TAHAL CONSULTING ENGINEERS LTD.

WESTERN NEGEV

EXPLOITATION OF BRACKISH WATER FOR AGRICULTURE

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TEL AVIV

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WESTERN NEGEV - EXPLOITATION OF BRACKISH WATER FOR AGRICULTURAL USE

Joseph Bar-Joseph[(1)] and Nathan Columbus[(2)]

INTRODUCTION

The occurrence of brackish and saline groundwater in the Western Negev area has been recognized for a long time, from deep oil and water drillings.

During the last decade as increasing demand of brackish water for agricultural purposes was noticed, a detailed study on brackish groundwater resources began, which set out to obtain quantitative and qualitative evaluations. Brackish groundwater appears in three groups of aquifers:

a. In deep limestone and dolomite formations of Cenomanian-Turonian age (Judea group).

b. In chalky limestones, chalks and flint of Eocene age (Hashefela group, Zora formation).

c. In calcareous sandstones and conglomerates of Plio-pleistocene age (Pleshet formation).

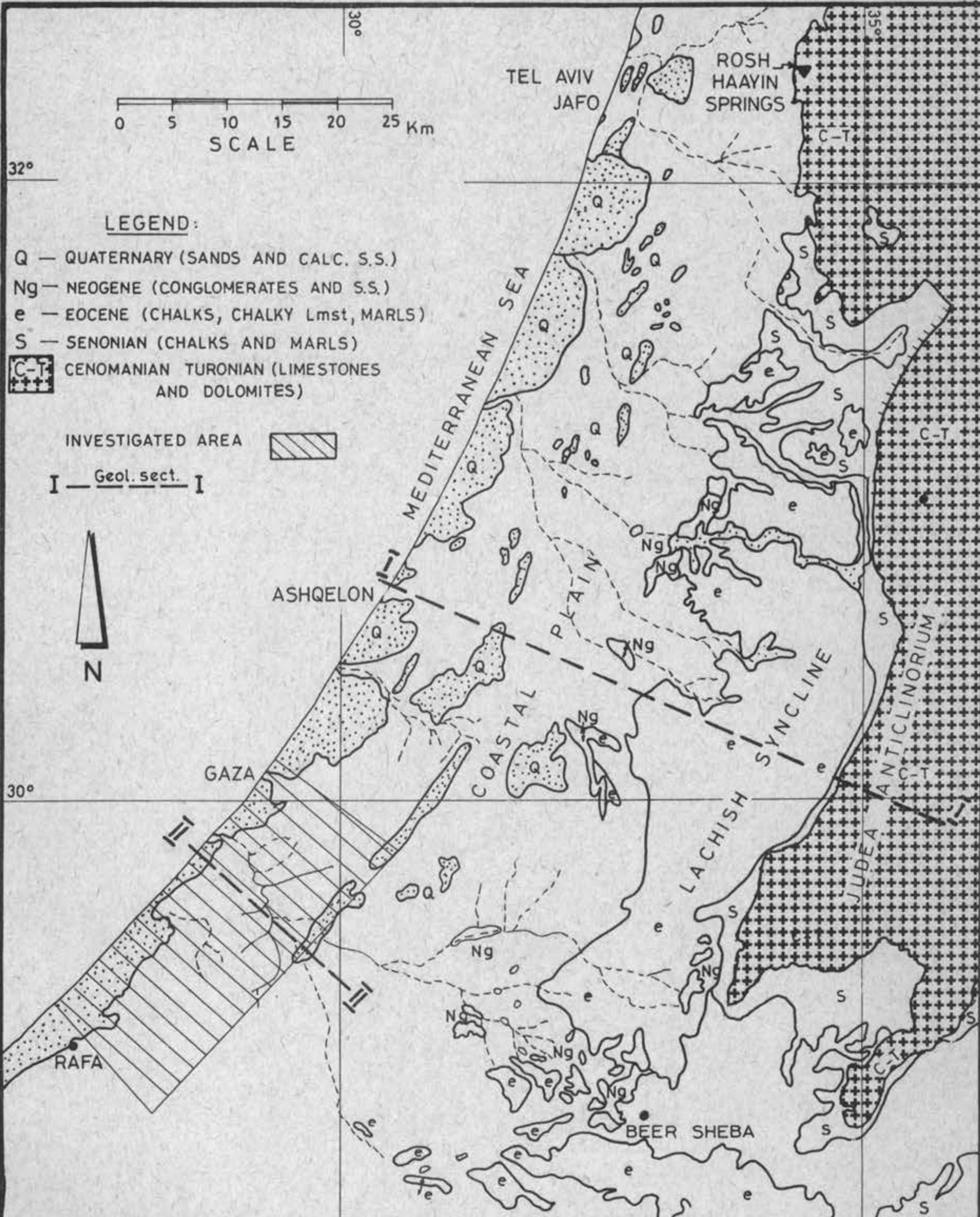
This paper presents the most recent findings on brackish water in the Plio-pleistocene aquifer in the coastal area, and briefly reviews other resources.

