第5章　本格調査の内容

5－1　調査の基本方針

事前調査団と水資源研究所（RIWR）との間で締結されたS/Wによれば，本格調査の目的は次のとおりである。

① シナイ半島の地下水資源評価を行うため水理地質図を中心とした資源評価図（1/25万程度）を作成する。

② 地下水資源評価に基づき，地下水開発の優先地域を選定し，地下水開発基本計画を策定する。

③ 日本側は本調査の期間中，調査に参加するエジプト側専門家に対し技術移転を行う。

シナイ半島の地下水に関する調査は，1980年代の初期から米国及びEC等の援助により進められている。しかし，その調査精度は半島北部のエル・アリシュ地域を除くと未だ十分ではない。したがって，地下水資源評価図作成に際しては，以下の方針のもとで，調査・解析を実施する。

(1) 既存資料の収集・整理・解析を重点とし，これにランドサット映像，航空写真の判読を加えて，まず予察的な水理地質図を作成する。

(2) 水理地質予察図に基づき，データの不足する地域，水理地質的に問題となる地域を抽出し，物理探査，ボーリング，揚水試験等の現場調査を実施する。

(3) シナイ半島の地下地質と帯水層の性状を把握するため第四紀層（浅層，0～200m未満）のみならず，中生代～古第三紀層の層相と帯水能の確認を目的とした中～深層（400～1,000m）級の物理探査と，それに基づく調査井の掘削を実施する。

(4) ナカブ地域については，水理地質予察図の作成後に精密な地表地質調査，物理探査を実施することとし，試掘井の掘削などボーリング調査はこれらの調査結果を踏まえ，その実施を検討する。

(5) 調査結果は地質図，断面図，帯水層構造図，帯水層定数分布図など一連の水理地質図にまとめるほか，これらを総合した地下水資源評価図を作成し，これを最終成果とする。

5－2　調査項目及び内容

5－2－1　調査対象範囲

調査対象範囲は図－5.1に示すシナイ半島北半部の北シナイ州全域であり，その面積は約26,000km^{2}である。

5－2－2　調査項目

本格調査において必要と考えられる調査項目は次の10項目である。

図－5.1　調 査 対 象 地 域

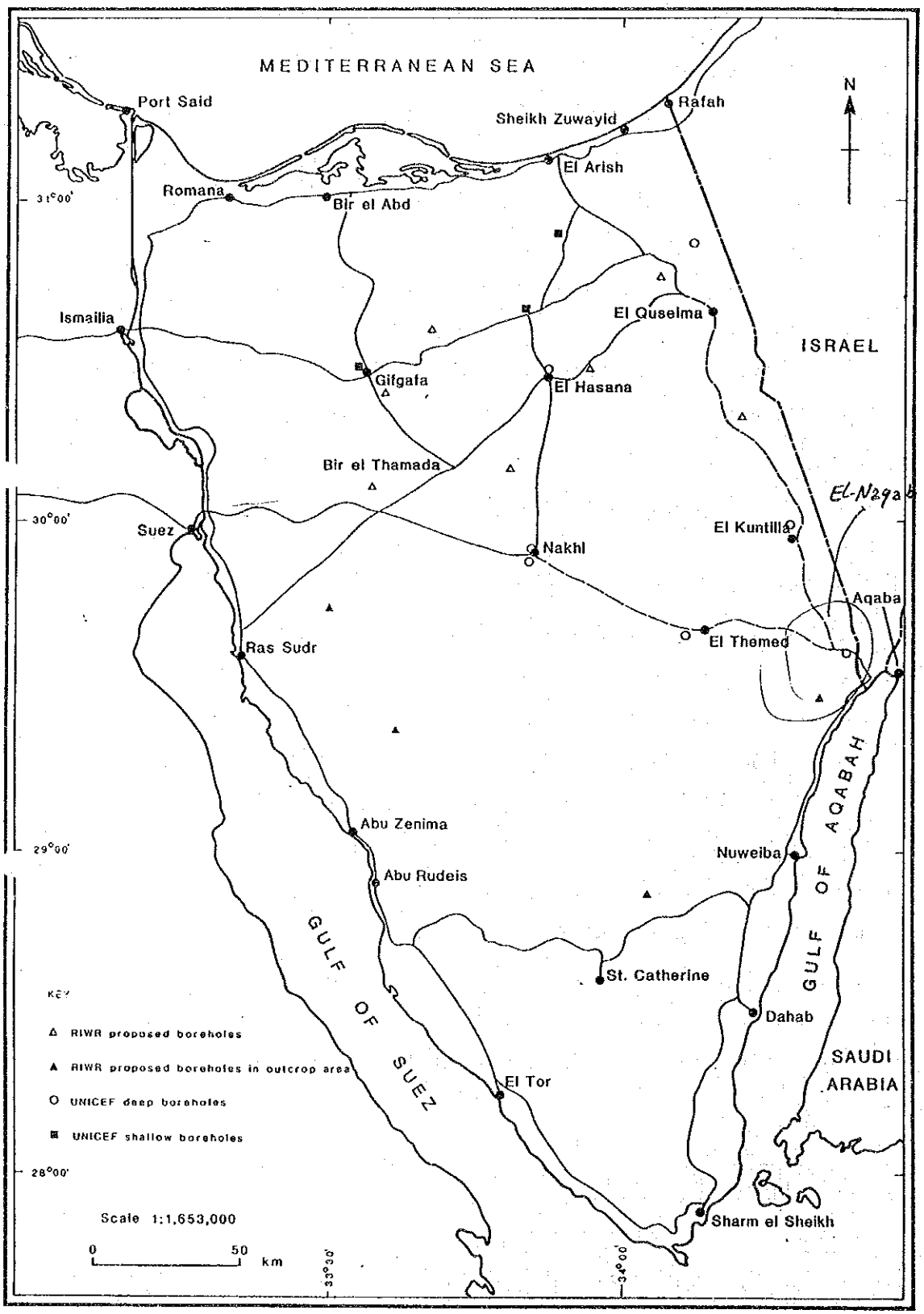


Figure 7

(1) 資料収集整理

(2) ランドサット映像解析

(3) 航空写真判読

(4) 地 質 調 査

(5) 水 文 調 査

(6) 電 気 探 査

(7) 重 力 探 査

(8) 試掘・揚水試験

(9) 地下水資源評価図作成

(10) 地下水開発基本計画策定

また，概要を表－5.1に示す。

5－2－3 調査内容

(1) 資料収集整理

シナイ半島についてはSDS，SWRSによる膨大な調査資料が集積されている。とくにSDSでは1980年代前半までの調査資料に基づきポートフォリオ，水源データブック等が作成されている。また，その後SWRSの一環として多数のボーリングが実施されている。資料収集にあたっては，まず，これら既存地下水調査のバックデータから始め，これらを整理・解析して水理地質予察図を作成するものとする。

資料収集整理項目は次のとおりである。

① 気象・水文資料：（降水量，気温，風向，風速，露，蒸発散量など）

② 社会・経済資料：

③ SDS及びSWRS関連資料：報告書，ポートフォリオ，水源データ，ボーリング柱状図，揚水試験記録，水質分析記録

④ その他の地下水調査資料：マガラプロジェクト報告書，ユニセフ井戸柱状図

⑤ その他関連プロジェクト資料：JICA報告書，エジプト関係機関報告書（農業，鉱業など）

(2) ランドサット映像解析

リモートセンシング手法は広域の土地利用，植生，地形，地質，土壌水分などをマクロ的に把握するのに有効である。

本格調査では，ランドサット MSSデータを用いて，シナイ半島北部の広域的な地形分類，表層地質分布，断層・リニアメントなどの地質構造及び植生と土地利用を解析，1/20万～1/25

表－5.1　調　査　概　要　一　覧　表　(1)

調　査　項　目	数　　量	目的・内容－成果	担　　当	備　　考
1）資料収集整理	1式 (26,000 km²)	・既存資料を整理分析して，水文地質予察図を作成する －気象・水文・社会・経済等資料 －SDS，SWRSレポート及び資料 ポートフォリオ，水源データ， 井戸柱状，揚水試験，水質 －その他の地下水調査資料 マガラプロジェクト，UNICEF等 ・水文地質予察図（断面図含む）	総括 水文地質A	1/25万
2）ランドサット 映像解析	5シーン (26,000 km²)	・ランドサットデータの画像解析を行い，地質構造，地形，植生分布を把握し，地下水資源評価の資料とする －フォールスカラー画像作成 －表層地質，地形，リニアメント， 植生，土地利用図 －資源評価基礎図	リモートセンシング	
3）航空写真判読	1式 (26,000 km²)	・1/2万航空写真から断層，摺曲，リニアメント等の地質構造，層相，地形を判読して，水文地質図の基礎とする ・1/10万　写真判読図にまとめる	水文地質B	
4）地質調査	1式	・航空写真判読結果をもとに現地踏査を行い，地質図を作成する －露頭観察及びマッピング －井戸地質柱状図による断面図作成 －物理探査，ボーリング地点の検討 ・地質図　1/10万作成	水文地質A 水文地質B	・全域は(1)により重点地区を選定する ・ナカブは約200km²を対象とし，1／5万を作成する
5）水文調査	1式	・既存井の一斉観測，地下水位定期観測及び採水・水質分析 －水文・気象資料整理 データベース作成 －水収支計算 －水質分析結果の解釈	水文	一斉観測地点は(1)により決定する

調　査　概　要　一　覧　表　(2)

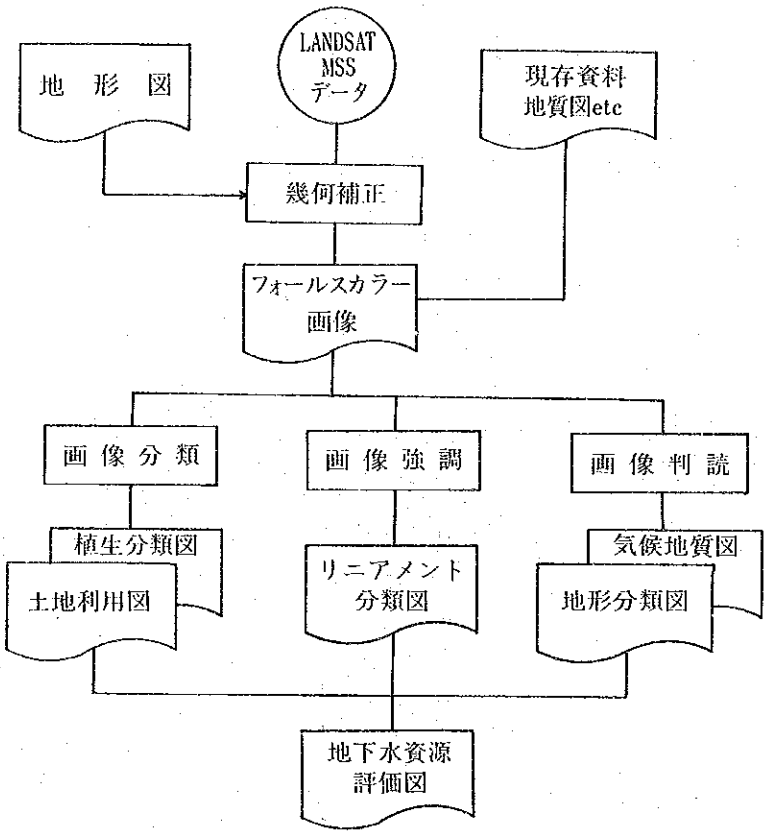
調査項目	数　量	目的・内容	担　当	備　考
6) 電気探査	1,450点	・水文地質予察の結果により調査範囲，深度を計画し，比抵抗電気探査により地下の比抵抗層を区分する —200m 級：主として洪積層 —500～1,000m級：主として中生層 ・比抵抗断面図，平面図	(全域) ・物理探査A ・物理探査B (ナカブ) ・物理探査C	供与機材　2台 携行機材　1台
7) 重力探査	1,000点	・ナカブ地域の基盤深度を求める —重力計による測定 —水準測量 ・ブーゲー異常分布図 1/5万	(ナカブ) ・物理探査D ・測量	ナカブのみ
8) 試掘・揚水試験	4,000m	・地質調査，物理探査結果に基づきボーリング，揚水試験を行う —1,000m級1カ所 — 400m〃3カ所 — 200m〃4カ所 （9カ所全域） ・ナカブ地域は物探により決定 総計1,000mとする 400m 2カ所 200m 1カ所	(全域) ・ボーリング管理 (ナカブ) ・ボーリング管理	ナカブ地域 1,000m
9) 地下水資源評価図	1式 (26,000 km²)	・シナイ半島北部の帯水層別地下水資源評価図を作成する —水理地質図・断面図 —帯水層・加圧層層厚分布図 —主帯水層等深線図 —水質区分図 —地下水資源評価図 ・（カラー印刷）評価図　1/25万	総括 水文地質A 水文地質B	500部印刷
10) 地下水開発基本計画	1式	・シナイ半島の地下水開発適地を選定し開発計画を立案する —範囲 —探査方法 —取水計画，取水可能量 ・開発基本計画案作成	総括 水文地質A	

万の図面にとりまとめて，一連の水理地質図と地下水資源評価図作成の基礎資料とする。

ランドサット映像解析のフローチャートは図－5.2に示す。

なお，ランドサット4～5号によるシナイ半島北部のカバレージは5シーンである。

図－5.2　ランドサット映像解析フローチャート



(3)　航空写真判読

シナイ半島のような砂漠地帯では航空写真判読は極めて有効な調査方法である。ランドサット映像の解析結果を踏まえ，さらに細部の地質構造，層相，地形を判読し，水理地質図作成のための基礎資料とする。

シナイ半島においては1/2万航空写真の入手が可能であるので，現地において判読を行い，1/10万程度の判読図（リニエーションマップ等）にとりまとめる。

(4)　地質調査

航空写真判読結果を基に現地踏査を行い，1/10万程度の地質図作成を目標とした地表地質調査を行う。

現地踏査においては，主要な地質単元ごとに水文地質的観点からの露頭観察，マッピング

を行う。

これらの調査結果を総合して，シナイ半島の水文地質単元を明確にし，地質図，断面図にとりまとめる。

また，水理地質図と地下水資源評価図作成にあたり，データの不足する地域や水文地質的観点からデータを補足すべき地域を抽出し，物理探査，ボーリングの実施計画を作成する。

(5) 水文調査

地下水の流動と涵養状況及び地下水の水質特性を明らかにするため地下水位観測と水質分析を実施する。また，主要な湧泉については湧水量を測定する。

また，本調査の一環として地質・地下水・水文に関するデータベースを作成する。

① 地下水位の長期観測

既存井及び本調査で掘削した深井戸の代表的なものについて自記水位計により地下水位の長期観測を実施する。極めて降雨量の乏しい地域であるので，降雨との関係はシナイ半島北東部を除き期待しにくいと思われるが，浅層・深層の長期的な挙動を把握のために実施する。

なお，本調査では自記水位計を携行しないが，カウンターパート側が保有する水位計を協議のうえ適切な台数，設置することとする。また既存井の観測は，できるだけ早期に開始する。

② 地下水位の一斉観測

既存井及び本調査で掘削した試掘井を利用し，地下水位の一斉観測を実施する。一斉観測は12～１月ごろの雨季（この２カ月の雨量が多い）と，５～９月ごろの乾季の各１回，実施する。

一斉観測の対象範囲はエル・アリシュ地域とする。

③ 湧泉・流量の観測

グダイラーツ湧泉など調査対象地域内の主要な湧泉の流量について可能な限り実測を行う。

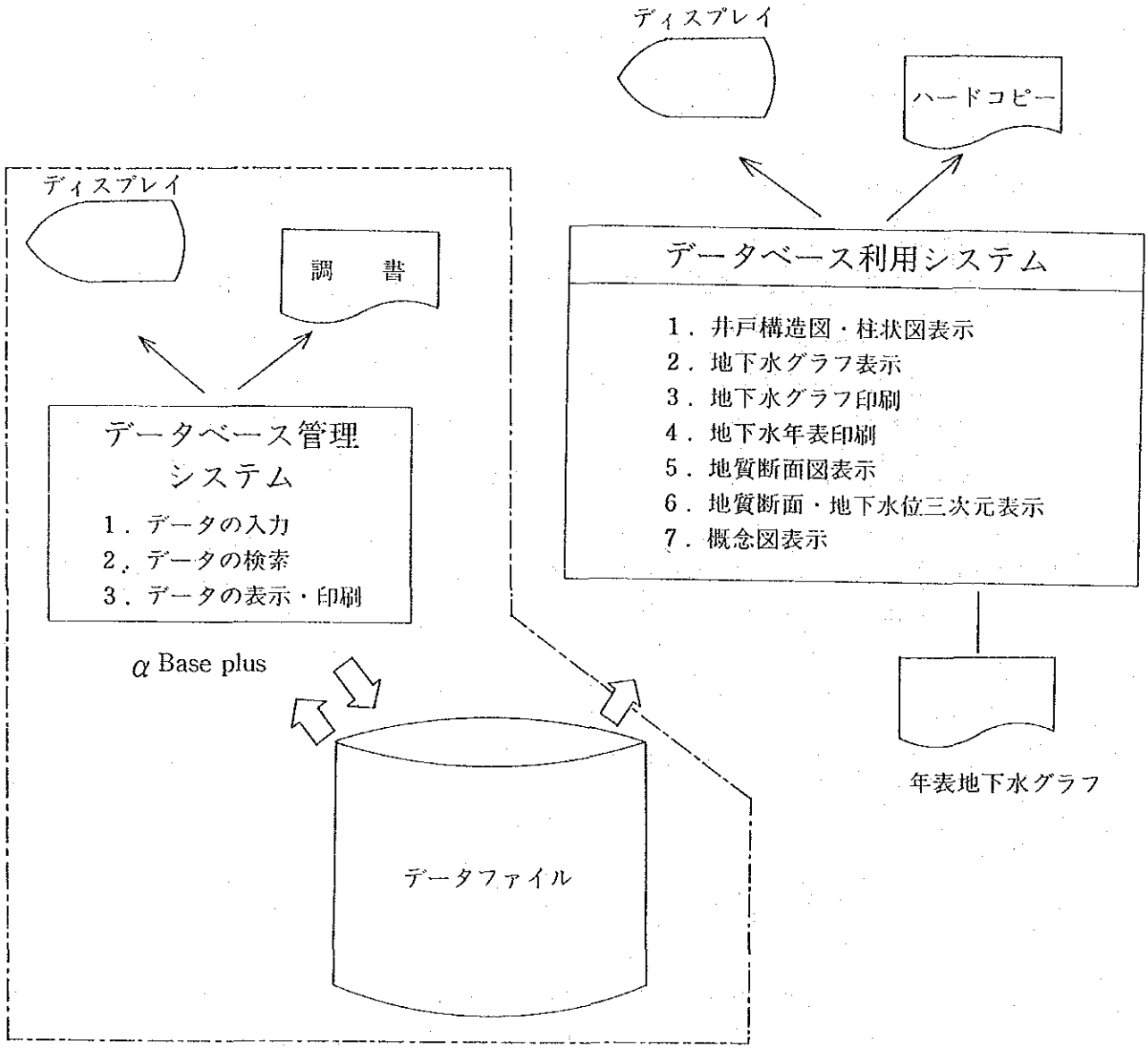
④ 水収支計算

調査対象地域を水系及び水文地質単元により大区分して，降雨量，蒸発散量など水収支要素を考慮した全体水収支を概算する。

⑤ データベース作成

シナイ半島の地質・地下水，水文に関するデータベースを，供与機材として携行するパーソナルコンピューターを利用し，市販ソフトウェアの d Base Plus をもとに入・出力，検索，修正プログラムを作成する（図－5.3参照）。

