20 Oct 59		2	Po,Pe,Be, Al, Ol	irr.	29,000	
3245-1235-1	Surman-Cabila Sorman Bashir Saad		46.2	Dr.	1957	2	9.74 10.06	11 Nov 57 14 Oct 59		2	Ol, On	irr.	20,000	
3245-1235-2	Surman-Cabila Magora Mohamed Milad		45.7	Dr.	1954		11.49 11.89	12 Nov 57 14 Oct 59		1½	Pe,Ol Pp	irr.	16,000	
3245-1235-3	Surman-Cabila Magora Mohamed Ben Abdussalam		24.4	Dr.	1956	2	10.39 10.99	11 Nov 57 14 Oct 59		3	Pe, Ol	irr.	39,000	
3245-1235-4	Surman-Cabila Magora Kalifa Ben Salem		41.5	Dr.	1956	2				½	Pe, Ol	irr.	6,000	
3245-1235-5	Surman-Cabila Magora Mehemmed Klat		41.4	Dr.	1954	2	9.21	11 Nov 57		3/4	Pe,Al,Ol	irr.	10,000	
3245-1235-6	Surman-Lot 39 Well 3 S.A.L.S.	17.664	46.6	Dr.	1957	2	15.51 15.2	23 July 60 21 Mar 62	100	10	Or	irr.	100,000	
3245-1235-7	Surman-Lot 39 Well 24 S.A.L.S.		62	Dr.	1938		17.25	30 Nov 38	17.5			unused		
3245-1235-8	Surman-Lot 39 Well 25 S.A.L.S.		58.8	Dr.	1939		14.90	13 Nov 39				unused		
3245-1235-9	Surman-Cabila Mahgeb Sheik Abed Belgasem		44.8	Dr.	1953	2	11.47 11.56	3 Dec 57 21 Oct 59	40	12	Po,Pe, Al,Pp	irr.	144,000	Chemical analysis.
3245-1235-10	Surman-Lot 39 Well 21 S.A.L.S.		55	Dr.	1950				70			ind.	252,000	

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Table 3 Cont'd.

WELL NUMBER	LOCATION AND OWNER 1/	ELEVATION ABOVE SEA LEVEL (meters)	DEPTH (meters)	TYPE OF WELL 2/	YEAR CONSTRUCTED	AQUIFER 5/	DEPTH TO WATER BELOW LAND SURFACE (meters)	DATE OF MEASUREMENT	REPORTED YIELD (m^3/hr)	HECTARES IRRIGATED	CROPS IRRIGATED 4/	USE 6/	ANNUAL DISCHARGE (m^3)	REMARKS 3/
3245-1235-11	Surman-Cabila Magora Bukeros Ben Ammar Maguri		40.5	Dr.	1957	2	[illegible] 11.8	27 Jan 58 21 Oct 59		1½	Gl, Pe Po, Al	irr.	18,000	
3245-1235-12	Surman-Cabila Magora Abdulla Klet		50	Dr.	1957	2	11.0 11.5	27 Jan 58 20 Oct 59		1½	Po, Pe, Be, Ol	irr.	18,000	
3245-1236-1	Surman-Lot 39 Well 4 S.A.L.S.		58.5	Dr.		2	10.21 12.88 13.36	5 Dec 52 1 June 59 23 Feb 61				unused		
3245-1236-2	Surman-Lot 39 Well 26 S.A.L.S.		53.67	Dr.		2	12.58	30 [illegible]	25			unused		
3245-1237-1	Surman-Cabila Ulad Hammad Mohamed Bhuma & Ali Belgasem		43.5	Dr.	1961	2	8.5	18 May 61	45				75,000	Chemical analysis.
3245-1237-2	Surman-Cabila Buisa Belgasem Mehmed		8.9	Dug	1947	1	5.41	1 Aug 59		1	Pp, Ol	irr.	3,000	
3245-1237-3	Surman-Cabila Hamra Tahar Bel Hag Belgasem		8.0	Dug		1	5.21 5.67	5 Dec 52 23 Feb 61				irr.	3,000	
3245-1237-4	Surman-Cabila Buisa Mossaud Bseem		19	Dug	1956	1	16.82 16.28	1 Aug 59 24 Mar 62		¼	Me, Pp	irr.	1,000	
3245-1237-5	Surman-Cabila Buisa Bashir Warary		13.4	Dug	1934	1	9.55	30 July 59		¼	Ol, Al	irr	1,500	
3245-1237-6	Surman-Cabila Buisa Mohamed Shaban		17	Dug		1	15.5	30 July 59		1/3	Ol, Co	irr.	1,500	
3245-1237-7	Surman-Cabila Buisa Fadlfa Nasuni		41.3	Dr.	1955	2	13.15	30 July 59	40	8	Pe,Ol,Co	irr.	58,000	
3245-1237-8	Surman-Cabila Buisa Mohamed Belgasem		43.9	Dr.	1958	2	13.58	30 July 59	50	8	Ol, Al	irr.	16,000	
3245-1238-1	Surman-Cabila Ulad Hammad Abdalam Ali Shteui		6.9	Dug	1940	1	3.53	18 May 61				irr.	2,000	Chemical analysis.
3245-1238-2	Surman-Cabila Buisa Ali Salem Swed		15.2	Dug		1	11.92	1 Aug 59		1	Ol	irr.	1,500	