GEOLOGY

The geological sequence in the area under discussion is composed of several thousand meters of marine sedimentary rocks of which the Upper-Cretaceous to Quaternary formations will be described.

Judea Group

Cenomanian-Turonian limestones, dolomites and marly layers with a thickness over 700 m compose the so-called Judea group. These rocks are exposed in the east along the Judean anticline (Fig. 1) and found



הוכן עבור

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תהל מהנדסים יועצים בע"מ

נושא השרטוט

GEOLOGICAL MAP
(AFTER L. PICARD)

שם הפרויקט

**WESTERN NEGEV
EXPLOITATION OF BRACKISH
WATER FOR AGRICULTURAL
USE**

FIG. 1 שרטוט מס'	ק.מ.	הוצאה	תאריך	אשר	בקר	הבין
מס' ארכ'			I.1975			

at depths of 400-600 m in the subsurface of the Lakhish syncline and the eastern coastal plain. In the western part of the coastal plain including the Gaza strip area, the shallow marine dolomitic facies of the Judea group interfingers and changes into deep marine marly beds known as Talme-yafe formation (Fig. 2).

The lower boundary of the Judea group lies conformably on Lower Cretaceous marls and marly dolomites.

The upper boundary is overlain conformably in the synclinal areas by marls and chalks of Senonian age, and unconformably in the buried structures of the coastal plain, by Paleocene shales, Mid-Eocene chalks or even Miocene clays.

Hashefela Group

This group includes a series of marls, shales, chalks and chalky limestones of Senonian to Mid-Eocene age. Its total thickness may reach 500-600 m in the synclinal areas and 100-200 m in the buried structures of the coastal plain.

The Eocene chalky formations are exposed over extensive areas in the Lakhish syncline in the east. In the coastal plain they are overlain by marls and clays of the Saqiye group (Upper-Eocene-Quaternary) or by conglomerates and sandstones of the Pleshet formation (Quaternary).

