دراسة

Sinai Development Study
Phase I
Final Report

VOLUME IV
THE LAND AND THE ENVIRONMENT OF SINAI

SUBMITTED TO:

THE ADVISORY COMMITTEE FOR RECONSTRUCTION
MINISTRY OF DEVELOPMENT
ARAB REPUBLIC OF EGYPT

USAID GRANT NO. 263-0113
MARCH, 1985

PREPARED BY:

Dames & Moore
In association with Industrial Development Programs SA

SINAI DEVELOPMENT STUDY, PHASE I

FINAL REPORT

VOLUME IV

THE LAND AND THE ENVIRONMENT OF SINAI

SUBMITTED TO:

THE ADVISORY COMMITTEE FOR RECONSTRUCTION
MINISTRY OF DEVELOPMENT
ARAB REPUBLIC OF EGYPT

MARCH 1985

PREPARED BY:

DAMES & MOORE
IN ASSOCIATION WITH INDUSTRIAL DEVELOPMENT PROGRAMMES SA

FINAL REPORT

LIST OF VOLUMES

Volume I	A Strategy for the Settlement of Sinai
Volume II	Managing Sinai's Development
Volume III	An Economic Development and Investment Plan, 1983 to 2000
Volume IV	**The Land and the Environment of Sinai**
Volume V	Water Supplies and Costs
Volume VI	Settlement and Social Development
Volume VII	Sinai Data Book

VOLUME IV

THE LAND AND THE ENVIRONMENT OF SINAI

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

1.0 INTRODUCTION 1-1

1.1 BACKGROUND 1-1

1.2 SCOPE 1-1

1.3 PROCESS 1-4

1.4 ISSUES 1-5

1.5 RECOMMENDATIONS 1-5

2.0 THE SINAI ENVIRONMENT 2-1

2.1 INTRODUCTION 2-1

2.2 GEOMORPHOLOGY 2-1

2.3 SOILS 2-2

2.4 CLIMATE 2-4

2.5 WATER RESOURCES 2-5

2.6 TERRESTRIAL ECOLOGY 2-6

2.7 THE MARINE ENVIRONMENT 2-8

2.8 OVERVIEW OF HUMAN ACTIVITIES 2-10

2.8.1 Population 2-10

2.8.2 Economic Activities 2-11

3.0 LAND PLANNING 3-1

3.1 INTRODUCTION 3-1

3.2 LAND RESOURCE UNITS 3-2

3.3 LAND AND WATER USE CATEGORIES 3-6

3.4 LAND AND WATER RESOURCES OF THE SUBREGIONS OF SINAI 3-10

3.4.1 Northwest Subregion 3-12

3.4.2 Northeast and Uplands Subregions 3-16

3.4.3 Southwest Subregion 3-19

3.4.4 Southeast Subregion 3-23

3.4.5 Summary 3-25

4.0 LAND CAPABILITY FOR URBANIZATION 4-1

4.1 INTRODUCTION 4-1

4.2 LAND CAPABILITY FOR HUMAN SETTLEMENTS 4-1

4.3 TOURISM 4-1

4.4 ACCESS TO WATER AND TO MARKETS 4-7

4.5 CONSERVATION OF FLORA AND FAUNA 4-9

4.6 SPATIAL CLUSTERS OF RESOURCES 4-9

4.7 LAND CAPABILITY PROBLEMS AND LAND USE CONFLICTS 4-10

4.7.1 El Arish 4-12

4.7.2 The Bitter Lakes 4-15

4.7.3 Ayun Musa (including El Shatt and Ras Misalla) 4-18

4.7.4 The Ras Taba Area 4-18

4.7.5 Nuweiba 4-24

4.7.6 Abu Rudeis (including Abu Zenima and the mouth of Wadi Feiran) 4-27

4.7.7 Conclusions 4-30

5.0 ENVIRONMENTAL MANAGEMENT 5-1

5.1 INTRODUCTION 5-1

5.2 IMPACTS OF DEVELOPMENT 5-1

5.2.1 Contamination of Surface Water or Groundwater 5-2

5.2.2 Lowering of the Groundwater Table 5-2

5.2.3 Flooding and Shifting Sands 5-3

5.2.4 Air Pollution 5-3

5.2.5 Hazardous Wastes 5-4

5.2.6 Dust Intrusion 5-4

5.2.7 Damage to Scenic Areas 5-5

5.2.8 Impact on Cultural Heritage 5-5

5.2.9 Impact on Natural Heritage 5-6

5.2.10 Land Use Conflicts 5-6

5.2.11 Summary and Conclusions 5-6

5.3 LAND USE CONFLICTS 5-8

5.3.1 Introduction 5-8

5.3.2 Zoning 5-9

5.3.3 Reserves 5-10

5.3.3.1 Preservation Areas 5-10
5.3.3.2 Conservation Areas 5-10

5.3.4 Hema System 5-11

5.3.5 Summary 5-11

5.4 MANAGING RESERVES AND ZONING 5-12

5.5 MONITORING THE ENVIRONMENT 5-13

APPENDIX A: RECONNAISSANCE SOIL CAPABILITY ASSESSMENT FOR IRRIGATED AGRICULTURE ON THE SINAI PENINSULA . . . A-1

A.1 INTRODUCTION A-1

A.2 PROCEDURES USED IN SOIL CAPABILITY ASSESSMENT A-1

A.2.1 Step One: Delineation of Land Resource Units . . . A-1

A.2.2 Step Two: Field Data for Land Resource Units . . . A-1

A.2.3 Step Three: Data Reduction A-2

A.2.4 Step Four: Data Presentation A-2

A.2.5 Step Five: Agricultural Capability Assessment . . . A-2

A.2.6 Step Six: Mapping Candidate Areas A-3

A.2.7 Cautionary Notes A-3

LITERATURE CITED A-12

APPENDIX B: SOIL PROPERTIES RELEVANT TO IRRIGATED AGRICULTURE IN SINAI B-1

B.1 SLOPE B-1

B.2 WATER TABLE B-1

B.3 EFFECTIVE ROOTING DEPTH B-1

B.4 PARTICLE SIZE DISTRIBUTION B-2

B.5 PERMEABILITY B-2

B.6 AVAILABLE WATER CAPACITY B-3

B.7 EXCHANGEABLE SODIUM PERCENTAGES (ESP) B-3

B.8 SALINITY B-3

B.8.1 Saline Soils B-4

B.8.2 Nonsaline-Alkali Soils B-5

B.8.3 Saline-Alkali Soils B-5

B.9 CALCIUM CARBONATE B-6

B.10 GYPSUM B-7

APPENDIX C: LAND CAPABILITY INTERPRETATION AIDS C-1

APPENDIX D: NATURAL AREAS AND CULTURAL/SCENIC SITES D-1

D.1 NATURAL AREAS D-1

D.1.1 Lake Bardawil D-1

D.1.2 Lake Malaha D-2

D.1.3 Gebel El Maghara (North Sinai) D-2

D.1.4 Mitla Pass D-2

D.1.5 East Suez D-2

D.1.6 Ras Sudr D-2

D.1.7 El Tih Plateau D-2

D.1.8 St. Catherine Area D-2

D.1.9 Ras Mohammad D-3

D.1.10 Gulf of Aqabah Coral Reefs D-3

D.2 CULTURAL AND SCENIC SITES D-3

D.2.1 Dahab Lighthouse D-4

D.2.2 El Arish D-4

D.2.3 El Tor D-4

D.2.4 Faraun Island (Gezira Faraun) D-5

D.2.5 Gebel Musa (Mount Sinai) D-5

D.2.6 Hammam Faraun D-5

D.2.7 Hammam Saidna Musa D-6

D.2.8 Marsa Bareika D-6

D.2.9 Marsa El At D-6

D.2.10 Qalat El Gindi D-6

D.2.11 Rod El Eir D-6

D.2.12 Sarabit El Khadim D-6

D.2.13 Wadi Feiran D-6

D.2.14 Wadi Hebran D-7

D.2.15 Wadi Isla D-7

D.2.16 Wadi El Maghara (South Sinai) D-7

D.2.17 Wadi Mukattab D-7

LIST OF FIGURES

NUMBER		PAGE
1.1	ORIENTATION MAP SHOWING CONTOURS, FIVE SUBREGIONS AND GOVERNORATES	1-2
1.2	NATURE CONSERVATION AREAS	1-6
2.1	GEOMORPHIC PROVINCES	2-3
2.2	GENERAL VEGETATION TYPES	2-7
3.1	LAND RESOURCE UNITS	3-3
3.2	PRIMARY EXPLORATION AREAS FOR CONSTRUCTION MATERIALS	3-11
3.3	PRINCIPAL KNOWN MINERALS	3-22
3.4	LAND RESOURCE UNITS WITH SOILS MOST SUITABLE FOR IRRIGATED AGRICULTURE	3-27
4.1	LOCATION OF PRINCIPAL TOURIST ATTRACTIONS	4-2
4.2	ACCESSIBILITY OF RESOURCES AND MARKETS	4-8
4.3	EXTENSIVE LAND USES	4-11
4.4	EL ARISH: PRELIMINARY SKETCH TO ASSIST IN LOCATING INDUSTRIAL AND WAREHOUSING CENTER	4-14
4.5	BITTER LAKES: PRELIMINARY SKETCH TO ASSIST IN ZONING FOR FUTURE LAND USE	4-17
4.6	AYUN MUSA: PRELIMINARY SKETCH TO ASSIST IN ZONING FOR FUTURE LAND USE	4-20
4.7	RECOMMENDED STRATEGY: RAS TABA AREA	4-23
4.8	NUWEIBA: PRELIMINARY SKETCH TO ASSIST IN LOCATING A TRANSPORTATION AND ADMINISTRATIVE CENTER	4-26
4.9	RECOMMENDED STRATEGY: ABU RUDEIS AREA	4-29
A.1	AREAS OF SOIL SAMPLING BY DESERT INSTITUTE (1981)	A-13

LIST OF TABLES

NUMBER		PAGE
3-1	LAND RESOURCE UNITS - GENERAL CHARACTERISTICS	3-4
3-2	LAND AND WATER USE CATEGORIES	3-7
3-3	LAND RESOURCE UNITS OF THE NORTHWEST SUBREGION GROUNDWATER, LANDFORMS, AREA, AND LIMITATIONS	3-13
3-4	LAND RESOURCE UNITS OF THE NORTHEAST AND UPLANDS SUBREGIONS. GROUNDWATER, LANDFORMS, AREA AND LIMITATIONS	3-17
3-5	LAND RESOURCE UNITS OF THE SOUTHWEST SUBREGION GROUNDWATER, LANDFORMS, AREA AND LIMITATIONS	3-20
3-6	LAND RESOURCE UNITS OF THE SOUTHEAST SUBREGION GROUNDWATER, LANDFORMS, AREA AND LIMITATIONS	3-24
3-7	SUMMARY OF LAND CAPABILITY BY SECTOR, SUBREGION, AND LAND RESOURCE UNIT	3-26
3-8	SUMMARY OF LAND RESOURCE UNITS WITH SOILS SUITABLE FOR IRRIGATED AGRICULTURE	3-28
4-1	TOURISM LAND CAPABILITY - EVALUATION MATRIX	4-5
4-2	LAND CAPABILITY WORKSHEET FOR EL ARISH	4-13
4-3	LAND CAPABILITY WORKSHEET FOR BITTER LAKES	4-16
4-4	LAND CAPABILITY WORKSHEET FOR AYUN MUSA AREA	4-19
4-5	LAND CAPABILITY WORKSHEET FOR THE RAS TABA AREA	4-22
4-6	LAND CAPABILITY WORKSHEET FOR NUWEIBA	4-25
4-7	LAND CAPABILITY WORKSHEET FOR ABU RUDEIS	4-28

APPENDIX A

A-1	LAND RESOURCE UNITS OF THE SINAI PENINSULA - LANDFORMS AND SOIL CHARACTERISTICS	A-6
A-2	LIMITATIONS FOR CROP CULTIVATION UNDER IRRIGATION . . .	A-9
A-3	AREAS OF LAND RESOURCE UNITS AND THEIR LANDFORMS	A-10

APPENDIX C

C-1	TOLERANCE OF VARIOUS CROPS TO ESP	C-1

NUMBER		PAGE
C-2	INFLUENCE OF ESP ON CROP REDUCTION	C-1
C-3	RELATIVE TOLERANCE OF VARIOUS CROPS TO SOIL SALINITY . .	C-2
C-4	GUIDE FOR SELECTING A METHOD OF IRRIGATION	C-4

THE LAND AND THE ENVIRONMENT OF SINAI

1.0 INTRODUCTION

1.1 BACKGROUND

This Volume of the Sinai Development Study, Phase One (SDS-I) Final Report presents an overview of the Sinai Peninsula environment and an assessment of its land capability. It was drafted to support other SDS-I work on such subjects as economics, agriculture and settlements, and to serve as a reference document for later planners and development executives. This volume summarizes additional analysis undertaken in 1982, particularly Chapter 3 on Land Planning and Chapter 4 on Land Capability for Urbanization. It is, however, firmly based on the Project's earlier (1981-1982) working papers, memoranda and maps, which are in the SDS-I files at the Ministry of Development.

Essential support and advice have been received from the Desert Institute (which was a subcontractor to the SDS-I Consultant, mainly during 1981 when much of the Study's field work was completed) and the General Organization for Research on Groundwater (REGWA). The Office of Arid Land Studies of the University of Arizona played a major role in preparing the rural land capability assessment in 1983.

1.2 SCOPE

The four main chapters of this volume:

- Present an overview of the Sinai environment.
- Consider the development potential of the peninsula's land and water resources, with principal emphasis on the identification of soils suitable for irrigation.
- Present the development potential for each of the five subregions*
- Look at the land capacity implications of selected nonagricultural land uses of relevance to the development strategy recommended in Volume I.

---

* To assist the 1983 land capability study, Sinai was analyzed in terms of subregions, based largely on watersheds but also considering other land features. (See Figure 1.1) At an early stage in the analysis, four subregions were considered, one facing each coast; later the Consultant found it more useful to split the original Northeastern subregion into two -- the Northeastern coastal strip and the Uplands area defined mainly by the upper El Arish basin. These subregional divisions are used to assist the analysis of Sinai and the formulation of spatial plans for its development; they do not have, and are not intended to have, administrative significance. In the text of this Report there are some passages, drafted relatively early in 1983, which refer to only four subregions, dividing the Northeast into an Uplands Zone and a Coastal Zone. What was earlier referred to as "Northeast-Uplands" is called the Uplands subregion in the final text.

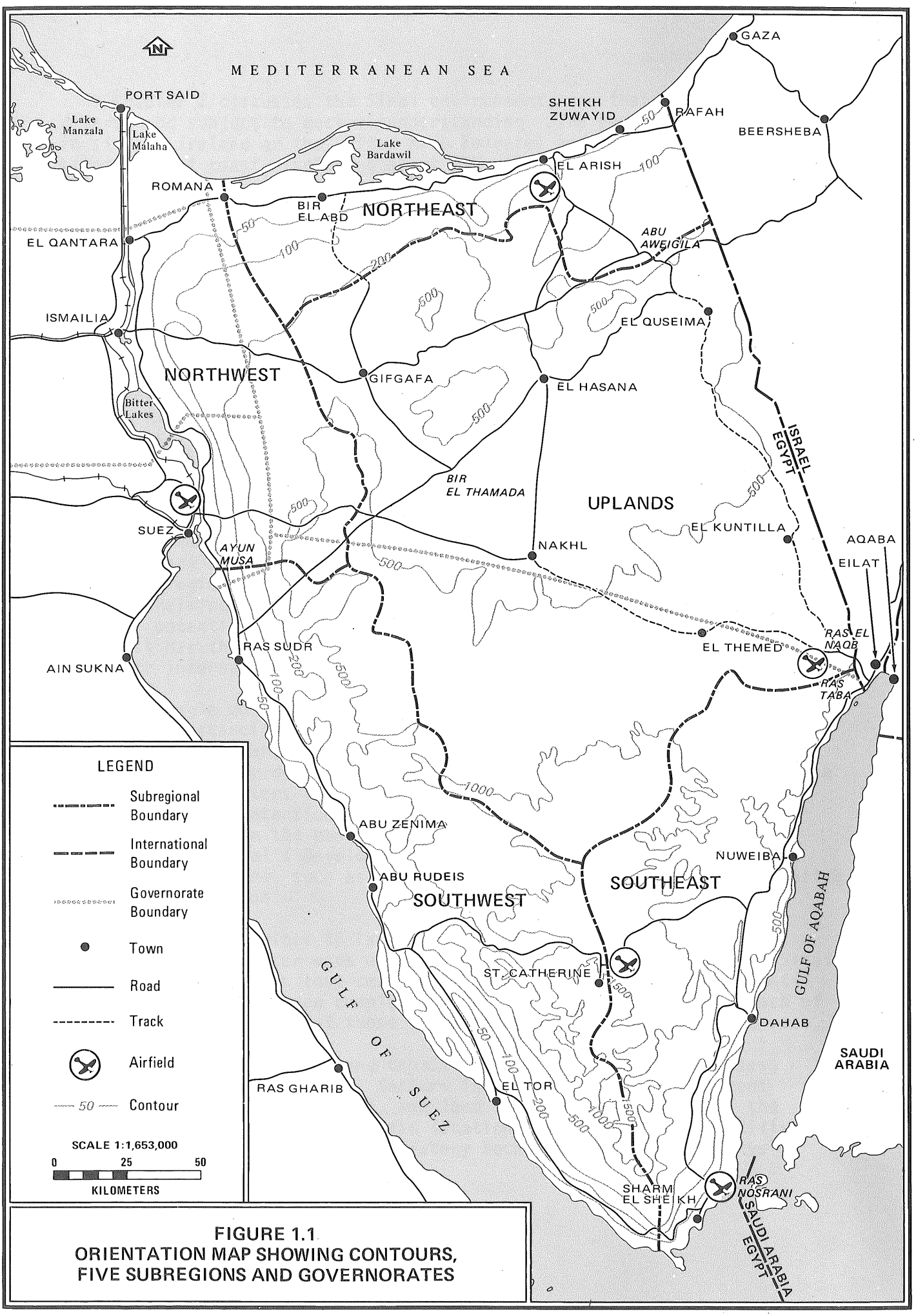


FIGURE 1.1
ORIENTATION MAP SHOWING CONTOURS, FIVE SUBREGIONS AND GOVERNORATES

Chapter 2 discusses the Sinai environment, one that is truly diverse and subject to much misunderstanding. The peninsula is similar in size to Ireland or the United Arab Emirates and has over 900 kilometers of coast, including about 155 kilometers along the eastern bank of the Suez Canal. Subregions of the Sinai vary in climate from arid-tropical, to Mediterranean, and to mountain-temperate, due to its coasts and mountains. Rainfall averages 20 millimeters in the southwest, whereas the northeast receives an average of 15 times that amount. Elevation drops to 1800 meters below the sea in the deepest parts of the Gulf of Aqabah and rises to more than 2500 meters above sea level at Gebel Musa. In the Southeast Subregion less than five percent of the land is flat, whereas about two-thirds of the Uplands is a vast undulating plateau.

Everything ecological is complicated in Sinai; it is the interface between Africa, Asia and Europe for birds, animals and plants. Its history is intertwined with many societies. Previous settlers include the ancient Egyptians, Nabateans, Romans, Byzantines, and Bedouin. Their experience can teach basic lessons to the new settlers of the late twentieth century.

A fundamental characteristic of Sinai's environmental resources is that they are not spread evenly across the landscape but are distributed in all subregions and sometimes clustered. Certain areas are favored but not overwhelmingly so: the Northeast and Uplands have the best agricultural potential, the Southwest has the most mineral resources, the Southeast has the best touristic sites, and the Northwest has the best access to international markets, the rest of Egypt and Nile water.

The single most basic unity in the Sinai environment is that all parts have a scarcity of water. On average rainfall is less than 40 millimeters per year, and much of the higher precipitation does not fall on fertile soil nor does it recharge an efficient aquifer. The lifestyle of the Bedouin setters in Sinai evolved in response to the environment. The Government's intention is to introduce a new lifestyle that earns better returns from the peninsula's resources. One message of this volume is that Sinai's development must be carefully executed to avoid environmental crises, such as pollution of aquifers or further overgrazing of sparse vegetation.

Chapter 3 describes 16 Land Resource Units (LRUs) and identifies about 70 land and water uses which are particularly appropriate for Sinai. It strongly recommends that certain of these should be restrained until further studies have been completed. Chapter 3 further analyzes each of the subregions in terms of those 16 LRUs and the 70 potential land uses.