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Table 3 Cont'd.

WELL NUMBER	LOCATION AND OWNER 1/	ELEVATION ABOVE SEA LEVEL (meters)	DEPTH (meters)	TYPE OF WELL 2/	YEAR CONSTRUCTED	AQUIFER 5/	DEPTH TO WATER BELOW LAND SURFACE (meters)	DATE OF MEASUREMENT	REPORTED YIELD (m^3/hr)	HECTARES IRRIGATED	CROPS IRRIGATED 4/	USE 6/	ANNUAL DISCHARGE (m^3)	REMARKS 3/
3245-1238-6	Zawiyah-Cabila Ulad Musa Saeda Ben Salem		11.8	Dug		1	9.32 9.36	18 May 61 24 Mar 62				irr.	2,000	Chemical analysis.
3245-1238-7	Surman-Cabila Buisa Bashir Lamury		15.67	Dug		1	12.04	1 Aug 59		½	To	irr.	3,000	
3245-1239-1	Zawiyah-Cabila Ulad Musa Orbi Habbas		29.5	Dr.	1937	2	8.63 11.05	25 Oct 37 9 June 60	45	6	Al,Pe,Pp To,Be	irr.	72,000	
3246-1230-1	Surman Hag Ahmed Funi		14.8	Dug	1957	1	14.1 13.9	11 June 58 17 Mar 62				unused		Chemical analysis.
3246-1230-2	Surman-Cabila Ftahlia Mohamed Ben Muftah			Dug		1	13.8	17 June 58		½	Al, To, Pp	irr.	2,000	
3246-1230-3	Surman-Cabila Ftahlia Mohamed Ben Omar Hirk	12.255	33	Dr.	1957	2	9.9 10.2 10.4	8 May 58 10 Oct 59 17 Mar 62	28.6	6	Pe	irr.	97,800	
3246-1230-4	Surman-Cabila Ftahlia		27	Dr.	1948	2	9.1 7.7	16 June 58 10 Oct 59		1	To, Al	irr.	13,500	
3246-1230-5	Surman Principe		22.3	Dr.	1930	2	21.4	5 Aug 58		1	Ol	irr.	2,000	
3246-1231-1	Surman-Cabila Sharfeldin Amer Ben Mobruk		30.2	Dr.	1954	2	11.1	11 June 58	45	5	Pe, Co	irr.	60,000	
3246-1231-2	Surman-Cabila Ftahlia Mohamed Ben Mohamed		12.5 30	Dug Dr.	1949 1960	1 2	12.2	11 June 58		1	Pe,To,Be, Pp, On	irr.	10,000	Well deepened in 1960
3246-1231-3	Surman-Cabila Ftahlia Attia Allaghi		26	Dr.	1953	2	13.3 13.1	8 May 58 10 Oct 59	60	30	Pe	irr.	280,000	
3246-1231-4	Surman-Cabila Ftahlia Attia Allaghi		19	Dr.	1953	2	5.6 6.1	8 May 58 10 Oct 59	60	3	Or	irr.	18,000	
3246-1231-5	Surman-Cabila Ulad El Isa Ali Ben Ahmed Abdalgader		5.8	Dug		1	5.2	28 July 58				unused		Water reported salty.
3246-1231-6	Surman-Cabila Sharfeldin Ali Ben Diab		7.0	Dug		1	6.5	18 Aug 58		½	Me	irr.	3,000	
3246-1231-7	Surman-Cabila Sharfeldin Ali Ben Diab		8.2	Dug		1	7.1	18 Aug 58		½	Me	irr.	3,000	