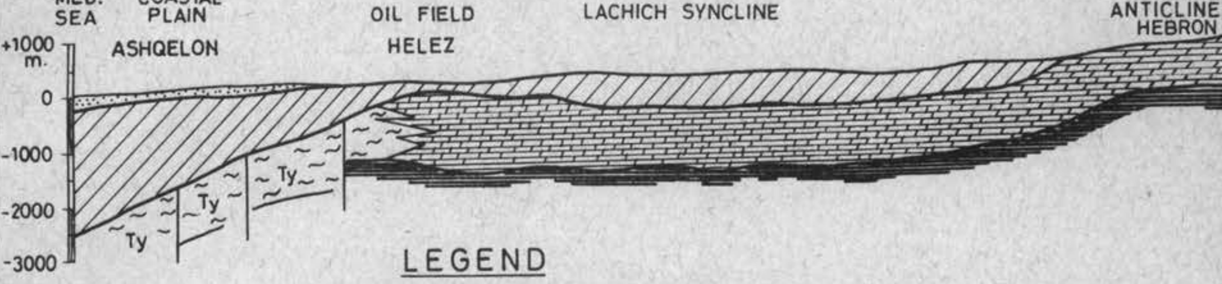
Saqiye Group

Sandy marls, blue clays and shales of Upper-Eocene to Quaternary age. These fine marine and lagoonal sediments were deposited over an older erosional relief and overlie unconformably older rocks of Lower Cretaceous to Eocene age. The total thickness of the group may

SECTION I

WNW ESE

SCHEMATIC REGIONAL GEOLOGICAL CROSS SECTION



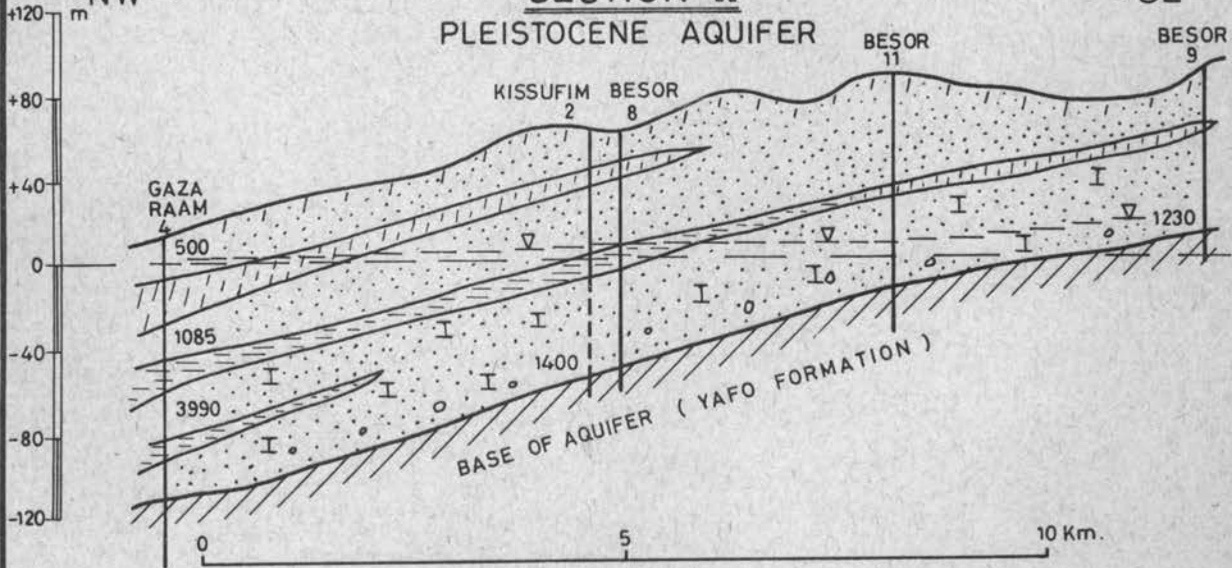
LEGEND

- PLEISTOCENE-COASTAL AQUIFER
- CENOMANIAN-TURONIAN AQUIFER
- AQUICLUDE-(SENONIAN-EOCENE-NEOGENE MARLS AND CLAYS)
- BASE OF AQUIFER-LOWER CRETACEOUS MARLS
- MARLS OF TALME-YAFE FORMATION

SECTION II

NW- -SE

PLEISTOCENE AQUIFER



LEGEND

- SAND
- CALC. SANDSTONE ("KURKAR")
- LOAM AND SANDY LŐESS
- CLAY
- 1400 -CHLORIDE IN p.p.m.
- ▽ -WATER TABLE

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תהל מהנדסים יועצים בע"מ

נושא השרטוט	שם הפרויקט
GEOLOGICAL CROSS-SECTIONS	WESTERN NEGEV EXPLOITATION OF BRACKISH WATER FOR AGRICULTURAL USE

FIG. 2 שרטוט מס'	ק.מ.	הוצאה	תאריך	אשר	בקר	הכין
מס' ארכ'			I.1975			

exceed 1,500 m in the coastal plain and it wedges out and disappears in easterly direction, at a distance of 15-20 km from the present shoreline.

