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HAIFA BAY AREA

INDUSTRIAL USE OF BRACKISH AND SALINE WATER

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C O N T E N T S

LIST OF DRAWINGS

INDUSTRIAL USE OF BRACKISH AND SALINE WATER IN THE HAIFA BAY AREA

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INTRODUCTION

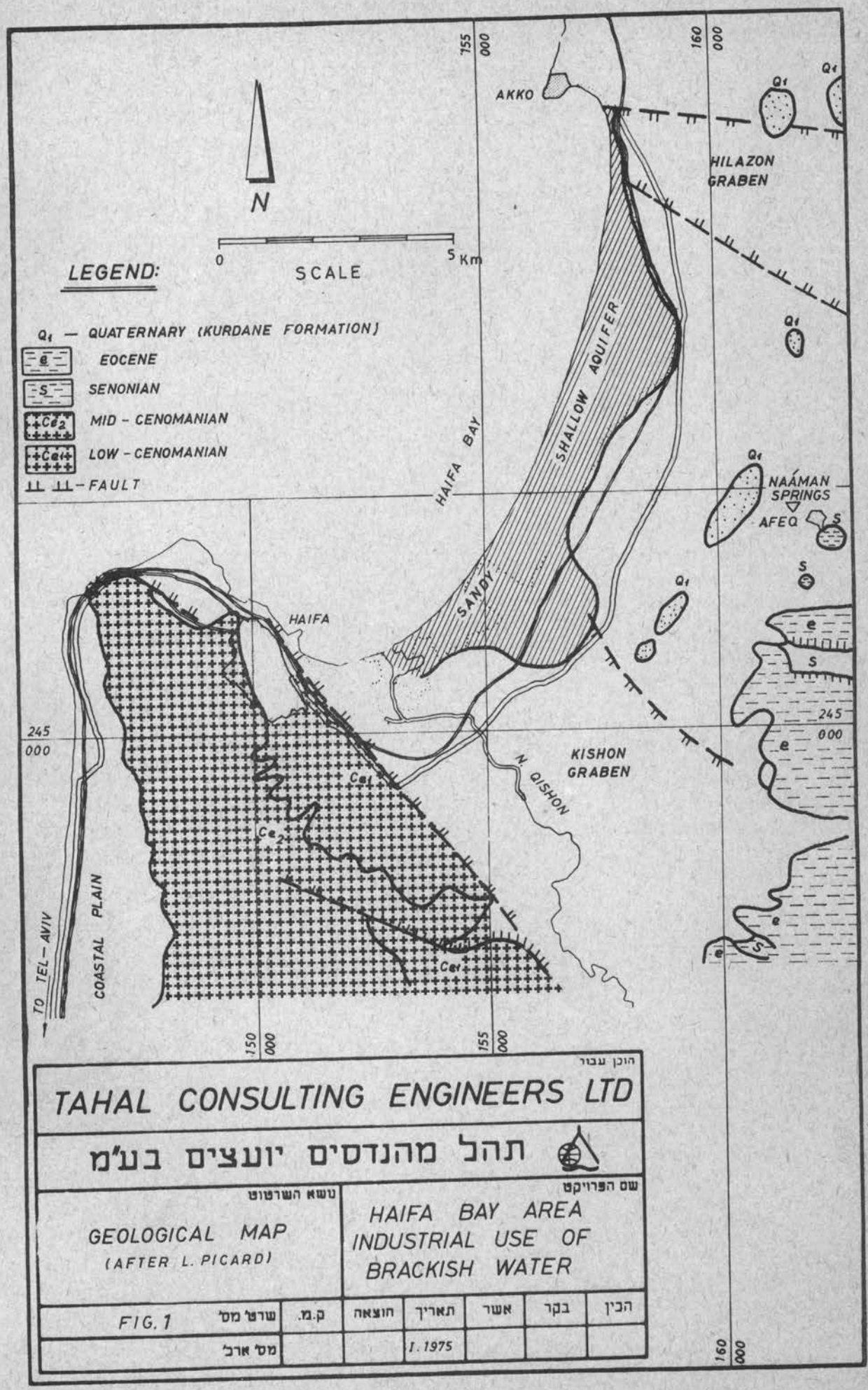
Industry today accounts for around 7% of Israel's total water consumption. Most of this water is used in the various industrial processes, some, however, is used for cooling. Cooling is also affected with sea water either pumped directly from the sea or indirectly through wells.