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Table 3 Cont'd.

WELL NUMBER [illegible]	LOCATION AND OWNER 1/	ELEVATION ABOVE SEA LEVEL (meters)	DEPTH (meters)	TYPE OF WELL 2/	YEAR CONSTRUCTED	AQUIFER 5/	DEPTH TO WATER BELOW LAND SURFACE (meters)	DATE OF MEASUREMENT	REPORTED YIELD (m^3/hr)	HECTARES IRRIGATED	CROPS IRRIGATED 4/	USE 6/	ANNUAL DISCHARGE (m^3)	REMARKS 3/
3246-1231-8	Sumam-Cabila Sultan Bashir Ben Kalifa		6.3	Dug		1	4.0	20 Aug 58				unused		Chemical analysis; Conductivity - 5400; Salty
3246-1231-9	Sumam-Cabila Sharfeldin Ahmed Ben Mehak		4.6	Dug	1955	1	3.8	20 Aug 58		¼	Pp, Me	irr.	2,000	Chemical analysis; Conductivity - 3720
3246-1231-10	Sumam-Cabila Sharfeldin Mohamed Ramadan Belaid		8.0 8.0	Dug Dr.	1958	1	5.29 4.34	16 June 58 10 Oct 59		1½	Pp, Co	irr.	12,000	Reported salty after deepened.
3246-1231-11	Sumam-Cabila Sharfeldin Ramadan Ben Nasser		5.7	Dug		1	4.0	20 Aug 58				unused		Chemical analysis.
3246-1231-12	Sumam-Cabila Ulad El Isa Mohamed Ben Rhana		5.3	Dug		1	4.9 4.6	10 June 58 17 Mar 62				unused		Water reported salty.
3246-1231-13	Sumam-Cabila Sharfeldin Kalifa Ben Ali		5.4	Dug		1	3.8	20 Aug 58		¼	To, Co	irr.	1,500	
3246-1231-14	Sumam-Cabila Katatba Ali Ben Abdulaziz		5.6	Dug		1	4.6	20 Aug 58		¼	To, Co	irr.	1,500	Salty - Conductivity - 7080
3246-1231-15	Sumam-Cabila Ftahlia Amer Ben Embarek		10.1	Dug		1	8.8	15 June 58		¼	Pe, To	irr.	1,500	Chemical analysis.
3246-1231-16	Sumam-Cabila Ftahlia Belgasem Farah		9.7	Dug		1	7.4	16 June 58		2	Ol, Po	irr.	3,000	
3246-1231-17	Sumam-Cabila Ftahlia Belgasem Ben Hafaid		6.5	Dug		1	5.4	18 Aug 58		⅛	Pp	irr.	4,000	Chemical analysis - Salty - Conductivity-4320
3246-1231-18	Sumam-Cabila Tebaa Ahmed Ben Ali Ben Atasha		5.1	Dug		1	3.4	25 Aug 58		¼	Pp, Co	irr.	1,500	Conductivity - 1860
3246-1231-19	Sumam-Cabila Ulad El Isa Hadi Ben Abdurrahman		9.6	Dug	1946	1	7.2	25 Aug 58		⅛	To, Co Me, Al	irr.	3,000	Conductivity - 1260
3246-1231-20	Sumam-Cabila Katatba Belgasem Ben Salah		8.4	Dug		1	[illegible]	25 Aug 58				irr.	3,000	Conductivity - 1200
3246-1231-21	Sumam-Cabila Katatba [illegible]		13.[illegible]	Dug	1959	1	13.3	8 July 58		1	Ol	irr.	2,000	
3246-1231-[illegible]	Sumam-Cabila Katatba Belgasem Ben Salah		26	Dr.	1958	1 & 2	6.4 7.1	8 July 58 10 Oct 59	20	1½	Al, Pe	irr.	18,000	Chemical analysis.