Pleshet Formation

The quaternary clastic deposits in the coastal plain are composed of calcareous sandstones ("kurkar"), conglomerates and sands with clays and sandy loams. The total thickness reaches its maximum, 120-150 m, near the present shoreline in the Gaza strip. It thins and wedges out eastwards towards the foothills region (Fig. 2).

These deposits overly conformably clays, of the Saqiye group in the coastal area and cover unconformably older beds of Mid-Upper Eocene in the foothills region.

HYDROGEOLOGY

Two main regional aquifers are defined within the above-described geological sequence. The dolomitic karstic Cenomanian aquifer and the sandy coastal Pleistocene aquifer. The Eocene chalks and chalky limestones can be regarded as semi aquifer. The rest of the Hashefela and the Saqiye groups act as impermeable regional aquicludes separating the deep Judea group from the plio-pleistocene aquifers.

The Judea Group Aquifer

The dolomitic aquifer (Judea Group) is recharged by rainfall on its outcrops on the Judea Hebron anticline (600-700 mm per year as average rainfall). Groundwater flows from the western flanks of the anticline in an east-west direction towards the foothills region, declining to depths of several hundred meters in the synclinal areas. The buried structural hinge line on the coastal plain (where the dolomitic facies disappear and is replaced by the marly Talme yafe facies) act as a hydrological boundary, preventing western outflow to the Mediterranean Sea. Thus flow direction is changed towards north and groundwater is discharged finally in the Rosh Haayin springs near Tel Aviv at a distance of 100 km north of the area under review.

Groundwater salinity in the aquifer increases from the replenishment area (50-100 ppm chlorides) through the foothills and synclinal regions (550-1500 ppm chlorides) to its highest salinity in the deep buried western boundary (5000 and more ppm chloride, including even brines). The detailed hydrogeological model of this huge karstic aquifer, and its exploitation schemes are beyond the scope of the present paper.

The Eocene Chalky Aquifer

The intake area of this low conductive aquifer is located over the Lakhish syncline where Low-Mid-Eocene formations are exposed.