Chapter 4 deals with land capability for non-agricultural uses, the role of non-environmental factors in land capability assessment (such as proximity and access), and land use conflicts. Much of the chapter is concerned with specific locations that have been identified as critical to the Recommended Strategy because of fairly intensive

development proposed for them. It is found that major settlements have a potential for growing where several resources coalesce or cluster; therefore, it is precisely where the most development potential exists that competition amongst land uses is likely, and careful land management will be most needed. For instance, in both El Arish and Abu Rudeis urban activities are expanding on the scarce land that has agriculture potential; urban activities also impinge on valuable tourist sites in both locations.

Chapter 5 addresses the problems of planning for and implementing major development projects in such a way that the sensitive environment described in Chapter 2 is neither polluted nor despoiled, and resources are not wasted by mislocating land uses. Ten basic issues concerning possible negative environmental impacts are discussed as part of the design of a pragmatic "Environmental Assessment" methodology.

Conservation procedures are described to protect special areas for future generations of Egyptians. Lastly, a management system is suggested for Sinai which includes monitoring, training, and enforcement.

Appendices A, B, and C present background detail for the soil capability assessment, with appropriate tables. Appendix D presents background material on selected natural areas and cultural/scenic sites. The Project files contain detail maps of Land Resource Units for each of the Subregions.

1.3 PROCESS

The concern of this Volume IV includes the translation of land capability assessment, integrated with other analyses, into comprehensive long-term development alternatives. This process, carried out during 1981, 1982, and 1983, considered first the sectoral capabilities of Sinai's land and water areas for the peninsula's development. Later, it assessed the integration of these capacities for smaller portions of the peninsula (subregions and zones within subregions) without cost constraints. Third, cost and time constraints were considered, and alternative development strategies were hypothesized. Finally, a Recommended Strategy was formulated.

This process indicated that the limits to Sinai's development have more to do with aridity, investment resources and project management than with land capability. However, in certain places the attributes of the land set the limits to development. For instance, physical features of the land are more limiting in the Southeast than in the Northeast.

The data assembled in this process, much of it on file at the Ministry of Development in tabular and map form, provide a basis for planning of land use (considering resources), infrastructure (considering proposed population and economic activities for subdivisions of the peninsula), and the conservation of the fragile Sinai environment.

1.4 ISSUES

Several issues emerge from this text. They are touched on appropriately in other volumes as well:

- Desertification: Evidence indicates overgrazing during recent decades in Sinai. Unless managed carefully, the introduction of Nile water could exacerbate this problem.

- Pollution: The oil industry on the Gulf of Suez is polluting the Gulf, the coast and the land (the last through urban sprawl).

- Conservation: Sinai is a natural museum and treasure house of rare marine and terrestrial flora and fauna. Development could threaten this natural heritage, which is of national and international importance.

1.5 RECOMMENDATIONS

The knowledge generated by the studies presented in this volume has generally been incorporated in proposals and recommendations in other volumes. Some recommendations relate to the subject matter of "Environment and Land" more than others:

- It is recommended that conservation areas be set aside in the vicinities of Lake Bardawil, Gebels El Maghara (both North and South, including Sarabit El Khadim), the El Tih and Igma Escarpments, St. Catherine and Gebel Musa. The two escarpments and the St. Catherine area could be identified conviently in appropriate legislation as all the area in Sinai that is over 1000 meters above sea level. (See Figure 1.2)

- Zoning of the coastline of Sinai is recommended to provide for recreation/conservation, industrial and other uses. One advantage that Sinai now has over its Mediterranean and Red Sea neighbors is its pristine beaches and coral. This advantage should be protected.

- Grazing should not be expanded before further studies of groundwater and surface water are completed and practical range management proposals are worked out in detail.

- New settlements in Sinai should be sited giving more than usual consideration to environmental criteria. It is recommended that new sites be found for some old settlements which are expected to grow rapidly as development plans for the peninsula are executed.

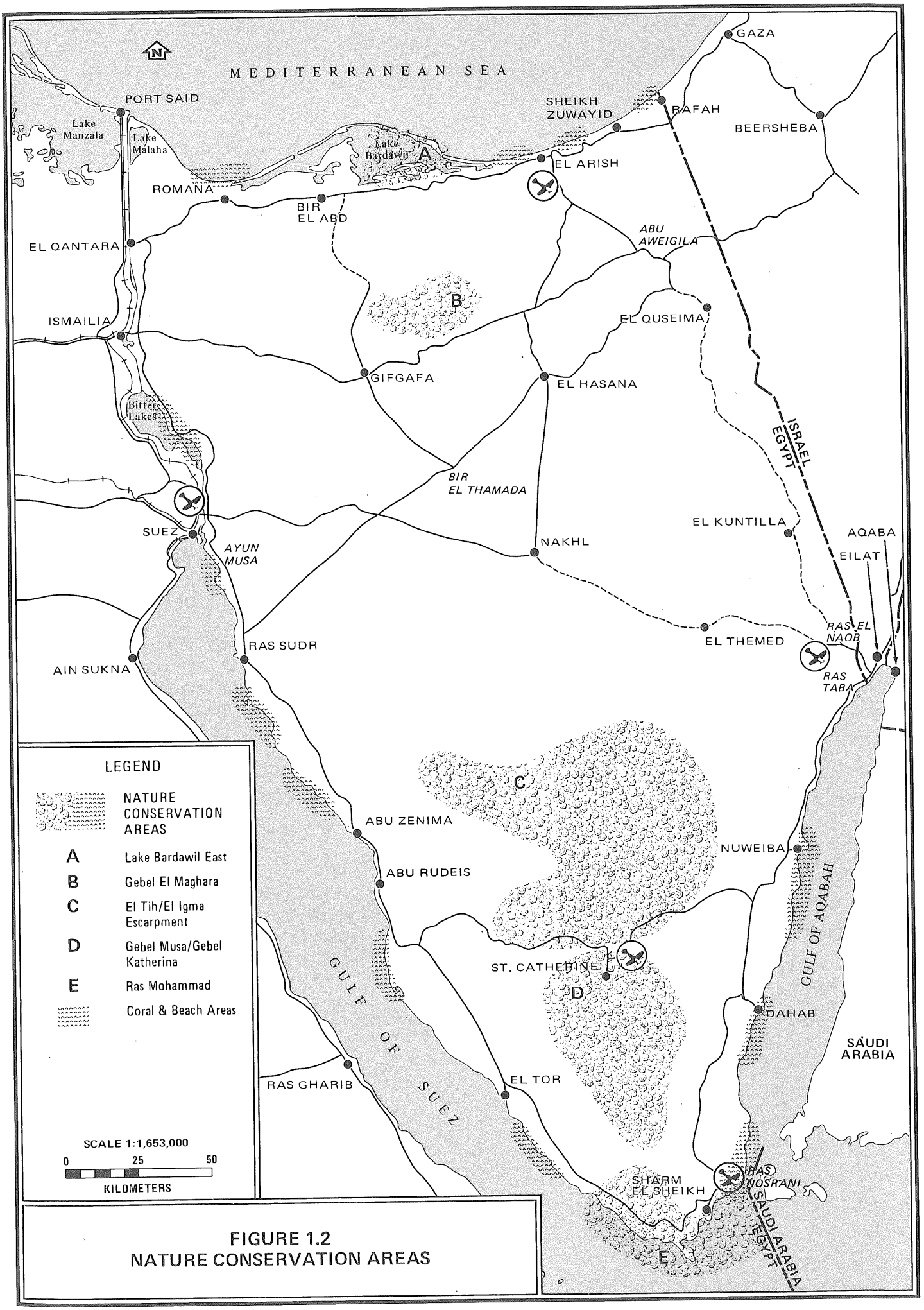


FIGURE 1.2
NATURE CONSERVATION AREAS

2.0 THE SINAI ENVIRONMENT

2.1 INTRODUCTION

The Sinai Peninsula is bounded by longitudes 32° 20' and 34° 52' E, and latitudes 27° 45' and 31° 10' N. Sinai extends over an area of approximately 61,000 square kilometers, which is about as large as Ireland, the United Arab Emirates, or West Virginia, U.S.A., six percent of the total surface area of Egypt. It is the meeting point of two continents: Africa on the west and Asia on the east. This union is reflected in Sinai's physiography, climate, and flora and fauna. The peninsula contains large tracts of desert and high rugged mountains, almost completely bare of vegetation. No permanent rivers flow from Sinai, yet during winter storms which may arise every three to five years, torrents of water will rush down the usually dry wadis and can wash away concrete bridges.

Sinai falls within the great arid belt crossing northern Africa and southwestern Asia. Most of Sinai is characterized by low rainfall, high evaporation, and a wide daily range in temperature. Low humidity allows up to more than 80 percent of solar insolation to penetrate the atmosphere and heat the ground during the day, but at night the lack of clouds allows the accumulated heat to radiate back to the atmosphere. This aridity is manifested by a degraded soil surface, expansive areas of sand dunes, salinization of soils and groundwater, numerous large dry water courses or channels (wadi beds), and rugged bare mountainous regions.

Although Sinai is a desert area, three-quarters of its boundary is marine coast: the Red Sea and the Suez Canal on the south and west, the Gulf of Aqabah on the southeast, and the Mediterranean Sea on the north. The Gulf of Suez and the Gulf of Aqabah are two large arms of the Red Sea, but the sea is continuous between the two gulfs. The Suez Canal directly connects the Gulf of Suez with the Mediterranean and is an important waterway for ship traffic. On the Mediterranean shoreline, Lake Bardawil is the most conspicuous and important marine and aviary habitat of Sinai.

2.2 GEOMORPHOLOGY

The Sinai Peninsula is a portion of the African Precambrian shield that arose between two rifted areas and became tilted downward in a northerly direction. Between the Precambrian and Quaternary periods, the peninsula was subjected to both long and short inundation by the Mediterranean Sea.

The Sinai Peninsula is characterized by five major geomorphic areas or provinces as follows:

- Mediterranean Foreshore
- Mobile Platform
- Stable Platform
- Suez Rift
- Southern Mountains

The Mediterranean Foreshore Province, an area of low relief terrain, extends along the entire northern coast of Sinai, inland to the mountains of the Mobile Platform Province. The landforms are predominantly sand dunes, sand sheets, and coastal depressions. (See Figure 2.1)

The Mobile Platform Province is a narrow northeast-southwest trending strip of the Syrian Arch, with elongate hills and low-lying plains. Prominent landforms are the Gebel El Maghara, Gebel Yelleq, and Gebel El Halal anticlines.

The Stable Platform Province is a gently dipping uplands area developed on limestones and sandstones. This province occupies 40 percent of the peninsula and is often described in terms of two parts, northern and southern.

The Suez Rift Province parallels the Gulf of Suez and extends inland from the coast to the western limits of the Southern Mountains, Stable Platform, and Mobile Platform Provinces. The terrain in this province is highly variable. Most features are aligned in a north-northwest to south-southeast direction. Inland the province is marked by steep slopes and high relief, and along the coast moderate to gentle slopes and flat or slightly undulating relief are typical.

The Southern Mountains Province is composed of the Afro-Arabian shield basement rocks and represents the structural core of the peninsula. This province is characterized by steep, rugged slopes and high relief terrain; about one-quarter of the province is over 1000 meters in elevation. A narrow strip along its eastern edge is sometimes referred to separately as the Aqabah Rift Province.

2.3 SOILS

The soils of Sinai consist principally of unconsolidated deposits formed from alluvial, aeolian, or lacustrine deposits and developed primarily under arid conditions. Soil profiles in Sinai seldom exhibit evidence of maturity, as reflected by the absence of conspicuous soil horizons. Mature profiles, where present, are probably due to long past conditions when Sinai had a more humid climate.

Soil erodes easily by runoff and is further cut by wind. In some areas, large alluvial fans stretch away from eroded angular peaks of more resistant rock and form wide and sometimes deep expanses of debris in wadis. Near the coast, the slopes level off to low basins which receive rainwater, but the water soon evaporates and leaves behind a dry wadi bed, sometimes with a crust of salt.

The soils with agricultural potential consist of alluvial or aeolian deposition. All soils in Sinai have a very low organic matter content, and their water retention capacity is low. Most of the soils are well drained except for the deltaic and lacustrine clay deposits of the El Tina Plain and a few low areas along the Suez Canal and Bitter Lakes. These deltaic soils are high in impermeable clay and are very saline. They lie at sea level or slightly above, with high water tables, and are difficult to drain and leach.

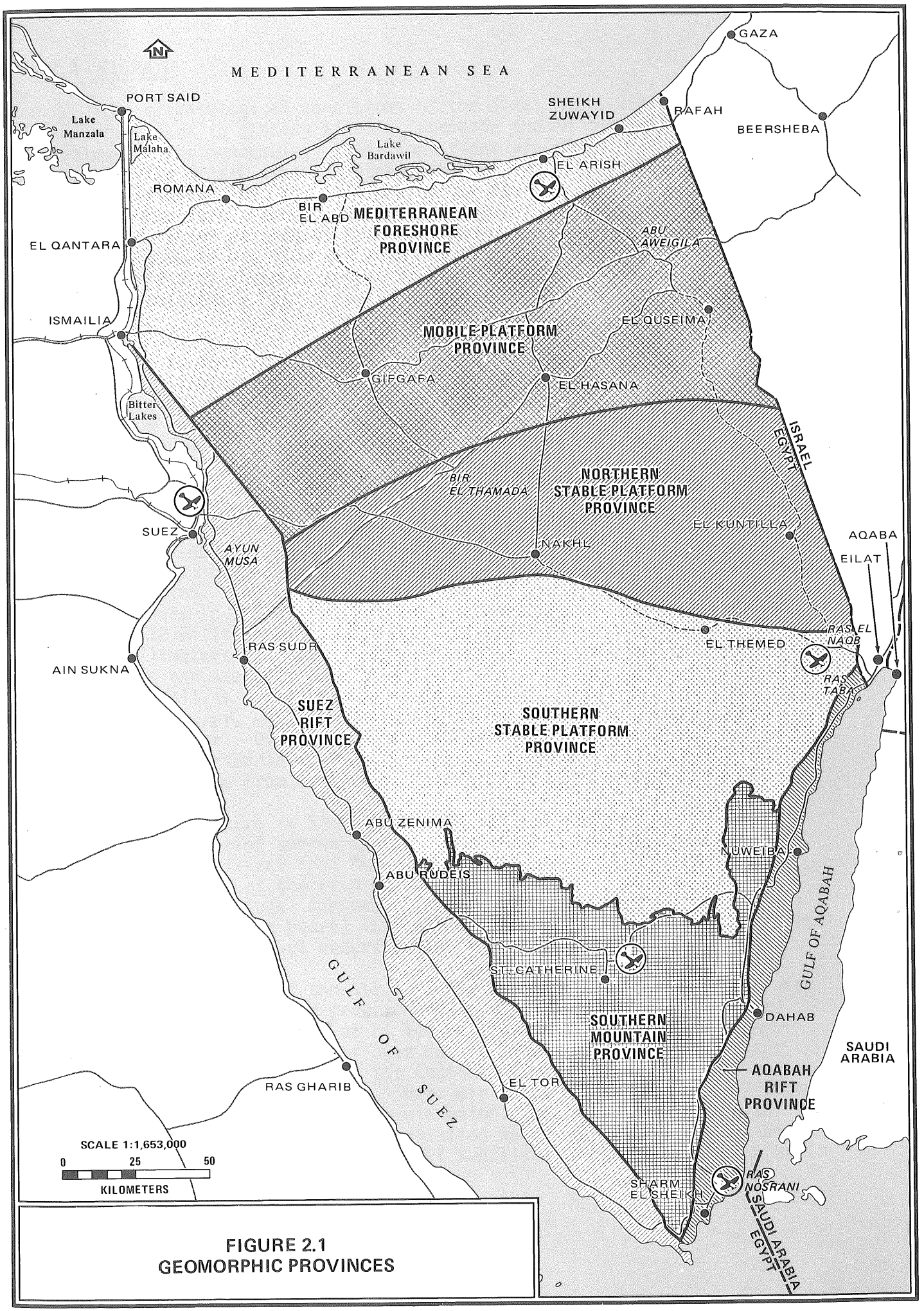


FIGURE 2.1
GEOMORPHIC PROVINCES

2.4 CLIMATE

The climatological conditions of the Sinai Peninsula play an important part in shaping Sinai's landscape and in controlling the ecology of the peninsula. These conditions are similar to those which characterize desert areas in other parts of the world. They include extreme aridity, long hot rainless summer periods, and mild winters in which storms rarely occur. During winter months, some areas of Sinai experience short periods of brief but heavy rainfalls that may cause the wadi beds to overflow and wash out roadways. Sinai is also characterized by khamseen storms or sandstorms, when violent winds blow intermittently over a period of about 50 days during February and March.

Sinai is located in an area of intense solar radiation and averages only 40 millimeters of rainfall annually. Many regions display zones in which rainfall is very unevenly distributed. The scarcity of rainfall may be due to the geographical position of these zones, which are located in rain shadows of the peninsula and other nearby regions.

Low and infrequent precipitation and low humidity play an important role in the climate and ecology of the Sinai Peninsula. The amount of rainfall in Sinai decreases from the northeast toward the southwest. The greatest amount of rain is found in Rafah (304 millimeters/yr) in the northeast; only about 10 millimeters/yr of rain occurs in the Southwest Subregion. The average annual rainfall along the Mediterranean Coast amounts to 121 millimeters/yr. Rainfall decreases in the Uplands to about 32 millimeters/yr, but then increases in the Southern Mountains to 62 millimeters/yr. Rain decreases in the southerly and westerly directions and averages only 12 millimeters/yr in the Southwest Subregion, where rainfall is variable; for example, at Abu Rudeis rainfall averages 22 millimeters/yr, while at Ras Sudr, to the north, it averages only 6 millimeters/yr. Overall, the annual average amount of rainfall for the entire Sinai Peninsula is 40 millimeters, of which 27 millimeters is estimated to come from individual storms of 10 millimeters or more.

Rainfall occurs in Sinai mainly during the winter season (November to March) and during spring or fall. Rainfall decreases markedly or is completely nonexistent from May to October. Along the Mediterranean Coast, 60 percent of the rain occurs in winter, while 40 percent falls during the transitional seasons. In the southern mountains, data for a limited period (three years) indicate that 20 percent of the rainfall is in winter and 80 percent occurs during the transitional seasons.

The temperature of the air in Sinai is subject to large variations, diurnally, seasonally and geographically. Maximum winter temperature ranges from a high of 21°C at El Tor to less than 10° at St. Catherine. The Mediterranean and Gulf of Suez Coasts show similar maximum winter (January) temperatures, while the southern mountains region shows a large variation in temperature. Here air temperatures decrease by about 6°C for each 1,000-meter rise in elevation. Maximum temperatures in summer (July) also show a large variation and range from near 20°C at St. Catherine to more than 36°C at El Kuntilla. During summer, the Gulf

of Suez Coast is much warmer than the Mediterranean Coast; Gulf temperatures are almost 35°C, while those along the northern coast are cooled by Mediterranean Sea breezes and are about 30°C. At St. Catherine, as expected because of its high elevation (about 2,000 meters), maximum summer temperatures in July are about 20°C--the coolest on the peninsula.

Sand or dust storms occur about three to five days each winter or transitional season in the northern region, and two to five days during each of these seasons in the middle plateau region. These storms affect many activities in Sinai, including agriculture; the sand can cover wide areas in a relatively short time.

It is fair to say that Sinai has a dry Mediterranean climate on its north coast, a dry tropical climate on its southern coasts and a dry temperate climate in the Southern Mountains. Such a wide variety of climates in a small area is due to the high mountains and extensive coastline.

2.5 WATER RESOURCES

When precipitation occurs in Sinai, and is less than about eight to ten millimeters, there is typically very little runoff of rainwater; most of this water either evaporates or percolates into the subsoil. When rainfall amounts to more than ten millimeters, runoff may occur and wadi beds will begin to carry water depending on the amount and duration of rainfall, the intake capacity of the basin's soils, and their moisture content.

A water-balance analysis was performed for several important hydrograph basins as described in Volume V. It is estimated that 60 percent of the mean annual rainfall for Sinai is lost to evapotranspiration, five percent runs off to the sea, and 35 percent percolates deep into the rocks and unconsolidated deposits. Much of the deep percolation constitutes groundwater recharge. Recharge values were estimated for the major aquifers of the peninsula. An average recharge of 90,000 cubic meters/day is estimated for the Lower Cretaceous sandstone and contiguous lower sandstones of Sinai, and about 192,000 cubic meters/day for the Middle Cretaceous sequence. The recharge to Quaternary aquifers in the southern El Qaa Plain and northern El Arish-Rafah areas are estimated to be 66,000 and 65,000 cubic meters/day, respectively. (See Volume V, Water Supplies and Costs, Chapter 2, especially pages 2-47 to 2-56, for further discussion of these aquifers.)