図-5.3 地下水データベース概念図(案)



⑥ 水質分析

既存井及び本格調査の試掘井より採取した地下水の水質分析を行い，地域別・帯水層別の水質特性を明らかにする。また，地質構造と層相と水質の関係を解析する。分析項目は次のものが考えられる。

ⓐ 一般項目

HCO_3^{--}，Cl^-，SO_4^{--}，K^+，Na^+，Ca^{++}，Mg^{++}，総硬度

ⓑ 水道項目

NO_3^{--}，NO_2^{--}，NH_4^+，F^-，Cr，Fe，Cu，Zn，Mn，Pb，その他必要項目

(6) 電気探査

前項(1)～(4)により作成した水理地質予察図に基づき，水文地質的に問題となる地域，データが不十分な地域を抽出し電気探査を行い，地下地質構造を把握する。

電気探査は垂直探査を行うことを基本とするが，地質条件に応じ，電極間隔を一定とした，水平探査を行い，帯水層・加圧層の水平分布を，できるだけ広域的に把握するよう努める。

本格調査において使用する比抵抗測定器の探査能力は次の2種とし，それぞれ浅層（沖～洪積層），中～深層（主として中生代層）を対象に探査を行う（なお，ナカブ地域は他地域より探査密度をあげることとする）。

① 深度 200m級 ：供与機材 2台

② 深度 500～1,000m級 ：携行機材 1台

なお，調査地は著しく乾燥した砂漠地のため接地抵抗が大きいと考えられるので，機器の能力，電極配置，解析方法等について事前に十分な検討を行う必要がある。

したがって，本格的な電気探査を行う前に地下地質状況が比較的よく判っている地域で試験的な電気探査を行い，方法論を詰めておくことが肝要であろう。

電気探査結果は，ボーリング地質柱状図と対比した比抵抗断面図及び水平比抵抗分布図等にとりまとめる。

表－5.2には電気探査測点数と工程に関する事前調査団案を示した。この案では全て垂直探査を行うことを条件に測定能率を設定し，稼動日数とチーム数から測定点数を計算してある。なお，全測点の探査深度別内訳（比率）は，200m未満（0.5），400～500m（0.3），1,000m（0.2）とした。

(7) 重力探査

ナカブ地域は図－4.6，図－4.8に示したように空港の周辺に基盤岩類が分布する。空港の西側を北に伸びるワジが地下水開発候補地域となると思われるが，東西性の断層の南側ではUNICEFが試掘を行い137mで火山岩に着岩している。

この地域の水文地質構造は，地質調査，電気探査とともに重力探査を実施して基盤岩の分

布深度を把握することにより明らかにできるものと考えられる。

したがって，重力探査の範囲は空港の西北側に北へ伸びるワジの約200km²を対称とし，4～6点/km²の割合で探査を行うものとする。なお，高度補正のための水準測量を必ず実施する。探査結果の解析を行い，地質調査，電気探査の結果と併せ，ブーゲー異常分布図，基盤岩等深線図にとりまとめる。

表－5.2　電気探査数量表（案）

深　　度	測定能率	稼動日数	チーム数	点　　数
1）200m未満	6点／日	177日	2	1,060（1,062）
2）400～500m	3点／日	107日	1	320（ 321）
3）1,000m	1点／日	73日	1	70（ 73）

現地稼動日数　30×0.7＝21日／月　　計1,450

探査深度比率

	比率	所要稼動日数（点数） A	B	ナカブ	計
200m未満	0.5	73日	73日	31日	177日
400～500m	0.3	44〃	44〃	19〃	107日
1,000m	0.2	30〃	30〃	13〃	73日
計	1.0	計147日	147日	63日	357日

(8)　試掘・揚水試験

地下地質状況，地下水揚水量，地下水位，水質を確認するための，物理探査結果に基づき試掘地点を選定し，さく井と揚水試験を実施する。地下水資源評価図の資料とするため，対象地域内で9カ所の試掘井を計画する。

①　200m級（6カ所）：主として沖～洪積層を対象に深度50～200mの試掘井を削井する。深度が浅い場合は6カ所以上掘削するか，または他の試掘井の増掘分に回すこととする。

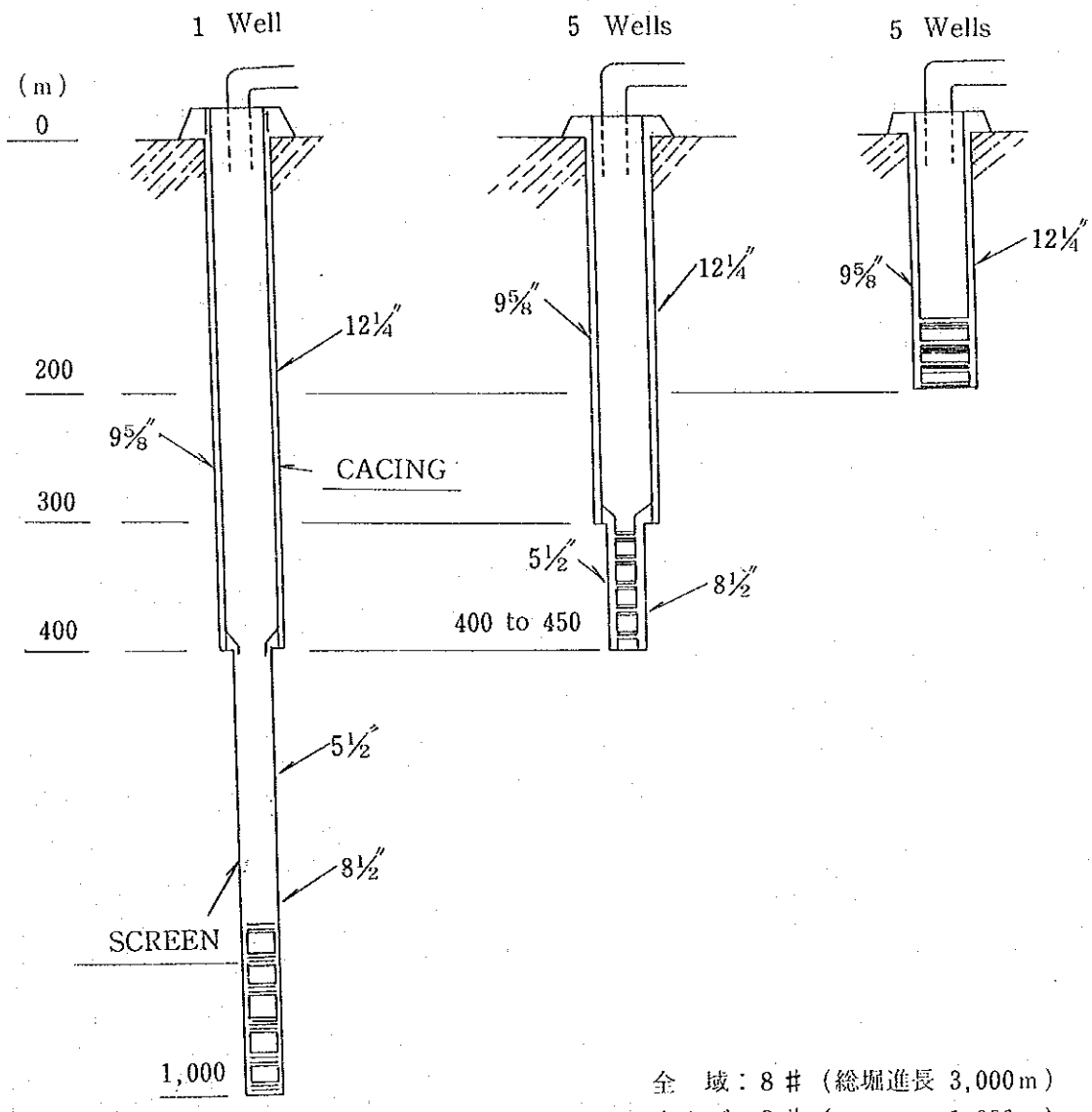
②　400m級（2カ所）：主として古第三紀～中生代層を対象とし深度300～400mの試掘井を削井する。

③　1,000m級（1カ所）：主として下部白亜紀層を対象として深度1,000mの試掘井を削井する。

各ボーリング地点の位置と予定深度を計画するにあたっては，既存の試掘井柱状図（ユニセフによるもの，または石油探鉱井）を十分検討するものとする。

口径，深度，ケーシング・プログラムについては事前調査団案を図－6.4に示すが，着手に際しては地元の掘削業者と綿密な打合せが必要である。

図-5.4 ケーシング・プログラム(案)



全　域：8 #（総堀進長 3,000m）
ナカブ：3 #（　〃　 1,000m）

なお，現地ではケーシング管などの材料入手が困難と考えられるので，後述するように，一部の材料を日本から現地へ送ることとする。

検層により地下水が確認された場合，スクリーンを設置し井戸を仕上げる。

井戸の仕上げ後，実際の揚水量と水位降下量の関係を求める。また，試験結果を解析し，各種の水理定数を求めるとともに，水質分析用に試料を採水する。

揚水試験は段階試験，定量試験，回復試験の3通りを行い，その結果を解析して，透水量係数，貯留係数，漏水係数，比湧出量などの水理定数を求める。

(9) 地下水資源評価図作成

前項(1)～(8)までの調査解析結果を総合し，シナイ半島北部（北シナイ州全域）を対象とした1/25万の水理地質図及び地下水資源評価図を作成する。一連の水理地質図類には下記の図面が含まれる。

① 水理地質平面図及び断面図
② 主帯水層及び加圧層等層厚線図
③ 主帯水層等深線図
④ 主帯水層被圧水頭分布図
⑤ 不圧地下水位等高線図
⑥ 比湧出量分布図
⑦ 透水量係数分布図
⑧ 水質分布図
⑨ 地下水資源評価図及び説明書

地下水資源評価図及び説明書は，報告書とは別に500部カラー印刷する。なお，水理地質図の作成にあたっては，IAH・IAHS・UNESCO（1983）による国際凡例（1983年改訂の暫定案）に準拠するものとする。

(10) 地下水開発基本計画策定

シナイ半島北部の地下水資源評価に基づき，地下水開発適地を選定し，開発計画を立案する。

① 開発適地選定

地下水ポテンシャル，水質，地下水の用途からみた地下水開発適地を選定し，ランク分け，開発の優先順位づけ等を行う。

② 探査方法の提案

開発のための詳細調査項目，調査方法を提案する。

③ 開発可能量の概算

各開発適地の水文地質状況に応じた1井当たりの取水可能量を算定する。また，群井配

置を行ったときの開発可能量を，通常の地下水理学的解析手法を用いて，いくつかのケースについて算定する。

5－3　調査の実施体制

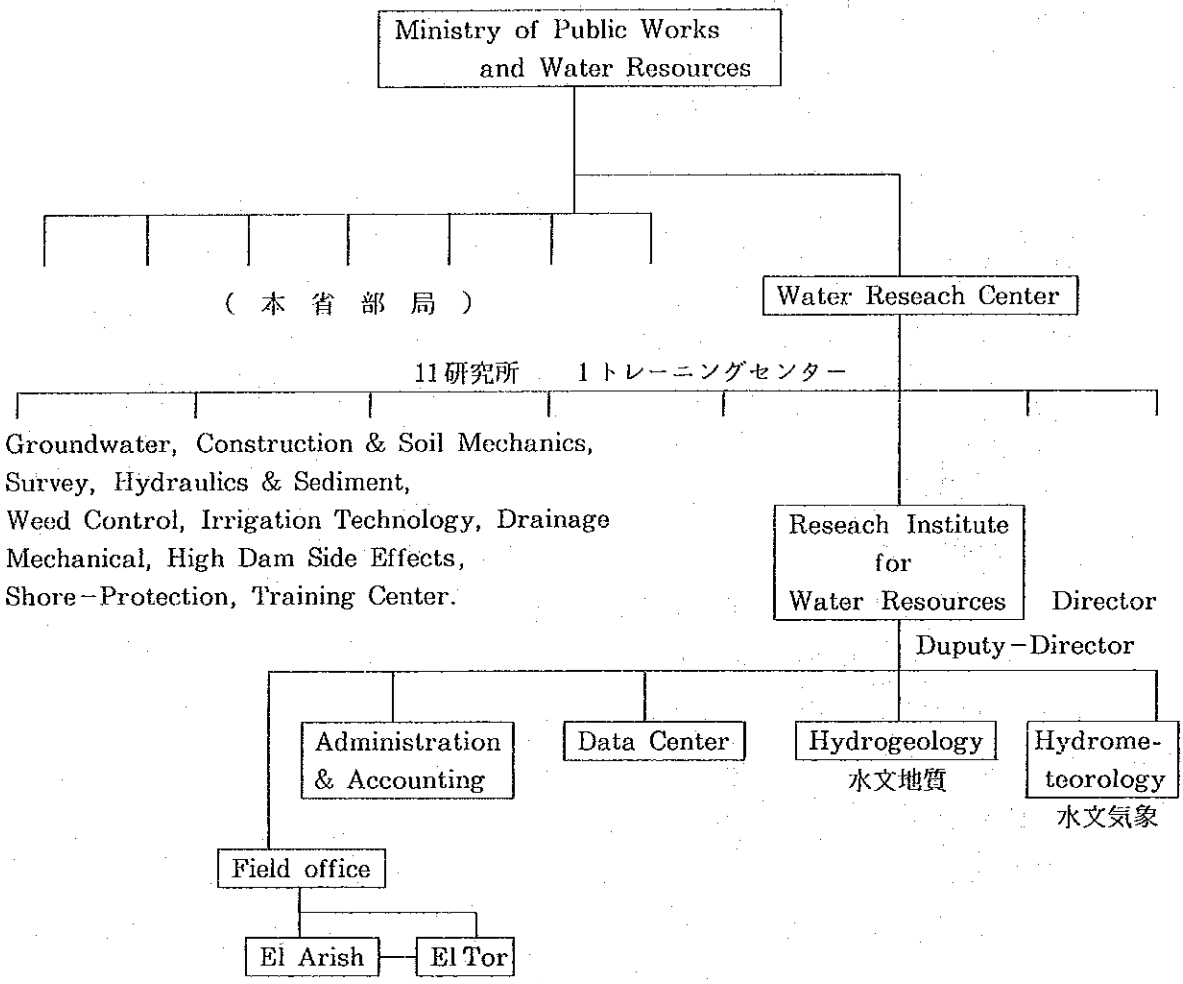
(1)　エジプト側

①　公共事業・水資源省は名称を1987年に，かんがい省から変更したものであるが，組織・機能の変更は全くなかった。農業関係4省の一つであるが，ナイル川のダム，堰，ナイルデルタのかんがい排水路の維持管理，各地の水配分の決定等を行っており，各州に地域事務所を有している。さらに他省と同じく，建設工事等の予算は関連公団，国営企業により実施されている。

研究機関としては Water Reseach Center（WRC）が12の個別の研究所・トレーニングセンターの調整機関として予算の配分等を行っている。

水資源研究所は1976年に創立されたが，当初の設立目的はナイル川の水資源の調整を課題としていたが，シナイ半島返還後は，ほぼシナイ半島の表流水・地下水双方の調査・研究についてほぼ組織の全力を挙げている。そのほか西部，東部の砂漠についても担当している。要約すれば新規開発地域の水資源の調査研究機関である。

他に関連する組織としては地下水研究所（1953年設立）があるが，対象はナイルデルタ域，ナイル川流域をそのその任務としており，本件調査対象域には関係がないことは確認したが，技術者，研究者は水資源研究所より多いようである。また，砂漠研究所は農業省管轄で土壌調査，栽培研究を主目的としている。



② 水資源研究所の人員，予算及び活動

水資源研究所の人員の分野，数は下記のとおりである。

	定員	定員外	計
所長・副所長	2	0	2
管理部門	47	34	81
Civil Engineer	10	1	11
Geologist	10	3	13
Drilling Engineer	1	1	2
Survey Engineer	1		1
Electoronic Engineer	1		1
Agricultural Engineer	1	1	2
Mathematic		1	1
Mechanical Engineer	1		1

（うち34名 研究職） 115

同研究所の1988/89年度（1988年7月～89年6月）の予算は1,365,100LE（約8,200万円）であり，本省交付金（1,100,100LE）及びWRC（265,000LE）となっている。

機材としてはパソコンがEECにより供与され，現在，表流水のデータのインプットを行っている。他に，電探，水位計算は有しているが，基本的には各国援助によっている。シナイ半島にはエル・アリシュ，エル・トールにフィールドオフィスを置き，他に観測所（雨量，温度，湿度等）を10カ所程度管理しているが，これについてはEECの援助を得つつ拡充を進めている。

最近の活動としては，80年から，米国のシナイ開発調査の水資源資料を補完すべく，表流水・地下水に関する調査をEECの技術協力を得て行ったが，機材の通関の遅れ，イタリアのコンサルタントの能力，カウンターパートの不足等により，必ずしも成功したとは言い難く，本年から，Phase Ⅱとして3カ年の技術協力を開始し，南西部及びエル・アリシュ域の水管理，Water Monitoring，観測所のネットワーク等の協力を行うこととしている。

ほかに，イタリアと北シナイ州政府との協力によるマガラ地域の総合開発に関し，地下水調査，水利用計画の部門に参加している。現在，対象地域に観測所を8本完成し，モニタリングを進め，今後，農業かんがいを行う予定で，イタリアとの交渉を行っている。

(2) 日本側実施体制

日本側本格調査団は下記の専門家が必要と考えられる。

① 総　　括：団　長
② 水文地質A：副総括，水文地質全般
③ 水文地質B：写真判読，地質調査
④ リモートセンシング：ランドサット映像解析（国内作業のみ）
⑤ 水　　文：地下水位観測，データベース作成，水質，水収支
⑥ 物理探査A：物理探査全般及び電気探査
⑦ 物理探査B：電気探査
⑧ 物理探査C：電気探査（ナカブ地域のみ）
⑨ 物理探査D：重力探査（ナカブ地域のみ）
⑩ ボーリング管理：さく井指導，揚水試験
⑪ ボーリング管理：さく井指導，揚水試験（ナカブ地域のみ）
⑫ 測　　量：重力探査地点測量（ナカブ地域のみ）

5－4　調査用資機材

本格調査に必要な調査用機材は表－5.3及び表－5.4に示すとおりである。表－5.3は日本

側において新たに購入するが，表－ 5.4の電気探査装置，重力探査装置は本格調査団が所持するものを携行する。

なお，ボーリングは地元の掘削会社に発注する予定であるが，ケーシング等の材料入手が困難と考えられるので，表－ 5.3に示すようにスクリーンとケーシングを日本側で準備することとした。

事前調査団が地元掘削業者から入手した見積り等は巻末資料に示す。

このほか表－ 5.5にはランドサットの映像解析に必要な作業項目と材料を示した。

表－ 5.3　調 査 用 機 材 リ ス ト

品　　名	数量	仕　　様	備　　考
1) 電気探査装置	2式	探査深度　200m以上	本体，電極，ケーブル
2) 井戸スクリーン及びケーシング	4,000 m	・スクリーン：$\varnothing 5\frac{1}{2}''$ 400m ：$\varnothing 9\frac{5}{8}''$ 200m　} 600m ・ケーシング：$\varnothing 5\frac{1}{2}''$ 700m ：$\varnothing 9\frac{5}{8}''$ 2700m　} 3400m	全域：3,000m ナカブ：1,000m スクリーンは全体の10%を見込む
3) ワゴン車	2台	・5～6人乗，左ハンドル，クーラー付き ・4輪駆動	
4) キャビン車	1台	・12人乗，左ハンドル，クーラー付き	
5) マイクロコンピューター		・CPU 16ビット ・主記憶，512KB以上 ・Hard Disk 10MB以上 ・プロッター，プリンター，ディジタイザー ・d Base Plus	
6) 水質分析装置	4台	・簡易分析キット （EC，PH，水温）デジタル表示	
7) 複写機	1台	・乾式　A3サイズまで複写可能なもの	
8) 手動式水位計	10台	・100m間及び200m間各5台	