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Table 3 Cont'd.

WELL NUMBER	LOCATION AND OWNER 1/	ELEVATION ABOVE SEA LEVEL (meters)	DEPTH (meters)	TYPE OF WELL 2/	YEAR CONSTRUCTED	AQUIFER 5/	DEPTH TO WATER BELOW LAND SURFACE (meters)	DATE OF MEASUREMENT	REPORTED YIELD (m^3/hr)	HECTARES IRRIGATED	CROPS IRRIGATED 4/	USE 6/	ANNUAL DISCHARGE (m^3)	REMARKS 3/
3246-1231-23	Surman-Cabila Yahya Mehemed Ben Omar		9.0	Dug	1948	1	6.9	25 Aug 58		½	Al, Ol	irr.	1,580	Conductivity - 1200
3246-1231-24	Surman-Cabila Yahya Mohamed Gedidi	6.221	30	Dr.	1957	2	5.4 5.8	8 July 58 10 Oct 59	20	1	To, Co	irr.	10,000	
3246-1231-25	Surman-Cabila Ulad El Isa Ahmed Ben Saad		9.7	Dug	1944	1	8.0	18 Aug 58		¼	Pp, Ol	irr.	2,000	
3246-1231-26	Surman-Cabila Ulad El Isa Omar Ben Ali Apup		10.2	Dug		1	8.3	18 Aug 58		1	Ol, Pp, To, Me	irr.	3,000	
3246-1231-27	Surman-Cabila Ulad El Isy Mohamed Ben Mohamed		7.2	Dug		1	6.1	21 July 58		½	To, Co	irr.	2,000	
3246-1231-28	Surman-Cabila Ulad El Isy Mohamed Ben Ali Bumrefig		8.2	Dug		1	7.0	18 Aug 58		½	Me, Pp	irr.	3,000	
3246-1231-29	Surman-Cabila Ulad El Isy Ramadan Ben Mohamed		8.8.	Dug	1943	1	7.4	25 Aug 58		¼	Pp, Al, Co, Ol	irr.	1,600	Conductivity - 1320
3246-1231-30	Surman-Cabila Ulad El Isa Mohamed Ben Ali Bumrefig		8.5	Dug		1	8.1	18 Aug 58		1	Ol, Pp	irr.	3,500	
3246-1231-31	Surman-Cabila Sharfeldin Ahmed Dready		6.9	Dug		1	4.0	20 Aug 58				unused		Chemical analysis.
3246-1231-32	Surman-Cabila Khtatlia Frag Ben Abdallah		11.1	Dug	1955	1	10.2	19 Aug 58		¼	To,Ol,On	irr.	1,600	
3246-1232-1	Surman-Cabila Ulad El Isy Milad Ben Mohamed		7.2	Dug		1	5.1	19 Aug 58		¼	Ol	irr.	1,500	Water reported salty.
3246-1232-2	Surman-Cabila Ulad El Isy Ahmed Ben Abu Abdulgasem		11.0	Dug		1	7.1	19 Aug 58		¼	Me, Pp	irr.	2,000	
3246-1232-3	Surman-Cabila Ulad El Isy Mohamed Ben Siad		9.3	Dug		1	7.4	19 Aug 58		¼	Me, Pp	irr.	2,000	
3246-1232-4	Surman-Cabila Zuaga Salem Ben Abdulaziz		7.4	Dug		1	7.0	19 Aug 58		¼	Pp, To	irr.	1,500	
3246-1232-5	Surman-Cabila Sharfeldin Mehemed Ben Ali		5.5	Dug		1	4.2	18 Aug 58		¼	Pp,Co,Ol	irr.	1,500	

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Table 3 Cont'd.