Generally, groundwater within Sinai may be classified into two main types:

- Shallow groundwater, occurring mainly within:

  -- weathered zone of igneous and metamorphic rocks
  -- quaternary rock
  -- recent deposits such as wadi fill or sediments
  -- sand dunes.

- Deep groundwater, mainly occurring in confined and semi-confined aquifers of pre-Quaternary formations.

Much potable and irrigation water in Sinai is drawn from the ground. Much of the groundwater is high in total dissolved solids (TDS) or salinity. After a rain, a large part of the flow in the wadis may percolate beneath the surface. There is thus an important interrelationship between surface and subsurface water resources. The occurrence and movement of subsurface water in the wadis are closely related to the geological structure of the water basins. Seepage from wadis into permeable gravels is likely to be a major source of recharge. These influent wadis are ephemeral (i.e., they are dry during most of the year).

Almost all of the groundwater in Sinai is from rainfall, but some water is probably connate water, present in rock during its formation and frequently highly saline. Connate water may also be a source of some of the undesirable minerals in the groundwater, such as boron. In some areas of Sinai, the aquifers intersect the earth's surface, where an oasis, spring, or seep may form. In other areas, artesian groundwater is present where the aquifers are deep and their water is under pressure. Data on the water points of Sinai are given in Volume V and in Working Papers 33 and 34, Water Resources and Hydrogeological Information Cards.

The important aquifers in Sinai necessarily derive their characteristics from past geological events of sedimentation and structural movements on the peninsula, as well as from regional and local recharge conditions over the past centuries.

The characteristic conditions of less than 50 millimeters of rainfall per year (excepting the Mediterranean coast and the high rocky mountains), and the lack of a simple large aquifer (such as the Nubian sandstone aquifer of the Western Desert), mean that groundwater in Sinai does not offer large scale development potential. However, small scale opportunities do exist in several places that have supported life for centuries and can enlarge that support.

2.6 TERRESTRIAL ECOLOGY

The Sinai is generally a hot desert ecosystem, but the central Sinai highlands, including the El Tih Plateau and the Southern Mountains area near St. Catherine, have a climate approaching that of a cool desert--with cool winters and warm summers. Vegetation is sparse and limited to specific areas. (Figure 2.2)* Wildlife is also scarce but is representative of several zoogeographical regions since the peninsula is the land bridge between Africa and Asia.

Generally, there are three types of plants in Sinai:

- the conspicuous desert shrubs that have numerous branches shooting out from a short basal trunk
- annual plants that grow only when moisture is adequate
- succulents that can store water

*Additional information is mapped on a scale of 1:750,000 in Plate 4-1 of Working Paper 45, Preliminary Map Portfolio.

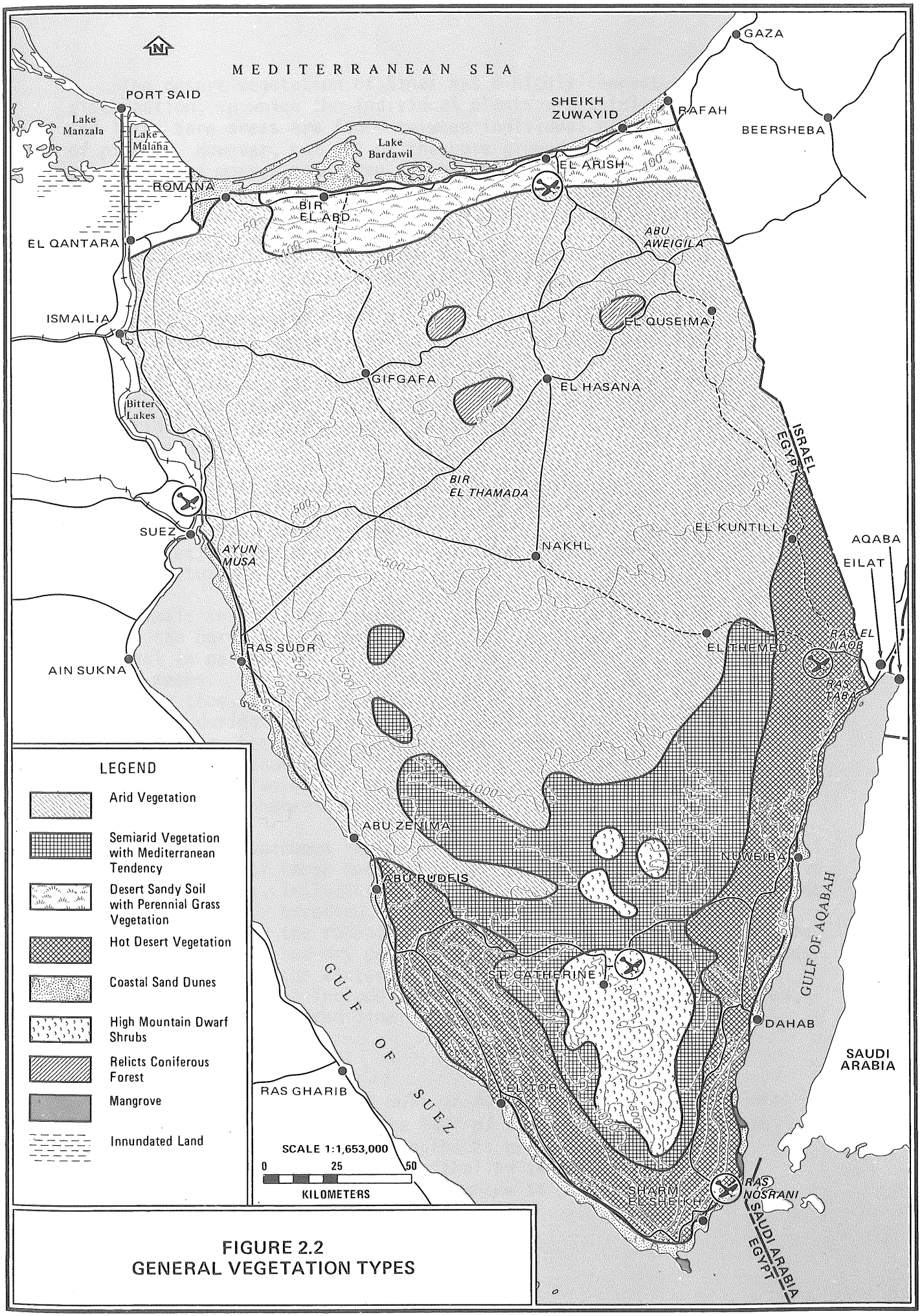


FIGURE 2.2
GENERAL VEGETATION TYPES

The desert vegetation of Sinai has a highly characteristic distribution, in which the individual plants are thinly scattered and large bare areas are found between individual plants and groups of plants. However, not all of the bare ground is truly free of plants, since mosses and algae can be observed in wet areas along the coastal plains, in the high mountainous regions, and on wet sands. On the other hand, plant species are almost totally absent in areas with active sand dunes or in the rock- and boulder-strewn (hammada) desert; in these areas, vegetation is only present in or adjacent to the wadi beds, and in some of the salt springs.

Various regions of Sinai are characterized by the specific types of vegetation that dominate that area. The eight major vegetative types adapted to Sinai conditions include: arid vegetation, semiarid vegetation with Mediterranean tendency, desert sandy soil with perennial grass vegetation, hot desert vegetation, coastal sand dunes vegetation, high mountain dwarf shrubs, relect coniferous forest, and mangrove swamps.

The floristic diversity of Sinai is high and is represented by approximately 1,000 species, of which 270 are indigenous to Sinai and not known in other parts of Egypt. Thirty-nine taxa (31 species and eight varieties) are unique to Sinai--that is, these species are found in nature only in Sinai.

Animals in Sinai are scarce. Those present are adapted in various ways to the harsh desert conditions. Many of the animals burrow, are nocturnal in nature, or can avoid dessication from the sun by physiological means. They may evade the aridity of the desert. This is especially true for insects and other invertebrates whose eggs or pupae lie dormant during long dry periods. When rains occur and plants flourish, ants, bees, wasps, butterflies, moths, and beetles become very active. In some cases, a particular bee or insect may emerge from its underground hive only when a specific flower is in bloom. Brine shrimp occur in ephemeral ponds.

The most conspicuous features of the vertebrate fauna of the Sinai are the scarcity of large mammals other than the camel and the relative profusion of birds, including tropical species. Many birds are present only seasonally for breeding, migration, or wintering. Mammals are best represented by the rodents. Many can live on dry seeds, and some enter torpor during hot dry periods. Among the amphibians, some toads are observed during the winter or spring following rains. Other indigenous vertebrates include snakes, lizards, the ibex, rock hyrax, and perhaps the endangered Sinai leopard.

2.7 THE MARINE ENVIRONMENT

The Gulf of Suez and the Gulf of Aqabah are a part of the Great Rift Valley of East Africa. The Gulf of Suez has an average depth of only 50 meters (compared to depths as great as 1,800 meters in the Gulf of Aqabah); it is very shallow in its northern extension and reaches only 80 meters where it joins the Red Sea.

The bottom is highly regular and slopes gently from the shallow areas in the north to the deeper areas in the south off Ras Mohammad.

The Gulf of Suez extends in a southeasterly direction from about 30°N latitude to 27° 45'N, a distance of some 154 nautical miles (roughly 287 kilometers). The Gulf is almost completely surrounded by tracts of desert, and both air and water temperatures are high for these latitudes. This results in the rapid evaporation of seawater, which maintains high salinity values. No perennial rivers empty into the Gulfs of Suez and Aqabah. The wadis that line the Sinai coastal area carry water to the gulfs only ephemerally.

Bottom deposits of the Gulf of Suez are mostly aeolian in origin, and the gulf is sandy or muddy in many places, especially near Suez. The western shoreline of Sinai is hard, rocky, and fringed with many coral reefs, especially south of El Tor. Development of flora and fauna in the gulf is due to secondary invasion initiated from the Indian Ocean through the Straits of Bab El Mandab. Since the widening of the Suez Canal, there has been some recruitment of Mediterranean aquatic flora and fauna, but these organisms have not been fully successful. The majority of these plants and animals are now indigenous only to habitats located in or near Suez Bay. Coral reefs and fishes are the most important biotic community along the southwestern coast.

The area between El Tor and Ras Mohammad contains wide, continuous, shallow luxuriant reefs of a wide variety. Off the Strait of Gubal, these reefs extend far out into the Gulf of Suez, leaving a narrow shipping channel. The distribution and productivity of the reefs in this area are due to a mixture of marine water from the Red Sea and Gulfs of Aqabah and Suez. In contrast, the coral reefs along the Gulf of Aqabah are narrow discontinuous reefs, the offshore sides of which fall sharply to great depths.

The Gulf of Aqabah is about 185 kilometers long and is 27 kilometers wide at its widest point. In contrast to its narrow width, the gulf is quite deep (more than 1,800 meters), with a very steep offshore gradient. The gulf is separated from the Red Sea by a sill about 250 to 350 meters deep at the Tiran Strait. The southeastern coastal area of Sinai along the gulf is very steep, rocky, and barren. Several small alluvial fans extend from the mountains to the gulf as a result of the wadis dissecting these mountains. Little is known about the bottom but it may hold mineral deposits such as exist between Saudi Arabia and Sudan.

At Ras Mohammad and along the southeastern shoreline of Sinai are several habitats occupied by halophilous mangrove swamps associated with the mature coral reefs. These mangroves are not part of the coral reef, but represent an intrusion of a quasiterrestrial niche on the marine environment of the reef. The mangroves support a small association of special marine organisms, such as gastropods, arthropods, fish, and relics of the displaced reef community.

Lake Bardawil is located on the northern shore of the Sinai Peninsula (longitude 32° 40' to 33° 28'E and latitude 31° 3' to 31° 14'N). The lake is a hypersaline lagoon bordering the Mediterranean Sea: The lagoon is about 76 kilometers long and 20 kilometers wide at its widest part and has a maximum depth of about 4 meters. The lake extends over an area of about 640 square kilometers.

Lake Bardawil includes:

- a highly saline marsh at its western end
- an openwater lagoon in its central part
- a series of low sand islands or bars along its eastern extremity.

Most of the shoreline and the bottom of the lake are composed of sandy sediments. The narrow semicircular barrier beach that forms the northern boundary of the lake separates it from the Mediterranean Sea. Artificially maintained inlets connect the lake with the sea. Lake Bardawil has no fresh water supply and no major source of enrichment other than the Mediterranean. The influx of water from the Mediterranean is very important to the ecology of the lake, since this inflow and outflow maintains the salt concentrations in the water at tolerable levels for fish.

Lake Malaha, at the western extreme of the Mediterranean coast, was cut off from Lake Manzala with the construction of the Suez Canal in the 19th century. In 1981 it was bisected by the new Suez Canal bypass. The barrier beach/dunes that separated it from the Mediterranean have been eroded during the past decade, so that it is more properly a bay than a lake in its present condition.

Lake Malaha is about 7 kilometers from east to west and 13 kilometers from north to south; its depth does not exceed 5 meters in the portions that are not dredged. The bottom includes sandy sediments and Nilotic clayey soils. During the past century it has been a rich source of fish (for the people of Port Said), and has been exploited for salt and water fowl.

Studies of the lake are urgently needed to determine its capabilities for food production, recreation, shipping and other uses following the changes wrought by the SCA and erosion.

2.8 OVERVIEW OF HUMAN ACTIVITIES

2.8.1. Population

Sinai's population was estimated to be about 172,000 in the early 1980's. With a land area of approximately 61,000 square kilometers, the average population density is less than three persons per square kilometer. This low density is characteristic of many undeveloped desert regions. The inland areas have a population density of barely one to two persons per square kilometer.

Between one-half and two-thirds of the people in Sinai are Bedouin. Scattered enclaves of seminomadic and nomadic Bedouin tribes make up a major element of Sinai's population and settlement base. The majority of the population is located along the Mediterranean Coast. Most of Sinai's communities are small, with populations of hundreds or a few thousand persons. Volume VI, Settlement and Social Development, describes demographic characteristics in more detail.

2.8.2. Economic Activities

The Sinai Peninsula has numerous natural resources, most of which have not been developed to their full potential, due primarily to lack of adequate local water supplies. Farming and animal husbandry are the most important subsistence activities found in Sinai. Agriculture is mainly limited to areas where irrigation water is available, whether by well, irrigation canal, or pipeline. Scattered cultivated plots are also found along wadi beds that receive flood water, and in oases. The most important agricultural areas are found in the lower basin of the El Arish Valley and the eastern portion of the Mediterranean Coast. Other agricultural areas are scattered throughout Sinai in several basins or valleys such as that at Feiran Oasis. A large agricultural project is taking place near New Mit Abul Kom, east of the Bitter Lakes, using Nile River water carried by siphon under the Suez Canal. Important products of the agricultural industry include citrus fruits, olives, castor oil, palm dates, and flowers. Small-scale fishing takes place off shore from El Arish, in Lake Bardawil, and in the Gulf of Suez.

Recreational, religious, and health tourism is relatively undeveloped in Sinai. The most important centers, with considerable potential for expansion, are located along the Gulf of Aqabah and at St. Catherine mostly year-round, and on the Mediterranean Coast in summer.

The type, abundance, and diversity of agricultural crops that have been developed in Sinai vary from area to area. For example, abundant plant growth is quite apparent both near El Arish and on the north coast and in Wadi Feiran in the Southern Mountains. In both of these areas, cultivation is carried out by Bedouin farmers. Windblown soils (loess) found underneath the sand, together with the high water table, allows farmers to grow thousands of date palms and vegetables such as cucumbers, tomatoes, and watermelons. Several wadis in northern and central Sinai are cultivated for wheat and barley by farmers who place low stone dams across the wadis to catch rainwater runoff. In some of the remote wadis (especially near St. Catherine), figs, olives, quince, almonds, and peaches are grown in small cultivated areas.

Traditionally animal husbandry in Sinai is based on the use of natural vegetation for rearing goats, sheep, and camels. The current estimate of the livestock population is very nearly the same as the estimate of human population. There is a trend toward increased animal numbers, which has contributed to a steady depletion of the available range forage over at least the last 30 years. Areas close to settlements have been overgrazed.

The Bedouin still follow traditional practices of livestock management. According to season, the livestock are generally moved between mountain and lowland pastures (transhumance). Traditional routes and tracks through the mountainous areas are used. In the plains and wadis, however, flocks and herds tend to meander over the whole area. Goats are the preferred animal in mountainous terrain. Sheep, on the other hand, tend to be more prevalent in the broader wadis and flatland country.

Animal watering holes, wells, and outlets along pipelines are few and scattered over wide areas. During the wetter seasons (winter and spring), sheep, goats, and camels are often not watered. They survive on the moisture in the plants they eat, or they may obtain an occasional drink in low areas where runoff has collected. During the summer season, they are usually kept within 50 kilometers of a watering point and watered every two or three days. Some are driven to the east delta for summer grazing.

There is no accurate count of poultry or other domestic small animals in Sinai. Chicken barns are operating at Bir El Abd and El Arish. Turkeys, rabbits, ducks, and geese are found in small numbers, and pigeons raised in mud towers.

By far the largest economic activity in Sinai is petroleum exploration and production. Petrobel has over 1,000 employees working from its headquarters in Abu Rudeis. SUCO is also preparing for production at Ras Budran. Gupco, Conoco, Gulf, Mobil, and others have concessions in the Southwest, Northwest, and Northeast Subregions.

Various mining and processing activities have been carried out around Abu Zenima and Umm Bugma. El Arish, St. Catherine, Nuweiba, Dahab, and Sharm El Sheikh have become tourist centers in recent years. There are small-scale fishery activities based at El Arish, Lake Bardawil, Lake Malaha, El Tor, and Ras Sudr. El Arish is the only real urban center with a diversity of trading, construction, and manufacturing enterprises.

3.0 LAND PLANNING

3.1 INTRODUCTION

There is often confusion in the use of the terms "land capability" and "land suitability" in planning. For the purposes of the Sinai Development Study, Phase I (SDS-I), the two terms are distinguished as follows:*

- Land Capability assessment focuses on a particular piece of land (its natural resources and location relative to inputs and markets) and seeks to identify particular uses which the land can sustain;

- Land Suitability assessment focuses on a particular set of land uses and seeks to identify pieces of land which can sustain those uses.

Land Planning is the process of matching land uses to land resources (which include both land and water) in a formal or informal sequence of capability assessment (geographic focus) and suitability assessment (sector or project focus). It is a subset of activities in the regional planning process.

Land capability assessment may be seen as a process of sieving development possibilities. The mesh of the sieve represents the selection criteria, which themselves reflect the physical constraints of each type of development (agriculture, fishing, grazing, industry, tourism, etc.) and the policy, financial and technical constraints of the developers (government, corporation, or individual). The development possibilities which pass the sieve are those that appear to have a good enough potential (as viable land and water uses) to merit investigation in greater detail. Land suitability assessment would permit site selection for these preferred land and water uses, based on information at a far more detailed scale than the land capability assessment performed in this reconnaissance-level study. The land capability assessment in SDS-I is intended to determine the best general locations for further study by land suitability assessment.

It will be useful to keep in mind that SDS-I is at the land capability assessment stage. Much information that is considered desirable for development planning will not be found in a capability assessment. Land capability assessment works at a scale that is too general (in mapping terms, it is too small) to answer many specific planning questions--for

---

* Based primarily on: A Framework for Land Evaluation, Soils Bulletin 32, FAO, Rome, 1976; and Dent, D. and Young, A. Soil Survey and Land Evaluation, George Allen and Unwin, London, 1981.

instance, about the best sites or areas for particular development activities. In short, the land capability assessment is a guide that helps planners recommend particular areas and sectors for further study. It is sufficient on a basis for a long-range development strategy but not for short or medium term development or land use plans. The process used is summarized in an Explanatory Note on page 3-13 and described in some detail in Appendix A.

3.2 LAND RESOURCE UNITS

The SDS-I land capability assessment for the Sinai Peninsula started with delineation of Land Resource Units (LRUs), using general information collected in the field and from remote sensing imagery (Figure 3.1 and Table 3-1). Landforms, geology, soils, water, vegetation and similar characteristics are relatively uniform within the LRUs, but distinct from the characteristics of neighboring units. Where available, more detailed physical information was used to assess the characteristics of each unit. The assessment shows what general constraints for development exist within the Land Resource Unit. This information was combined with information on access to inputs and markets to yield a preliminary summary of options for development. Within the framework of government policies, the generalized options were used to generate strategies composed of spatial arrays of projects specified by type, general location, scale, and phasing in time.