注）探査深度200m以上とは，0～200m及び可能な限りそれ以深の比抵抗値を把握できる能力をもつものをいう。

表－5.4　その他の携行機材（損料ベース）

品　　名	数量	内　　容	備　　考
1) 電気探査装置	1式	探査深度※1,000m以上 調査地域は既存資料解析結果により決定する。 探査能率：1,000m　1　点／日 （垂直探査）4～500m　2～3点／日 200m　5　点／日	
2) 重力探査装置	1式	ナカブ空港西北側約200km²のワジを対象とする。 測点：4～6点／km² 能率：15～20点／日 高度補正のため，別途水準測量が必要である。	主な重量計 North American Askamia Worden

※探査深度1,000m以上とは，0～1,000m及び可能な限りそれ以深の比抵抗値を把握できる能力をもつものをいう。

表－5.5　ランドサット画像解析に必要な作業項目と材料

項　　目	数量	内　　容	備　　考
1) TM　CCTテープ	5巻	Computer Compatible Tape	
2) ワークテープ	20巻		
3) デジタル画像解析システム	20日	使用料	
4) フォールスカラー画像	1式	5シーン×1部　　合成	
5) 主題図	〃	5シーン×5種×1部	
6) 評価図	〃	5シーン×1種×1部	

5－5　調査工程

本調査の全体所要月数は36カ月が見込まれる。シナイ砂漠は6月末～8月にかけて酷暑の季節となり，この間の野外作業の能率は著しく低下すると予想される。そこで本調査においては，厳暑の季節の野外作業（ボーリング作業を除く）を避け，表－5.6に示すような調査工程を暫

定的に作成した。

本調査の最終成果となる地下水資源評価図は印刷に時間を要すると考えられるので，実質的には調査開始後27カ月後のプログレス(2)の段階で原案を提示し，34カ月後のドラフトレポート段階で完成提出する工程とした。

5－6　調査実施にあたっての留意点

(1)　水文地質調査の主目標

本格調査では，1980年代初期に行われた SDS 及び SWRS の調査資料を有効に利用することが肝要である。SDS の調査により，すでにある程度の精度の水理地質図が作られているが，本格調査では，その後の資料を追加して，これらを修正するとともに，新たに行うべき地質調査，物理探査の範囲と位置を決定するものとする。

とくに，シナイ半島においては下部白亜系（ヌビア帯水層）の存在を明らかにすることを重点とし，併せて中生層～古第三紀層の地下水開発可能性を評価することを主眼とすべきであろう。

(2)　地下水の水質の評価

一般に乾燥地域においては高塩分濃度の地下水が賦存し，利用上の障害となっている。シナイ半島においても地形・地質的条件が複雑に絡み合い，各帯水層ごとの水質の様相は極めて複雑である。

このような条件下では，なかなか難しいことではあるが，地下水開発可能性の評価に際しては，帯水層の分布や，その水理特性からだけでなく，水質特性を加味して行うことが重要と考えられる。

(3)　他の外国援助との協力

シナイ半島では EEC，UNICEF，イタリア，日本が，それぞれ目的，調査対象範囲，調査項目が異なるものの，同じフィールドの中で調査を実施していくことになる。本格調査の実施に際しては，これらの関連する調査プロジェクトの進捗状況，調査内容にも十分注意を払い，それらの資料も十分活用しながら，能率的に作業を進めることが望ましい。

(4)　現地の条件

シナイ半島においては6月～8月は最も気温の高い季節で，炎天下の砂漠では50℃近くにも上昇するため，この時期の作業能率は著しく低下するものと考えられる。作業計画の立案にあたっては，これらの条件を十分考慮すべきである。

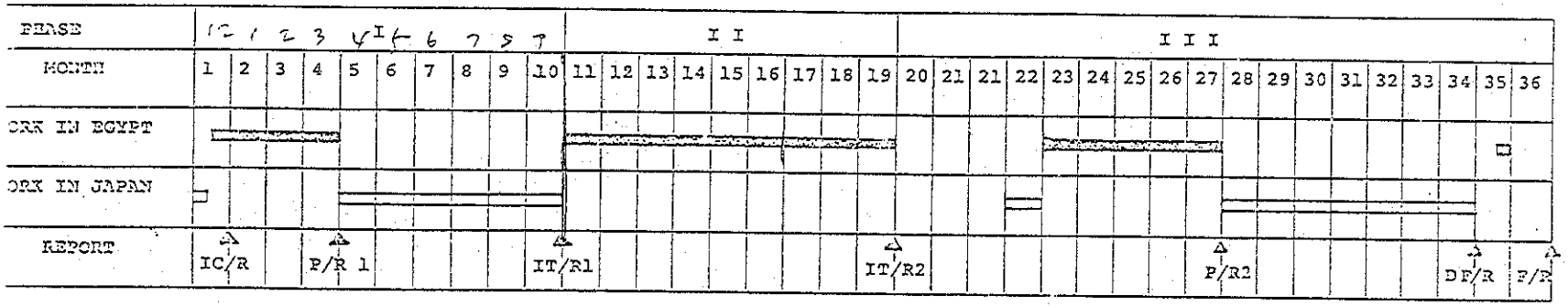
また風土・気候が厳しいため，車両，機器類にトラブルが発生しやすいので，入念な保守点検・整備が必要である。

(5) カウンターパート

RIWRの地質，水文地質などの専門家は，当然のことながら，この地のgeologyに関し深い経験と知識を有している。

しかしながらシナイ半島の地下地質については本格調査団はもちろんのこと，RIWRの専門家たちにとっても未知の領域である。調査に際しては両者のもてる経験を十分に発揮し，地下水開発可能性の評価を日・エ共同で成し遂げることこそが本調査の最大の目的であろう。

表6.6　　S/W 記載　　TENTATIVE SCHEDULE



(REMARKS)

IC / R :　Inception Report
P / R :　Progress Report
IT / R :　Interim Report
DF / R :　Draft Final Report
F / R :　Final Report

資　　料　　編

1. 要請書（原文コピー）
2. 現地収集資料リスト
3. 面会者リスト
4. ボーリング見積り
5. 価格調査結果
6. 深井戸地質柱状図の１例
7. 井戸台帳の１例
8. シナイ半島地形図索引
9. 水文地質図の国際凡例（IAH，IAHS，UNESCO，1983）

1. 要 請 書（原文コピー）

MINISTRY OF IRRIGATION
WATER RESEARCH CENTER
RESEARCH INSTITUTE FOR WATER RESOURCES

WATER RESOURCES MAP AND WATER DEVELOPMENT STUDY FOR SINAI PENNINSULA

Tentative Scope of Work

MARCH 1987

I. INTRODUCTION

As the land junction between the two continents Africa and Asia, Sinai Penninsula enjoys a strategical location at the heart of the Middle East. By virtue of its location Sinai has played a main roll as the route for the transfer of civilization and culture across its land in both directions. Sinai has been the path for trade, for religious pilgrimage and also for wars between the conflecting interests since ancient times.

It is interesting to notice that although millions of people have crossed its land, sinai did not attract them to settle in it and to make it as their home. In spite of its beautiful land and wide resources, the main reason behind the lack of interest to settle in sinai may be the water shortage.

With an area of about 61,000 Sq. Km, the Penninsula has about 900 Km of coastline along the two old seas of the Mediterranean and the Red Sea, along the famous naval rout of the Suez Canal and the Bitter Lakes. Its geography provide a wide range of landscape from the sandy temperate beaches along the Northern Mediterranean coast good as summer resourts, to the high upland at the middle, the rugged and high mountains to the south and ending with splendid coral reefs and all season worm beaches at the south.

As part of Egypt, Sinai has been considered by the Nile loving Egyptians as a remote area providing their formidable barrier against invasion from the East. The construction of the Suez Canal in the nineteen century has helped to deepen the isolation of the Penninsula because it provided a water barier between it and the main land of Egypt.

With the signing of the peace treaty between Egypt and Israel in 1979, a new look to Sinia has started to take shape. Now Sinai is not only considered as an integrated part of Egypt, but also it is considered as one of the main regions which will help make the future of Egypt into the next century. With its natural unspoiled environment and vast mineral resources, Sania has the potential to absorb part of the expanding population of Egypt.

Although Egypt has more than one million Sq. Km. of land for its current population of about 50 million, it is clearly misleading to divide the number of population on the total area to get the inhabitance per Sq. Km.

This is simply so because this vast land lacks the most important and vital element for human life, i.e. water. Most of the Egyptian population live along the narrow banks of the River Nile and its Delta to the North. The populated area is a mere 4% of the total. The rapid population increase in Egypt during the 20th century from around 15 million at the its turn to a present population of about 50 million and an estimated 70 million by year 2000, put a tremendous and dangerous pressure on the very limitted arable land of Egypt. Although Egypt has been making a continuous efforts to increase its cultivated area by reclaiming new lands from the desert, the net increase of the arable land has been limited because the concentration of the population around the Nile and the Delta has forced to change large areas of the fertile land from its life supporting roll of agriculture to other sevices use as urbanization and infrastructure. Such dangerous trend if continued will deprive Egypt of its most precious asset, its agriculture land. The Egyptian government is fully aware of this situation and has embarked on an ambitious scheme of developing new lands to accommodate the population increase in lands outside the Nile Valley and the Delta. Out of the available limited alternatives, the coastal areas along the Mediterrenean and the Red Sea is more attractive than the arid deseret of the hinterland. One of the most promissing regions for such development is Sinai.

Sinai has a central location on the map of the Middle East. Its zone of influence extends to the developing centers of Aqaba of Jordon, Yanbu of Saudi Arabia, the Suez Canal Three main cities of Port Said, Ismailia and Suez, and above all it is close to Cairo when compared to other coastal areas.

Recognizing this potential, the Egyptian government has not only commissioned several studies for the development of Sinai, but also has started a large scale development scheme to integrate the Penninsula into the main stream of the life of Egypt. These efforts include the completion of Ahmad Hamdy Tunnel under the Suez Canal to provide a continuous onland link, the construction and operation of the new port at Nuweiba on the Aqaba Gulf to provide a shorter link with the arab countries East of the Red Sea, land reclamation schemes which has started production, a modern road network which connect all parts of the Penninsula and a telecommunication network to provide a direct connection with the rest of Egypt

In Sinai, as in any other arid area, the most prominent factor which control the rythem and scope of development is the availability of water.

The Sinai Development Study, Phase I (SDS) completed in 1985 has proposed to start a large scale project for the transfer of about 1.6 billion m³/year of the Nile water by year 2000. The investment required is estimated to be more than 2.2 billion L.E., a very high cost to be borne by the limited resources of the Egyptian economy. Besides, the Nile water itself is not unlimited quantity. Egypt is approaching the full use of its share of the limited Nile water and the Water Master Plan has proposed several schemes for water conservation and water re-use to meet the expected shortage by the turn of the century. More over, from the national point of view, it is more economical to use the Nile water in reclamation of land closer to the Nile Valley and the Delta and to limit water transfer to Sinai to minimum by exploitation of all possible water resources within the Penninsula.

To this end it is most imperative to study and evaluate all available water resources in the Sinai Penninsula through a comprehensive and aystematic analysis of all water related data. The aim is to reach the most economical scheme for water supply to the development of Sinai. The present requested study addresses this subject of preparing a water resources map and water development plan for all water resources in Sinai Penninsula.

II. THE STUDY AREA

Fig.1 shows the map of Sinai and its location in Egypt and Fig.2 shows the orientation showing contours, the administrative governorates and the five subregions as recommended by SDS.

From the administrative point of view most of the area of Sinai is divided between the two governorates of North and South Sinai, but the western strip along the Suez Canal has 3 parts which belong to the respective governorates on the west of the Canal. These Governorates are Port Said at the North, Ismailia at the Middle and Suez at the tip of the Suez Gulf.

III. WATER DEMAND AND WATER POTENTIAL

The Sinai Development Study - Phase I after considering various alternatives has proposed a recommended strategy for the development of Sinai. This strategy aims at increasing the population of the Penninsula from the current population of less than 200,000 to one million by year 2000. In late 1981 water use in Sinai was approximatly 115,000 m³/day, of this total 46,300 m³/day consisted of groundwater. The study estimated the water

requiements to be in the range of 4.7 million m³/day by year 2000.

The proposed development is based on a solid base of resources within the Sinai Penninsula which can be summarized as:

1- Reclaimable land for agriculture with estimated area of about 700,000 feddan and suitable lands for grazing and livestock.
2- Large mineral deposits including oil, kaolin, manganese, copper, high silica glass sand, turquoise, gold, salt, coal, iron, gypsum, and others. Fig.3 shows the principal known minerals and potential exploration areas.
3- Fisheries in Lake Bardawil and fish farms along the Mediterranean and the Red Sea coasts.
4- Industrial potential using the available minerals and supported by the proximity to possible markets in Egypt and the Midde East.
5- Touristic wealth on its beaches or above its mountains.

Although the SDS has proposed to fulfill most of the water requirements by transfering water from the River Nile, the cost involved and the limitations of the Nile water necessitate to exploit all other water resources Sinai. The following is a brief account of the water resources of the Sinai Penninsula.

a) Rainfall

The annual average rainfall varies for the different regions of Sinai from a low of between 22 to 40 mm/year in the central uplands and the South West region to the highest of 304 mm/year at the North-East tip of the Penninsula at Rafah. Desert areas such as Sinai exhibit a great variability of yearly rainfall. In Sinai, it is commonly held that large floods or torrents occur about once every five years. Because of such concentrated rainfall, the water is not rapidly evapourated but find its way either to ground layers or as rapid runoff. The latter can be collected and used by the construction of dams, etc.

Diurnal mist and dew are noticed to be sufficiently heavy in some high mountain valleys to be supporting some economic grazing. No sufficient data is available for this water source, and more investigations is required in this field.

b) Surface Water

According to SDS, seven dams exist in Sinai to collect the runoff

water. Due to the lack of measured data, no concrete estimation of the quantity of the runoff water was made. The present requested study will fill this gap by providing equipments to measure the runoff water and study of the existing dams. The study will lead also to proposing new sites for other dams and their specifications. The study will also deal with the development of runoff farms and water spreading agriculture. Reservoir siltation will also be an important item in the requested study. Fig.4 shows the hydrographic basins, existing dams and possiple dam sites.

c) Groundwater

The SDS has estimated that the available groundwater potential to be in the range of 700,000 m³/day, but admits that this is an extremely crude approximation. The SDS points up to the urgency of performing a carefully formulated exploratory well drilling and aquifer testing program to reach more definite conclusions about the usability of the different available aquifer. This is in fact the main task of the present requested study.

d) Desalinization

Desalinization is used in Sinai to decrease the salt content in the pumped groundwater. The systems in use for desalinization are the reverse osmosis and the electrodialysis. Sinai has 900 Km of coast line and year round solar availability in its most areas. New methods for using solar energy in desalinization should be studied especially for remote high profit touristic projects.

IV. PREVIOUS AND CURRENT STUDIES

1. Sinai Development Study - Phase I (SDS)

Completed by Dames & Moore and financed by the USAID for the Ministry of Development, this study was the first detail study for the development of Sinai. The study has proposed a strategy for the settlement of Sinia and defined economic and investment plans, 1983-2000. The Study gave an account of the land and environment of Sinai and provided a data book of all available data.

The study used the available data to make cost estimates for the different water schemes. It recommended further studies to fully assess the potential of water resources in the Penninsula.

2. North Sinai Integrated Rural Development Project

The study, which will start in the near future, is financed by JICA of Japan. It will cover the Northern narrow strip linking Port Fuad, Qantara and El Arish with an area of about 500,000 feddan inclusive of 180,000 feddan of Lake Bardawil. The study will establish an integrated agriculture, fisheries, industrial and tourism development in the said area. The agriculture development will make use of the water planned to be transferred from River Nile through El Salam Canal.

3. Integrated Rural Development Project for Sinai Northern Uplands

Expected to be financed by the Italian Government, the project which is planned to extend for three years will establish a multipurpose development center, deal with studies of groundwater and establish a pilot farm of 5,000 feddan at El Naghara, El Halal and Yelleq areas.

4. Study on the Development Plan of Suez Bay Coastal Area

Completed by JICA in 1986, the study area covered the part of the Suez Governorate on the Sinai side of the Suez Gulf. The study recommended resort development at Ras Sudr and industrial development at North Ayun Musa, ..

5. Other Related Studies

a) Water resources development in Wadi El Arish Basin.
b) Development of Northern Sinai (financed by EEC)
c) Development of Southern Sinai (expected financing by EEC)
d) Installation and observation of meteorological station and runoff gauges by the Research Institute for Water Resources.
e) Drilling, testing and observation of 62 test wells and observation wells by the Research Institute for Water Resources.

V. THE ORGANIZATION IN CHARGE OF THE STUDY

The Research Institute for Water Resources (Water Research Center, Ministry of Irrigation) is in charge of study, planning and execution of water development projects in Sinai. The Institute will be the Egyptian counterpart for the requested study. Assistance and colaboration from the Research Insitute for Groundwater, the Desret Research Institute and the Geological Survey Department will be solicited whenever necessary. Other related organizations are:

a) Ministry of Development
b) Ministry of Land Reclamation
c) North Sinai Governorate
d) South Sinai Governorate
e) Port Said Governorate
f) Ismailia Governorate
g) Suez Governorate

VI. OBJECTIVES OF THE STUDY

The objectives of the study are:

1. Prepare a comprehensive data base by collecting, storage and processing of all available data related to water resources in the Sinai Penninsula. The Study will fill the gaps of the existing data by collecting further detailed informations.
2. Prepare an integrated water resources map for both groundwater and surface water.
3. Prepare a short term water development plan, including general specifications for urgent projects.
4. Prepare a long term water resources comprehensive plan.
5. Insure technical transfer and training of the national staff on hydrological mapping techniques

VII. SCOPE OF WORK

1. The Data Base
   a- Data collection
      a-1 All available reports related to water resources in Sinai and related areas.
      a-2 Geological and geophysical data
      a-3 Water level and water quality data
      a-4 Climatological data
      a-5 Runoff data
      a-6 Areal photographs
   b- Data processing and storage
      The collected data will be processed and stored on a computer compatible with the National Water Resources Data Base of the Research Institute for Ground Water, Ministry of Irrigation.

c- Supplementing of additional data

c-1 Collecting data from the existing network of climatological stations, runoff gauges and observation wells.

c-2 Installation and monitoring of measuring equipment to fill the gaps of the available data with the aim of having a complete and uniform data base for all parts of the study area.

c-3 Conduct field work related to surveying by geophysical and other means some areas for investigation of the stratigraphy of the geological formations.

c-4 Completion of the geological map of scale 1:100,000 using areal photos and field checks.

2. The Water Resources Maps

a- Preparation of the base maps

The data stored in the data base will be used to prepare the base maps using the existing topographical maps.

b- Preparation of the interpretation maps

Using the base maps and supporting calculations, the interpretation maps will be prepared, they include:

b-1 Isopiezometric contour maps

b-2 Depth to water table maps

b-3 Isopach maps for each productive layer

b-4 Climatological maps

b-5 Water quality maps

b-6 Geological structure maps

b-7 Well inventory maps

b-8 Others

c- Preparation of the water resources map

The water resources map which is a combination of the hydrogeological map and a surface water map will be prepared using international legend.