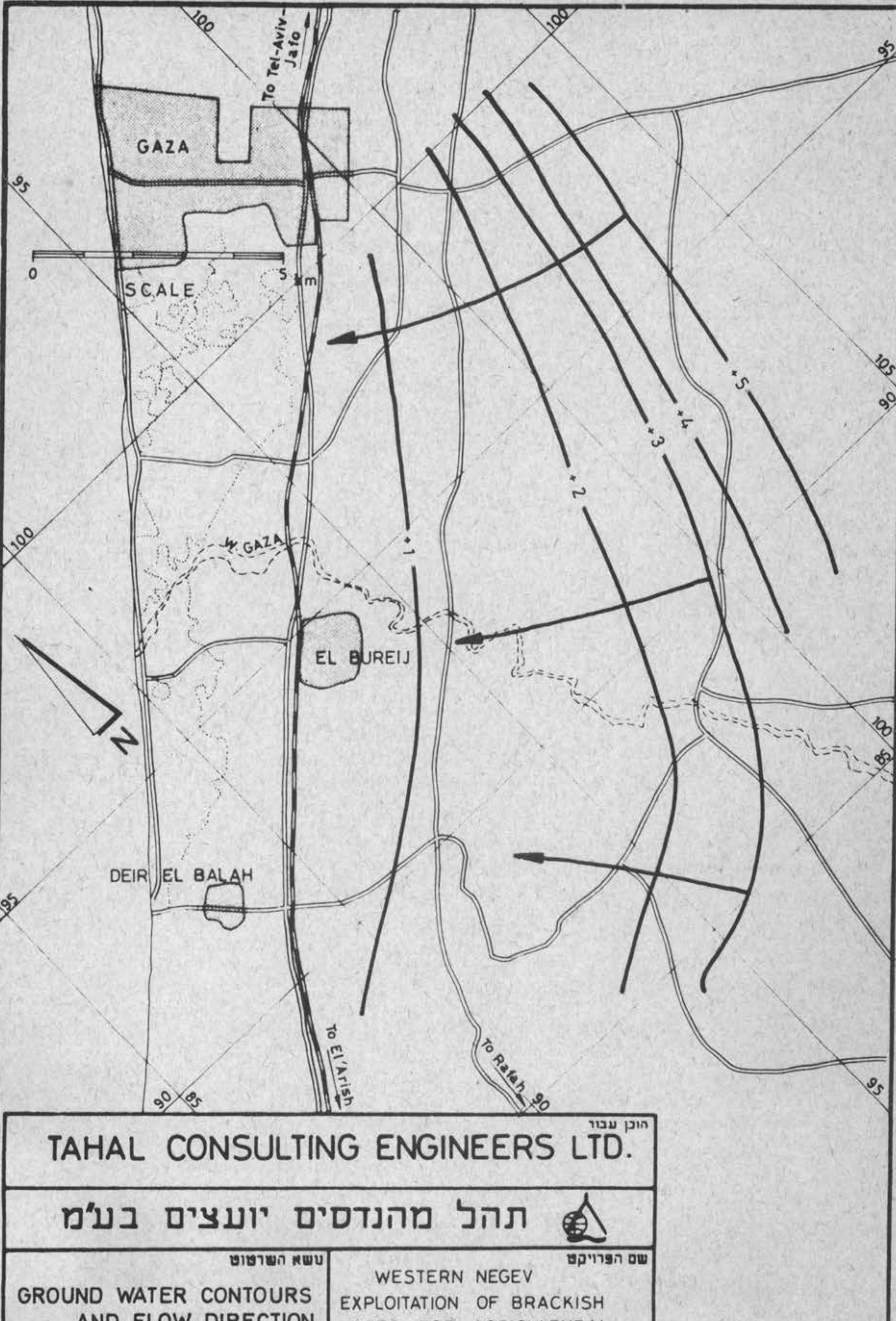
The average annual rainfall on this area is 300-400 mm.

Groundwater is discharged in part into small saline springs along the main western wadis and streams (Be'er Sheva', Besor, Grar and Wadi Hesi). The rest enters as subsurface inflow into the overlying plio-pleistocene aquifer.

The Plio-Pleistocene Aquifer

Groundwater flow:

The aquifer is composed of layers with high transmissivities such as calcareous sandstones, coquina and conglomerates intercalated by impermeable clays or sandy loams. As a result one may observe (mainly in the near shore area) an upper phreatic aquifer and several confined



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תהל מהנדסים יועצים בע"מ

נשא השרטוט

GROUND WATER CONTOURS AND FLOW DIRECTION

IN m ABOVE m.s.l.

שם הפרויקט

WESTERN NEGEV
EXPLOITATION OF BRACKISH WATER FOR AGRICULTURAL USE

FIG. 3 שרט' מס'	ק.מ.	הוצאה	תאריך	אשר	בקר	הכין
מס' ארכ'			I.1975			

sub-aquifers, which eventually, to the east, are connected into one aquiferic unit (Fig. 2).

The aquifer is recharged from several sources:

a. Rainfall over its outcrops (300-330 mm per year) of which about 50 mm can be assumed as the net infiltration to groundwater.

b. Infiltration through streams and wadi beds during winter floods.

c. By underground inflow from the Eocene aquifer (mainly brackish water) as mentioned before.

The water level contour map (Fig. 3) shows a general east-west flow direction, with a steeper flow gradient in the east and a moderate one in the west. The change is mainly due to the increasing transmissivity in the western part.