WELL NUMBER	LOCATION AND OWNER 1/	ELEVATION ABOVE SEA LEVEL (meters)	DEPTH (meters)	TYPE OF WELL 2/	YEAR CONSTRUCTED	AQUIFER 5/	DEPTH TO WATER BELOW LAND SURFACE (meters)	DATE OF MEASUREMENT	REPORTED YIELD (m^3/hr)	HECTARES IRRIGATED	CROPS IRRIGATED 4/	USE 6/	ANNUAL DISCHARGE (m^3)	REMARKS 3/
3246-1232-6	Surman-Cabila Ulad Yahya Mohamed Elfarrah		6.8	Dug		1	5.0	19 Aug 58		3	To,Pp,Be, Co, Al	irr.	3,000	
3246-1232-7	Surman-Cabila Tahia Mohamed Elfarrah		7.9	Dug		1	5.8	19 Aug 58		¼	Pp, To	irr.	1,500	
3246-1232-8	Surman-Cabila Ulad El Isa Hag Ali Kafage		6.8	Dug		1	3.5	21 July 53		½	Co,To,Pp	irr.	2,000	
3246-1232-9	Surman-Cabila Grablia Mohamed Ben Ramadan		4.0	Dug		1	3.7 2.9	21 July 53 17 Mar 62		1	Co,To,Pp	irr.	2,000	
3246-1232-10	Surman-Cabila Grablia Ali Ben Mohamed		6.6	Dug		1	5.4	19 Aug 58		3½	Pp,To,Be, Ba,Al,Ol	irr.	51,000	
3246-1232-11	Surman-Cabila Tahia Ali Ben Bugela		8.8	Dug		1	8.0	19 Aug 58		¼	Me	irr.	1,500	
3246-1232-12	Surman-Cabila Katalba Mobruk Ben Salah		9.5	Dug		1	7.7	19 Aug 58		¼	Pe, Ol	irr.	1,500	
3246-1232-13	Surman-Cabila Ulad El Isy Mossaud Ben Abdallah		6.1	Dug	1949	1	5.5	5 Dec 52				irr.	2 000	
3246-1234-1	Surman-Cabila Ugba Lofi Ben Mansur		14.8	Dug	1957	1	13.5 14.1	24 Nov 57 14 Oct 59		3	Po,Pp,To, Al,Ol, Co	irr.	19,000	
3246-1234-2	Surman-Cabila Ugba Hag Kalifa		25.0	Dr.	1956	2	6.1 6.8 6.4	12 Nov 57 14 Oct 59 24 Mar 62	30	3	Pe, Or	irr.	39,000	
3246-1234-3	Surman-Cabila Magura Hag Salem		48	Dr.	1954	2	8.20 8.74	12 Nov 57 14 Oct 59		3	Pe,Co,Ba	irr.	40,000	
3246-1235-1	Surman-Lot 39 Well 16 S.A.L.S.		50.9	Dr.	1939	2	16.90	14 Nov 39	15.5			unused		
3246-1235-2	Surman-Lot 39 Well 23 S.A.L.S.		55.8	Dr.	1939	2	19.78	30 Oct 39	17			unused		
3246-1235-3	Surman-Lot 39 Well 22 S.A.L.S.		46	Dr.	1938		9.2 9.5	30 Nov 38 1 June 59	18			unused		
3246-1235-4	Surman-Lot 39 Well 5 S.A.L.S.		54.7	Dr.	1938	2	8.3 9.6	28 Nov 38 1 June 59	50			unused		

4/ Pe - Peanuts; Po - Potatoes; Pp - Peppers; Be - Beans; Al - Alfalfa, Ol - Olives; Da - Date Palm; Or - Oranges; On Onions ; Ba - Barley; To - Tomatoes; Co - Corn; Me - Melons

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Table 3 Cont'd.