The industrial development envisaged for the coming 25 years will demand a considerable supply of water, particularly for cooling purposes. If an industrial plant is located along the coast, sea water can often be used directly for cooling. However, because of the overall pumping plan and other considerations, it is not always feasible to pump directly from the sea. Where this is the case it may become more economical to pump saline water by means of wells sunk near the major industrial enterprises in the area. Many enterprises in the Haifa Bay area, such as the refineries, electrochemicals, and steel mills, require large quantities of water for cooling.

The object of the present study was to evaluate the possibilities of extracting saline water for cooling purposes by means of wells sunk in the industrial zone of Haifa Bay.

HYDROGEOLOGY OF THE HAIFA BAY AREA

The area under study is located in the northern part of Israel between the towns of Haifa and Akko along the Haifa Bay Coast. A general location and geological map of the area is presented in Figure 1.



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נושא השרטוט	שם הפרויקט
GEOLOGICAL MAP (AFTER L. PICARD)	HAIFA BAY AREA INDUSTRIAL USE OF BRACKISH WATER

הכין	בקר	אשר	תאריך	חוצאה	ק.מ.	שרט' מס'
			1.1975			FIG. 1
						מס' ארכ'

Two major geological features delimit the area to the north and to the south: the Hilazon graben and Qishon graben, respectively. They enclose a structurally uplifted area. Eocene formations outcrop in the east and north while Cenomanian formations comprise the Carmel mountain block to the south-west and the Western Galilee hills further east.

Several aquifers underlie this area:

(1) A deep confined and saline limestone and dolomitic aquifer (Judean group) of Cenomanian-Turonian age;