Following SDS-I, the next required step will be an assessment of the feasibility of carrying out each of the proposed projects. One part of each feasibility study will be the land suitability assessment, which will focus on finding particular pieces of land to sustain the proposed project (i.e., finding the best site for each project, and the best combination of projects in areas of intensive development where several land uses compete for space and/or complement each other). This usually requires much more detailed, site-specific information than is found in a reconnaissance level survey typical of land capability assessments. However, the land capability information for each Land Resource Unit can be used to specify candidate areas which warrant more detailed investigation (suitability assessment) and specific project feasibility studies. Indeed, following completion of SDS-I reconnaisance field work in 1981, Regwa has been active in Sinai, preparing more detailed soil surveys needed to select specific areas worthy of detailed feasibility analysis.

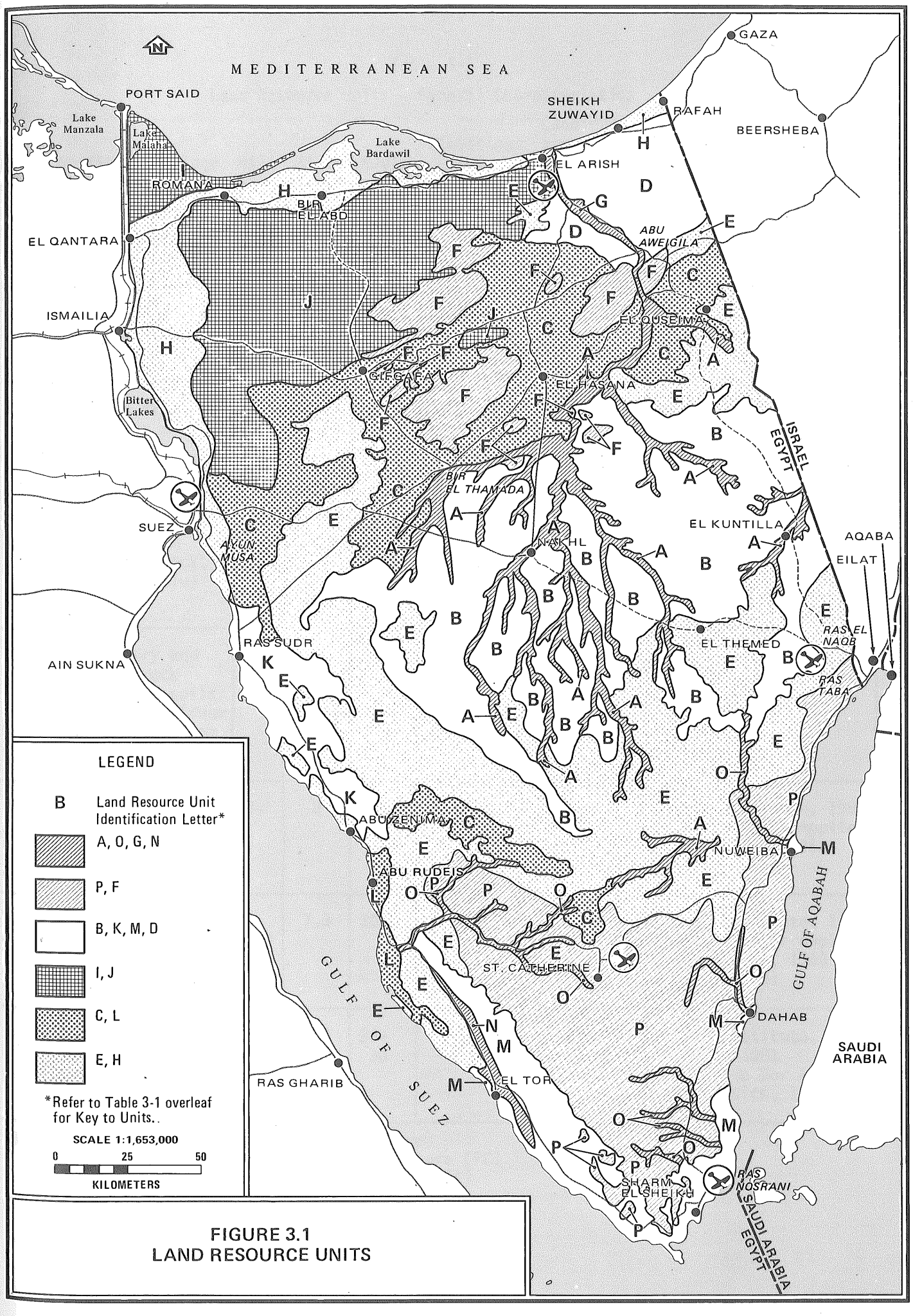


FIGURE 3.1
LAND RESOURCE UNITS

Table 3-1

Land Resource Units - General Characteristics

L.R. Unit	Surficial Geology	MAP[1]	MJaT[2]	MJuT[3]	Elevation (m)	Candidate area for agriculture	Source of Information
A	alluvium from mixed calcareous rock	24	6	36	250-500	yes	Desert Institute, 1981 Enterprise for Applied Geophysics, 1963
B	alluvium and residuum from limestone	24	51	36	200-650	Marginal	Desert Institute, 1981 Enterprise for Applied Geophysics, 1963
C	alluvium from calcareous sedimentory rock partially covered with aeolian sand	24	8.1	36.4	300-400	yes	Desert Institute, 1981
D	alluvium from calcareous rock, aeolian & alluvial sand	40-200	6	35	0-200	yes	Desert Institute, 1981 Enterprise for Applied Geophysics, 1963 (Adjusted for field observations in 1983)
E	sedimentary and volcanic rock outcrop and soils formed in residuum and alluvium from them	20	4	34	400-800	no	Desert Institute, 1981 (Nakhl study area)
F	dome mountain complex & calcareous sedimentary rock	40-	8	35	200-900	no	Desert Institute, 1981 Enterprise for Applied Geophysics, 1963
G	lower Wadi El Arish; alluvial terraces with aeolian sand	80-100	7.3	30.2	0-150	yes	Desert Institute, 1981 Enterprise for Applied Geophysics, 1963 REGWA, 1981
H	Mediterranean coastal plain and Suez Canal lowlands	20-300	7.8	26-30	0-200	yes	Desert Institute, 1981 REGWA, 1981 Enterprise for Applied Geophysics, 1963

NOTES: [1]MAP = Mean annual precipitation (mm)
[2]MJaT= Mean minimum January temperature (°C)
[3]MJuT= Mean maximum July temperature (°C)

Table 3-1 (cont'd)

L.R. Unit	Surficial Geology	MAP[1]	MJaT[2]	MJuT[3]	Elevation (m)	Candidate area for agriculture	Source of Information
I	El Tina Plain delta and lagoon desposits mixed with sand	73	11.2	30.4	0-10	yes*	REGWA, 1981
J	aeolian deposits, primarily moving sand dunes	20-40	7	35	0-250	no	Desert Institute, 1982 REGWA, 1981 Enterprise for Applied Geophysics, 1963
K	alluvial plains and wadi deposits	6-22	8	36	0-200	marginal	Desert Institute, 1981
L	alluvial plains and recent wadi alluvium derived from silicious rock	6-22	8	36	0-200	yes	Desert Institute, 1981
M	coarse alluvium primarily from igneous and metamorphic rock	10-20	8	36	0-400	marginal	Desert Institute, 1981
N	medium textured alluvium from mixed calcareous and igneous rock	10-20	8	36	10-100	yes	Desert Institute, 1981
O	coarse wadi alluvium from igneous & metamorphic rock	30-60	6	35	0-1500	yes	Desert Institute, 1981
P	bare igneous and metamorphic rock and alluvium	40-	5	20	300-2300	no	Desert Institute, 1981

NOTES: [1]MAP = Mean annual precipitation (mm)
[2]MJaT = Mean minimum January temperature (°C)
[3]MJuT = Mean maximum July temperature (°C)

* Agriculture subject to poldering or other process to eliminate shallow saline water table.

SOURCE: See Appendix A for further information about Land Resource Units and methods the Consultant used to delineate them.

3.3 LAND AND WATER USE CATEGORIES

Table 3-2, "Land and Water Use Categories", shows a wide range of land and water uses that can conceivably be developed in the Sinai Peninsula. These are the major possibilities to be retained or discarded (sieved) by the land capability assessment.

Each category of land and water use has certain physical resource requirements. For instance, the basic requirements for crop and livestock production are adequate solar radiation, temperature, water and suitable soil. In Sinai, solar radiation and temperature are not important constraints, except as they affect water balance. Frost is only a problem in the higher elevations of southern Sinai. Cloud cover, however, is frequent during winter and spring near the Mediterranean coast. Water and soils are the critical constraints--water more than soil.

Large areas of cultivable and grazable soil exist in Sinai. However, there is little truly "good" soil for cultivated vegetation, and the scarcity of water is everywhere a major problem. Rainfall is inadequate and unpredictable, even in the semiarid northeastern corner of the peninsula. Sahelian countries such as Niger have legislated the 250 mm isohyet as the lower limit beyond which rainfed agriculture is not permitted. In Sinai, this criterion would rule out all but the small coastal area between Sheikh Zuwayid and Rafah. In Saudi Arabia, by contrast, areas with over 100 mm rainfall a year are considered "good" grazing land; barely one eighth of Sinai receives that much.

Data on "mean" rainfall in arid and semiarid climates are quite misleading. Most years are much drier than the mean, and a few years are very much wetter; there is seldom a year with the mean rainfall. Only intermittent agriculture can be supported by rainfall alone.

The amount of water is only one variable of water harvesting; of similar importance are soil type and slope. Water harvesting is practiced now by Bedouin and was practiced by the Nabateans thousands of years ago in Sinai. However, this type of agriculture is also subject to the uncertainty of rainfall timing, meaning that most years are insufficient to support farming. Nabhan and Hutchinson* identified a runoff farming site in current but only occasional use in northern Mexico with mean rainfall of about 100mm; they assert that this site represents the most arid margin for runoff agriculture.

---

* Note: Nabhan, G.P. and Hutchinson, C.F., "Native American Runoff Agriculture at its Most Arid Margins," manuscript submitted to Science (Office of Arid Lands Studies, University of Arizona, Tucson), 1983.

TABLE 3-2

LAND AND WATER USE CATEGORIES

A. Agriculture: Crops (including cultivated trees)
   1. Irrigated
      a. Method: flood
      b. Method: sprinkler
      c. Method: drip
      d. Source: Nile water (canal/pipe)
      e. Source: groundwater (pumped)
      f. Source: runoff water (stored)
      g. Controlled environment (greenhouse, etc.)
      h. Oasis (modified micro-climate)
   2. Rainfed (dry farming)
      *a. Direct rainfall
      *b. Waterharvesting from catchment areas
      c. Water table shallow below surface - within root zone

B. Agriculture: Livestock
   1. Grazing
      *a. Natural vegetation (grasses, forbs, shrubs)
   2. Feeding
      a. Feeding with forage crops
         i. Irrigation
         *ii. Rainfed
      b. Controlled environment (small animal)

C. Fish, water birds and aquatic crops
   1. Open water fishing
      a. Offshore
      b. Lagoon (saline water)
      c. Canal
      d. Coral Reef
   2. Aquaculture
      a. Ponds (filled with ground or transported water)
      b. Canals (built for irrigation water transport)
      c. Controlled environment (cement ponds, etc.)
      d. Open water (cages, etc.)
   3. Mariculture
      a. Salt marsh
      b. Coral reef
      c. Open water (cages, etc.)
      d. Mangrove swamp
   4. Conservation
      a. Multiple use management
      b. Preservation

D. Trees, shrubs, and other natural vegetation
   *1. Exploitation of natural stands of trees and shrubs for fuel and construction materials
   *2. Exploitation of natural stands of shrubs, forbs and grasses for livestock forage
   3. Conservation
      a. Multiple use management
      b. Preservation

---

*Subject to further study

TABLE 3-2 (cont'd)

E. Wildlife
   *1. Exploitation by hunting and trapping
   2. Conservation
      a. Multiple use management
      b. Preservation

F. Tourism
   1. Beach and water sports
   2. Coral reef diving/snorkeling/glass bottom boats
   3. Cultural/historical sightseeing
   4. Landscape/wildlife sightseeing
   5. Health (hot springs, etc.)

G. Minerals, oil, and construction materials
   1. Metals and other minerals mining
      a. Underground mines
      b. Open-pit mines
      c. Seabed harvesting
   2. Oil and gas
      a. Drilling and pumping - onshore
      b. Drilling and pumping - offshore
   3. Construction materials
      a. Sand and gravel quarrying
      b. Limestone/dolomite quarrying
      c. Brick-making materials
         i. Clay excavation
         ii. Shale quarrying
      d. Building stone quarrying

H. Water management
   1. Dams and dikes
   2. Aquifer recharge areas
   3. Flood protection areas

I. Transportation and Utilities
   1. Roads
   2. Pipelines and canals
   3. Air and sea ports
   4. Electric lines

J. Settlements
   1. Large
   2. Small

K. Institutions
   1. Military bases
   2. Universities
   3. Research facilities
   4. Other

L. Industry
   1. Heavy manufacturing
   2. Minerals and oil processing
   3. Light manufacturing
   4. Agricultural product processing

---

*Subject to further study

The same problem of uncertainty applies to livestock grazing on natural vegetation. Only nomadic or transhumant grazing is possible. There is evidence from satellite photography that Sinai has experienced desertification in recent decades. Desertification is difficult to document precisely, but in so far as it is occurring, overgrazing is the probable cause. Therefore, the prospects for further development of the livestock grazing sector are quite limited without new measures for range management which protect and enhance the natural vegetation.

In general, the exploitation of any production which is dependent on rainfall, whether direct or collected through various water harvesting techniques, is not recommended without careful further study. This includes cultivation of crops (annual or perennial, including arid-adapted trees and shrubs), grazing of livestock on rainfed crops of natural vegetation, other exploitation of natural vegetation (such as woodcutting), and the exploitation of wildlife (which also depends on rainfed vegetation). The existence of arid-adapted vegetation and wildlife in Sinai should not mislead planners to suppose that rainfed plant and animal production can be expected to increase without specific steps to permit or to encourage that increase. Even the species found in Sinai appear generally to be at the limit of their tolerance of aridity; therefore, they can reproduce themselves and grow only very slowly. In Table 3-2 an asterisk (*) is used to indicate those possibilities which should be subject to further study before expansion is permitted, due to the absence of adequate, predictable rainfall in most of Sinai.

The other land and water uses listed in Table 3-2 pass the first general sieving based on Sinai's low rainfall, so long as that rainfall is supplemented by groundwater, imported water (from the Nile River or Delta drainage system) or desalinized water as their primary water source. There are adequate soils for irrigated crop cultivation and for animal production based on irrigated forage crops. There are many small areas in which non-irrigated crops, especially tree crops, can be grown because the water is shallow enough to supply the roots directly (wadi beds, oases, springs). Appropriate combinations of aquatic resources are adequate to support open water fishing, aquaculture, and mariculture.

Sinai's wide selection of interesting plants and animals underlines the desirability of conservation of its natural communities. Many beaches, coral reefs, cultural/historical sites, landscapes, and even hot springs can support tourism. The peninsula's mineral deposits (including oil, gas, coal, and construction materials) will support mining and quarrying. The coasts provide opportunities for construction of ports (bays and headlands which provide shelter from the open sea) and smaller landing sites for off-loading goods and passengers.

The possibilities for finding brick-making materials, especially suitable clays or shale, are not widespread. Making good bricks that do not deteriorate rapidly in a hot, dry climate, requires soils with 20 to 30 percent clay or silt. These soils should have very low calcium carbonate and soluble salt contents. The high calcium carbonate and salt levels of most northern Sinai soils rule out large areas as potential sources. However, there are undoubtedly useful deposits to be found locally. In the wadis of southern Sinai, some of the older terraces may be promising sources if they are not saline. (Figure 3.2 maps preliminary estimates of sources of construction materials in Sinai.)

Shale can also be used to make bricks. Shale is most likely to be found in the rocky outcrops (Land Resource Unit E) near the Gulf of Suez coast, particularly near Ras Sudr and Ras Misalla, in the Umm Bugma area, and around the north end of the El Qaa Plain (north of El Tor). However, the shale in these areas is likely to have high salt and calcium carbonate contents. Moreover, the currently available information is inadequate to allow any final assessment of Sinai's capability for producing brick-making materials.

Each of the possible land and water uses of the Sinai has a particular set of special physical requirements which are considered in more detail in the other volumes. The following subregional profiles summarize the geographic distributions of the development possibilities.

3.4 LAND AND WATER RESOURCES OF THE SUBREGIONS OF SINAI

When identifying development options and constraints, it is not enough to treat each land resource unit in isolation. Interaction and complementarity of neighboring units must be considered. One way to initiate this process is by analyzing spatial clusters of land resource units. Rather than start by looking at the whole peninsula at once, the planner can work more effectively by breaking the Sinai into natural subregions and initially considering each subregion as a separate planning problem. (Figure 1.1 shows the subregions used for this Study.) If the subregions are natural planning units, the component land resource units will constitute interacting spatial clusters.

These subregions serve two purposes:

- they provide a geographic framework within which information about the Sinai can be conveniently stored, retrieved and presented; and

- they allow planners to consider parts of the Peninsula as separate planning areas.

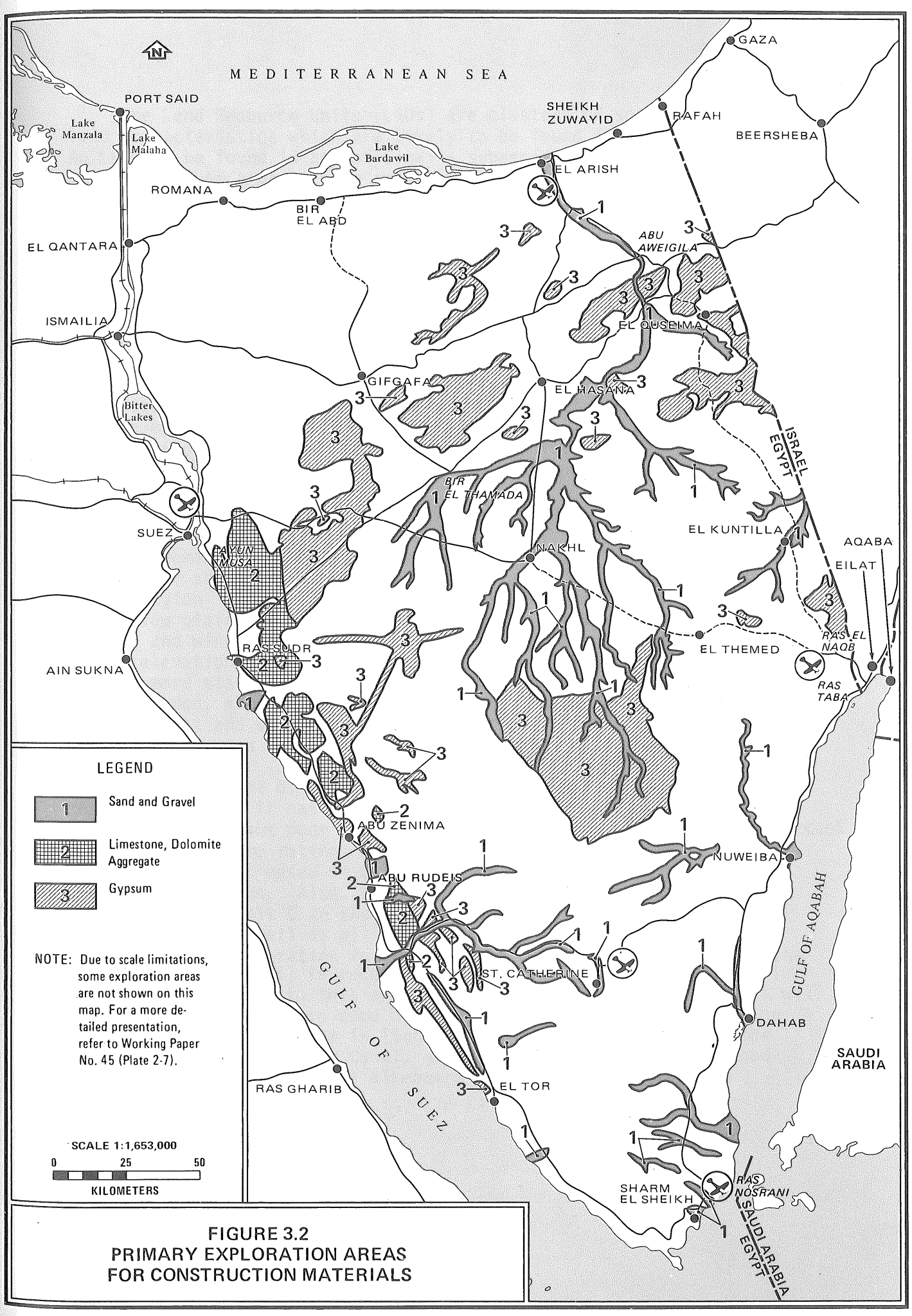


FIGURE 3.2
PRIMARY EXPLORATION AREAS
FOR CONSTRUCTION MATERIALS

The Land Resource Units (LRUs) are clusters of soils and other land characteristics which are likely to be found from place to place. An LRU may be found in any of Sinai's subregions, although it may be most typical of a particular area. Subregions and LRUs overlap as subregions follow drainage boundaries.