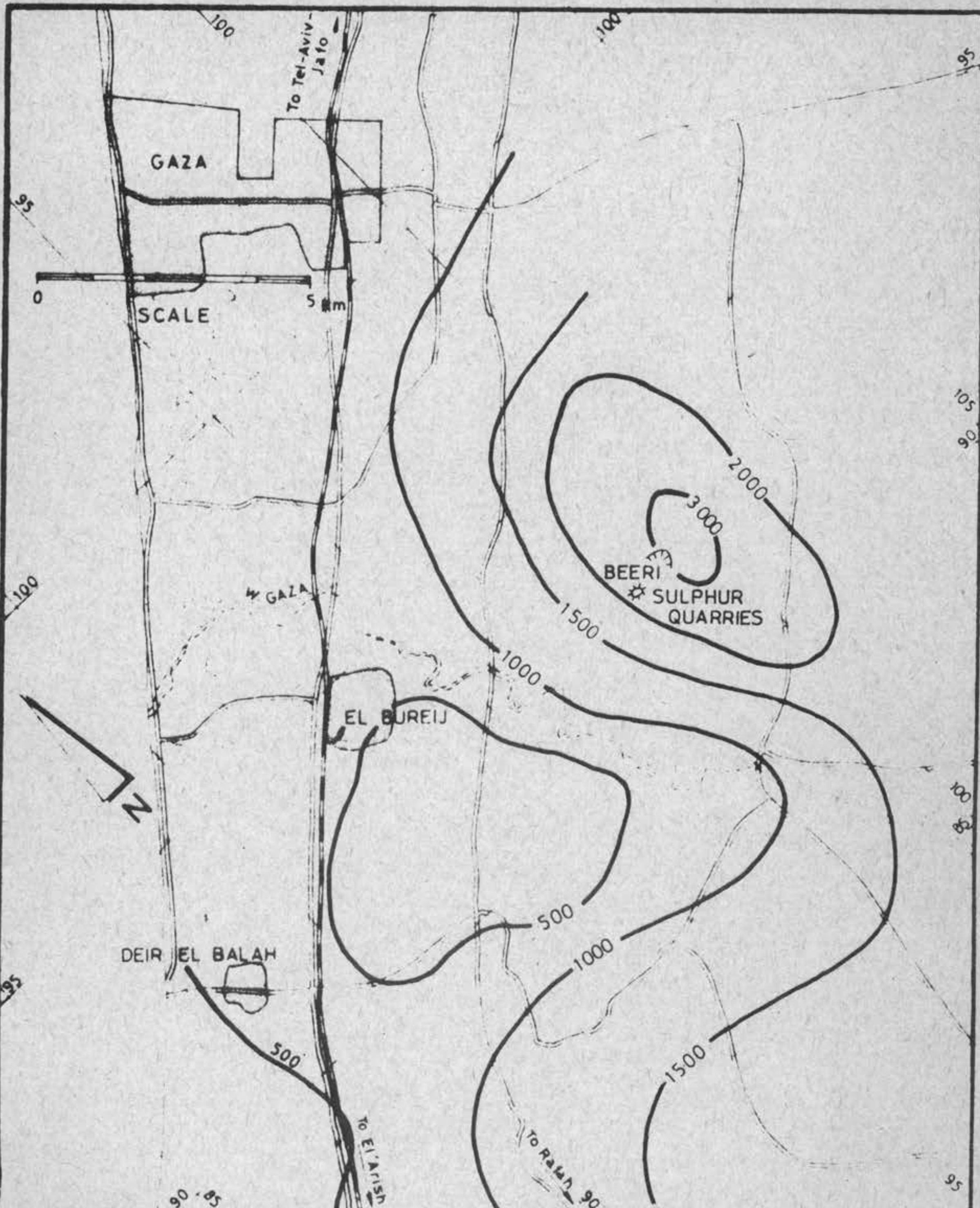
Groundwater is discharged to the Mediterranean Sea through the upper section of the aquifer, while its basic part is believed to be closed to the sea by clayey layers, and is saturated by seawater.