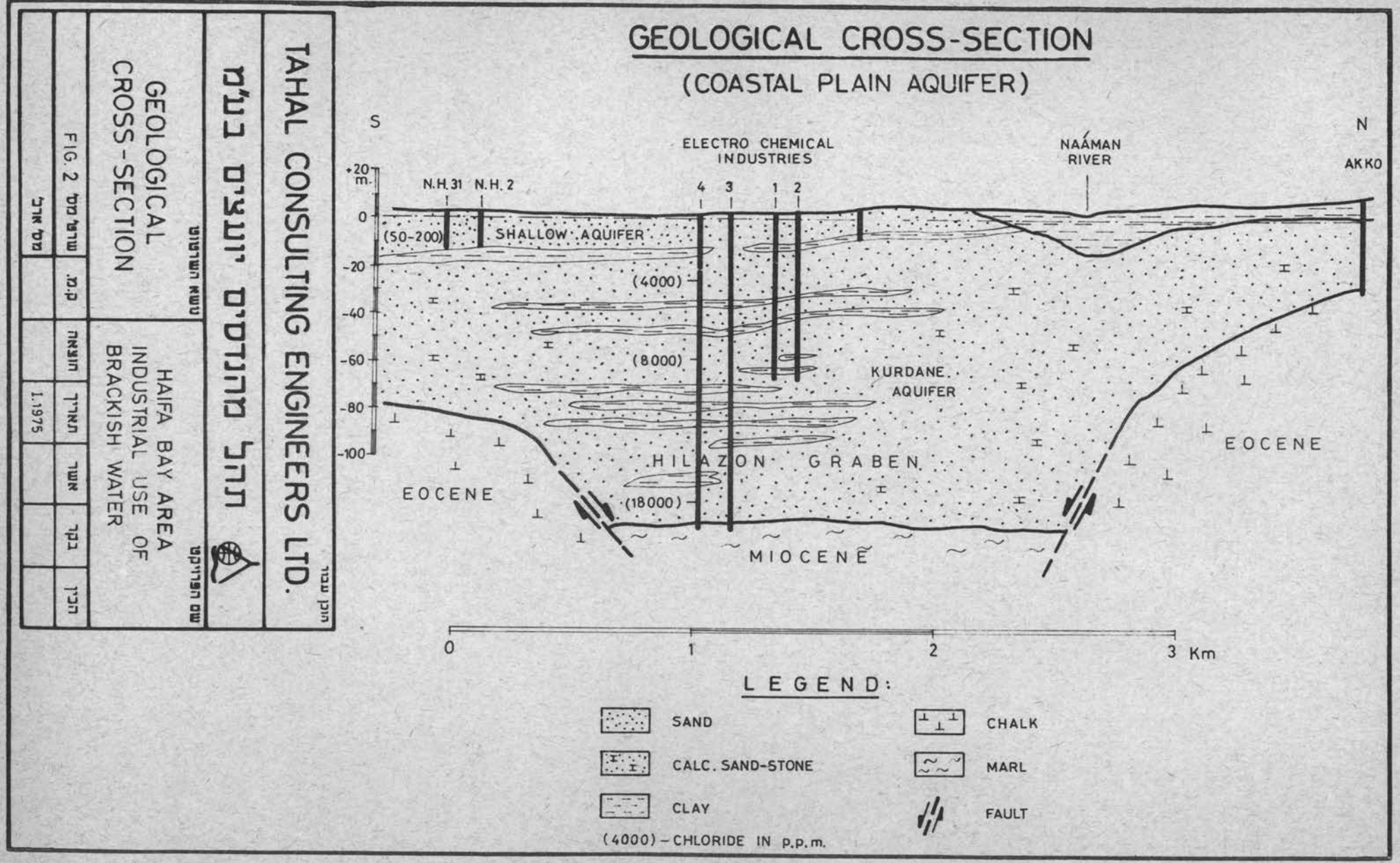
(2) A brackish and saline confined calcareous sandstone aquifer (Kurdane Formation) of early Quaternary age;

(3) Shallow phreatic sandy dunes aquifer of Pleistocene age.

The three aquifers are generally separated by impermeable layers. The dolomitic aquifer is separated from the Kurdane aquifer by thick beds of marls and chalks of Senonian to Eogene age. Between the Kurdane aquifer and the sand dunes are thin, clay layers, which may disappear here and there, creating a direct connection between the two aquifers.

The aquifer proposed for the exploitation of saline water is the Kurdane Formation, composed of highly porous calcareous sandstones. This aquifer reaches a thickness of around 100 metres within the northern Hilazon graben. To the north of this graben the Kurdane thins out to about 30 m and to the south to 40-50 m until it reaches the Qishon graben. Figure 2 is a geological cross-section along the coast from north to south.

The Kurdane Formation contains several intermediate clay layers, which are more continuous within the Hilazon graben and less frequent elsewhere. As a consequence, large sections of the Kurdane Formation act as confined aquifers within the graben zone.



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GEOLOGICAL CROSS-SECTION

HAIFA BAY AREA
INDUSTRIAL USE OF
BRACKISH WATER

מס' אורך	שרטט מס' FIG. 2	ק.מ.	תוצאה	תאריך	אשר	בקר	הכין
				1.1975			

GROUNDWATER HYDROLOGY OF THE KURDANE FORMATION

Boundaries and Recharge

The Kurdane aquifer is bounded by the Mediterranean Sea in the west. To the east it outcrops near the foothills overlying impermeable Eocene chalks. Within a limited area in the east around the Na'aman springs, the Kurdane Formation overlies unconformably dolomitic beds of the Judean group.