3. The Short Term Water Development Plan

Based on the currently available data and the existing water demand, the study will prepare alternative schemes of water supply and conduct cost analysis and economic evaluation for the urgent water development projects. The output will constitute of a detailed list of the urgent projects together with their general specifications to enable immediate implementation.

4. The Long Term Water Resources Plan

After the completion of the water resources map, a detailed analysis of the long term water demand based on the development strategy suggested by the SDS and making use of all available water resources, a comprehensive water resources plan including cost analysis, economic evaluation and implementation plan will be prepared.

5. Study of Specific Tasks

a- Study of the diurnal mist and dew with the aim of evaluating their potential and use.

b- Study of runoff farms and suggeting their possible locations, candidate crops and study their economic viability.

c- Study the siltation problems of existing and future dams.

6. Technical Transfer and Training Program

To be agreed upon after consultation between the concrned parties.

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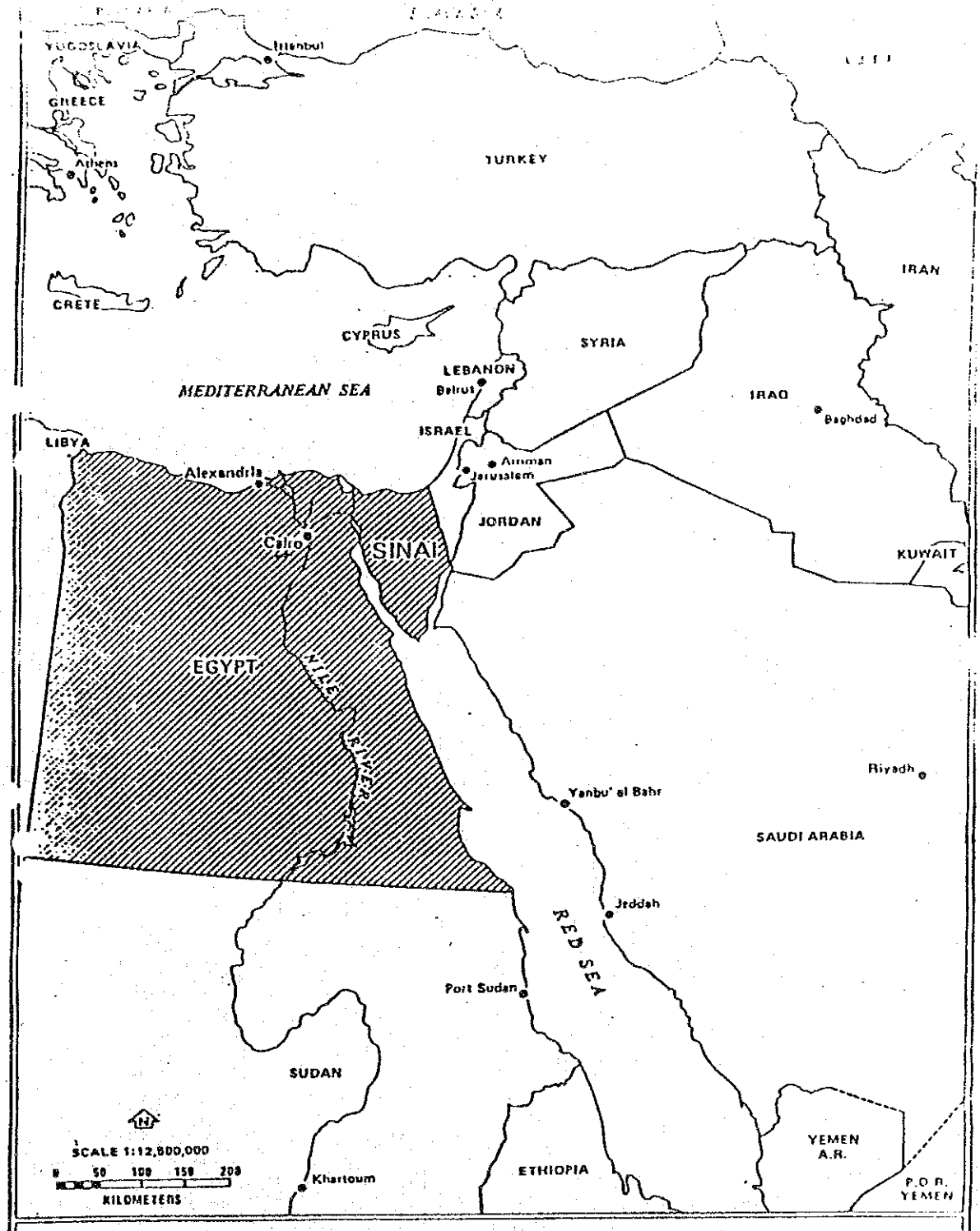

FIGURE 1
LOCATION MAP

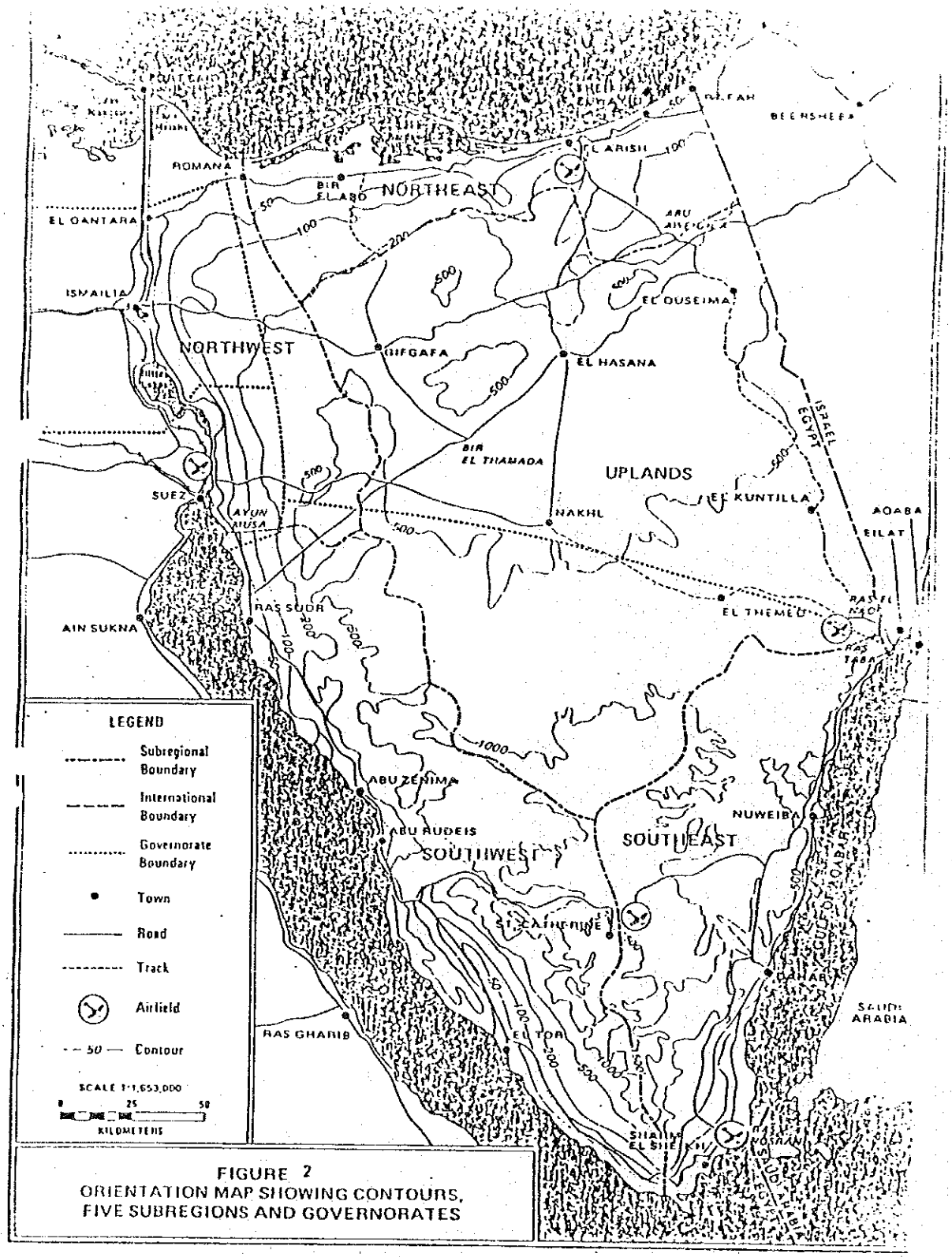

FIGURE 2
ORIENTATION MAP SHOWING CONTOURS, FIVE SUBREGIONS AND GOVERNORATES

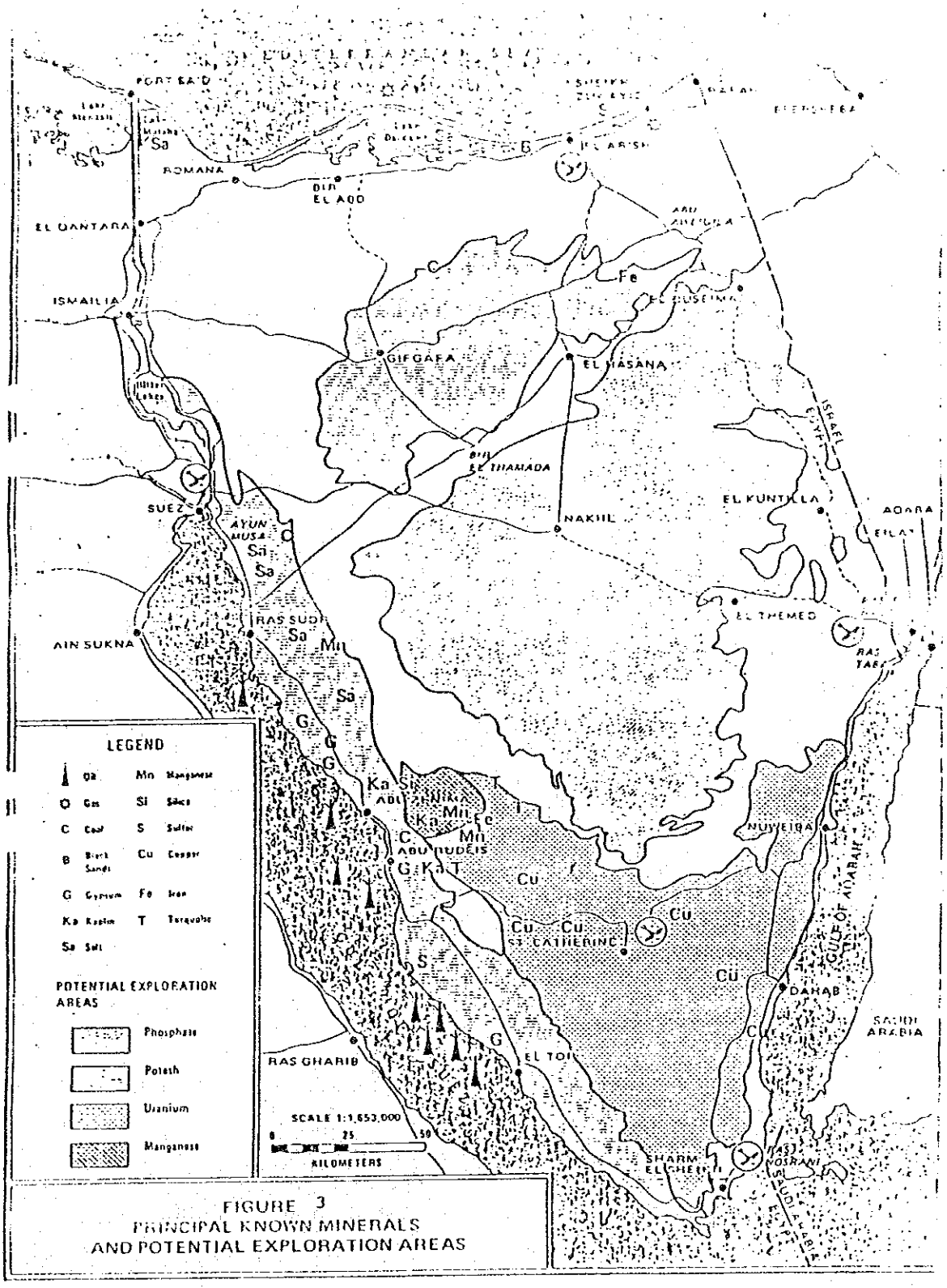

FIGURE 3
PRINCIPAL KNOWN MINERALS
AND POTENTIAL EXPLORATION AREAS

2. 現地収集資料リスト（年代順）

＜報告書等＞

(1) Rift Valleys Afro－Arabian, p.355－407, Ed. by A.M. Quennell, Hutchinson Ross Publ. Comp. (1960)

(2) Geophysical Investigations for Groundwater in Maghara Area Northern Sinai, by Geological Survey Egypt (1967)

(3) Landforms of Eqypt, by M.S. ABU AL－IZZ, The American University in Cairo/ Press

(4) Sinai Water Resources Study Final Report, Min. Irrigation, RIWR (1983)

(5) エジプト・アラブ共和国シナイ半島，エル・アリシュ流域水資源及び農業開発計画事前調査報告書（昭和58年），ECFA

(6) エジプト・アラブ共和国シナイ半島ワジ・エル・アリシュ流域水資源及び農業開発計画事前調査報告書（昭和59年）ADCA

(7) Preliminary Report on Development Strategy for Water Resources and Agriculture in Wadi El Arish Basin in Sinai, The Arab Republic of Egypt, by SANYU CONSULTANTS INC. (1984)

(8) Sinai Development Study Final Report, by DAMES & MOORE (1985)

Vol. Ⅰ A Strategy for the Settlement of Sinai

Vol. Ⅱ Managing Sinai's Development

Vol. Ⅲ An Economic Development and Investment Plan, 1983 to 2000

Vol. Ⅳ The Land and the Enviroment of Sinai

Vol. Ⅴ Water Supplies and Costs

Vol. Ⅵ Settlement and Social Development

Vol. Ⅶ Sinai Data Book

(9) International Legend for Hydrogeological Maps－Revised preliminary version, 1983－, UNESCO－IAH－IAHS, Vol.7 (1985)

(10) Final Report on Geophysical Studies on Groundwater at Norsthern and Central Sinai, by The Egyptian Geological Survey and Mining Authority

(11) Federation of Egyptian Industries Year Book 1984/1985

(12) Statistical year Book, by Central Agency for Public Mobilizstion and Statistics (1987)

(13) Population, Housing, and Establishment Census 1986 by Central Agency for Public Mobilization and Statistic (1987)

(14) Groundwater Management Study in El－Arish Rafaa Plain Area Phase Ⅰ Interim

Report, by Cairo Univ, and RIWR

(15) Technical Report Well No. UNS−2 Al Hassana, by UNICEF Assisted Drinking Water Supply Project, North Sinai Governorate

(16) Report on Progress and Planning of Sinai Water Resources Study, Egypt by British Geological Survey (1987)

(17) Sinai Water Resources Study : Project Assessment by British geological Survey (1987)

(18) Sinai Water Resources Study (Phase Ⅱ) external consultant services technical proposal, by BRGM (1988)

(19) Water Source Point Information Card

＜図 葉 等＞

(20) Geological Map of Egypt (1981) : Scale 1 : 2,000,000 by The Egyptian Geological Survey and Mining Authority

(21) Geological Map of Sinai (1987) : Scale 1 : 1,000,000 by RIWR

(22) Hydrogeological Map of the Az Zaqaziq−Al Ismailiyah Area, Egypt : Scale 1 : 100,000 by Research Institue for Groundwater

この他の重要資料として次のものがある。これらは事前調査の段階では全てのコピーをとることができなかったものである。

——Gebel El Maghara Rural Development Project, Hydrogeological Studies Final Report, Rome, by Foster Wheeler Italiana (1988)

——Map Portfolio, Sinai Development Study, Phase I, Draft Final Report (1983)

とくに，Map Portfolio は全部で88シートからなるシナイ全域の基図，地形，気象，環境，水文地質，マスタープランからなり，本格調査において極めて有用な資料である。

3. 面会者リスト

(1) 国際協力省（Ministry of International Cooperation）

Mr. Saad Mohamed Bayoumi	Under Secretary
Mr. Hamed Moustafa	Director of Asian Section
Mr. Mohsen Sadek	Staff of Asian Section

(2) 開発省（Ministry of Development）

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Eng. Hassan Bayoumi	Acting Director, Field Office El Arish
Eng. El Shinnaw Ibrahim	Geologist, Field Office El Arish
Eng. Moustafa Lafty	Geologist, Field Office El-Tor(Nuweiba駐在)

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Gen. Shash	Governor
Mr. Mohamed Kouray	Manager of Production and Economic Development

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Dr. M. Samir Farid	

(8) シナイ開発庁（Sinai Development Authority）

General El Qatury	Chairman

(9) Nuweiba City

General Ahmed Nagi	Chief, City of Nuweiba

(10) El－Naqb

Colonel Taha	Chief, Naqb Town

(11) UNICEF シナイプロジェクトオフィス

Eng. Mohamed El Shawzly	Project Manager（N. Shinai Governor afe）
Mr. Magdy	Representative

(12) EEC ヨーロッパ共同体 カイロ事務所

Mr. Antony Kirk	Technical Project Dept.