Groundwater salinity:

The salinity map of the sandy aquifer shows high concentrations of salts in the eastern boundary (Fig. 4).

A general trend of decrease in salinity in an east-west direction can be observed in the shallow parts of the aquifer, while in its deeper parts, salinity continues to increase in the same direction (Fig. 2). This phenomenon is due to higher rainfall infiltration in the sand dune areas in the west (Gaza strip) in relation to the small infiltration through the loess and loamy soil in the east.

It does not affect the deeper section because of good spearation between the sub-aquifers by impermeable clayey layers.



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תהל מהנדסים יועצים בע'מ

נושא השרטוט

SALINITY MAP
(ISOCONES)
Cl IN p.p.m.

שם הפרויקט

WESTERN NEGEV
EXPLOITATION OF BRACKISH
WATER FOR AGRICULTURAL
USE

FIG. 4 שרטוט מס'	ק מ	הוצאה	תאריך	אשר	בדק	הכין
מס' ארכ			I.1975			

Three salinity sources are observed in this area:

a. Salinity caused by concentration of airborne salts brought from the Mediterranean Sea. The process of salt accumulation is well known in areas characterized by low precipitation, high evapotranspiration and small soil infiltration.

b. Lateral inflow of brackish groundwater from the Eocene aquifer.

c. Unleached saline water and brines trapped since late Neogene - Early Pleistocene time. Evidences for trapped brine water were found in several investigation boreholes in the Gaza strip. The gypsum and sulphur quarries in the Be'eri area (Fig. 5) represent presumably relics of coastal lagoons originated in the late Neogene area.

The chemical composition of brackish groundwater in the sandy coastal aquifer is characterized by the following constituants:

Total dissolved solids (TDS)	2000 - 6000 ppm
Chloride (Cl^-)	500 - > 3000 ppm
Sulfates (SO_4^{--})	300 - 1000 ppm
Sodium (Na^+)	500 - 1300 ppm
Sodium adsorption ratio (SAR)	15 - 23
pH	7.8 - 8.4

Groundwater with chloride salinity of 800 ppm is used for cotton irrigation in Kibbutz Kfar Aza, with 1200 ppm Cl in the nearby Kibbutz Nahal Oz, and as high as 1400 ppm in the Kissufim area. SAR values range between 14-18.

THE EXPLOITATION SCHEME

The expected yield of brackish groundwater to be exploited in the eastern coastal aquifer was based on the following criteria:

a. Possible deterioration of the brackish water by surrounding high saline water.

b. Prevention of possible damage to the freshwater aquifer in the densely exploited Gaza strip area.

As a result of the study, two exploitation sites were located: one in the north and one in the south. Hence, it was recommended to drill exploratory production wells (Fig. 5).