The land and water resources of each subregion are summarized in the following text and Tables 3-3 to 3-6. (An explanatory note regarding these tables is on page 3-14.) The subregional profiles below abstract the important development options and constraints which emerge from analysis of the tabular and map information. The potentials of the LRUs in each subregion are evaluated relative to each other on a regional basis; that is, the capability of a unit is rated for agriculture, fisheries, mining, tourism and infrastructure development by comparison to the other land resource units of Sinai. These evaluations must be considered as assignments of probability. In other words, where the likelihood of finding land of good capability for a particular use is higher, that land resource unit is given a high rating for that use.

3.4.1 Northwest Subregion

The dominant feature of this subregion is the Suez Canal. There are smaller shorelines on the Mediterranean Sea and the Gulf of Suez. The subregion is composed of five land resource units. Unit H is a sandy, low plain which is salt-affected near the Canal and the other shores, and wind-eroded on higher ground. Further inland and at slightly higher elevation (100-300 meters) are the mobile dune fields of Unit J and the more stable sand plains of Unit C. Higher still (300-850 meters) is the eroded, exposed bedrock area of Unit E. Unit I is primarily a tidal mudflat and salt marsh (including the El Tina Plain and Lake Malaha) which used to be part of the Nile delta with aeolian additions.

Thirty percent of Unit H is given the highest rating for irrigated crop cultivation; it has the one major limitation of a coarse soil texture, which means poor water retention (see Table 3-3). Sixty percent of Unit C has the same rating, but there is little field data to support that rating; it is based on extrapolation from similar areas in the Northeast Subregion. Also, there is disagreement among experts about the boundary of Unit C in the Northwest Subregion. The remainders of Units C and H, as well as all of Units E and J, have been set aside from further consideration for agriculture by this study. Part of the El Tina Plain (Unit I) is recommended for large scale irrigated agricultural development in this analysis, on the understanding that it will be poldered or treated in some other way to lower the shallow saline water table. This is done in light of the fine textured soils, the proximity to the El Salaam Canal, good accesibility and recent good experience with such methods elsewhere in Egypt.

Table 3-3

Land Resource Units of the Northwest Subregion
(6,656 square kilometers total)

Land Resource Unit	Groundwater Available: Low Salinity ($000m^3$/day)	Groundwater Available: High Salinity ($000m^3$/day)	Component Landforms	Area Percent	Area Sq Km	Agricultural Limitations
C	3.6	7.0	Total	100	1,270	-
			Alluvial plain	40	508	*
			Sand sheet	40	508	1
			Active wadis	20	254	1
E	6.4	3.0	Total	100	658	-
			Rock outcrop	70	460	*
			Residual soil	20	132	*
			Small swales & wadis	10	66	*
H	0	2.5	Total	100	1,936	-
			Aeolian sandsheet	30	581	1
			Mobile sand dunes	30	581	*
			Coastal beach wet subkha	25	483	*
			Sandy dry sabkha	10	193	*
			Lagoonal sediments	5	98	*
I	0	0	Total	100	541	-
			**Deltaic & lacustrine deposits (very poorly drained)	40	215	2
			**Deltaic & lacustrine deposits (poorly drained)	30	161	2
			Wet sandy sabkha	20	110	*
			Dry sandy sabkha	10	55	*
J	0	7.8	Mobile dune and interdune sand	100	2,251	*
			Total Northwest Subregion		6,656	

* Set aside from further consideration for irrigated agriculture due to limitations considered impossible or highly impractical to remedy. (See Appendix A.)

** Subject to poldering or other process to manage shallow saline water table.

Source: Prepared by the University of Arizona Team for the Sinai Development Study, Phase I, February, 1983. Appendix A provides further detail.

Explanatory Note to Tables 3-3 through 3-6:

The identification of Land Resource Units and their component landforms is described in Appendix A. Total areas of land resource units were measured directly from maps at a scale of 1:750,000 with a planimeter. Percentages of the component landforms were estimated on the basis of the field surveys cited in Appendix A. Areas of the component landforms were calculated by taking the appropriate percentage of the total area of land resource unit.

The soils of the component landforms were assessed for capability to support irrigated agriculture. Those soils having limitations that are nearly impossible to remedy (such as exposed bedrock or shallow depth to bedrock) or highly impractical to remedy (such as extremely saline soils, shallow depth to a saline water table, or mobile dunes) were set aside from further consideration. The remaining soils were assessed in terms of characteristics important to irrigation capability (such as texture, salinity, calcium carbonate, exchangeable sodium, flood hazard, and presence of gravel or surface stones). For each characteristic an acceptable level was set, beyond which the soil was assessed as having a limitation in that characteristic. The number of limitations for irrigated agriculture are shown for each landform with usable soils (those with manageable limitations--not impossible or impracticable to remedy). In general, the greater the number of limitations, the more costly the reclamation and sustained irrigation of the soil. Soils with four or fewer limitations are considered candidates for further investigation. Each Land Resource Unit containing candidate soils is classified and mapped according to the number of limitations of its component soil with the fewest limitations; for instance, LRU D is classified as having two limitations, although 15 percent of soils in that Unit have three limitations and 45 percent has limitations considered impossible or highly impractical to remedy.

As a further step toward estimating agricultural potential, the map of Land Resource Units was superimposed on the maps of groundwater availability to estimate the amount of groundwater likely to be available in each LRU. The maximum safe yields of all underlying aquifers were summed. Water from those aquifers with a median estimated salinity value less than 3000 milligrams/liter was classified as "low salinity". Water with 3000 milligrams/liter or greater total dissolved solids was classed as "high salinity". The summed yields of low and high salinity groundwater are shown for each Land Resource Unit.

The Consultant estimates that approximately 71,000* feddans will be found within Units H and I for development of major irrigated agricultural projects in the Northwest Subregion. Full exploitation of this feddanage will require Nile and drainage irrigation water, since only about 122 feddans could be cropped with the groundwater currently estimated to underlie Unit H (assuming 7,500 cubic meters/feddan/year to allow adequately for the estimated evapotranspiration in the Northwest Subregion). Even if all the groundwater estimated to be available for the Northwest Subregion were devoted to agriculture, less than 1,500 feddans could be supported. It is also possible that most of this groundwater is highly saline (TDS greater than 3000 mg/1).

With annual rainfall in the order of 80 millimeters/year in the northern portion of the subregion, decreasing to 20 millimeters/year in the south, rainfed agriculture is improbable, even if water harvesting were possible (soils are too porous for this to be considered realistic). The lack of rainfall and water retention of the soil are reflected by the near absence of natural vegetation, except in the salt marsh areas of Units H and I and the small wadis of Units C and E. Opportunities for further animal grazing based on natural vegetation are quite limited.

There are potential oil/gas fields near New Mit Abul Kom and offshore in the Mediterranean Sea. There is a small deposit of gypsum near Ayun Musa. Building stone, limestone and dolomite aggregate may be found in Unit E. There is good potential for salt production in the El Tina Plain unit and at Ayun Musa. However, the subregion is poor in both mineral and quarrying resources compared to the other subregions.

Marine fishing occurs in the El Tina or Pelusian Bay of the Mediterranean and at the head of the Gulf of Suez. It may be possible to increase fishing in Lake Malaha and the Bitter Lakes with agricultural drainage. Unit I (El Tina Plain) has the highest rating for fish pond construction, due to the fine texture of the soils. This capability, combined with the salt marshes and tidal inundation, indicate potential for aquaculture.

The Suez Canal and the east shore of the Bitter Lakes are the major tourist attractions of this subregion. Ayun Musa (the Springs of Moses) and Ras Misalla have a fine beach.

The wetlands of Unit I, especially Lake Malaha, play an important role in bird migration and off-shore fisheries. These functions have been reduced by the recently completed Suez Canal by-pass through the lake.

---

*20,000 feddans are proposed for actual cultivation out of about 96,000 feddans of "candidate" soils in LRU I on the El Tina Plain. In LRU H (which has an estimated 140,000 feddans of candidate soils in the Northwest subregion) 30,000 feddans are proposed for irrigated agriculture east of Bitter Lakes (including 14,000 feddans already under development), 5,000 feddans in the southwest corner of the subregion, and another 16,000 feddans in the Qantara-Baloza area. Since less than one-third of "candidate" soils are proposed for irrigation in the Recommended Strategy, there should be ample opportunity to take into account considerations of access, engineering, economics and social factors as well as the results of more detailed soil surveys before deciding the exact location of these projects.

3.4.2 Northeast and Uplands Subregions

The large wadi El Arish watershed can be split into two subregions: in the north, which is called the Northeast subregion in other volumes of this study, the lower elevation sandy plains (up to about 200 meters) of Units C, D, G, H, and J with the calcereous dome mountains of Unit F; in the south, the higher elevation valleys, badlands, and plains (generally above 200 meters), of Units A, B, and C, flanked by the calcereous plateaus and mountains of Unit E, which comprise the Uplands subregion.

Candidate areas for irrigated agriculture are widespread (Table 3-4). The highest rated soils (only one limitation) are found mainly in Units C and H, which are similar to the candidate soils of the Northwest subregion, and in Unit G (the Lower Wadi El Arish), which has the best soils of the Sinai Peninsula. Moderately high salinity of the surface layer is the only important limitation; this can probably be overcome due to excellent subsoil drainage for leaching water. The ratings for the C and D sub-units east of Wadi El Arish are less certain than the others; they are assumed to be similar to the western sub-units, but soil data are scarce for the areas east of the Interim Withdrawal Line. The soils of Unit A, the higher elevation valleys such as Upper Wadi El Arish and Wadi El Bruk, have two important limitations: high salinity combined with high calcium carbonate content. These soils have excellent texture for irrigated agriculture, but require careful management.

The Recommended Strategy includes 52,000 feddans in major irrigation projects in the Northeast (in addition to about 3,000 feddans served by local groundwater). In the Uplands major irrigation projects are recommended to cultivate 51,000 feddans (again, in addition to about 3,000 feddans to be served by water-spreading schemes and local groundwater). Given the fact that there are nearly one million feddans included in "candidate" areas, mainly in the Uplands, another 105,000 feddans are considered likely to be suitable for irrigation (possibly as optional extensions of the Recommended Strategy or for development after the year 2000), provided water can be delivered there (presumably from the Nile system) at reasonable cost.

These agricultural possibilities, which are discussed further in Volume III, An Economic Development and Investment Plan, would use land mainly in Units C, D, G and H (primarily below 300 meters elevation and in Unit A primarily above 300 meters). None of these units appears to have enough underlying groundwater to realize more than a small fraction of this potential. Unit G comes closest to having enough (14 percent of requirement, assuming 7500 cubic meters/feddan/year), but most of this groundwater is already committed to support the urban requirements of El Arish. If all the groundwater estimated to be available in the Northeast and Uplands subregions were committed to irrigated agriculture, 26,530 feddans cound be supported (assuming 7500 cubic meters/feddan/year below 300 meters and 8400 cubic meters/feddan/year above 300 meters: the farther inland, the higher the elevation, but the hotter the temperature and the lower the humidity, especially in the summer months).

Table 3-4

Land Resource Units of the Northeast and Uplands Subregions

(31,63C square kilometers total)

Land Resource Unit	Groundwater Available: Low Salinity (000m³/day)	Groundwater Available: High Salinity (000m³/day)	Component Landforms	Area: Percent	Area: Square Kilometers	Agricultural Limitations
A	26.8	2.8	Total	100	2,216	-
			Floodplain	80	1,768	2
			Active wadi beds	20	448	2
B	155.6	1.6	Total	100	10,883	-
			Alluvial plain	35	3,807	*
			Eroded alluvial plain	25	2,720	*
			Small swales & wadis	20	2,178	5
			Rock outcrop	20	2,178	*
C	49.7	3.0	Total	100	4,920	-
			Alluvial plain	40	1,968	*
			Sand sheet	40	1,968	1
			Active wadi beds	20	984	1
D	19.8	10.0	Total	100	2,027	-
			Alluvial sand deposits	40	811	2
			Sand dunes	30	610	*
			Alluvial plain	15	303	*
			Active wadi beds	15	303	3
E	82.8	5.2	Total	100	4,556	-
			Rock outcrop	70	3,189	*
			Residual soil	20	912	*
			Small swales & wadis	10	455	*
F	70.2	42.8	Total	100	2,011	-
			Rock outcrop	90	1,810	*
			Aeolian sand	10	201	*
G	12.3	0	Total	100	143	-
			Aeolian sand sheet	40	57	*
			Alluvial soil on lower terraces	40	57	1
			Alluvial soil on higher terraces	20	29	*
H	0	8.1	Total	100	1,013	-
			Aeolian sand sheet	30	304	1
			Mobile sand dunes	30	304	*
			Coastal beach and wet sabkha	25	253	*
			Sandy dry sabkha	10	101	*
			Lagoonal sediments	5	51	*
I	-	-	(See Northwest Subregion)	100	24	2
J	14.1	27.4	Mobile dune & interdune sand	100	3,830	*
P	-	-	(See Southwest Subregion)	100	7	*
	Total Northeast and Uplands Subregions				31,630	

*Set aside from further consideration for irrigated agriculture due to limitations considered impossible or highly impractical to remedy. (See Appendix A.)

Source: Prepared by the University of Arizona Team for the Sinai Development Study, Phase I, February, 1983. Appendix A provides further detail.

Annual rainfall varies between about 100 millimeters at El Arish and about 300 millimeters at Rafah. In this marginally semi-arid corner of the subregion, rainfed agriculture is possible on a regular basis, though subject to frequent debilitating drought. Elsewhere, annual rainfall is considerably less than 100 millimeters, and rainfed crop production is not viable. However, runoff agriculture aided by water harvesting is possible in the medium-textured wadi soils like those of Units A and G.

Natural vegetation, aside from salt marshes along the coast, reflects the distribution of rainfall and accumulations of run-off water. Therefore, the best potential for grazing is in the northeastern-most corner of the subregion and again in the wadis of Units A and G.

The dominant feature of the coast of the Northeast Subregion is Lake Bardawil, a saline lagoon and wetland complex separated from the Mediterranean Sea by a narrow barrier beach. Two artificially maintained inlets are designed to keep water salinity at levels tolerable for fish, and when properly managed, the lagoon is a good source of fish such as bream and mullet. In addition, offshore marine fishing is good. Already many fishing activities are carried out in the lake and offshore. Aquaculture is another possibility, because the medium-textured soils such as those in Units A and D have fair potential for fish pond construction.

There are oil/gas fields reported along the Mediterranean coast, both offshore and onshore, especially east of Lake Bardawil. A major coal deposit is located in the Gebel El Maghara (largest sub-unit of Unit F). Iron deposits are present in the Gebel El Halal (Unit F near Abu Aweigila). Sulfur and blacksands are found on the coast a few kilometers east of the lake. Salt is produced on the shores of the lake. Sand is abundant, and limestone, dolomite aggregate and building stone are available in the mountains of Unit F and Unit E. Gravel is harder to find, but small deposits may be found in Unit D. Building stone is available in Units E and F.

The major tourist attraction of the subregion is the extensive stretch of excellent beach just west of El Arish (where Unit J meets the sea).* Secondary attractions are Lake Bardawil for birdwatching, Ain El Gudeirat (near El Quseima) which has an ancient Citadel, the Darb El Hagg (Pilgrim Road) and the 14 kilometer mountain road on Gebel El Maghara.

The Lake Barawil ecosystem requires priority attention for environmental management and conservation, partly to maintain its productive function in the lagoon and offshore fisheries, and partly to protect its important role in bird migration between Eurasia and Africa. Additional attention should be given to rare and endangered plant and animal species in and around the isolated mountain systems of Unit F, especially Gebel El Maghara, and the upland plateaus of Unit E in the extreme south of the subregion.

3.4.3 Southwest Subregion.

There are three distinct coastal plains in this subregion which faces the Gulf of Suez: the broad alluvial plain around Ras Sudr (Unit K), the alluvial fan plains of Wadis Baba and Feiran near Abu Rudeis (Unit L), and the alluvial plain and playa of the El Qaa Plain (Units M and N) around El Tor. These features are separated by the calcareous coastal mountains of Unit E. Farther inland are rugged calcareous mountains and plateaus of Unit E north of Umm Bugma and the crystalline mountains of Unit P south of Umm Bugma, rising to 2500 meters. Near the boundary between Units E and P in the uplands is a major basin draining through the mountains to the Gulf (Unit C). There are also many mountain wadis, most notably Wadi Feiran and its tributaries (Unit O).

The candidate areas for agriculture are located mainly in the southern half of the subregion (Units C, L, N, and O), where about 200,000 feddans are recommended for further study with a view to selecting specific sites for 18,000 feddans in major irrigation projects (including over 4,000 feddans in the El Qaa Plain already being developed with local groundwater). Small candidate areas are found in Units C and H on the northern boundary of the subregion, where 1,000 feddans adjacent to the Northwest subregion are recommended for development. These are extensions of the same land resource units in the Northwest Subregion; and the soils suffer from coarse texture and therefore poor water retention. The wadi terrace soils of Unit O have high salinity and subsurface hardpans. Unit N of the El Qaa Plain has three candidate soils which all have problems of high salinity and high exchangeable sodium; however, they also have significant amounts of gypsum, which alleviates the sodium problem, and parts of this area are now being developed with local groundwater. Prospects for reclamation of large blocks of land for irrigated agriculture are good in Unit N, with care and skill in management; experience with groundwater irrigation may provide justification for bringing Nile waters to this area at some later date. Unit L soils have multiple problems of coarse texture, high sodium, surface stones, and flooding.

---

*This beach is reported to be eroding relatively rapidly in recent years.

Table 3-5

Land Resource Units of the Southwest Subregion

(12,826 square kilometers total)

Land Resource Unit	Groundwater Available: Low Salinity (000m³/day)	Groundwater Available: High Salinity (000m³/day)	Component Landforms	Area: Percent	Area: Square Kilometers	Agricultural Limitations
B	5.8	0	Total	100	386	-
			Alluvial plain	35	123	*
			Eroded alluvial plain	25	105	*
			Small swales/wadi beds	20	79	5
			Rock outcrop	20	79	*
C	9.2	0.4	Total	100	915	-
			Alluvial plain	40	366	*
			Sandsheet	40	366	1
			Active wadi beds	20	183	1
E	43.9	1.9	Total	100	4,617	-
			Rock outcrop	70	3,232	*
			Residual soil	20	924	*
			Small swales/wadi beds	10	461	*
H	0	0.5	Total	100	51	-
			Aeolian sand sheets	30	15	1
			Mobile sand sheets	30	15	*
			Beach wet sabkha	25	13	*
			Sandy dry sabkha	10	5	*
			Lagoonal sediments	5	3	*
K	4.3	10.5	Total	100	1,516	-
			Alluvial plains	50	758	7
			Active wadi beds	40	606	*
			Wet sabkha on deltas	10	152	*
L	1.6	0.3	Total	100	348	-
			Alluvial plains & active wadi beds	60	209	4
			Coastal plain	40	139	5
M	82.5	0.2	Total	100	1,644	-
			Mountain front alluvial fans	50	820	5
			Alluvial plains	30	493	5
			Active wadi beds	15	248	5
			Coastal strip	5	83	5
N	16.5	0	Total	100	208	-
			Alluvial plain	45	94	4
			Playa	45	94	3
			Active wadi beds	10	20	4
O	6.3	0.1	Total	100	254	-
			Active wadi beds	90	229	5
			Terraces	10	25	2
P	12.8	0	Total	100	2,887	-
			Rock outcrop	98	2,830	*
			Active wadi beds	2	57	6
			Total Southwest Subregion		12,826	

*Set aside from further consideration for irrigated agriculture due to limitations considered impossible or highly impractical to remedy (see Appendix A).