WELL NUMBER	LOCATION AND OWNER 1/	ELEVATION ABOVE SEA LEVEL (meters)	DEPTH (meters)	TYPE OF WELL 2/	YEAR CONSTRUCTED	AQUIFER 5/	DEPTH TO WATER BELOW LAND SURFACE (meters)	DATE OF MEASUREMENT	REPORTED YIELD (m^3/hr)	HECTARES IRRIGATED	CROPS IRRIGATED 4/	USE 6/	ANNUAL DISCHARGE (m^3)	REMARKS 3/
3246-1235-5	Surman-Cabila Ulad Amara Abdullah El Asheg		41.3	Dr.	1956	2				6	Pe	irr.	78,000	
3246-1235-6	Surman-Lot 39 Well 12 S.A.L.S.		48.6	Dr.	1938	2	17.10	30 Nov 38	24			unused		
3246-1235-7	Surman-Cabila Amara Belgasem Ben Mahemed			Dr.	1956	2	6.3 6.7	12 Nov 57 14 Oct 59		2½	Pe, Ol	irr.	33,000	
3246-1235-8	Surman-Cabila Ulad Amara Abdullah El Asheg		46.9	Dr.	1952	2	11.1 11.6 11.6	11 Nov 57 14 Oct 59 21 Mar 62	28	6	Pe, Po, Pp,Al,Ol	irr.	92,000	
3246-1235-9	Surman-Lot 39 Well 11 S.A.L.S.		7.9	Dug		1	7.3	1 June 59				unused		
3246-1235-10	Surman-Cabila Ulad Amara Ali Hasheg		54.5	Dr.	1954	2	9.9	12 Nov 57	60	8	Pe, Po, Al, Pp	irr.	105,000	
3246-1237-1	Surman-Cabila Heracta Hilani Ali Naas		6.4	Dug		1	5.9 4.2	18 May 61 7 Apr 62				irr.	3,000	Chemical analysis.
3247-1231-1	Surman-Cabila Zawagha Mustafa Murabet		4.6	Dug		1	3.2 2.5	28 Aug 58 17 Mar 62		¼	To, Co	irr.	1,500	Water salty; Conductivity - 4800
3247-1231-2	Surman Mohamed Tabib		8.1	Dug		1	8.0	17 June 58		1	To, Co	irr.	4,000	
3247-1231-3	Surman-Cabila Sharfeldin Busgela Sharfeldin		9.8	Dug		1	7.4	17 June 58		½	Co	irr.	2,000	
3247-1231-4	Surman-Cabila Sharfeldin Shabani Ben Hag			Dr.	1955	2	12.3	11 June 58	20	5	Al, Co	irr.	44,000	Chemical analysis; Conductivity - 2925
3247-1234-1	Surman-Cabila Ogba Ali Ben Salah		10.1	Dug		1	9.4 9.5	24 Nov 57 24 Mar 62		2½	Ol, Pe, Po, Al	irr.	4,500	
3247-1234-2	Surman-Cabila Ogba Hag Kalifa Abdulgibil		49.4	Dr.	1952	2	14.3 14.9	12 Nov 57 14 Oct 59	38	14	Pe,Ba,Ol	irr.	11,400	Chemical analysis.
3247-1235-1	Surman-Cabila Ogba Ali Ben Salah		11.9	Dug	1947	1	10.6	24 Nov 57		½	Pe,Po,Ol	irr.	1,500	Chemical analysis.
3247-1235-2	Surman S.A.L.S.		17	Dr.			14.6 15.3	1 June 59 21 Mar 62				unused		

4/ Pe - Peanuts; Po - Potatoes; Pp - Peppers; Be - Beans; Al - Alfalfa; Ol - Olives; Da - Date Palm; Or - Oranges; On Onions; Ba - Barley; Tomatoes - To; Co - Corn; Me - Melons