(13) Bureau de Recherches Geologiques et Minieres（BRGM フランス地質鉱山研究所）

Mr. J.R. Daum	Senior Hydrogeologist （EEC プロジェクト Coordinator）

(14) Jobel EL Maghara Rural Development Project

Mr. Orlando Ingola	Assistant Resident Manager （Foster Wheeler Italiana プロジェクト コンサルタント）

(15) The General Company for Research and Ground Water
（REGWA 国営ボーリング会社）

Mr. Mahmoud El－Hamahmy	Technical Director

(16) National Egyptian Drilling and Petrolium Services Co.（DASCO ボーリング会社）

Mr. Mahmoud Abd El Hamid

(17) 在エジプト日本大使館

井上 進	一等書記官
高嶺 彰	一等書記官

(18) JICA エジプト事務所

飯村 圭司	所 長
小森 毅	所 員

4. ボーリング見積り

対象とした調査会社は，RIWRからの推薦があった以下の3社であり，特に，REGWA，DASCOの2社が，シナイ半島においても深層ボーリングの実績を多くもつ。また，ACDについては，調査期間中に回答を回収することはできなかった。

(1) THE GENERAL COMPANY FOR RESEARCH AND GROUND WATER (REGWA)

Adress：19 Emad EL din St. Cairo, Egypt

Tel ：934644－934506

(2) NATIONAL EGYPTIAN DRILLING & PETROLIUM SERVICES CO. DASCO

Adress：13 Swiss Co. St., NEW MADOI, Cairo, Egypt

Tel ：3531228－3531229

(3) ARAB CONTRACTING FOR DRILLING

Adress：18, St. No. 5, Area 4, El Merghani, Heliopolis, Cairo, Egypt

結果としては，REGWAからの回答が1988年前半部にRIWRから受注した時の提示見積であり，DASCOからは，全長3,200mに対しての1988年8月時点での見積り価格であった。

これらの見積りに基づいて，各項目ごとに概算単価を求めると，別表のとおりとなる。

しかし，REGWA，DASCOからの聞き取り調査によると，予定価格の設定には以下の2点に注意する必要がある。

① ここ数年間，エジプトのインフレ率は20～25%/年程度であり，全般的な工事価格もこの影響を受けるものと考えられる。

② とくに，スクリーン，ケーシング等の材料については日本等から輸入している場合が多く，'87/'88の間に35～40%の値上がりがあった。

また，エジプト国内の資材調達については，輸入材料もしくはその加工品は遅れる場合も考えられるため，スクリーン，ケーシング等の材料について，日本側からの直接持ち込みを検討する必要があろう。

提出見積りの単価による概算工事価格

(DASCO)

1.	材　料	525,000	175 LM/m × 3,000
2.	移　動	65,000	
3.	掘　削	540,000	180 LM/m × 3,000
4.	検　層	99,000	33 LM/m × 3,000
5.	揚水試験	72,000	8,000 LM/個 × 9
6.	仕上げ	45,000	5,000 LM/個 × 9
	計	LE 1,346,000	

(REGWA)

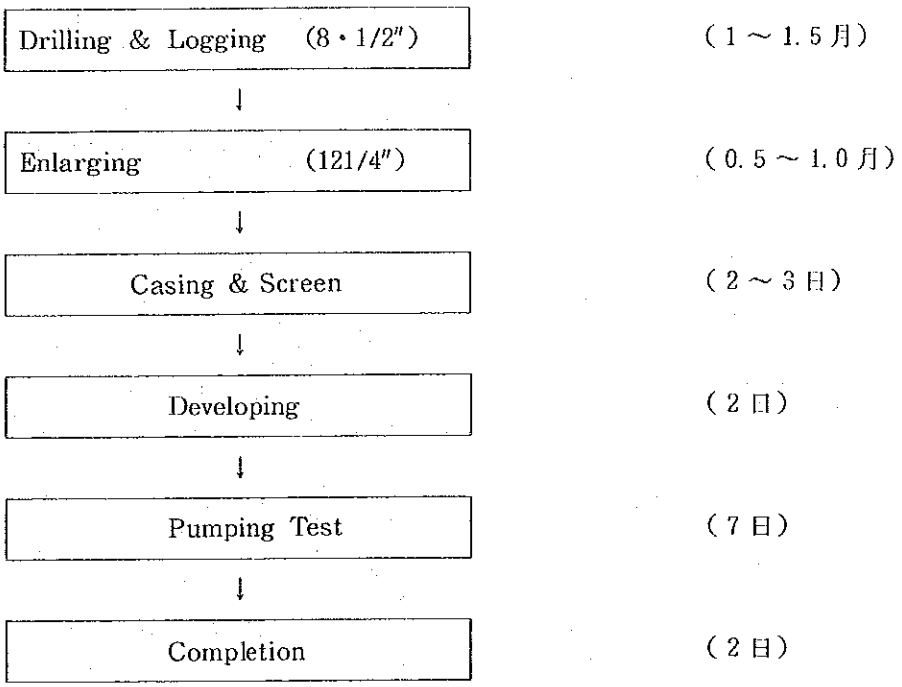
1.	材　料	614,400	250 × 30 m × 4本 180 × 2,530 m 300 × 350 m 6,000 × 4
2.	移　動	75,000	30,000 + 5,000 × 9
3.	掘　削	438,000	146 × 3,000
4.	検　層	66,000	22 × 3,000
5.	揚水試験	18,000	2,000 × 9
6.	仕上げ	33,750	3,750 × 9
	計	LE 1,242,150	

ただし，スクリーンはステンレスであり，総延長350mを見込む

各単価ごとの比較		
項　　目	DASCO	REGWA
材　　料	LE 560,000/9well=3,000m incl. Casing. Scream Adapter, Welding Connection, Water Bentnite	ドライブパイプ　LE　250/m ケーシング　LE　180/m スクリーン　LE　300/m ハンガー　LE 6,000/m
移　　動	LE 65,000/9wells=3,000m Accmodation of Tent, Car for Worker Staff	(1) 800m級　5カ所で 30,000+5,000×5
掘　　削	LE 180/m	(2) (3) (5) LE 146/m
検　　層	LE 33/m	(4) LE 22/m GR, SP, Res, Cal を含む
揚水試験	LE 8,000/well	(14) LE 2,000/well
仕　　上　　げ	LE 5,000/well	(11～13) LE 3,750/well

1. REGWA内の（　）については，提出書類上で該当する項目。
2. 揚水試験等，内容について完全に一致していないため注意を要する。

工　　程



しかし，深層ボーリングを行う場合，地層状況に大きく影響され，各現場ごとに工事に要する日数は大きく変わってくる。

例えば，コンタクト・ミッション時に現地調査を行った UNISEF の現場では同じ1,000m のボーリングに対して6カ月程度の期間を要した。

予定期間の検討にあたっては，材料の運搬等の準備も含めて十分な余裕をみていくことが肝要である。

ＲＥＧＷＡ　参考見積り日本語訳
１９８８年前半工事価格としてＲＩＷＲに提出したもの
－井戸数　５　本
－平均掘削～８００ｍ

項　　目	単　位	数　量	単位(L・E)	価 格(L・E)	備　　考
1. 移動，保管費					
(Cairo→Sinai)		1	30,000	30,000	シナイ半島にて
(in Sinai)		5	5,000	25,000	保管する
2. 表層部					(ドライブパイプ)
掘　　削	m	150	150	22,500	ロータリー，30m以下コア採取，監督員込 Ø17.5
パイプ設置	m	150	250	37,500	セメント工事含 Ø13 2/8″
3. 掘　削	m	4,100	105	430,500	Ø 8.5 柱状揚水等含
4. 検　層					
GR	m	4,100	7	28,700	
SP	m	4,100	4	16,400	
Res	m	4,100	4	16,400	
Cal	m	4,100	7	28,700	
5.孔の拡張	m	3,600	40	144,000	Ø8 1/2″→12 1/14″
	m	550	40	22,000	〃
6. パイプの設置 (材料込)	m	3,600	180	648,000	ガルバー Ø9 5/8″ セメント込
7. スクリーン設置 (材料込)	m	500	300	150,000	ステンレス Ø6 5/8″ (4mm)

項　　目	単　位	数　量	単価(L・E)	価 格(L・E)	備　　考
8. スクリーン・ハンガー	個	5	6,000	30,000	
9. （不　明）	m	100	280	28,000	
10. スクリーン用巻き線	m	500	—	—	必要に応じて
11. デベロッピング	回	5	5,000	25,000	
12. 表面処理	個	15	2,000	30,000	コンクリートブロック 1.5×1.5×0.5
13. 保護物の塗装 ロック	個	5 5	500 250	2,500 1,250	ブリキ箱
14. 揚水試験	箇所	5	2,000	10,000	Techniarl Report も含む
15. 土質試験	hr	10	—	—	
計				1,726,450	

الشركة العامة للأبحاث والمياه الجوفية ريجوا
(REGWA)

ملف رقم :
صادر رقم :

تحريرا فى ١٠/٨/١٩٨٨

السيد الدكتور / اكيرا كاماتا
مدير ابحاث الخزان الجوفى بشمال سيناء
هيئة المعونة الفنية اليابانية " جايكا "
٢٦ شارع القدس الشريف - المهندسين

تحية طيبة وبعد ،،

ايماءا الى كتابكم الوارد فى ١٩٨٨/٨/٢٣ بخصوص تسعير التكاليف التقديرية لحفر الآبار بشمال سيناء .

نتشرف بان نحيطكم علما بان الشركة قد تعاقدت مع معهد بحوث وتنمية الموارد لحفر ٥ آبار بشمال سيناء وان جدول البنات المرفق يعطيكم بكل البيانات المطلوبة وخاصة التكاليف الكلية وتكلفة حفر المتر وتكلفة المواد (المسرات والمصافى وأجهزة التصليب (Cine Hanger) واسعار النفر والرصد الجيوفيزيقى وتجارب الضخ مع الاخذ فى الاعتبار للتسعير :-

١ - زيادة اسعار جميع البنود من ٢٠٪ الى ٢٥٪ منها وذلك نتيجة الزيادة فى الاسعار العالمية .

٢ - زيادة اسعار المواسير والمصافى من ٣٥٪ الى ٤٥٪ وذلك نتيجة لزيادة اسعار المواسير والمصافى فى الاسعار المدرجة فى جدول البنات وقت التعاقد السابق .

٣ - اما بالنسبة لاجور العمالة فان الاجور يتم الحصول عليها من جهاز التنسيق والادارة المركزية لشئون العاملة لانها الجهة المسئولة عن تحديد الاجور للعاملين بالدولة وان الشركة هى احدى شركات القطاع العام بالدولة .

٤ - بالنسبة لايجار وحدات الحفر وملحقاتها فانها كالاتى :

أ) وحدة الحفر مرسيدس ٤٥٠٠ الدزينة لحفر بئر بعمق ١٠٠٠ متر ايجارها اليومى ١٠٠٠ جنيه مصرى فقط وقدره اربعة الاف جنيه مصرى لاغير (غير شامل المواد المستهلكة من المواسير والمصافى)

ب) وحدة الحفر مرسيدس ٢٥٠٠ الدزينة لحفر بئر بعمق ٤٠٠ - ٤٥٠ متر ايجارها اليومى ٢٦٠٠ جنيه مصرى وقدره " ثلاثة الاف وستمائة جنيه مصرى لاغير " .

(غير شامل المواد المستهلكة من المواسير والمصافى)

يتبع / ٢

القاهرة : ١٩ شارع عماد الدين - برقيا : " ريجوا - القاهرة " - ص.ب : ٧٤٧
تليفون : ٩٣٤٦٤٤ - ٩٣٤٥٠٦ - تلكس U.N.٩٣٧٦٢
الخرطوم : ص.ب : برقيا : " ريجوا الخرطوم " - تليفون : ٨٠٩٣٧ - ٧٣٤٧٤
طرابلس : ص.ب : ٣٠٥٥ برقيا : " ريجوا - طرابلس " - تليفون :

ملف رقم : .....
صادر رقم : .....

تحريرا فى ٢٧ / ٨ / ١٩٨٨

(٢)

جـ) وحده حفر فيلتر ١٥٠٠ اللازمة لحفر بئر بعمق ١٠٠ متر ايجارها الشهرى ٢٠٠٠ جنيه مصرى لاغير " فقط وقدره الفان جنيه مصرى لاغير " غير شامل الضريبة المضافة

٥ - مرفق برنامج زمنى لحفر الابار المقترح تنفيذها فى عمال غمينه .

وتفضلوا بقبول فائق الاحترام ...

رئيس مجلس الادارة

مهندس / صلاح الشافعى

فاطمة / أ

القاهرة : ١٩ شارع عماد الدين - برقيا : " ريجوا - القاهرة " - ص.ب ٧٤٧
تليفون : ٩٣٤٦٤٤ - ٦ ٩٣٤٥ - تلكس U.N. ٩٣٧٦٢
الخرطوم : ص.ب : ٢٠٠١ برقيا : " ريجوا كو - الخرطوم " - تليفون : ٨٠٩٣٧ - ٧٢٤٧٤
طرابلس : ص.ب : ٣٠٥٥ برقيا : " ريجوا - طرابلس " - تليفون : ٣٩١١

جدول الكميات والفئات

لعملية حفر عدد ٥ آبار عميقة في شمال وجنوب سيناء

رقم البند	بيان الاعمال	الوحدة	الكمية	الفئة	الجملة
١	نقل معدات ومهمات الحفر الى منطقة التعويمات بسيناء .	بالعدد	١	٣٠٠٠٠ عشرون الف جنيه	٣٠٠٠٠
٢	نقل معدات الحفر من منطقة الى اخرى كما هو مبين بالخريطة المرفقة .	,,	٥	٥٠٠٠ خمسة آلاف جنيه	٢٥٠٠٠
٣	الحفر بقطر ١٧ ١/٢ بوصة بطريقة الحفر الدوراني بالمواقع الموضحة بالخريطة المعتمدة وبعمق لايزيد عن ٣٠م من سطح الارض وحسب تعليمات المهندس المشرف والفئة تشمل ومحمل عليها اخذ عينات التربة والمياه وحسب المواصفات والاشتراطات .	م.ط	١٥٠	١٥٠ مائة وخمسون جنيه	٢٢٥٠٠
٤	توريد وتركيب مواسير تغليف ١٣ ٣/٨ بوصة وتغليفها بالاسمنت من السطح حتى عمق ٣٠م	,,	١٥٠	٢٥٠ مائتان وخمسون جنيه	٣٧٥٠٠
٥	حفر الجة بقطر ٨ ١/٢ بوصة حتى العمق النهائي للبئر وحسب التعليمات والاشتراطات	,,	٤١٠٠	١٠٥ مائة وخمسة جنيه	٤٣٠٥٠٠
٦	اجراء التسجيلات الجيوفيزيقية الاتية وحسب الاشتراطات والمواصفات مع تحليل النتائج :				
	أ) اشعة جاما GR.	,,	٤١٠٠	سبعة جنيهات	٢٨٧٠٠
	ب) الجهد الذاتي SP.	,,	٤١٠٠	اربعة جنيهات	١٦٤٠٠
	ج) المقاومة Res.	,,	٤١٠٠	اربعة جنيهات	١٦٤٠٠
	د) قطر الحفر Cal.	,,	٤١٠٠	سبعة جنيهات	٢٨٧٠٠
٧	توسيع الجة في بند(٥) من قطر ٨ ١/٢ بوصة الى ١٢ ١/٤ بوصة وحسب التعليمات والاشتراطات وطبقا لنتائج الحفر والتسجيلات الجيوفيزيقية .	,,	٣٦٠٠	اربعون جنيه ٤٠	١٤٤٠٠٠

تابع جدول الكميات والفئات

لعملية حفر عدد ٥ آبار عميقة فى شمال وجنوب سيناء

بيان الاعمال	الوحدة	الكمية	الفئة	الاجمالى
٨ توريد وانزال وتركيب مواسير ٩ ٥/٨ بوصة [illegible] بالأسمنت مع استخدام مركزات .	م.ط	٣٦٠٠	١٨٠ مائة وثمانون جنيه	٦٤٨٠٠٠
٩ توسيع الجسه بعد (٥) من قطر ٨ ١/٢ بوصة الى قطر ١٢ ١/٤ بوصة (under Reaming)	م	٥٥٠	٤٠ اربعون جنيه	٢٢٠٠٠
١٠ توريد وانزال مصافى ٦ ٥/٨ بوصة من الصلب المجلفن وحسب الشروط والمواصفات X	م	٥٠٠	٣٠٠ ثلاثمائة جنيه	١٥٠٠٠٠
١ جهاز تعليق المصافى	الوحدة	٥	٦٠٠٠ ستة آلاف جنيه	٣٠٠٠٠
١ توريد وانزال مواسير قطر ٦ ٥/٨ بوصة حسب الشروط والمواصفات .	م.ط	١٠٠	٢٨٠ مائتان وثمانون جنيه	٢٨٠٠٠
ف المصافى بحصى من السلك المجلفن (اذا لزم الامر) XX	"	٥٠٠	—	—
... البئر واعداده للانتاج حسب المواصفات والفئة يحمل عليها توريد ... الى البئر وجميع المعدات والمواد المستعملة .	الوحدة	٥	٥٠٠٠ خمسة آلاف جنيه	٢٥٠٠٠
... عينات لبية استراتيجية طبقا للشروط والمواصفات وحسب تعليمات المهندس المشرف ... ملاطة خرسانية حول مواسير سطح ... مقاس ٠,٥×١,٥×١,٥ متر مع اغلاق المواسير بالطبات القلاووظ اللازمة لقفل	"	١٥	٢٠٠٠ الفان جنيه	٣٠٠٠٠

X السعر المقدم للمصافى صلب مجلفن للمواصفات ... حسب المواصفات وشروط العطاء ...

XX موضح فى شروط الشركة بند رقم ١٣

تابع جدول الكميات والفئات

لعملية حفر عدد ٥ آبار عميقة فى شمال وجنوب سيناء

رقم	بيان الاعمال	الوحدة	الكمية	الفئة	الاجمالى
	البئر وحسب الشروط والمواصفات وتعليمات المهندس المشرف	بالعدد	٥	٥٠٠ خمسمائة جنيه	٢٥٠٠
١٧	تصنيع وتركيب صندوق من الصاج مع دهانه وتركيب قفل عليه وذلك طبقا للمواصفات والشروط .	"	٥	٢٥٠ مائتان وخمسون جنيه	١٢٥٠
١٨	اجراء تجارب الضخ على الآبار التى يصير تحويلها الى آبار انتاجية حسب المواصفات والاشتراطات مع تقديم التقارير الفنية عنها ويصير تحديد عددها حسب تعليمات المعهد .	"	٥	٢٠٠٠ الفان جنيه	١٠٠٠٠
١٩	اختبار الطبقات الحاملة للمياه حسب تعليمات المعهد . X	بالساعة	١٠	(X) —	—
	الاجمالى (فقط مليون وسبعمائة وستة وسبعون جنيه لاغير)				١٧٧٦٤٥٠
	العبرة بما يتم تنفيذه من أعمال .				

X موضح بالشروط الخاصة بالبند بجدول رقم (٢٥٠٩)

بسم الله الرحمن الرحيم

NATIONAL EGYPTIAN DRILLING
& PETROLIUM SERVICES
CO. DASCO

تقدم الوفد ليابان
١٩٨٨/٨/٢٨

REF. 32/B2/88

August 28th., 1988.

TO : JAPAN INTERNATIONAL COOPERATION AGENCY
26, EL Kods El Sharif Str., Mohandiseen,
Cairo.

Dear Sirs,

With reference to your letter dated 23/8/1988 please find attached with the cost estimate for test drilling of the North Sinai ground water resoures study detailed as required by your letter.

In case of any further questions are required ; please do not hesitate to contact us.

We will be pleased to have the chance to quote for the Job when ever needed.

Best regards.

M. I. BADAWI
MANAGING DIRECTOR

MS/ei

13 SWISS CO. ST., NEW MAADI - CAIRO TEL.: 3531228 - 3531229 TELEX: 20128 DASCO UN
P.O. Box : 87 EL MAADI - Code No. : 11742

NATIONAL EGYPTIAN DRILLING
& PETROLIUM SERVICES
CO. DASCO

担当 : Md. MAHMOUD Abd. El. Hamid

(1) WEEL CONSTRUCTION :

A- Total cost for works LE. 576,000

B- Cost of materials for well construction LE. 560,000
C- Mobilization / demobilization LE. 65,000
D- Unit cost for drilling of wells per one meter LE. 180
E- Cost of geophysical Logging for one meter LE. 33
F- Pumping test LE. 8000/well
G- Well completion LE. 5,000 /well

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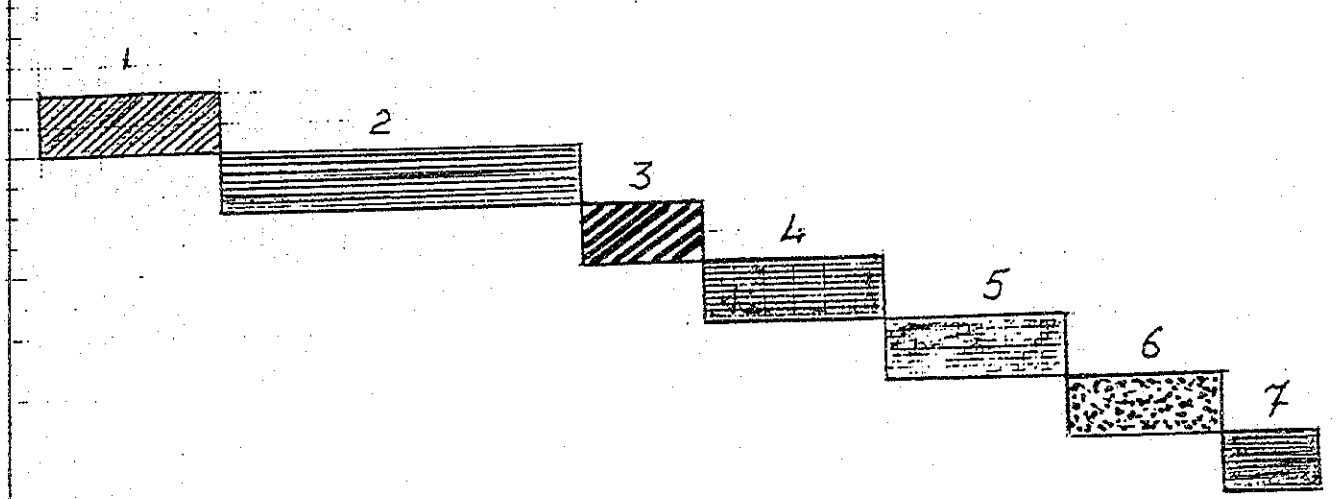
(2) WORK SCHEDULE



1- Mobilization.,.
2- Drilling 8½" hole.
3- Geophysical logging.
4- Reaming to 12 1/4" hole.
5- Installation of casing and screen.
6- Development and pumping test.
7- well completion.