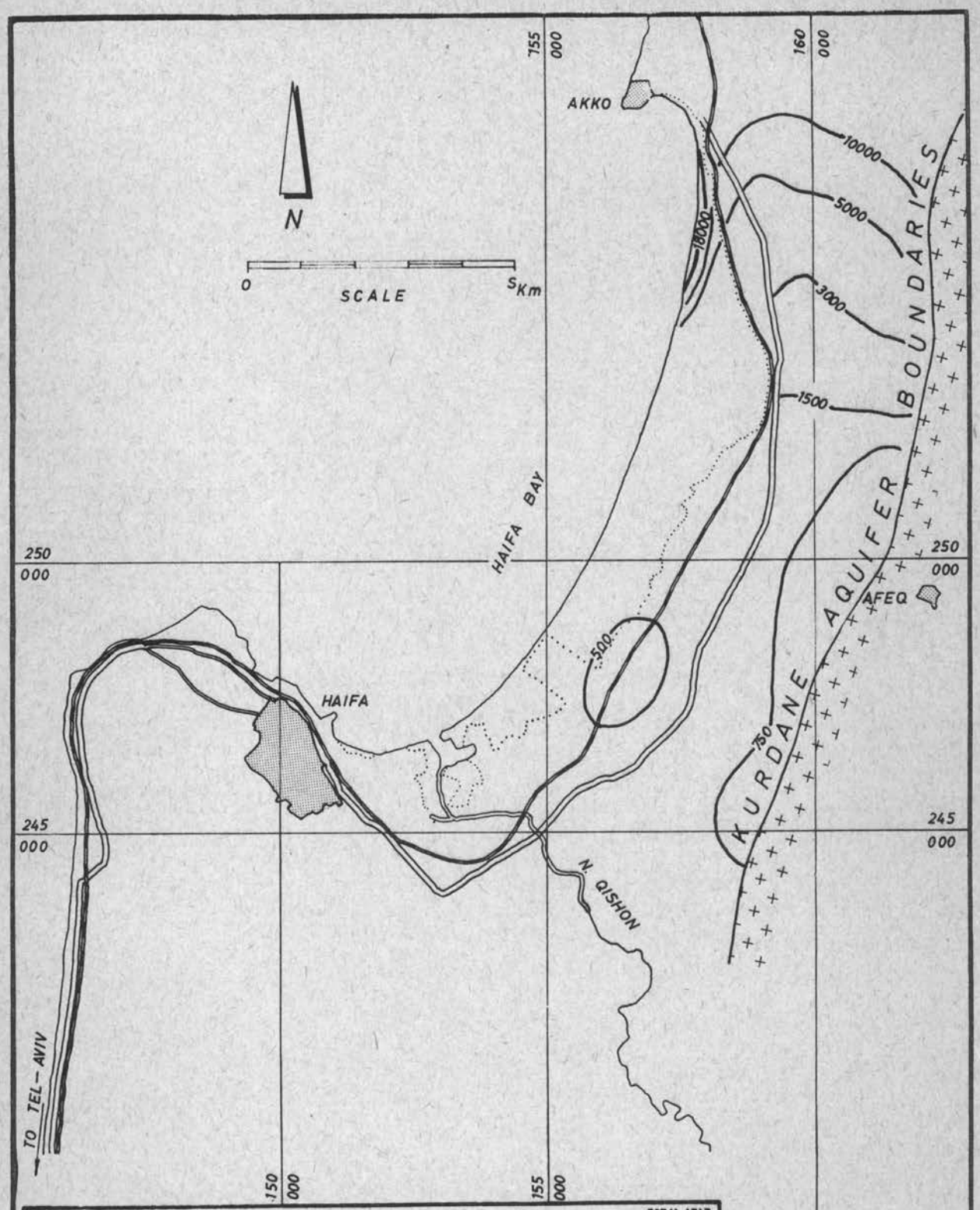
This area is the principal recharge and intake zone of the aquifer. In addition to small natural replenishment from rainfall the Kurdane is recharged from the Na'aman springs and through lateral inflow from the dolomitic cenomanian aquifer.