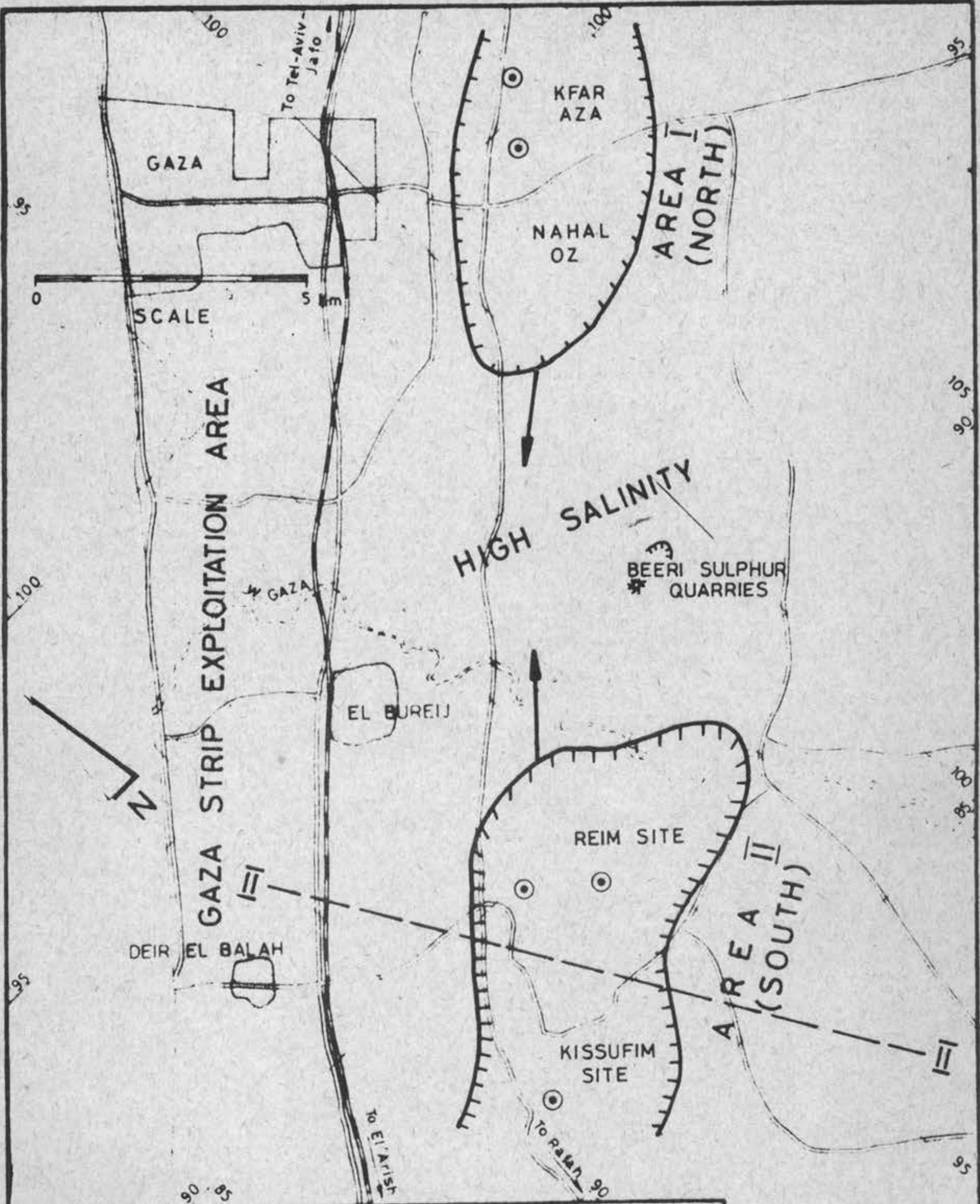
The wells are to be located 500 m apart and each of them is planned to pump about 0.5×10^6 m^3/year. The total amount to be exploited in the northern site is estimated at about 2×10^6 m^3/year, and in the southern site at about 3×10^6 m^3/year.

The depth of the wells will be around 100-120 m. The depth from the surface to the water table around 50-70 m.

The average discharge of each of the wells is assumed to be around 200-250 m^3/h. The salinity limitation for the present scheme of exploitation is 1500 ppm chloride.

It is planned to execute the program in stages. The first stage has already been carried out and two wells have been drilled and pumped (one in each site).

Once the two wells in both sites have pumped continuously for a complete season the hydrological data will be evaluated and conclusions drawn as to the continuation of the program. It is anticipated that after 3 years of pumping a complete review of the flow regime will be carried out and a more exact balance will be drawn.



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נושא השרטוט	שם הפרויקט
EXPLOITATION SITES	WESTERN NEGEV EXPLOITATION OF BRACKISH WATER FOR AGRICULTURAL USE

FIG. 5 שרטוט מס'	ק.מ.	הוצאה	תאריך	אשר	בקר	הכין
מס' ארכ'			I.1975			

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