(3) LIST OF EQUIPMENTS :

1- Drilling rig = 500 mt. capacity complete with drill string handling tools, mud pump, water truck, power machines...etc.

2- Drilling rig - 1300 mt. capacity complete with drill string,handling tools, mud pumps, water trucks, power machines...etc.

3- Air compressor 25 bar/ 700 - 800 CFM.

4- Submersible pumps with H = 300-500m
Q = 50 -60 m^3/hr.

5- Logging unit - capacity 1000m.

13 SWISS CO. ST., NEW MAADI - CAIRO TEL. : 3531228 - 3531229 TELEX : 20128 DASCO UN
P.O. Box : 87 EL MAADI - Code No. : 11742

بسم الله الرحمن الرحيم

الشركة الوطنية المصرية للحفر والخدمات البترولية
ش. م. م. DASCO - S. A. E.

نبذه عن تاريخ الشركة :

الشركة الوطنية المصرية للحفر والخدمات البترولية " داسكو " شركة مساهمة مصرية تعمل فى مجال حفر آبار المياه الجوفية وجميع الاعمال المتعلقة من دراسة وأبحاث وأعمال صيانة وتوريد وانزال مضخات ، ايضا بها قسم خاص للاعمال المدنية متخصص فى انشاء الخزانات العلوية للمياه .

تأسست الشركة عام ١٩٨٣ ومقرها الحالى ١٣ شارع الشركة السويسرية المعادى الجديدة - القاهرة .

أقسام الشركة :

١) قسم الحفر :

ويضم القسم أربعة وحدات حفر حديثة " نظام الحفر الرحوى " ويمكن حفر أعماق تصل الى ٥٠٠ متر .

وحدات الحفر مجهزة للعمل فى جميع المناطق وتحت جميع الظروف .

٢) قسم الدراسات الفنية :

ويضم مجموعة متخصصة فى مجال الجيولوجيا والهيدرولوجيا والجيوفيزياء لاجراء جميع الدراسات المتعلقة بأعمال المياه الجوفية والرصد الكهربائى .

٣) قسم الاعمال المدنية :

خاص بالاعمال المدنية المتعلقة بأنشاء الخزانات العلوية والارضية للمياه ومد خطوط الصرف .

٤) قسم الخدمات والصيانة :

ومقره الحالى مدينة ٦ اكتوبر - المنطقة الصناعية - لغرض خدمة وصيانة جميع معدات الشركة .

١٣ شارع الشركة السويسرية - المعادى الجديدة - القاهرة - ت : ٣٥٣١٢٢٨ - ٣٥٣١٢٢٩ - تلكس : ٢٠١٢٨
ص ب : ٨٧ المعادى الجديدة - الرمز البريدى : ١١٧٤٢

انجازات الشـــركة :

١) تنفيذ مشروع حفر وانشاء عدد ٦٠ بئر لاعماق تصل الى ٢٠٠ متر لحساب معهد بحوث تنمية الموارد المائية فى جنوب ووسط وشمال سيناء لغرض دراسة واستكشاف الطبقات الحاوية للمياه .

٢) حفر عدد ١٥ بئر بمنطقة شمال سيناء ووادى العريش بغرض الدراسة وتابعة لمعهد بحوث تنمية الموارد المائية .

٣) حفر عدد ١٠ آبار بمنطقة جنوب سيناء ايضا بغرض الدراسة والاستكشاف (منطقة نويبع) لمعهد بحوث تنمية الموارد المائية .

٤) تنفيذ مشروع تنمية مياه الشرب بمحافظة البحيرة لحساب الهيئة القومية لمياه الشرب والصرف الصحى ويضم المشروع تنفيذ عدد ١٧ محطة متكاملة على مستوى محافظة البحيرة ، وتضم كل محطة عدد ٢ بئر بعمق يتراوح من ٥٠ الى ٧٠ متر وخزان علوى بسعة تتراوح من ١٠٠م٣ الى ١٣٠ م٣ ايضا تنزيل وتوريد المضخات الغاطسة الخاصة ، والاعمال الكهربائية الخاصة بالمشروع .

٥) حفر وانشاء عدد ٥٢ بئر بمنطقة صحراء بلبيس بغرض استصلاح الاراضى التابعة لجمعية بين المطاريـــن .

٦) حفر وانشاء أكثر من ٣٠ بئر بأعماق تصل الى ٢٠٠ متر شرق وغرب طريق مصر الاسكندرية الصحراوى لغرض استصلاح الاراضى لصالح عدد من جمعيات الاستصلاح .

٧) تنفيذ مشروع دندرة لغرض تخفيض منسوب المياه لحماية الاثار الفرعونية لحساب الهيئة المصرية العامة للاثـــار .

٨) حفر وانشاء أكثر من ١٥٠ بئرا خاص بالاهالى وجمعيات الاستصلاح فى مناطق متفرقة من الجمهورية (القاهرة - بنها - أسيوط - سوهاج - كوم أمبو حلوان - مدينة السادات - المنيا - الجيزة - طريق الاسماعيلية - غرب الاسكندرية - الخطاطبة - الواحات البحرية).

٩) عقد الصيانة الدورية للابار والمضخات يجدد سنويا منذ عام ١٩٨٣ لحساب الشركة المصرية للحوم والالبان بغرب النوبارية .

١٠) حفر وانشاء آبار تصل الى ٤٥٠ مترا عمق ، لخدمة شركات البترول المختلفة فى الصحراء الغربية .

5. 価格調査結果

－この価格調査は2度にわたる事前調査時のものである。

第1回 ： 1988年 6月29日～7月13日

第2回 ： 1988年 8月22日～9月 3日

－外貨交換レートは USドル1.00＝LE（エジプトポンド）2.315である。

－現在インフレ進行中であり，1985/1986で約20％，1986/1987が約25％。

(1) 交 通

a．レンタカー

市内レンタカー会社での見積りによる。

① PEGOUT 504

運転手，保険込み，100km/日まで含む LE 73.92/日 extra 0.25LE/km

② 4WD JEEP（2,000cc 8人乗り）

運転手，保険込み，100km/日まで含む US$ 2,349/月 extra 0.30US$/km

b．ガソリン LE 0.40/ℓ

ディーゼル LE 0.15/ℓ

(2) ホテル

a．カイロ市内（ゲジラシェラトン） LE 140/日

b．ヌ エ バ（ホリディホテル） LE 35/日

c．エル・アリシュ（ヌベロイホテル） LE 49/日

(3) 人件費

a．技術者（国営企業） LE 200～1,000/月

b．ドライバー LE 800/月

c．労務者 LE 10/日

d．トラックドライバー LE 15/日

(4) 資 料

a．地 図 LE 5/シート

b．航空写真 LE 3～5/シート

(5) 機器等

a．電気タイプライター LE 1,000～1,500/台

b．冷蔵庫（中型） LE 500/台

c．エアコン LE 2,000/台

d．バッテリー（専用） LE 100～ 200/台

(6) 資機材

a. セメント	LE	120/t
b. サンド	LE	3/m^3
c. 砂　利	LE	12/m^3
d. ブリック	LE	55/m^3

(7) 電　話

カイロ市内	LE	0.1/6min

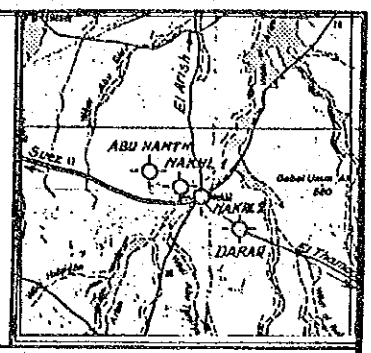
6. 深井戸地質柱状図の１例

Source : Gebel El Maghara Develoment Report (1988)

BOREHOLE N° ABU HAMTH

Owner : STANDARD OIL C° EGYPT
Driller : —
Year of completion : Before 1962
Use : Oil survey

Sheet : —
Locotion : NAKHL
Longitudine : 33° 38' 47"
Latitudine : 29° 67' 56"
Elevation : ~ 500 m



TECHNICAL DATA

Total depth : 2179 m
Casing ø = —
" ø = —
" ø = —
Screen ø = —
" ø = —
" ø = —

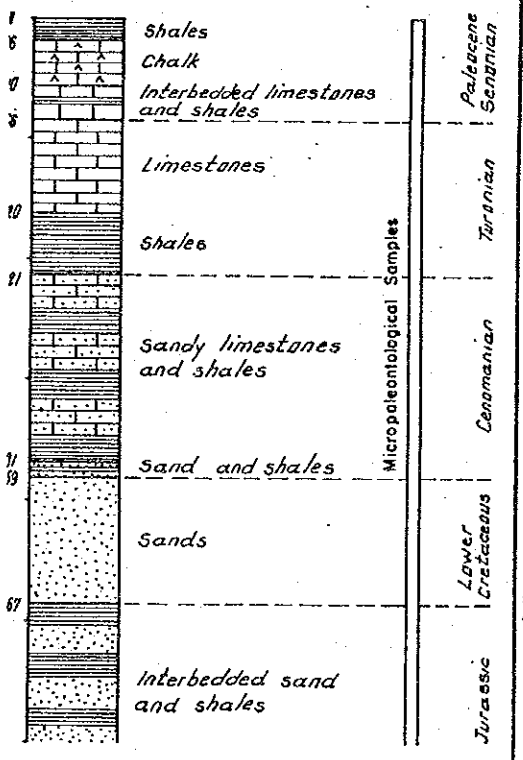
HYDROLOGICAL DATA

Acquiferous formations — nature —, depth —
Static level — date —, depth —
Pumping test — date —, rate —, drawdown —

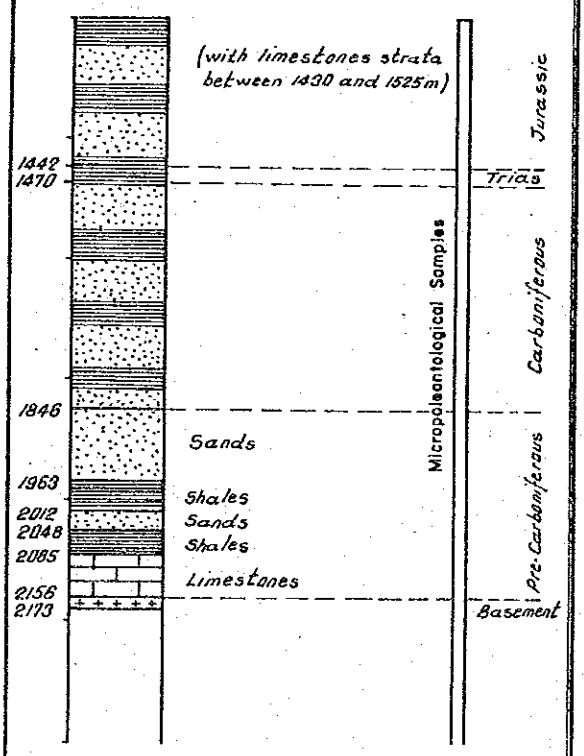
OBSERVATIONS : Data from "The Geology of Egypt Rashdi Said - Elsevier 1962"

ANALYSIS Date	EC mS	TDS ppm	Hard. °F	pH	HCO^3 ppm	SO^4 ppm	Cl ppm	Mg ppm	Ca ppm	Na ppm	K ppm

LITHOLOGICAL LOG



LITHOLOGICAL LOG



LOGS : —

Scale 1 : 10.000

7. 井戸台帳の１例

Source : Gebel El Maghara Development Report (1988)

1) WELLS AND RESERVOIRS OF BEDUINS

FWI N°	PREVIOUS N°	SHEET 1/50.000	LOCATION	TYPE	ELEVATION m	TECHNICAL DATA TOTAL DEPTH m	TECHNICAL DATA Ø m	AQUIFEROUS DEPHT m	AQUIFEROUS FORMATION	DATE	S.W.L. DEPHT -m- FWI MEASUR.	S.W.L. DEPHT -m- OTHERS MEASUR.	WATER QUALITY EC µS	WATER QUALITY Cl ppm	WATER QUALITY HARD. °F	WATER QUALITY TDS ppm	OBSERVATIONS	LITHOLOGIC LOG	CHEMICAL ANALYSIS	PUMPING TEST
B1		K1c	BIR GIFGAFA	DW	307	2,0	2,0		ALLUVIUM	6/12/87	> 2,0						PARTLY FILLED UP WITH SAND			
B2	(119 - 120) (131 - 132)	K1b	BIR THAMADA	DW	368	3,0	2,0		ALLUVIUM	(1963)	—	(2,65 + 4,00)				TDS ppm (3140 ÷ 6850)				
										10/1/88	1,65		4880	1420	79	2790				
B3		K1b	BIR THAMADA	DW	369	3,2	2,5		ALLUVIUM	(1963)										
										26/11/87	2,25		4170	950	62	2380				
B4		K1b	BIR THAMADA	DW	368	4,0	2,0		ALLUVIUM	(1963)										
										10/1/88	2,25		3120	590	55	1830				
B5	(126 - 129)	K2d	EL MASSANA	DW	229	(8)	(2)		CHALK	(1963)		(4,2÷5,5)	(6800 ÷1400)				GROUP OF 6 WELLS			
						"8"	"2"			"1981"						"4500"				
						6	2			26/11/87	5,03		12160	2800	266	6950				
B6	(130)	K2d	EL MASSANA	DW	225	-	-		ALLUVIUM	(1963)		(4,59)	(5050							
						"10,0"	-			"1981"						"1500 3000"				
						5,0	2			26/11/87	4,80		4460	990	91	2550				
B7		K2d	BIR METHETNEY	DW	245	1,5	1,5			14/1/88	> 1,5						PARTLY FILLED UP WITH SAND			
B8		K2d	BIR ASHAIDA	DW	245												PARTLY FILLED UP WITH SAND			
B9		K2d	BIR EL MISHESH	DW	261															
B10		K4b	TURKISH WELL	DW	259	6,0	2,0		ALLUVIUM AND CHALK	6/1/88	> 6,0						PARTLY FILLED UP WITH SAND			
B11	(99)	K4b	BIR MAGHARA	DW	380	-			ALLUVIUM	(1963)		(4,40)	(4580)	-	-	-	WELL DRY IN NOVEMBER-DECEMBER 1987			
						"6,0"				"1981"			-	-	-	"2800"				
						6,0	2,0			26/1/88	5,10		3950	820	90	2370				
B12	(102)	K4b	BIR UM MOWERIB	DW	400	-			ALLUVIUM	(1963)		(7,15)	(4340)	-	-	-				
						"7"				"1981"			-	-	-	"4000"				
						7	2,0			29/11/87	6,05		4750	1240	121	2710				

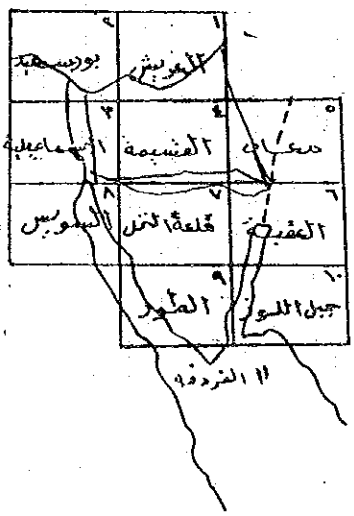
DW = DUG WELL
BH = BORE HOLE
RES = RESERVOIR
PZ = PIEZOMETER
S = SPRING

Data from (GEOFIZIKA) report 1963
Data from "DAKES AND MOORE" report 1981

8　シナイ半島地形図索引

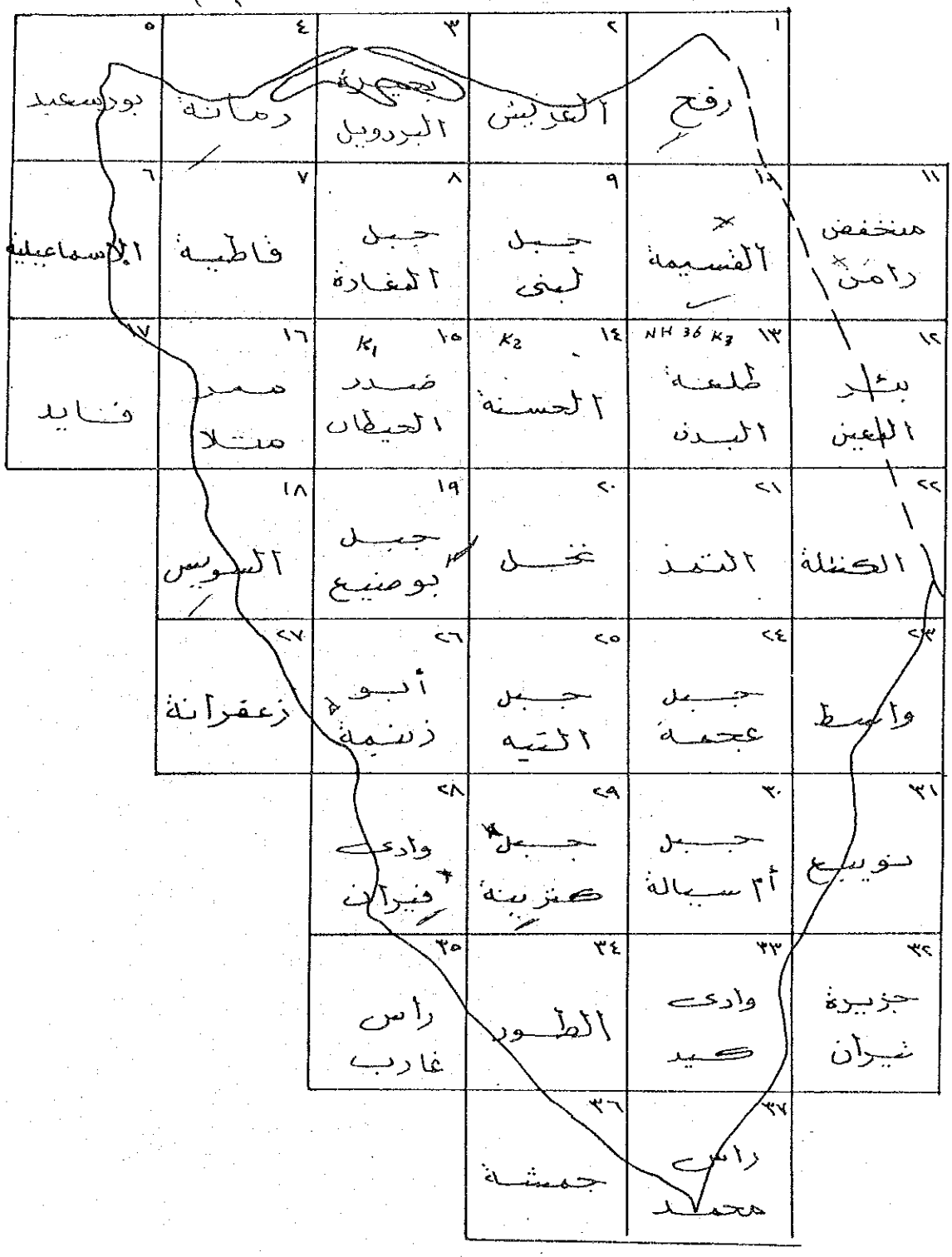
1 ：250,000	10葉
1 ：100,000	37葉
1 ： 50,000	113葉