Hydraulic Parameters

The Kurdane calcareous sandstone formations serve as a major aquiferic unit having transmissivities of around 1,500 m^2/day. The storativity within the confined zones is around 10^{-4}. Outside the graben area there may be a hydraulic connection between the sandy shallow aquifer and the underlying Kurdane formation. Thus, any pumping scheme which may be planned for the Kurdane formation should take into account possible effects on the sandy shallow aquifer.

Quality of Groundwater

While the sandy shallow aquifer contains water of 50-200 ppm chlorides, the underlying Kurdane formation serves as the main brackish and saline water aquifer. Figure 2 shows the various horizons and the different qualities of water they contain. As indicated in the figure, the salinity increases with depth until the water at the lowest horizon contains 18,000 ppm chlorides. Sea water at this location contains around 19,000 ppm chlorides. Figure 3 illustrates the areal distribution of groundwater of varying salinity within the Kurdane formation.



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שם הפרויקט	עשא השרטוט
HAIFA BAY AREA INDUSTRIAL USE OF BRACKISH WATER	BRACKISH GROUND WATER MAP (KURDANE FORMATION) (ppm CHLORIDES)

הכין	בקר	אשר	תאריך	חוצאה	ק.מ.	שרט' מס'
			1.1975			FIG. 3
						מס' ארכ'

THE KURDANE AQUIFER EXPLOITATION SCHEME

In order to facilitate the exploitation of saline groundwater several simulation runs were performed, using the hydrogeological model previously mentioned. The plan would be to drill wells into the lowermost part of the Kurdane formation where the groundwater and the sea water are of about the same quality.

Based on the hydraulic parameters and on experience with production wells serving the Frutarom Electrochemical Industries it was estimated that a series of wells drilled 300 metres apart, each pumping 500 m^3/h, could produce around 15,000 m^3/h on an annual basis or around 100 MCM per year of saline water. About 95% of this would be sea water and 5% would come from fresh or brackish sources within the aquifers. The wells would be between 60 and 150 metres deep.

To develop this scheme, considerable information is still needed so that more complete plans can be drawn up. At all events, any programme for the utilization of the area's brackish and saline water would have to be carried out in stages, even though this makes it rather unattractive to potential large-scale users who would have to know in advance the ultimate available yield.

Further study is particularly essential since equipment ordered for the cooling process as is designed for specific types of water. Thus if sweet water were used, then the process would probably be based on a cooling tower and recycling of the water. However, if brackish or saline water were used then the cooling system would be based on passing the water through the system and disposing of it finally at a higher temperature. The temperature gradient is around $5^{\circ}C$.

CONCLUSIONS

With an anticipated increase in demand for cooling water for industrial use and taking into account the country's dwindling resources of fresh water, brackish and saline water resources, were they exploited, could alleviate industrial cooling problems significantly.

The alternative to pumping saline water by means of wells is to pump it directly from the sea and the question in either case would be one of economics and feasibility. Up to certain quantities and if the area to be exploited is not too scattered, wells are the more economical. However, for larger quantities (of the order of tens of thousands of m^3 per hour) direct pumping from the sea would be less costly.

In the area under investigation the major aquifer which could serve as the source for saline water is the Kurdane formation, whose lower horizon contains saline water of sea water quality.

The present investigation concludes that saline water can serve as a reliable source of cooling water for small and medium sized enterprises located along the coast in the Haifa Bay and elsewhere in Israel, small enterprises such as hotels and industries could use saline water derived from wells for their cooling needs thereby relieving the water authorities of the responsibility of furnishing then with fresh water for this purpose, and avoiding depletion of fresh water resources.

It is estimated that around 100 MCM of saline water can be extracted within the area under review. However, further studies and investigations would have to be carried out to obtain more accurate data as to the exploitable quantities.

Any development scheme would have to proceed stage by stage up to completion.

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