Source: Prepared by the University of Arizona Team for the Sinai Development Study, Phase I, February, 1983. Appendix A provides further detail.

As mentioned earlier agricultural proposals call for about 19,000 feddans to be irrigated for crop cultivation, although twice that area is likely to have soils suitable for irrigation. Disregarding Unit C, for which there is little direct information, and 8,000 feddans are considered possible for post-year 2000 development, much of this candidate land is located in Unit L and Unit N. As in the other subregions, groundwater is insufficient to irrigate more than a small fraction of the candidate land, even in Unit N; if all the groundwater estimated to be available in Units N and M was devoted to irrigation of Unit N soils, some 4,000 feddans could be supported (assuming 11,500 cubic meters/feddan/year to compensate for the high temperatures and winds of this area). However, a good proportion of the Unit M groundwater may have to be moved distances up to 20 kilometers or more. Also, some of the groundwater is used already to support domestic and commercial requirements at El Tor. There is also a danger that much of the groundwater directly underlying the irrigated areas would be heavily salinized by leaching of the saline soils during irrigation.

Annual rainfall is very low along the coast (6-22 millimeters) and only slightly higher (50-60 millimeters) in the mountains, which rise to more than 2500 meters elevation in Unit P. Correspondingly, natural vegetation is scarce, except in wadi beds and oases, and on mountaintops. Opportunities for rainfed cultivation (even with water harvesting) and grazing are scarce. The low rainfall is made even less effective by hot summer temperatures (30-35 C in July) and persistent winds on the southern coastal plains (annual mean wind velocity is 9.4 knots at Abu Rudeis and 8.2 knots at El Tor, double that at El Arish in the north).

Mineral resources (Figure 3.3) are relatively abundant in the Southwest. They include potentially economic deposits of copper, sulfur, manganese, iron, glass sand, kaolin, turquoise, and coal concentrated in the geologically complex Umm Bugma area in the mountains and plateaus above Abu Zenima and Abu Rudeis (boundary zone between Units E and P). In addition, major oil fields are located offshore from Hammam Faraun (Unit K), Abu Rudeis and El Belayim (Unit L), El Tor and the southern tip of the subregion (Unit M), as well as onshore near Ras Sudr (Unit K). Major gypsum deposits are located along the coast, especially in Unit K at Ras Malaab and in Unit H near Ras Misalla. This subregion also has good supplies of gravel as well as sand in Units K, L, M, and O. Limestone and dolomite aggregate can be found in Unit E. Building stone can be found in Units E, L, M, O, and P.

Offshore fishing in the Gulf of Suez is relatively good, mostly for pelagic species such as spotted sardinella, Indian mackerel, and little tuna. Most of the fishing potential is already being exploited by purse seiners operating from the port of Suez. Some smaller fishing

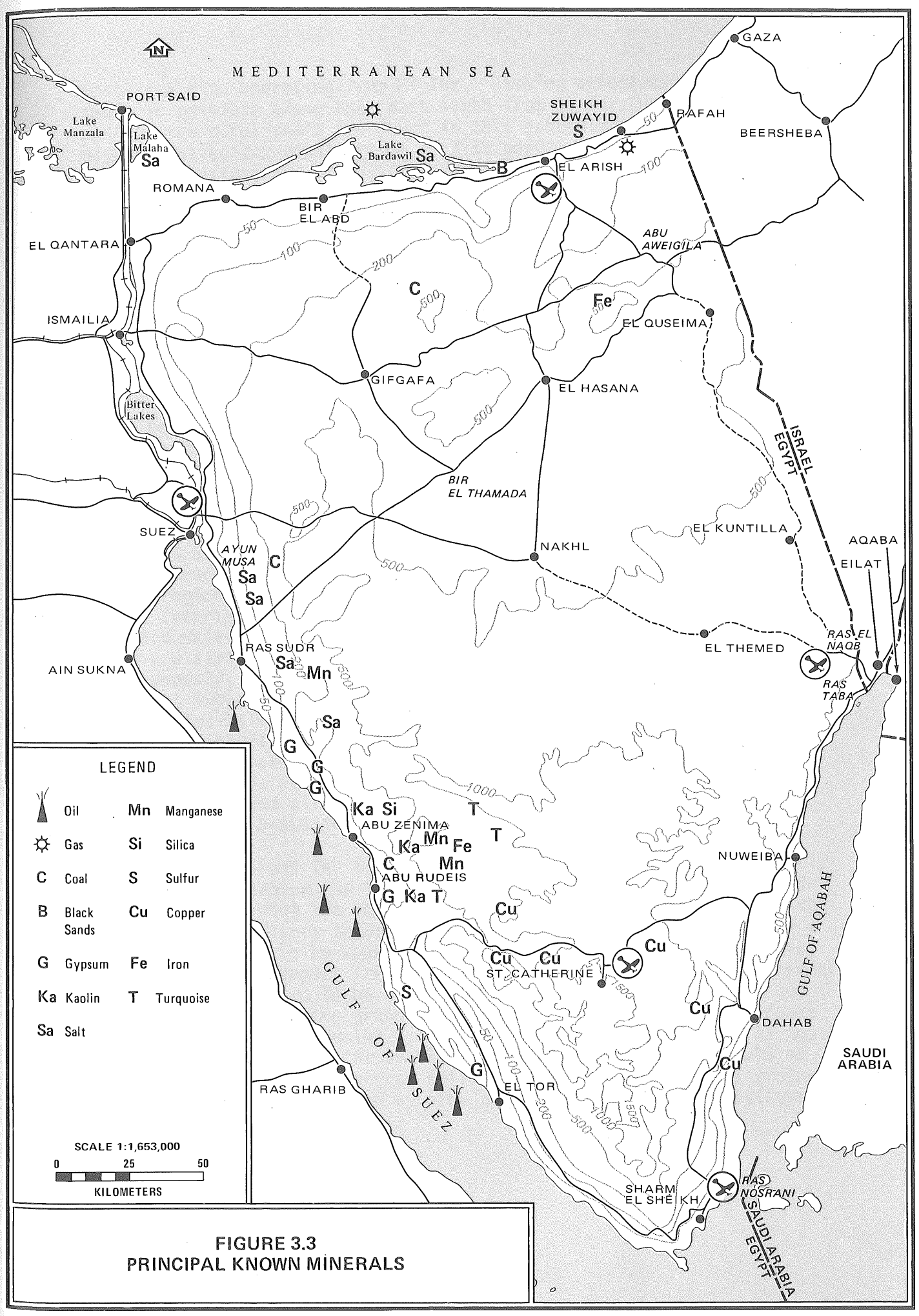


FIGURE 3.3
PRINCIPAL KNOWN MINERALS

boats are also operating from El Tor. Fishing associated with coral reefs is possible along the coast south from El Tor (Unit M), where most of the coral reefs are found in this subregion. Unit N has the highest rating for construction of fish ponds, due to its relatively fine soil texture.

The Southwest Subregion is well-endowed with tourist attractions, including spectacular mountains, wadis, extensive beaches, and coral reefs as well as cultural, historical, and archeaological sites. Most notable are the St. Catherine Monastery and nearby Gebel Musa, Gebel Katherina, Gebel Serbal, and Feiran Oasis. There are also the Pharaonic mining center at Sarabit El Khadim near Umm Bugma, the pilgrim's port at El Tor, the hot springs and beaches at Hammam Faraun, and the fortress of Qalat El Gindi at the entrance to Wadi Sudr inland from Ras Sudr.

The vegetation and wildlife of the high wadis and mountains around St. Catherine (Unit P) and the coral reefs south of El Tor (Unit M) are the priority features requiring careful management for conservation.

3.4.4 Southeast Subregion

This Subregion is dominated by its rugged, high mountains that descend precipitously to the deep, narrow Gulf of Aqabah. Most of the Subregion is in Units E or P. Most of of this subregion is east of the Interim Withdrawal Line, so direct field information on the land and water resources is skimpy. It is surmised that the major wadis are similar to the Unit O of the Southwest Subregion. Unit A is an anomaly, which may in fact not be similar to Unit A of the Northeast Subregion. It appears to be a basin of internal drainage and contains saline soils. The discontinuous coastal strip (Unit M) is composed primarily of alluvial fans at the mouths of the major mountain wadis. Coral reefs fringe almost the entire length of the subregion's coast. The reefs around Ras Mohammad, at the extreme southern tip of the subregion (and all Sinai), are considered to be among the most interesting and beautiful in the world.

Candidate areas for irrigated agriculture are quite limited: only Units A and C, behind the most rugged mountains, and Unit O, the major wadis. Disregarding the more remote soils of Unit A and C, for which there is little direct information to support their rating in Table 3-6, there appear to be about 2,100 feddans of wadi terrace soils in Unit O likely to support irrigated agriculture under careful management. Groundwater estimated to be available in the wadis could support 300 feddans. Adding all the groundwater of Unit P, perhaps 1,700 feddans could be irrigated (assuming 8,400 cubic meters/feddan/year). Of course, it is unlikely that all the available groundwater of Unit P could be transported to the wadi terrace soils. Also, some of the wadi groundwater is already transported by pipe to support the coastal settlements.

Table 3-6

Land Resource Units of the Southeast Subregion

(9,895 square kilometers total)

Land Resource Unit	Groundwater Available: Low salinity (000m³/day)	Groundwater Available: High salinity (000m³/day)	Component Landforms	Area: Percent	Area: Square Kilometers	Agricultural Limitations
A	2.8	0.3	Total	100	150	-
			Floodplain	80	123	2
			Active wadi beds	20	27	2
B	5.1	2.2	Total	100	249	-
			Alluvial plain	35	99	*
			Eroded Alluvial plain	25	54	*
			Small swales & wadis	20	48	5
			Rock outcrop	20	48	*
C	0.7	0	Total	100	48	-
			Alluvial plain	40	20	*
			Sand sheet	40	20	1
			Active wadi beds	20	8	1
E	18.5	21.4	Total	100	3,450	-
			Rock outcrop	70	2,415	*
			Residual soil	20	690	*
			Small swales & wadis	10	345	*
M	5.0	0.6	Total	100	555	-
			Mountain front alluvial fans	50	277	5
			Alluvial plains	30	166	5
			Active wadi beds	15	84	5
			Coastal strip	5	28	5
O	6.6	0.3	Total	100	290	-
			Active wadi beds	90	262	5
			Terraces	10	28	2
P	22.2	2.6	Total	100	5,153	-
			Rock outcrop	98	5,050	*
			Active wadi beds	2	103	6
			Total Southeast Subregion		9,895	

* Set aside from further consideration for irrigated agriculture due to limitations considered impossible or highly impractical to remedy (see Appendix A).

Source: Prepared by the University of Arizona Team for the Sinai Development Study, Phase I, February, 1983. Appendix A provides further detail.

Annual rainfall is reported in the 20-30 millimeter range along the coast, rising to only about 60 millimeters at the highest elevations (up to 2500 meters). Sparse natural vegetation is therefore found almost solely in wadis and high, cool mountains. Rainfed agriculture is improbable, except sporadically on wadi bottoms. The soils of Units O and M are too porous for significant water harvesting. Grazing has quite limited prospects, even in the major wadis.

This subregion has only a few known mineral deposits: some copper in Unit P and manganese near Sharm El Sheikh. None of these deposits is known to have economic potential. Both sand and gravel are readily available in Units M and O. Limestone and dolomite aggregate are hard to find, except possibly inland in Unit E, but building stone can be found in Units E, M, O, and P.

The fishing potential of the Gulf of Aqabah may be good, but there is little fishing occurring at present. The Gulf is very deep (1800 meters), which is not good for fish, but coral reefs are abundant, which is good not only for open-water fishing but also for mariculture projects. In addition, mangrove swamps are located at Ras Mohammed and around Nebq. These, in association with the coral communities, have good potential for mariculture. Minerals have been found in the Red Sea between Saudi Arabia and Sudan at similar depths to those in the Gulf of Aqabah.

The outstanding feature of the Southeast Subregion is its natural beauty, with the colorful mountains dropping steeply into the Gulf of Aqabah which is fringed by coral reefs. There are some beautifully located beaches at Nuweiba, Dahab, and Marsa El Att near Sharm El Sheikh. In addition, Faraun Island, in the Gulf just off Ras Taba, is an important historical site. Ras Mohammad, with its surrounding reefs and views, is probably the most spectacular tourist attraction.

The coral reefs of the Southeast Subregion are the focus of major international conservation concern, in particular the Ras Mohammad area. The mangrove swamps of Ras Mohammad and Nebq also deserve conservation management, as do the high mountain vegetation and wildlife in the St. Catherine area.

3.4.5 Summary

Table 3-7 summarizes the preceding subregional profiles. It shows for each subregion the LRUs which have some significant potential in each of the six sectors discussed. More detailed information on these potentials is discussed further in the following chapters. Table 3-8 lists only those Land Resource Units considered to have soils suitable for irrigated agriculture and serves as a key to Figure 3.4, which highlights areas with few enough limitations to be recommended for further studies to determine particular locations for major irrigation projects.

Table 3-7

Summary of Land Capability by Sector, Subregion, and Land Resource Unit

Land Resource Unit	Agriculture	Minerals	Fishing	Tourism	Conservation	Construction Materials
	NORTHWEST SUBREGION					
C	LC	--	--	--	--	--
E	--	--	--	LC	--	LC
H	LC	LC	LC	LC	--	--
I	LC	LC	LC	--	LC	--
J	--	--	--	--	--	--
Offshore	--	LC	LC	--	--	--
	NORTHEAST AND UPLANDS SUBREGIONS					
A	LC	--	LC	--	--	--
B	--	--	--	--	--	--
C	LC	--	--	--	--	--
D	LC	LC	LC	--	--	--
E	--	--	--	LC	LC	LC
F	--	LC	--	--	LC	LC
G	LC	--	--	--	--	--
H	LC	LC	--	--	--	--
J	--	--	--	LC	LC	--
Bardawil	--	LC	LC	LC	LC	--
Offshore	--	LC	LC	--	--	--
	SOUTHWEST SUBREGION					
B	--	--	--	--	--	--
C	LC	--	--	--	--	--
E	--	LC	--	LC	--	LC
H	LC	LC	--	LC	--	--
K	--	LC	--	LC	--	LC
L	LC	LC	--	--	--	LC
M	--	LC	--	--	LC	LC
N	LC	--	LC	--	--	--
O	LC	--	--	LC	--	LC
P	--	LC	--	LC	LC	LC
Offshore	--	LC	LC	--	--	--
	SOUTHEAST SUBREGION					
A	LC	--	LC	--	--	--
B	--	--	--	--	--	--
C	LC	--	--	--	--	--
E	--	--	--	--	--	LC
M	--	LC	LC	LC	LC	LC
O	LC	--	--	--	--	LC
P	--	LC	--	LC	LC	LC
Offshore	--	--	LC	--	--	--

LC = Some significant land capability potential.

NOTE: Agriculture = irrigated cultivation of food, fiber, and forage crops;
Minerals = minerals, oil, gas, coal, and salt;
Fishing = marine fishing, mariculture, and aquaculture;
Construction Materials = gravel, limestone/dolomite, and building stone.

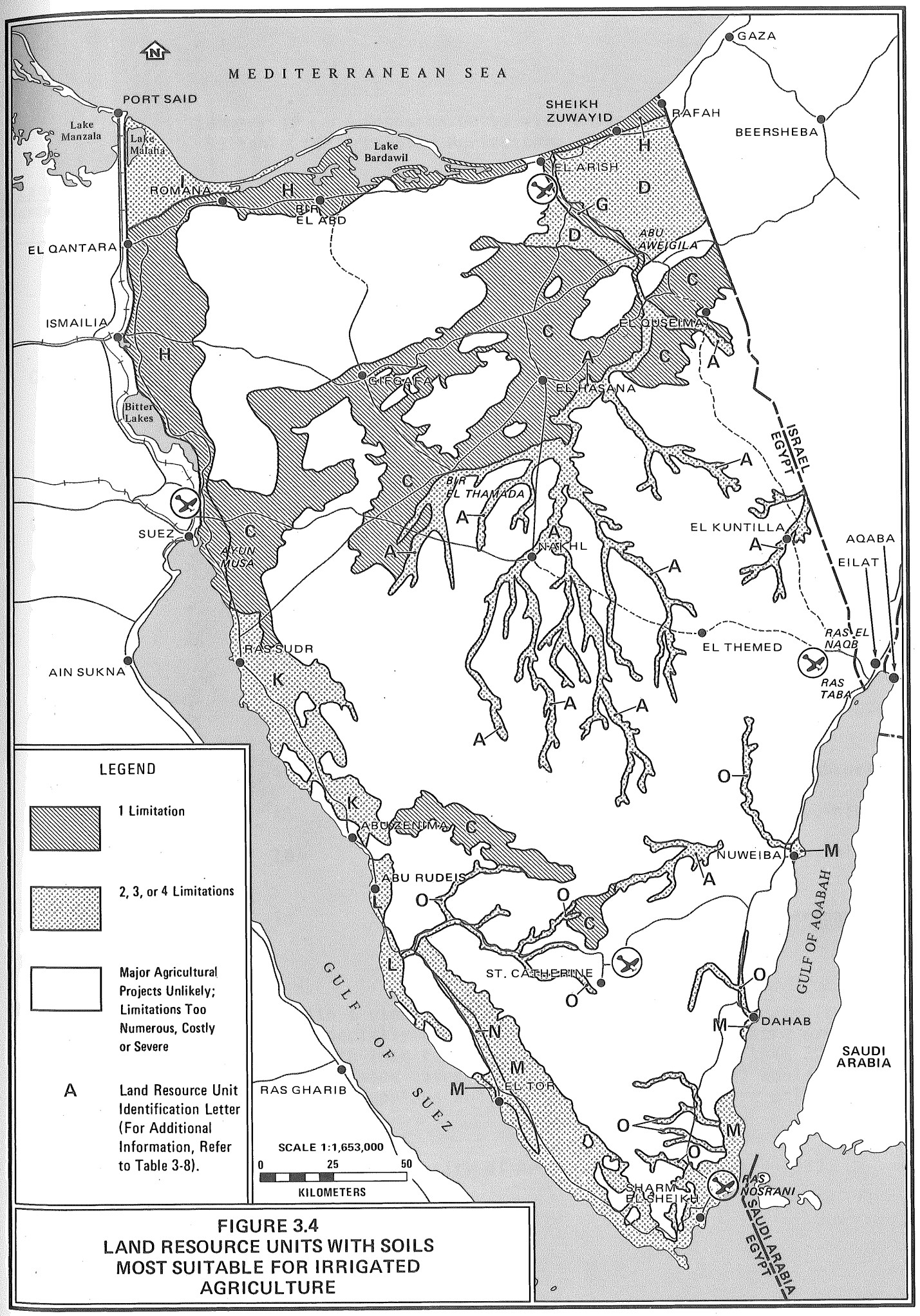


FIGURE 3.4
LAND RESOURCE UNITS WITH SOILS MOST SUITABLE FOR IRRIGATED AGRICULTURE

TABLE 3-8

Summary of Land Resource Units with Soils Suitable for Irrigated Agriculture

Land Resource Unit Number of Limitations 1	2	3	4	Candidate Areas Percent of LRU	Approximate feddanage[a] (000)	Type of Soil Limitation
-	A	-	-	80	462	high salinity, high calcium carbonate
				20	116	high calcium carbonate, wadi flooding (no data on sodium)
C	-	-	-	40	699	coarse texture
				20	349	wadi flooding
-	D	-	-	40	198	high calcium carbonate, coarse texture
				15	74	high calcium carbonate, wadi flooding, and surface stones (no data on sodium)
G	-	-	-	40	14	high salinity
H	-	-	-	30	220	coarse texture
-	-	I	-	40	55	high salinity, very shallow to saline water table, and flooding
				30	41	high salinity, shallow to saline water table, poorly drained
-	-	-	L	60	51	coarse texture, high sodium, surface stones, and flooding
-	-	N	-	45	23	high salinity, high sodium, subsurface hardpan
				45	23	coarse texture, high salinity, high sodium, and gravel
				10	5	coarse texture, high salinity, high sodium, wadi flooding
-	0	-	-	10	13	high salinity, subsurface hardpan
1,282	863	147	51		2,343	Total of candidate areas[a]

[a] Total area to be studied with a view to finding sites for irrigated agriculture. As the text explains (see especially Appendix page A-3, Note Two), there are a variety of considerations which lead to the conclusion that no more than 30 percent of these areas (and in some cases a much smaller percentage) would actually be cropped, even if water supplies and investment resources were unlimited.