دليل خرائط سيناء المصورة (١ : ٢٥٠,٠٠٠)
250.000



دليل خرائط سيناء المصورة (١ : ١٠٠,٠٠٠)

١٠٥,٠٠٠



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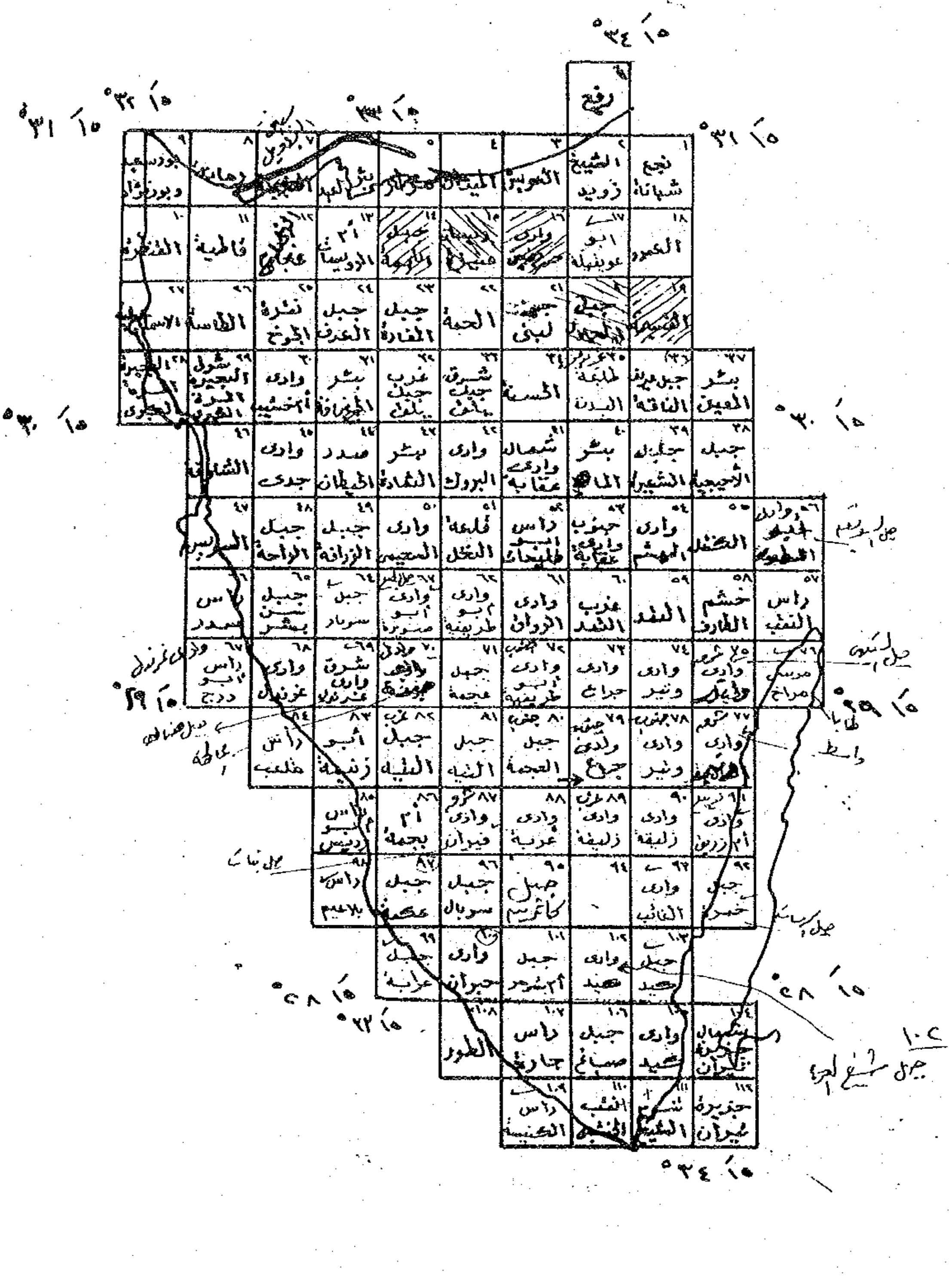

9. 水文地質図の国際凡例

ANNEX III

INTERNATIONAL ASSOCIATION OF HYDROGEOLOGISTS (IAH)

INTERNATIONAL ASSOCIATION OF HYDROLOGICAL SCIENCES (IAHS)

UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION

(UNESCO)

International Legend

for Hydrogeological Maps

- Revised preliminary version, 1983 -

FOREWORD

The large and growing number of hydrogeological maps throughout the world is evidence of the general tendency to present both data and their interpretation in map form. This method of presentation permits a rapid areal evaluation of the hydrogeology linked to the advantages of a topographic base. There is, however, likely to be a considerable variation in the amount of information depicted upon a given map, depending both upon the chosen scale and upon the purpose the map is intended to serve.

This Legend is intended to be a guide to the preparation of hydrogeological maps at any scale to a uniform standard. A list is given of the symbols, ornaments and colours which have specific meanings and that are internationally recognised.

This present Legend is based upon the International Legend for Hydrogeological Maps, published jointly in 1970 by the International Association of Hydrogeologists, the International Association of Hydrological Sciences, UNESCO, and the Institute of Geological Sciences (London). Used in many mapping projects throughout the world, the 1970 Legend is now out of print, and a revised edition is being prepared. As a preliminary step, a simple and inexpensive version has been produced here as a UNESCO document in English language only, and without colour illustrations. At some future date, after adequate review and trial of this revised Legend, it is intended that a definitive and multi-lingual version with colour illustrations will be published.

For the compilation of the 1970 Legend, working gr ps were set up within the International Association of Hydrogeologists (IAH) and the International Association of Hydrological Sciences (IAHS). The recommendations of these working groups have come to fruition with the continuing publication of the various sheets of the International Hydrogeological Map of Europe on a scale of 1 : 1 500 000, a project largely carried out by the IAH Commission on Hydrogeological Maps and published jointly by UNESCO and BGR (Federal Institute for Geosciences and Natural Resources of the Federal Republic of Germany). For this reason, that Commission was given the task of preparing the revised Legend, taking into account nearly two decades of experience in hydrogeological mapping. In making this revision, the Commission has collaborated with IAHS and with UNESCO and was supported by BGR.

As a consequence of the application of the original Legend to widely differing environments, varying from tropical climates to permafrost regions, a number of amendments and additions have been proposed. Nevertheless, the basic techniques proved to be universally applicable and have led, in Europe in particular, to a useful degree of uniformity. This successful outcome has encouraged the Commission to press for the continued general acceptance of the Legend as a basis for the preparation of hydrogeological maps.

This revised Legend is intended to provide for the requirements of a general hydrogeological map rather than one produced solely to emphasize one or more particular aspects. Such specialized maps may of necessity use non-standard symbols, ornaments or colours. Suggestions for legends for certain specialized maps have been published, for example, Hydrogeology of Karstic Terrains (IAH, IAHS and UNESCO, 1976) and Legend for Geohydrochemical Maps (UNESCO, 1978). However, the Commission strongly recommends the preparation of a general hydrogeological map before any attempt to produce specialized maps.

The revised Lege. contains a list of all the hydrogeological maps known to the Commission which have been published after 1970 at a scale of 1 : 200 000 or less. The exhaustive bibliography on the methodology of hydrogeological mapping that was included in the 1970 Legend has been omitted from the revised version.

Final editing of the revised Legend was carried out by a panel consisting of the following members:

W. Struckmeier (Chairman, IAH)
R. A. Monkhouse (IAH)
S. Jelgersma (IAHS)
W. H. Gilbrich (UNESCO)

The Commission would be glad to receive criticisms and suggestions for amendments or additions to the revised Legend from hydrogeologists throughout the world. These should be addressed to the Chairman of the IAH Commission of Hydrogeological Maps.

G. CASTANY	H. KARRENBERG	W. STRUCKMEIER
President of IAH	Advisor to IAH	Chairman of the IAH Commission on Hydrogeological Maps

Definitions

Certain terms are used rather loosely in both hydrogeology and cartography, and it is easy for misunderstandings to arise. A short list of definitions is here included which refer to the usage for this Legend.

Ornament: a pattern of marks, lines or other symbols denoting the occurrence of a particular factor over an area of ground as represented upon the map; e.g. a stipple to represent sandy strata.

Symbol: a single graphical representation to denote the presence of a particular factor at a point location on the map; e.g. a small circle to show the location of a spring.

Line: a solid or broken line may be used either to delimit an area (such as an aquifer outcrop), or to join points of equal altitude (contour), equal thickness (isopachyte), or similar parameters.

Sign: a sign may consist of a line, a symbol, or an ornament, or a combination of any or all of these.

Colour: a colour refers to an even "wash" of constant tone. It may be used for lines, symbols or ornaments as well as for emphasising areas of importance.

Tone: screens may be used in order to reduce the density of a colour. The value of the tone is usually expressed as a percentage of the original or full (100%) colour.

Background information (Section A of the Legend)

This comprises largely geographical detail such as major roads, railways, the larger conurbations, and so forth. Relief is generally not shown on the map since it tends to obscure hydrogeological detail, but insert maps can be used for the purpose. The international grid (UTM grid-Universal Transversal Mercator projection - is suggested), a national grid, or lines of latitude and longitude should be shown.

Background information is generally printed in grey with the grid or latitude-longitude lines in black. Regional and town names may also be printed in black, but the type faces should be clearly different from those used for the stratigraphic symbols (see Section E).

Aquifers and non-aquifers (Section B of the Legend)

All strata that appear in outcrop upon the map, whether aquifers or non-aquifers are shown in plain colour. Intergranular aquifers are coloured blue and fissure aquifers are coloured green, in each case a dark colour indicating an extensive and highly productive aquifer while a lighter tone indicates other aquifers (see Sections B.I and B.II).

Formations giving only limited or local yields are coloured a light tone of brown, while strata with essentially no groundwater resources are coloured dark brown (see Section B.III, a and b).

Where it is considered to be particularly important to show the continuation of an aquifer beneath a thin but persistent cover of drift, the appropriate aquifer colour (blue or green) may be continued over the relevant area, but should be crossed by vertical bands of the appropriate colour of brown (see Section B.III c). The legend normally printed in the margin of the map sheet should state the order of maximum thickness of the drift cover.

Lithology (Section C of the Legend)

The lithology of the strata in outcrop is represented by ornament printed in grey beneath the colour. Where the ornament indicates recognisably stratified bedrock, the ornament itself is also recognisably laminar: when the ornament is arranged horizontally (in an east-west orientation upon the map), it indicates horizontal or gently inclined strata, and arranged in a vertical position (a north-south orientation upon the map) indicates steeply inclined or folded strata.

A list of suggested ornaments is given in Section C of the Legend, and these may be varied in size, or combined with each other, either to show mixed lithologies or to differentiate between different formations.

Representation of detailed data (Section D of the Legend)

Detailed hydrological information is shown by the use of symbols, and occasionally of lines and ornaments, printed in various colours. Numerical figures, in the same colours, may be added for clarification, e.g. to put values on contours.

The different sections into which the data are grouped are as follows:

	Group	Colour
1.	groundwater, including springs	violet
2.	groundwater quality and temperature	orange
3.	surface water and karst hydrography	blue
4.	man-made features and alterations to the natural groundwater regime	red
5.	horizon contours, isopachytes and limits of permafrost	dark green
6.	geological and stratigraphical information	black

Stratigraphy (Section F of the Legend)

While stratigrapnic information is not of primary importance upon hydrogeological maps, it is generally convenient to indicate at least the approximate age of the strata depicted. The symbols, printed in black, are listed in Section E, and are taken from the International Geological Map of Europe 1 : 1 500 000 scale. On large scale hydrogeological maps, it may prove adviseable to use symbols of more local than international significance.

Climatology (Section F of the Legend)

It is rarely possible to include meteorological information on a hydrogeological map without obscuring more pertinent data. It is, therefore, recommended that climatological information be presented either in insert maps upon the margins of the hydrogeological map, or as figures in any accompanying text.

Vertical sections (Section G of the Legend)

Vertical cross-sections are commonly used to illustrate the relationships between aquifers and non-aquifers in relation to depth. Other hydrogeological features are also amenable to such treatment. The use of vertical cross-sections to accompany hydrogeological maps is strongly recommended. The colours, lines, symbols and ornaments used on the vertical cross-sections should be the same as those used upon the map. While in general the horizontal scale should be the same as that of the map, the vertical scale may need to be exaggerated to permit detail to be shown. However, the minimum exaggeration possible should be employed since, particularly upon large scale maps, an over-exaggeration may present a misleading picture.

1. HISTORICAL DEVELOPMENT OF THE INTERNATIONAL LEG FOR HYDROGEOLOGICAL MAPS

The first hydrogeological maps were produced in several countries during the two decades from 1940. The scales employed varied widely, for the most part between 1 : 25 000 and 1 : 200 000, but with a few maps up to 1 : 500 000 (Grahmann, 1952 - 57) and even smaller. These maps were intended to serve as a basis for the water resources planning required to satisfy the generally increasing demand by agriculture, industry and public supply, particularly so since the groundwater resources were not limitless. Since these hydrogeological maps were produced in connection with local developments, the features shown tended to be those considered important to each individual scheme, and even when these features were common to a number of maps they were generally depicted in different colours, with various dissimilar ornaments, and by a wide range of symbols. Comparison of the hydrogeology between areas shown on different, even neighbouring, maps was often difficult, and the maps themselves were not always easy to understand. Moreover, there were few, if any, hydrogeological maps which displayed a coverage on an international, a national, or even a truly regional basis.

The numerous and diverse ideas of the map-makers were demonstrated at an exhibition held in Helsinki in 1961 during the general meeting of the International Association of Hydrological Sciences (IAHS). Approximately 200 hydrological and hydrogeological maps wre displayed, with an extraordinary variety of map content, of colour, and of ornament and symbol use. During 1960 and 1961, the International Association of Hydrogeologists (IAH) attempted a survey of the techniques used in the preparation of such maps by circulating a questionnaire to hydrogeologists in many countries.

The replies receiv[illegible]ere revealing. Apart from the widely varying opinions expressed, largely due to a concentration on individual projects to the neglect of universally acceptable concepts, great weight was generally placed on theoretical considerations which altogether ignored the practical difficulties of expressing such matters on a two-dimensional map.

In short, there was a complete lack of uniformity, whereby a symbol, an ornament or a colour would have the same hydrogeological significance on whatever map it might appear. There were few maps with a regional rather than a parochial outlook, and there was no consensus of opinion as to what hydrogeological features would be significant on a regional or international rather than a local basis. Above all, there were no specialists in the preparation and production of hydrogeological maps.

Two factors had become clear, the necessity for co-ordination on an international basis on the methods of presenting hydrogeological information in map form, and agreement, again on an international basis, on which hydrogeological features were of sufficient importance to require depiction upon a map wherever and whenever they occurred within the area covered.

Two international scientific bodies in particular, IAH and IAHS, concerned themselves with these problems. After many discussions, IAH had established in 1959 the Commission for Hydrogeological Maps with a remit first to prepare a Legend of recommended symbols, ornaments and colours, and secondly to plan the production of a series of small scale maps to cover the whole of Europe (Karrenberg, 1964). A Working Group wasset up within the Commission to provide co-ordination on these projects. Simultaneously, IAHS

established within their Commission for Underground Water a Permanent Standing Committee on Hydrogeological Maps. Contacts were established with UNESCO, with FAO, and with interested parties of many nationalities. As a starting point, both the Working Group and the Standing Committee considered the legend that had been produced for the hydrogeological maps of Morocco (Ambroggi and Margat, 1960).

A joint meeting of the IAHS Committee and the IAH Working Group was held in Paris 1962 under the auspices of UNESCO. Representatives of the latter organisation and of FAO attended. Agreement was reached on a draft legend for hydrogeological maps, and this was published by UNESCO in the following year (Anon, 1963). The purpose of the legend was stated in the preface to be to "facilitate the work of all those, whether specialists or not, who are concerned in the problem of water resources".

Since part of the draft Legend was based more on theoretical considerations rather than on practical experience, the IAH Commission used the preparation of the series of hydrogeological maps for Europe, named the International Hydrogeological Map of Europe, as a practical test. Part of the Sheet C5 (Bern) was selected for the prototype since it covered a region with very varied geology and for which a large amount of data was available. The scale was 1 : 1 500 000. Hydrogeologists from Austria, Czechoslovakia, the Federal Republic of Germany, France, Italy, Switzerland and Yugoslavia were involved in the compilation of this map from 1962 to 1964. In order to evaluate the different ideas put forward to the Working Group, many of which differed from the draft Legend, it was necessary to produce printed examples of the map. In all, four variations were printed, referred to as Models 1 to 4, using the relatively inexpensive but less accurately registerable silk-screen process. The printing costs were borne by the Deutsche Forschungsgemeinschaft (as part of the German contribution to International Hydrological Decade) by the International Union of Geological Sciences, by the Bundesanstalt für Bodenforschung, and by the Geologisches Landesamt Nordrhein-Westfalen.

Models 1 and 2 were presented at the International Congress in New Delhi (1964). Both models were basically geological maps, with Model 1 having notes in the map legend on the permeability and other hydrogeological data for each formation depicted, while Model 2 attempted to show potential source yields in the different formations. Neither model proved generally acceptable.

A third version, Model 3, was produced in 1965. Geological formations were classified into good aquifers, moderate aquifers, and poor aquifers (including non-aquifers). The lithology was illustrated by a background ornament in grey. Good aquifers were distinguished by a blue colour, moderate by green, and the poor by brown. Unfortunately, the members of the Working Group experienced considerable difficulty in finding general agreement on what constituted "good", "moderate" and "poor". In consequence, Model 4 was placed in 1966 before a joint meeting of the IAH Working Group and the IAHS Committee. This version took the fundamental step of illustrating the aquifer type by colouring green the outcrop of those aquifers through which the dominant groundwater flow was by fissures, and blue for those with dominant intergranular flow. Brown was reserved for those strata not generally considered to be aquifers. Additionally, dark green and dark blue indicated the outcrop of extensive aquifers with large resources, while light green and light blue indicated local or discontinuous aquifers with lesser resources. Similarly, light brown represented strata which might have small but very localised resources (aquitards), and dark brown related to rocks with little or no usable

groundwater (aquicludes and aquifuges). Lithology was still shown by grey base ornament, and was used also to assist in stratigraphic differentiation. While Model 3 had departed from being a simple geological map with hydrogeological additions, Model 4 had moved away from the concept of well yield into that of aquifers and groundwater resources. Even at the present day, more than a decade after the first appearance of such a map, the world at large barely appreciates the importance of groundwater resources and their distribution as against the mere ability of a well to yield water, the latter often no more than a measure of technical efficiency in well construction. Model 4 was accepted as the prototype of the planned series of the International Hydrogeological Map of Europe, scale 1:1 500 000, and the final version on Sheet C5 (Bern) was published in 1970, financed primarily by contributions from UNESCO and from the Bundesanstalt für Bodenforschung, predecessor of the Federal Institute for Geosciences and Natural Resources (BGR).

Much of the information assembled during the preparation of Sheet C5 could not be shown on the map itself without obscuring more essential features. After the sheet had been published, it was considered adviseable to prepare a volume of Explanatory Notes, limited to not more than 100 pages on an B5 format. This volume could, it was felt, usefully supplement the map with tabulated information (particularly on groundwater chemistry), detailed vertical cross-sections of special interest, additional small maps to illustrate features of local importance, and a general explanatory text. Compiling this first volume involved the participation of more than fourteen geological surveys. The Explanatory Notes for Sheet C5 (Bern) were published as a 96 page volume in Hannover in 1974. The same principle has been followed with the subsequent sheets of the series, similar volumes being published as standard accompaniments.

The progress through four versions of the draft for sheet C5 led naturally to additions and modifications to the draft Legend. Moreover, new symbols and ornaments for karst areas, for arid zone features and for other hydrogeological aspects had been considered by the IAH Working Group and by the IAHS Committee at joint meetings during 1967. The revised draft was finally published in 1970 in the United Kingdom under the supervision of the Institute of Geological Sciences. The publication was in colour, and the text was printed in English, French, Spanish and Russian. An interesting feature was the deliberate incorporation of a wide margin in which a manuscript translation of the text in any other language could be inserted.

Work upon the European hydrogeological map series has shown up a number of inadequacies in the 1970 Legend. The lithologies of the strata depicted upon the maps proved to be more varied than had been anticipated, and additional symbols were needed to quantify groundwater resources, to illustrate groundwater flow, and to accomodate ideas on aquifer protection. A special additional list of these symbols and ornaments was prepared in 1974 for use by the editors of the European map series (KARRENBERG et al, 1974), but it was not published for general use.

Since its publication in 1970, the Legend has provided the basis for the preparation of many hydrogeological maps, both inside and outside Europe. Although now out of print, the Legend is still in demand, and serious thought has been given to its reprinting. However, in its 1970 form, the Legend already contained some supplementary information appended to the main text, and work both on the European map series and elsewhere had suggested the need for further modifications and additions. To publish a new Legend in a definitive form containing these changes would, nevertheless, have been inappropriate before the latter had been tested in practical

map production. The IAH Commission has, therefore decic upon the production, with the co-operation of UN. O and IAHS, of this revised Legend as a single language, mono-colour publication at minimum cost. The intention is that, after a trial of a few years in practical use, a fully revised version in colour and with a multi-lingual text will be published.

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Karrenberg, H. 1964. Der Plan der A.I.H. bezüglich einer hydrogeologischen Karte von Europa 1 : 1 500 000. Mem. Assoc. Int. Hydrogeol., Athens, V, 386-393.

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2. INTRODUCTION

This legend has been compiled in order to present an internationally agreed means of displaying hydrogeological information in map form.
Hydrogeological maps are maps upon which are depicted the extent of aquifers, together with such geological, hydrogeological, meteorological and surface water features that may be necessary for an understanding of the groundwater regime. Such maps may be international, national, regional or local, and may vary from small (1 : 1 000 000, or smaller) to large (1 : 250 000, or greater) in scale.

Hydrogeological maps are of importance to hydrogeologists and groundwater specialists. They are of use also to non-specialists such as administrators and economists, engineers in the fields of town and country planning, technicians in agriculture and horticulture, as well as to farmers, schoolteachers and private individuals.

Purpose of hydrogeological maps

The purpose of hydrogeological maps is to enable various areas to be distinguished according to their hydrological character in relation to the geology. They should indicate, on a topographic base, such items as the extent of the principal groundwater bodies, the scarcity of groundwater elsewhere, the known or possible occurrence of artesian basins, areas of saline groundwater and the potability of groundwater. They should also show, according to scale, information of a local character, such as the location of boreholes, wells and other works, contours of the potentiometric surface, the direction of groundwater flow, and variations in water quality.

In general, any formation leading to a better understanding of occurrence, movement, quantity and quality of groundwater, should be shown on hydrogeological maps, depending upon the scale adopted. The data normally presented relate to such matters as precipitation, evaporation, surface hydrology, geometric data on water-bearing formations, hydrochemistry and availability of water. In addition, sufficient geology should be shown to lead to a proper understanding of the hydrogeological conditions. However, the geology should remain subdued and the hydrogeological features should be prominent.

Scales

In general, small scale maps (1:1 000 000, or smaller) will show only the general location and disposition of aquifers and non-aquifers, together with a broad picture of the surface drainage. It may be possible in some cases to show a small number of other features, such as generalised contours of the potentiometric surface in the more extensive and important aquifers. However, the introduction of fine detail is not usually warranted, and on such small scales may well be meaningless.

At the other extreme, a considerable array of data may be expressed on large scale maps (1 : 250 000, or greater), and this may often be increased by insert maps, on a small scale, illustrating factors of general importance such as rainfall, relief and certain aspects of groundwater chemistry.

The selection of a particular scale for a hydrogeological map may depend not only upon the purpose to which the map may be put, but also to the amount of information that is either available for inclusion or desired to be shown. There is little advantage in producing large scale maps of areas for which there is only scanty information, and equally little in entering data so profusely upon a small scale map that a clear distinction of the individual factors can no longer be made.

3. International Legend for Hydrogeological Maps

A Background information

1. All background information is printed in screened black with the exception of the simplified topographic base map which is printed in dark grey (60% black). It presents mainly the

   location and names of important localities and the geographic names (streams, lakes, mountains, etc.), international and administrative boundaries.

2. The actualized drainage network is printed in blue.

3. Grids or lines of longitude and latitude are printed in black.

4. Additional background information to topography and orography where required is presented in the explanatory notes or on insert maps.

B Groundwater and rock

1. Intergranular aquifers

blue	1.1	Extensive and highly productive aquifers
screened blue	1.2	Local or discontinuous productive aquifers or extensive but only moderately productive aquifers

2. Fissured aquifers, including karst aquifers

green	2.1	Extensive and highly productive aquifers
screened green	2.2	Local or discontinuous productive aquifers, or extensive but only moderately productive aquifers

3. Strata (intergranular or fissured rocks) with local and limited groundwater resources or strata with essentially no groundwater resources

screened brown	3.1	Strata with local and limited groundwater resources
brown	3.2	Strata with essentially no groundwater resources
brown stripes	3.3	Where there is an extensive aquifer immediately underlying a thin cover the option be used of continuing the appropriate aquifer colour crossed by brown stripes (one mm wide and three mm separation)

Note:
Certain aquifers combine intergranular and fissure characteristics. In such cases the relevant colours described in sections 1 and 2 should be used depending on which characteristic is dominant. Further explanation, if required may be added to the map legend.

C Lithology

Ornament indicating the lithology is printed in grey.

The orientation of the ornament indicates the type of bedding:

Horizontal = unfolded horizontal or gently inclined strata

Vertical = folded strata

The following list contains ornaments which indicate general lithological types as well as some combinations to symbolize strata of varying lithology.

Note:
The ornament represents the lithology of the strata which is shown on the map. The exact lithological composition may be explained in detail in the map legend. Where combinations of ornaments are required, examples are shown in section C 3.
Combination of more than two ornaments is not recommended.

The identification numbers given below are purely for convenience and do not refer to any commercial listings.

Additional ornaments other than listed here can be used for special purposes.

Recommended ornaments:

1. Lithology of sedimentary rocks

1  clay, clayey loam, mud, silt, marl

2  clayey-loamy alteration products

3  loess

4  sands (units can be distinguished by variation of thickness of points)

5  gravels (distinction by variation of the arrangement of circles)

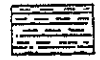
6  moraines

7  peat

8  lignite

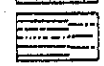
9  pyroclastics

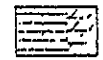
10  made ground

20  claystone, siltstone, shale

21  sandstone (distinction by variation of size)

22  conglomerate

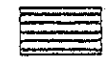
23  limestones (distinction by variation of rectangle size)

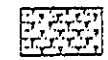
24  dolomites (distinction by variation of parallelogram size)

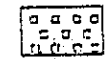
25  travertine

26  marlstone

27  flysch

28  complex alternation of different lithology

29  radiolarite, lydite, siliceous shale

30  rock salt

31  gypsum

2. Lithologies of igneous and metamorphic rocks

40  acid to intermediate extrusives (distinction by variation of triangle size)

41  basic extrusives (distinction by variation of triangle size)

42  ultrabasite, serpentinite

43  acid to intermediate intrusives (distinction by variation of arrangement of crosses)

44  basic intrusives

45  slate, phyllite, mica schist, etc.

46  gneiss

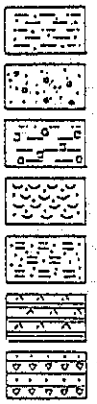
47  gneiss and granite, undifferentiated

48  marble

49  quartzite

50  metamorphic rocks, undifferentiated

3. Examples of combination types



Distinction between different geological formations may be made by varying the size of the ornament.

D Representation of detailed data

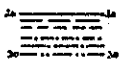
Signs are printed in several colours grouped as shown below:

1. violet: groundwater and springs
2. orange: groundwater quality and temperature
3. blue: surface water and karst hydrography
4. red: man made features and alterations of the natural groundwater regime
5. dark green: horizon contours (isopachytes) and limits of certain features, such as permafrost
6. black: geological information

Detailed examples of internationally used colour charts* are given in brackets to standardize the colours.

1 Groundwater and springs

Colour: violet (ITC No. 062, RCC)



1.1 Contours of the potentiometric surface (solid or broken lines with height relative to reference level)

1.2 Direction of groundwater flow

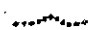
a)
b)

1.3 Connection between karstic loss and resurgence a) proven, b) inferred

a)
b) 

1.4 Groundwater divide a) stationary, b) periodically changing

*) ITC Colour Chart (1982), ITC Journal 1982-2, Enschede
Rock Colour Chart (1963), Geological Society of America, N.Y.



1. Limit of area with confined groundwater

1.6 Limit of area of artesian flow

1.7 Lens of fresh water surrounded by salt water

1.8 Limit of area with insignificant natural replenishment to the groundwater (50% screen colour)

average discharge of a) less than 100 l/s
b) 100 - 1000 l/s,
c) more than 1000 l/s

a) b) c)

1.10 Spring

1.11 Perennial karst spring } Fresh water

1.12 Submarine spring

1.13 Spring

1.14 Perennial karst spring } Brackish water

1.15 Submarine spring

1.16 Group of springs (relevant symbols are enclosed of circles)

1.17 Temporary karst spring (large: 0 - less than 1 m^3/s, small: 0 - more than 1 m^3/s)

 1.18 Line of springs

 1.19 Groundwater seepage area

2 Groundwater quality and temperature

Colour: orange (ITC No. 650, RCC)

 2.1 Boundary of saline groundwater in an aquifer

 2.2 Isolines of equal groundwater salinity

 2.3 Contours of the interface between fresh and saline groundwater, in m below reference level

 2.4 Area of sea water intrusion

 2.5 Limit of mineralization of shallow groundwater inland

 2.6 Area of mineralized groundwater inland

 2.7 Area with mineralized water overlying fresh groundwater

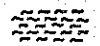
 2.8 Limit of continental mineralization

 2.9 Stream with mineralized water (blue stream with orange band)

 2.10 Lagoon or lake with saline or brackish water (blue shore line with orange band inside)

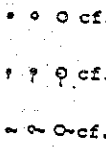
 2.11 Periodical salt-water lake (broken blue shore line with orange band inside)

 2.12 Shotts (playas) with epidosical water (dotted blue shore line with orange band inside)



2.13 Salt marsh

2.14 Limit of formations containing minerals susceptible for groundwater quality deterioration (grey line with orange band)



cf. 1.13 Spring

cf. 1.14 Perennial karst spring

cf. 1.15 Submarine spring

} Brackish water (circles in violet, centres in orange)

2.15 Cold mineral spring

2.16 Thermomineral spring

2.17 Thermal spring

2.18 Area of increased geothermal heat

2.19 Meltwater chamber beneath glacier

2.20 Glacier burst from meltwater chamber beneath glacier

3 Surface water and karst hydrography

Colour: blue (ITC No. 006, RCC No)

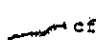
3.1 Stream with perennial runoff

3.2 Stream with intermittent runoff

3.3 Dry valley, possibly with episodical runoff (ephemeral stream)

3.4 Sander

3.5 Stream ending in inland depression



cf. 2.9 Stream with mineralized water (blue stream with orange band)

3.7 Karstic loss in river valley

a) a) perennial flow downstream

b) b) seasonal flow downstream

c) c) no flow downstream

3.8 Aven

3.9 Doline filled with water

3.10 Dry doline

3.11 Limit of karst area

3.12 Main surface water divide

3.13 Secondary water divide

3.14 Flow gauging station
mean annual runoff $[m^3/s]$ / catchment area $[\cdot\ 1000\ km^2]$

3.15 Glacier

3.16 Glacier burst from ice dammed lake

3.17 Waterfall

3.18 Fresh water lake

cf. 2.10 Lagoon or lake with mineralized water (blue shore line with orange band inside)

cf. 2.11 Periodical salt-water lake (broken blue shore line with orange band inside)

cf. 2.12 Shotts (playas) with episodical water (dotted blue shore line with orange band inside)

3.19 Periodical fresh water lake

3.20 Dry lake with only episodical water

3.21 River marsh

3.22 Bog

4. Man made feature nd alterations of the natural groundwater reg

Colour: red (ITC No. 660, RCC No.)

• 4.1 Well, shaft or borehole, with phreatic or confined groundwater

• 4.2 Group of wells or boreholes, with phreatic or confined groundwater

⁞ 4.3 Well or borehole, artesian flowing

⁞ 4.4 Group of wells or boreholes, artesian flowing

◦ 4.5 Mineral water well

⊙ 4.6 Thermomineral water well

◎ 4.7 Thermal water well

⁞ 4.8 Injection well

average quantity of discharge or pumping (categories at the discretion of the author, e.g.
a) 3 - 30 million m^3/year
b) 30 - 300 " " "
c) more than 300 million m^3/year)

a) b) c)

▫ □ ▢	4.9	Pumping station, pumped well
▫ ⊡ ⊡	4.10	Pumping station from spring (red square with violet dot inside)
⊥ ⊥ ⊥	4.11	River intake
----------	4.12	Pipeline
————	4.13	Aqueduct
○	4.14	Storage reservoir or pond
—— m ——	4.15	Dam or weir, with capacity of the reservoir in million m^3
—·—·—	4.16	Levee or coastal dike
	4.17	Flood-tide barrage or tidal power plant
	4.18	Groundwater recharge site
⊡	4.19	Installation for desalination
∪	4.20	Oasis cultivation
	4.21	Limit of area of intensive groundwater exploitation
	4.22	Area of underground mining effecting the natural groundwater regime
	4.23	Area of open cast mining effecting the natural groundwater regime

5 Horizon contours [illegible] of certain features, [illegible] as permafrost

Colour: dark green (ITC No. 606, RCC No.)

	5.1	Horizon contours or isopachytes (solid or broken lines with depth in m relative to reference level)
30	5.2	Thickness of aquifer in m
	5.3	Limit of permafrost area (variation of broken lines for continuous, discontinuous and isolated distribution)
	5.4	Talik (unfrozen zone) under a river, lake or reservoir (river or lake in blue, green dots surrounding)

6 Geological information

Colour: black

6.1 Geological or hydrogeological boundary

6.2 Fault, certain (solid line) or inferred (broken line)

6.3 Overthrust, certain or inferred

6.4 Boundary of infilled erosional channel

6.5 Fractured belt of hydrogeological importance

cf. 2.14 Limit of formations containing minerals susceptible for groundwater quality deterioration (grey line with orange band)

6.6 Salt plug (diapir)
a) near surface,
b) at depth (dotted line)

6.7 Area and edge of solution chambers formed in salinar formations (subrosion)

6.8 Volcanic cone

6.9 Volcanic crater

6.10 Line of cross-section

Σ Stratigraphic symbols

Simple stratigraphic symbols are printed in black.

They help to identify the unit which is represented on the map, whenever it is not characterized unequivocally by the combination of areal colour and screen. With the knowledge of the stratigraphy, the map reader can recognize the geological structures in an easier way.

It is recommended to use the stratigraphic symbols according to the general legend of the "International Geological Map of Europe and the Mediterranean Region 1 : 1 500 000, Hannover 1962" for areas built up of sedimentary strata. In magmatic and metamorphic areas, however, the age determination is often problematically. It is, therefore, up to the author to decide whether or not it is necessary to present stratigraphic symbols in those areas, since the combination of areal colour and screen is often sufficient.

Note: Stratigraphic symbols are to be used sparingly on hydrogeological maps. The representation of hydrogeological features is in any case predominant.

List of stratigraphic symbols

q	-	Quaternary undifferentiated	q+m-Cenozoic
qh	-	Holocene	
qp	-	Pleistocene	
m	-	Tertiary undifferentiated	
m4	-	Pliocene	
m3	-	Miocene	
m2	-	Oligocene	
m1	-	Eocene and Paleocene	
c	-	Cretaceous undifferentiated	ms-Mesozoic
c2	-	Upper Cretaceous	
c1	-	Lower Cretaceous	
j	-	Jurassic undifferentiated	
j3	-	Upper Jurassic	
j2	-	Middle Jurassic	
j1	-	Lower Jurassic	
t	-	Triassic undifferentiated	
t3	-	Upper Triassic	
t2	-	Middle Triassic	
t1	-	Lower Triassic	
p	-	Permian undifferentiated	pl-Paleozoic
p2	-	Upper Permian	
p1	-	Lower Permian	
h	-	Carboniferous undifferentiated	
h2	-	Upper Carboniferous	
h1	-	Lower Carboniferous	
d	-	Devonian undifferentiated	
d3	-	Upper Devonian	
d2	-	Middle Devonian	
d1	-	Lower Devonian	
s	-	Silurian	
o	-	Ordovician	
cb	-	Cambrian	
eo	-	Eocambrian	
pr	-	Pre-Cambrian	

F Climatology

Maps showing climatological features, e.g. precipitation, evaporation, temperature or other climatological features, should be presented separately from the hydrogeological map, either as an insert map on the main map or as figures in an accompanying explanatory text.

G Vertical cross-sections

It is standard practice to illustrate the geology and hydrogeology at depth by the use of vertical cross-sections. These sections may be printed upon the margin of the map, or alternatively within an accompanying explanatory text.

The lines along which the sections are drawn should be clearly indicated by lines printed in black upon the map. The significance of these lines should be clearly explained in the sheet legend and labelled, also in black, with the number identifying the particular section.

The horizontal scale of the cross-section should generally be the same as that of the map. The vertical scale is often exaggerated; however, the vertical exaggeration should be limited to that necessary to illustrate the required detail since over-exaggeration, expecially upon large scales, may present a grossly misleading picture.

The lines, symbols and ornament used upon the cross-section should be the same as those used upon the map.

The end-points of each section, together with any point of importance along the section, should have their locations specified, preferably by the use of grid references. A bar-scale of altitude (vertical scale) at each end of the section is compulsory.