Source: Based on analysis by the University of Arizona Team in February 1983. Appendix A provides further detail.

4.0: LAND CAPABILITY FOR URBANIZATION

4.1 INTRODUCTION

This chapter discusses the following major topics:

- human settlements
- tourism
- access to water and markets
- conservation of flora and fauna
- spatial clusters of resources, and
- land capability problems and land use conflicts.

It is closely integrated with the work presented in Volume III and the "Settlements" Chapter of Volume VI. The sections concerning human settlements and tourism are particularly closely linked to the climate, and to Sinai's cultural and natural heritage. The sections concerning access and urban land use are more concerned with topography, cost and proximity as land development determinants, and with the choices to be made among land uses at clusters of activities.

4.2 LAND CAPABILITY FOR HUMAN SETTLEMENTS

Some of the settlements in Sinai are well sited in terms of offering maximum comfort and efficiency to their residents, while others are not so well sited. Several new settlements have been proposed that will have to be sited; Volume VI recommends guidelines for site selection. It may be worthwhile to review the following points: First, no settlement site selection in Sinai will be similar to that in the Delta or the Nile Valley. Second, factors involved in site selection will differ according to Sinai's geographic regions (i.e., broad coasts as opposed to mountains). Third, site selection in a hot arid zone such as Sinai is a more important part of the total community building process than it would be in more temperate climates.

4.3 TOURISM

The first step in the tourism land capability analysis was to inventory and evaluate all tourist attractions and sites in Sinai. Major attractions are shown on Figure 4.1 and described briefly in Appendix D. The complete inventory (included in Working Paper No. 39 on file in the Ministry of Development) identified all existing tourist facilities and potential tourist attractions in Sinai, including:

- beaches
- existing and potential resort sites
- antiquities and historical sites
- buildings and sites of religions significance
- locations and resources of special scenic value, including coastal areas, mountains, and oases

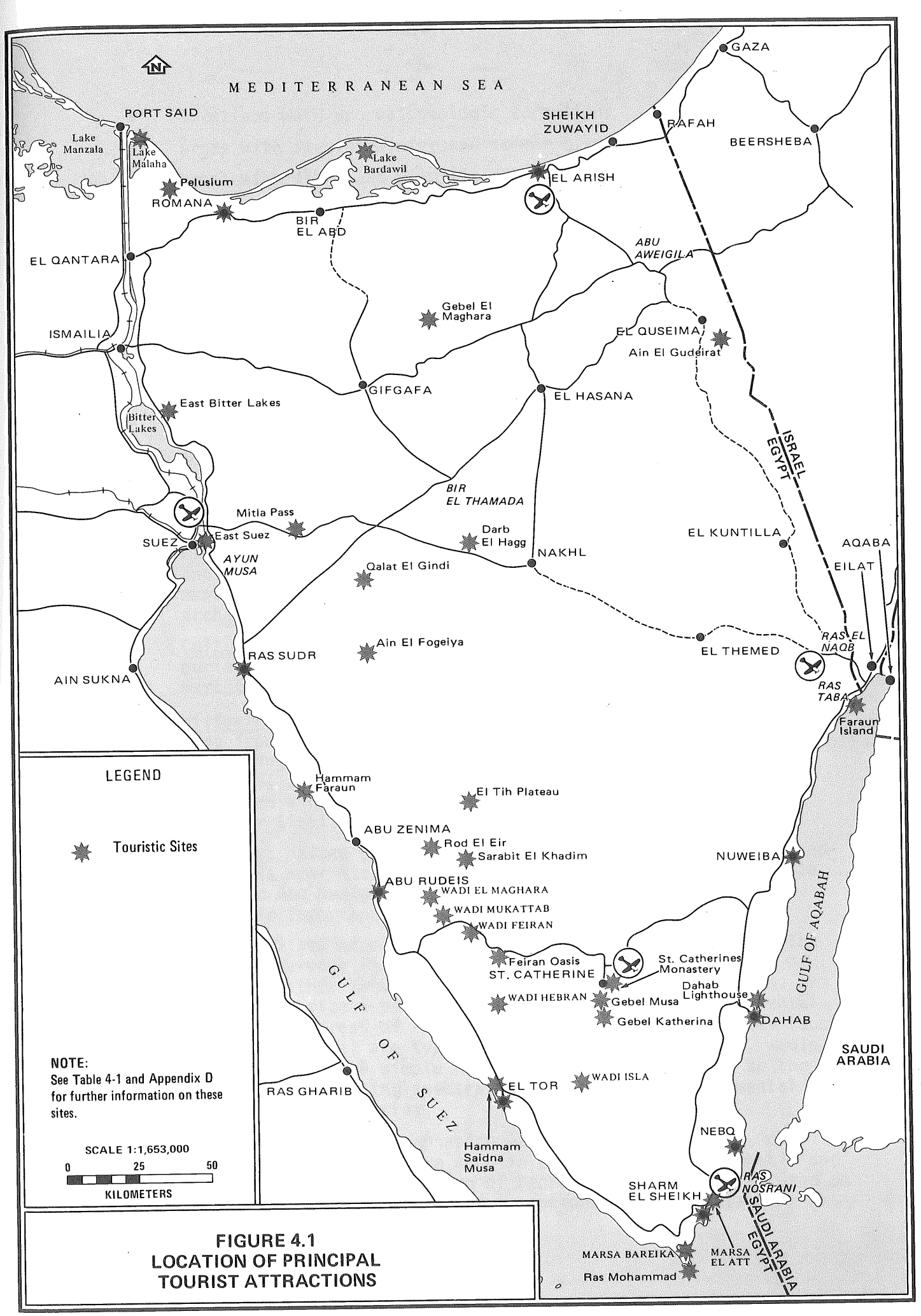


FIGURE 4.1
LOCATION OF PRINCIPAL TOURIST ATTRACTIONS

- locations with unusual geologic formations
- areas with special winter and summer climatic advantages
- areas with flora and wildlife of particular interest
- sites that are of significance because of local culture, folklore, handicrafts, or special products.

Three hundred places of interest were included in the list of Sinai attractions. As more people become interested in the history and culture of Sinai, the significance of more sites will be documented and additional attractions can be added to the list.

The sites were also characterized according to tourism sector, level of interest, and development potential. The eight tourism sectors are as follows:

- Aesthetic: Sites provide unique vistas, such as the brilliant blues and tans of Ras Mohammad, or the unexpected green of the lush vegetation in the Feiran Oasis contrasted with the surrounding pink and black granites.
- Archaeological: Sites include pharonic burial grounds or ancient settlements such as Ain El Fogeiya, the oldest settlement in Sinai. Ancient inscriptions can be found at numerous archaeological sites, such as Sarabit El Khadim.
- Cultural: Sites include old cemeteries reflecting tribal burial beliefs and practices, and Bedouin villages and markaz marketplaces where local handicrafts can be purchased.
- Historical: Sites include ancient roads, such as the Darb El Hagg from Cairo to Taba; old mining villages and mines such as Umm Bugma; old citadels such as those at El Arish, Qalat El Gindi, and Gezira Faraun. Many of these sites should be conserved and protected as part of the overall development plan for Sinai.
- Military: Sites generally reflect war remains, such as burned-out tanks near Mitla Pass and troop carriers at Nakhl. Mitla Pass and Abu Aweigila are also included because of their strategic importance in past hostilities.
- Nature: Sites have much in common with aesthetic sites. The major difference is that sites selected for the enjoyment of nature--whether focusing on geology, geomorphology, flora, or fauna--emphasize a particular feature or unique environmental niche. The Forest of Pillars, springs, and hanging oases (such as Ain Umm Saida) are typical examples. In many cases, wadis are listed for the simple reason that while traveling up the wadi an ever-changing spectra of geologic and environmental features are on display.
- Recreational: Sites emphasize either swimming, diving, or hiking. These sites have much in common with the aesthetic and nature sites. The selection of recreational sites is focused on those with existing trails or exceptional scenic vistas.

- Religious: Sites include sheikhs' tombs, St. Catherine Monastery, other old monasteries, and ancient religious routes. Several biblical or religious sites are listed, including Gebel Musa, Ain El Quseima, Tell El Mahmadia (or Baal-Zephon), and Ayun Musa.

In addition to categorization according to tourism sector, the sites were further evaluated in terms of level of interest--special, general, or primary--as follows:

- Special interest: Denotes sites that appeal to tourists with specialized recreational or occupational interests. Typical sites which would qualify only for special interest are oases that require off-road hikes, military battlefields, and ancient monuments. This category represents the lowest level of usage.
- General interest: Denotes sites that appeal to general tourists, but are not normally the focal point of their trips. These sites are usually combined with tours to primary points of interest.
- Primary interest: Denotes a site that is often the focal point of a Sinai tour. These sites represent the initial stimulus that attracts tourists to the area. St. Catherine Monastery and Sharm El Sheikh coral reefs are well known examples of primary interest sites.

These levels of interest can be expected to change as specific sites are marketed and infrastructure is improved.

Based on this inventory and evaluation, the Consultant then selected the 30 most promising sites in terms of development potential and special, unique interest for further and more detailed evaluation. Sites in each of the subregions are included. These sites were compared in the "Evaluation Matrix" (Table 4-1). Coastal and mountain sites are listed separately.

Thirteen criteria were utilized to evaluate the tourist development potential of each site. These criteria are:

- Beach: The broad characteristics of the beach area in terms of sand texture, beach depth, drop off, wave height, wind and length of beach stretch.
- Coral: General evaluation of coral, aesthetic appeal, and associated marine life.
- Historic: Sites with historic, religious, cultural, or archaeological appeal.
- Scenic: Sites with aesthetic appeal, or which have particular or unique natural characteristics.

Table 4.1

TOURISM LAND CAPABILITY - EVALUATION MATRIX

Tourism Site	Subregion	Season	Beach	Coral	Historic	Scenic	Tourism circuit	Potable water	Access: road	Access: sea	Access: air	Proximity to Suez Canal	Proximity to urban center	Pollution free	Agricultural soil	Other land uses	Climate: summer	Climate: winter
Coastal																		
Gezira Faraun	SE	W	+	+	+	+	+	-	0	+	-	-	+	+	+	+	-	+
Nuweiba	SE	W	+	+	-	+	+	+	+	+	-	-	-	+	+	+	-	+
Dahab	SE	W	+	+	-	+	+	+	+	+	-	-	-	+	+	+	-	+
Marsa El Att	SE	W	++	+	-	+	+	+	+	+	+	-	+	+	+	+	-	+
Sharm El Sheikh	SE	W	+	++	-	-	+	+	+	++	++	-	+	+	?	?	-	+
Ras Muhammad	SE	W	+	++	-	++	+	-	-	-	0	-	+	-	+	+	-	+
Nebq	SE	W	+	+	-	+	-	-	-	-	0	-	-	+	+	+	-	+
El Tor	SW	W	+	+	+	0	-	+	+	+	0	-	+	-	+	?	-	-
Hammam Saidna Musa	SW	W/S	+	+	+	+	-	?	?	-	-	-	+	?	+	?	-	-
Abu Rudeis/Zenima	SW	W/S	+	0	-	-	+	+	+	+	+	-	+	-	+	?	-	-
Hammam Faraun	SW	W/S	+	0	+	+	+	+	?	-	-	+	+	?	+	+	-	-
Ras Matarma	SW	S	+	+	-	+	-	+	?	-	-	+	+	-	+	+	-	-
Ayun Musa	NW	S	+	0	+	-	-	+	+	-	-	++	+	-	-	-	-	-
East of Bitter Lakes	NW	S	+	-	-	+	-	+	+	0	-	++	+	0	-	+	-	-
Pelusium	NW	W/S	-	-	++	-	-	-	+	-	-	++	+	+	-	+	+	-
Romana	NE	S	++	-	0	+	-	+	+	0	-	++	+	+	+	+	+	-
Lake Bardawil	NE	S	+	-	0	+	-	+	0	+	-	+	+	+	-	+	+	-
El Arish	NE	S	++	-	+	0	+	+	+	++	++	0	++	-	-	-	+	-
Mountain																		
Ain Guderat/Kadesh Barnea	UP	W/S	0	0	++	+	-	+	0	0	-	-	-	+	+	+	+	-
Gebel El Maghara	UP	W/S	0	0	+	+	-	+	+	0	-	+	-	+	+	+	+	-
Darb El Hagg	UP	W/S	0	0	+	+	+	-	+	0	0	0	-	+	0	-	-	-
Ain El Fogeiya	SW	W	0	0	++	-	-	?	0	0	-	-	-	+	+	+	-	-
Sarabit El Khadim	SW	W/S	0	0	++	++	-	-	0	0	-	-	-	+	+	+	+	+
Wadi Maghara	SW	W/S	0	0	-	+	-	-	0	0	-	-	+	+	+	+	-	+
Wadi Feiran	SW	W	0	0	-	+	+	+	+	0	-	-	-	-	-	-	-	+
Feiran Oasis	SW	W	0	0	-	+	+	+	+	0	-	-	-	-	-	-	-	+
Qalat El Gindi	SW	W	0	0	++	-	+	+	+	0	0	+	-	+	+	+	-	+
St. Catherine Monastery	SW	W/S	0	0	++	+	+	+	+	0	++	-	-	+	+	-	+	+
Gebel Musa	SW	W/S	0	0	++	++	+	-	0	0	+	-	-	+	+	+	+	+
Gebel Katherina	SW	W/S	0	0	+	++	+	-	0	0	+	-	-	+	+	+	+	+

SE = Southeast (7 sites), SW = Southwest (14), NW = Northwest (3), NE = Northeast (3) and UP = Uplands (3).

+ means site judged advantageous in terms of that criterion; ++ means very advantageous; - means disadvantage or problem; 0 means neutral or not applicable; ? situation uncertain. Coding is explained further in the middle of page 4-6.

- Tourism Circuit: The site's location relative to other touristic sites and the potential for travel between them.
- Potable Water: The availability of potable water.
- Access: Evaluation in terms of existing or potential access by land, sea, and air; related largely to existing infrastructure.
- Proximity to Suez Canal: Distance and travel time to Suez Canal; thus proximity to Suez Canal cities and other domestic (Cairo and Alexandria) markets.
- Proximity to Urban Center: Distance and travel time to urban center; chances for integrated development with tourist site (i.e., provision of supplies and labor to site).
- Pollution Free: Absence of current or potential sources of air, water, land, noise, or environmental pollution.
- Agricultural Soil: The likelihood that tourist site development will not infringe or encroach upon prime agricultural soil, preempting potential agricultural cultivation.
- Other Land Uses: The likelihood that the tourist site will not conflict with other land uses (industry, mining, fishing, grazing, conservation).
- Good Climate: Relative to Egypt as a whole and to neighboring countries in winter or summer.

The plus/minus system assists in evaluation of the 30 identified sites in terms of the 13 criteria listed above. A double plus indicates the full achievement or satisfaction of the criterion (for example, El Arish or Marsa El Att receive double pluses under the "beach" category). A double minus would indicate a retarding element or conflict which could thwart touristic development potential (e.g., if pollution of the water at Hammam Faraun were to develop, or pollution from Suez shipping traffic at Ayun Musa). A zero indicates noncompliance, neutrality, or the inappropriateness of the criteria (e.g., Gebel Musa or Ain Guderat receive zero under the categories of "beach" and "coral").

The evaluation will assist policy makers and planners in knowing which "bottlenecks" need to be alleviated at a particular site, allow potential conflicts to be prevented, and promote integrated development.

It should be noted that there is a complementarity between summer and winter tourism between the southern and the northern tourist sites.

The Southwest Subregion has almost half of all the leading tourist attractions in Sinai which are divided among winter and summer climates as well as coast and mountain terrains.

Overall, Sinai's land capability for tourism is outstanding. Investments in appropriate infrastructure will improve it. Administrative/regulatory action to protect tourism potential will be necessary to prevent its preemption by other land uses. Sinai currently has the advantage of relatively unspoiled beaches and other scenic sites compared to its Mediterranean competitors.

4.4 ACCESS TO WATER AND TO MARKETS

Resource locations in relation to each other, markets for products, and sources of inputs can be factored into the analysis of the economic value of the resources (Figure 4.2). At the reconnaissance level of this land capability assessment, the analysis suggests directions for further study to determine the sites for the development of resources.

Markets for the products of Sinai's resources are mainly outside the peninsula, in centers of population and industry. These include Europe, Saudi Arabia, the Arabian Gulf, Jordan, Iraq, the Canal Zone Upper Egypt through Safaga on the Red Sea coast, and most significantly, Cairo. There are smaller markets within Sinai, notably El Arish and the other towns in the El Qantara-to-Rafah north coast axis. Clearly, the Sinai Peninsula has some locational advantages in its situation astride major sea, air, and land routes between continents and major economies.

Likewise, large scale development of Sinai's resources depends on a critical input from outside the peninsula, particularly, water from the Nile River. Sinai already produces and sells much more energy than it needs to develop its resources, but the indigenous sources of water are quite inadequate to develop fully Sinai's agricultural and other potentials.

Sinai's land resources increase in value in proportion to their proximity to outside markets and to distribution points for Nile water, all other factors being equal. The primary market for the near future is Nilotic Egypt across the Suez Canal. Nile water today comes under the Canal at Deversoir, Port Said, Suez, Qantara, and the Hamdi tunnel. In these respects the Northwest Subregion has a distinct, albeit temporary locational advantage over the other subregions.

The great intrinsic value of the resources of Northeast and Southwest Subregions makes the economic potential of these subregions at least as great as the more accessible Northwest. That this is also the assessment of the Egyptian Government is demonstrated by current construction of domestic water pipelines to deliver Nile water along the north coast at least as far east as El Arish and along the southwest coast at least as far south as Abu Rudeis.

A maritime route was inaugurated between Sinai and Aqaba, Jordan during February 1983. A port is in construction at El Arish. Half a dozen jetties are in operation on other coasts. There are over 20 airfields in Sinai, some of which are adequate for 747s, and Sinai Airlines is in operation. With the completion of the Camp David process, free

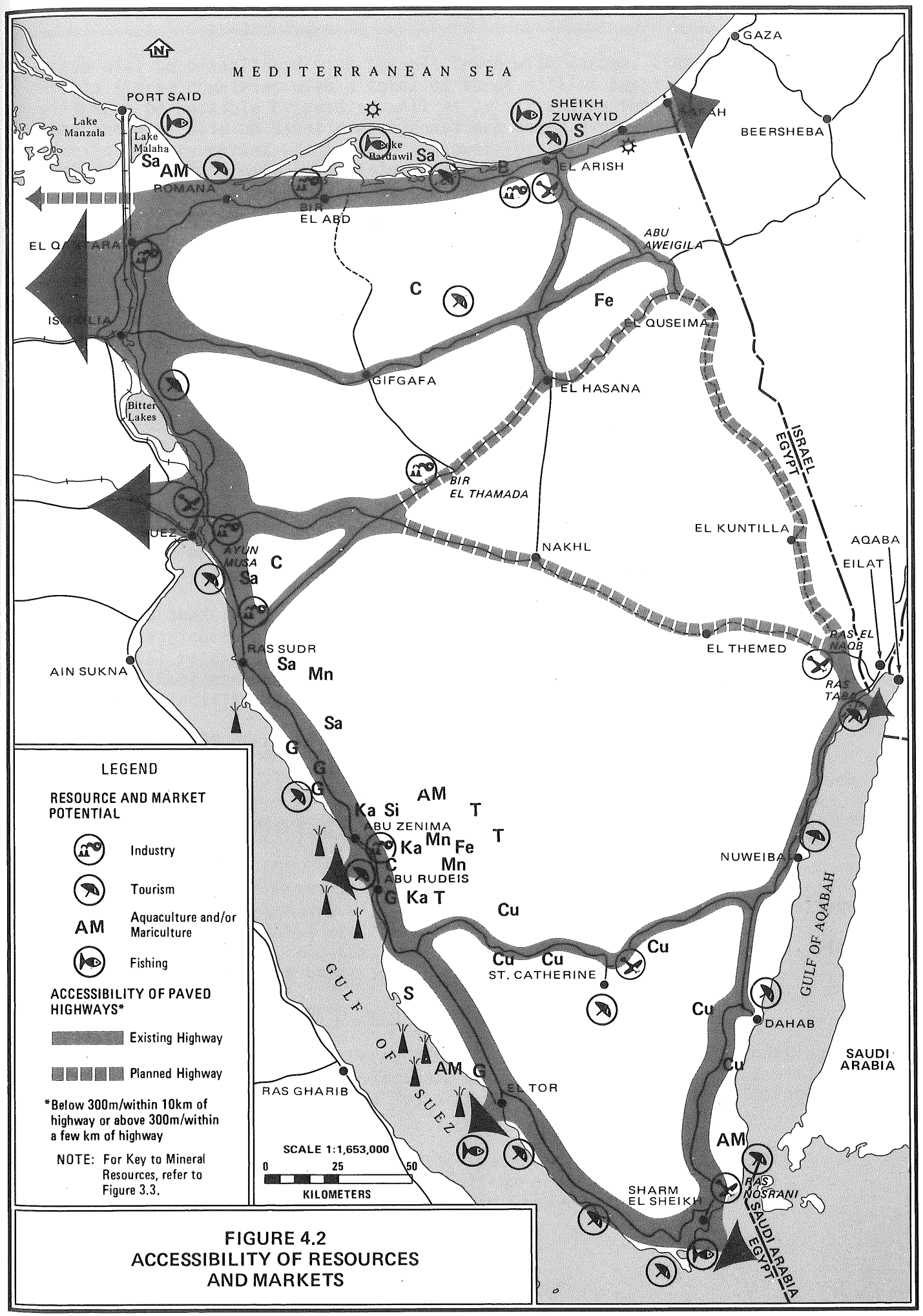


FIGURE 4.2
ACCESSIBILITY OF RESOURCES AND MARKETS

trade will be established with Israel; trade with Jordan, Iraq and Saudi Arabia (three countries with a total of three million Egyptians in residence) will soon be possible by road as well as by air and by sea. The ports of Suez and Port Said on Sinai's west coast are being expanded. Thus, although Sinai's primary market was limited to lower Egypt in 1983, that limitation on further economic growth is rapidly being relaxed.

Each of the subregions has some comparative locational advantage in land resources over the others. Good planning will optimize these advantages. The Southeast Subregion has the best winter climate, good groundwater and the best seaside and mountain tourism sites. It is also closest to Egypt's major trading partners in the Middle East. With enrichment of its landscape to include a seaport and with good land access to the Nile Delta and Saudi Arabia, its resources can be better developed.

The Southwest Subregion is the richest in mineral and cultural resources (Sarabit El Khadim and St. Catherine) and has some agricultural soils both on the coast and in the highlands. It is also close to the world's shipping routes and to the growing OPEC economies. With enrichment of its facilities to include fresh water and a good sea port it could develop rapidly.

The Northwest is the poorest subregion in terms of land resources and can boast mainly of its agricultural soil. However, it has the great benefits of a location on the Suez Canal, proximity to the large market of the Nile Delta, and easy access to Nile water.

The Northeast and Uplands subregions have the most soils suitable for irrigated agriculture; they also benefit from a large coastal lagoon, gas, oil and coal reserves, beach and mountain tourism sites, and the wettest climate. These resources are relatively easy to exploit because of good road and airport facilities.

4.5 CONSERVATION OF FLORA & FAUNA

An additional locational factor to be considered is reserving areas such as Lake Bardawil, Gebel El Maghara, El Tih/El Igma Plateaus, St. Catherine area, and the coral reefs of the gulf coasts because of their ecological significance. These areas are shown in Figure 1.2. Conservation in these areas will generally not be compatible with large-scale crop production, major extraction or processing of minerals, or urban development, but limited cropping and grazing will be possible. Tourism, fishing, mariculture, processing of agricultural and fish products, limited extraction of construction materials, and construction of communication routes (roads, pipelines) may be compatible under special management conditions.

4.6 SPATIAL CLUSTERS OF RESOURCES

Spatial clusters of resources can complement each other in supporting an urban center. Resource clusters are most noticeable around Abu Zenima/Abu Rudeis, El Arish/Rafah, Land Resource Unit H of the Northwest Subregion, and El Tor.

In the Abu Rudeis/Abu Zenima area, the principal resources are the various minerals around Umm Bugma, oil offshore, agriculture in Unit L, and tourism to Sarabit El Khadim and the Hammam Faraun hot springs. In the

El Arish/Rafah area, there are resources for agriculture in Units G, D, and H, beach tourism, offshore fishing, a shallow groundwater aquifer, offshore and onshore oil and/or gas, and good locations for light manufacturing and processing of agricultural and fish products for export to Europe by sea and air, and to Mideast markets by road. In Unit H of the Northwest Subregion there is agriculture, tourism on the Bitter Lakes, oil and/or gas, and locations (astride the principal routes to mainland Egypt) for light manufacturing, agricultural and fish produce processing. Around El Tor, there is potential for agriculture, fishing, aquaculture, groundwater, offshore oil, beach/coral reef tourism and cultural tourism.

This clustering of resources and potentials, when combined with a significant access potential such as a good port site or at the mouth of a major valley (as at El Arish and Abu Rudeis) provides the location for a city. However, such clustering also contains inherent problems in siting as the development of the clustered resources can engender land use conflicts.

4.7 LAND CAPABILITY PROBLEMS AND LAND USE CONFLICTS

The major land capability issue of Sinai is overgrazing. Grazing has gone beyond the capacity of the land and is destroying the resource. (Overfishing is also an issue, especially in Lake Bardawil, but may be more quickly overcome since the Ministry of Agriculture is already engaged in finding solutions). The introduction of Nile water to Sinai will place irrigated agriculture on grazing land and could exacerbate the current condition. Nile water conveyances will also provide watering points to animals and allow them to graze more intensely in some areas. Therefore, range management programs might well be focused along the proposed Nile water conveyances described in Volume V.

Within the conservation areas shown on Figure 4.3 there are several locations of potential land-use conflict. For example, Lake Bardawil (conservation, tourism, fishing, salt production) and the Gebel El Maghara (conservation, agriculture, tourism, and coal extraction) are locations requiring integrated management plans. The St. Catherine area and the coral reefs of the gulf coasts are also areas of potential conflict between conservation, tourism, and urban development. In the coral reef case, threats to be considered include fishing, oil pollution from offshore oil fields and ships in the Gulf of Suez, tourism-related pollution, and even vandalism.

The most likely conflict with an agricultural area is in Land Resource Unit G, where expansion of El Arish could take over large tracts of land with good agricultural potential. At El Tor, conversely, the groundwater supplies could be ruined for domestic use by reclamation of the saline soils of the El Qaa Plain (Unit N). The beaches near El Arish are threatened by the city's expansion. All the beaches along the coast of the Southwest Subregion are threatened by oil spills from offshore drilling, pumping rigs, and passing tankers en route to the Canal. A petrochemical facility, power generating plant, oil refinery, cement plant and other heavy industry projects being considered for the Southwest Subregion all pose environmental threats and could conflict with tourism, fishing and

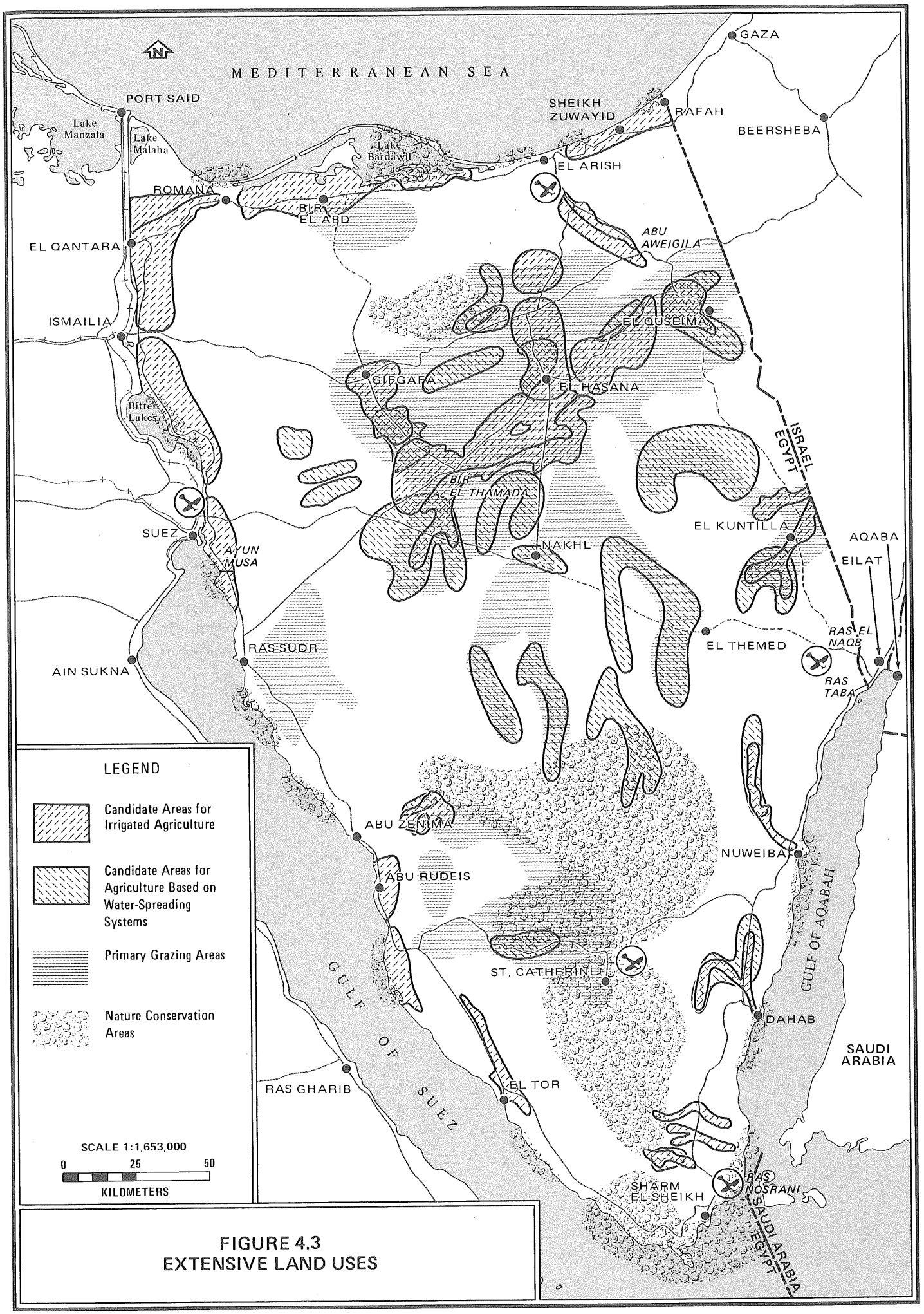


FIGURE 4.3
EXTENSIVE LAND USES

agriculture. This is of particular concern near Abu Rudeis and between Suez City and Ras Sudr. In the Southeast Subregion the absolute scarcity of land and its prime potential for tourism establish conflict potentials with more mundane, less aesthetically demanding land uses, particularly those associated with transportation.

The land capability work by the Sinai Development Study, Phase I team included peninsula-wide analysis of each major land use. This exercise was then repeated for each of the five subregions. Certain places required further attention, and these were studied at a town planning scale. The six such places discussed below are El Arish, the Bitter Lakes, Ayun Musa, Taba, Nuweiba and Abu Rudeis.

4.7.1 El Arish

El Arish is sited where the Wadi Arish ends its 200 kilometer journey from the El Tih desert to the Mediterranean. Its site is gently rolling from the coast to about 25 meters above mean sea level. To the south and east is good agricultural land. To the west, a strip of good agricultural land, three or four kilometers back from the coast, begins about five kilometers from the center of town and extends to Bir El Abd. Beneath this good agricultural land is a shallow aquifer which is quite susceptible to both pollution and salt water intrusion since the soils are highly permeable. Both east and west of El Arish the coast is attractive and suited to tourism. The wadi bed is subject to flooding, and the beach to erosion.

Land use conflicts currently include:

- an inter-city highway on a tourist beach
- an airport on agricultural soil
- urban development in a flood plain
- urban development on good agricultural soils
- development over a shallow aquifer.

It is proposed that in the future El Arish expand from 40,000 to over 200,000 persons. At year 2000 it may be expected that El Arish, still the largest city in Sinai, will require about 50 square kilometers, including 50 hectares for a central business area, 100 hectares for industry, 100 for warehousing and shipping, 250 for beach-oriented tourism, and about 4,000 hectares for other uses.

A simple land capability analysis of El Arish suggests that a key decision will be where to locate industry and warehousing/distribution. This should be off the aquifer, off agricultural land (i.e., away from the airport), off the flood plain, away from the central business district, away from tourism and away from residential areas. (See Worksheet, Table 4-2.)

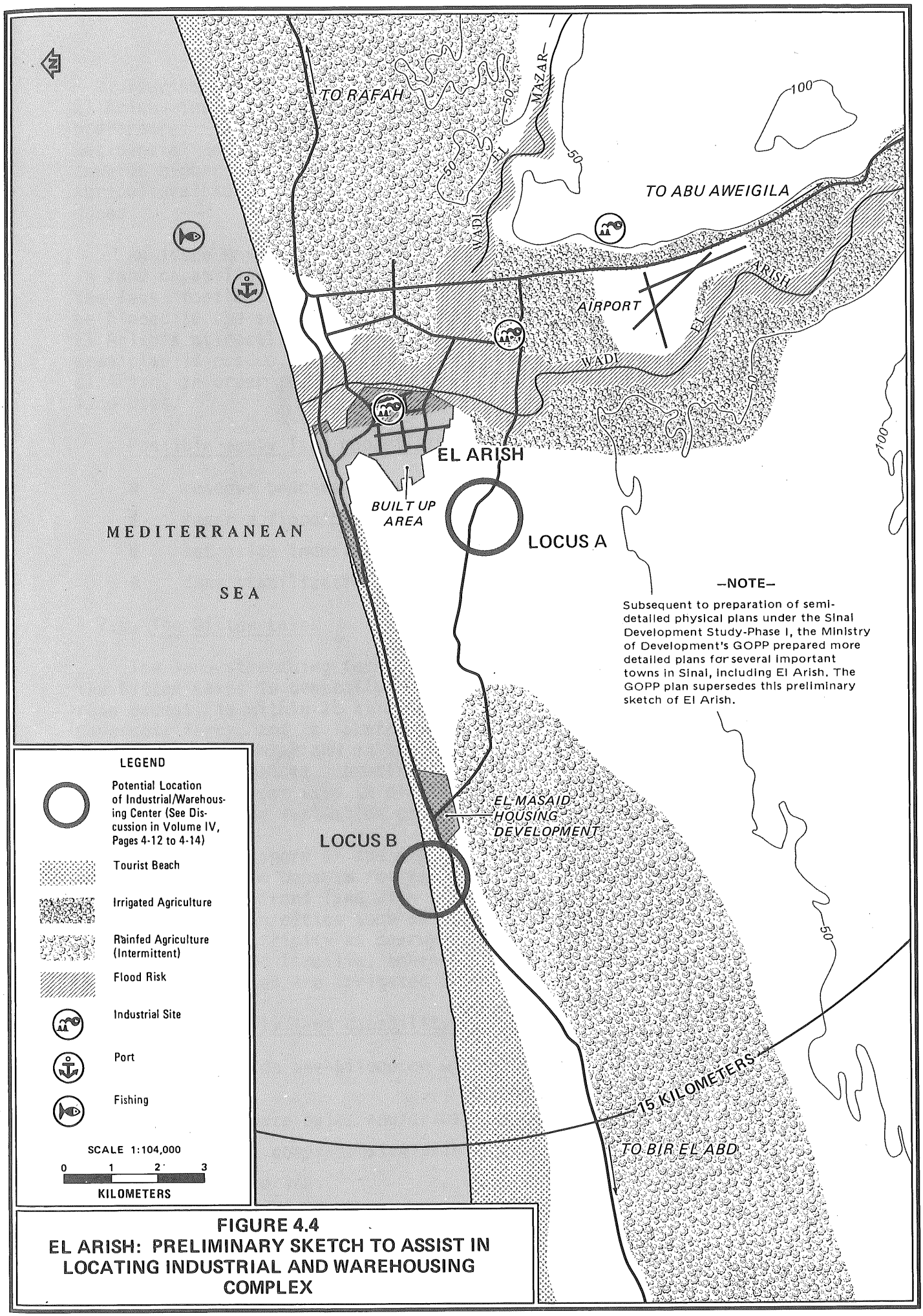
TABLE 4-2

LAND CAPABILITY WORKSHEET FOR: EL ARISH

Land Use/Site	Land Character: Access	Soil	Coast	Coral	Slope	Flood	Higher Elevation	Infra-structure	Aquifer	Dunes	Rank
Industry											
P.S.	+	+	-	0	+	-	0	++	-	0	3
Locus A	+	+	-	0	0	+	0	+	+	-	2
Locus B	+	-	+	-	+	+	0	+	-	-	1
Agriculture											
P.S.	+	++	0	0	+	-	0	+	+	-	1
Locus A	+	-	0	0	-	0	0	+	+	0	3
Locus B	+	+	0	0	+	0	0	+	0	-	2
Residence											
P.S.	+	0	-	0	-	-	-	+	-	-	2
Locus A	+	0	-	0	+	+	+	+	+	-	1
Locus B	+	0	+	0	+	+	-	+	-	+	1
Tourism											
P.S.	+	0	-	0	0	-	-	+	-	-	3
Locus A	+	0	-	0	0	+	+	+	+	-	2
Locus B	+	0	+	0	0	+	-	+	-	+	1
Fishing											
P.S.	+	0	-	0	0	0	0	+	0	0	2
Locus A	+	0	-	0	0	0	0	+	0	0	2
Locus B	+	0	+	0	0	0	0	+	0	0	1
Admin.											
P.S.	+	0	0	0	0	0	-	-	0	0	2
Locus A	++	0	0	0	0	0	+	+	0	0	1
Locus B	-	0	0	0	0	0	-	-	0	0	2
Shipping/ Warehousing											
P.S.	+	0	0	0	+	-	0	+	0	-	2
Locus A	++	0	0	0	-	0	0	0	0	-	1
Locus B	-	0	0	0	+	+	0	-	0	+	2
University											
P.S.	N/A										
Locus A											
Locus B											

CODE: P.S.: Present Site (near airport)
Locus A: At ring road two kilometers west of wadi
Locus B: Palm beach ten kilometers west of wadi

+ means site judged advantageous in terms of that criterion; ++ means very advantageous; - means disadvantage or problem; 0 means neutral or not applicable; ? situation uncertain. Coding is explained further in the middle of page 4-6.



—NOTE—

Subsequent to preparation of semi-detailed physical plans under the Sinai Development Study-Phase I, the Ministry of Development's GOPP prepared more detailed plans for several important towns in Sinai, including El Arish. The GOPP plan supersedes this preliminary sketch of El Arish.

FIGURE 4.4
EL ARISH: PRELIMINARY SKETCH TO ASSIST IN LOCATING INDUSTRIAL AND WAREHOUSING COMPLEX

Tourism has the most restrictive land suitability criteria in El Arish--insisting on ocean frontage--and should, therefore, be given preference. The central business district can expand where it is. Residential and institutional uses can best expand to the southwest, towards higher elevations, away from the flood plain and away from agricultural soil. This area is, however, subject to intrusion by dunes.

An issue may exist in the finding that palm beach is best suited in land capability terms for both industry and tourism. As tourism is the less "footloose" of the two uses, the analysis suggests industry be placed to the south. The analysis helps to clarify the problems of El Arish's attractive but difficult site for a large city. A metropolitan area plan is needed, covering the area within at least 20 kilometers of El Arish, in order to plan for rural and touristic as well as urban land uses.

Possible early land capability actions:

- reserve beaches for tourism and recreation
- reserve flood plain for agriculture and recreation
- set aside industrial park site(s)
- dune stabilization program.

4.7.2. The Bitter Lakes

The land stretching for 40 kilometers along the eastern shore of the Bitter Lakes is generally suitable for agriculture: it has good road access, is within 15 kilometers of the Hamdi tunnel and/or the Deversoir ferry, and is lakefront land within a two-hour drive of Cairo. Villas on Lake Timsah and on the west shore of Great Bitter Lake are selling at high prices. Specific locations can be selected for evaluation as a next step in planning for this area; Table 4-3 can be used to assist the evaluation of alternative locations.

The eastern shore of the Great Bitter Lake can be ranked most highly for tourism because recreational tourism is particularly suitable to waterfront land with good accessibility, particularly from large metropolitan cities such as Cairo. The convenience of Nile water and reliable electricity at nearby Deversoir, and the existence of all urban amenities at Ismailia, enhance this potential. The possible competing land uses are irrigated agriculture and light industry.

Possible early land capability actions:

- set aside one-kilometer wide strip as recreation/tourism area
- plant date palms and/or other trees
- prepare comprehensive plan
- build marina.

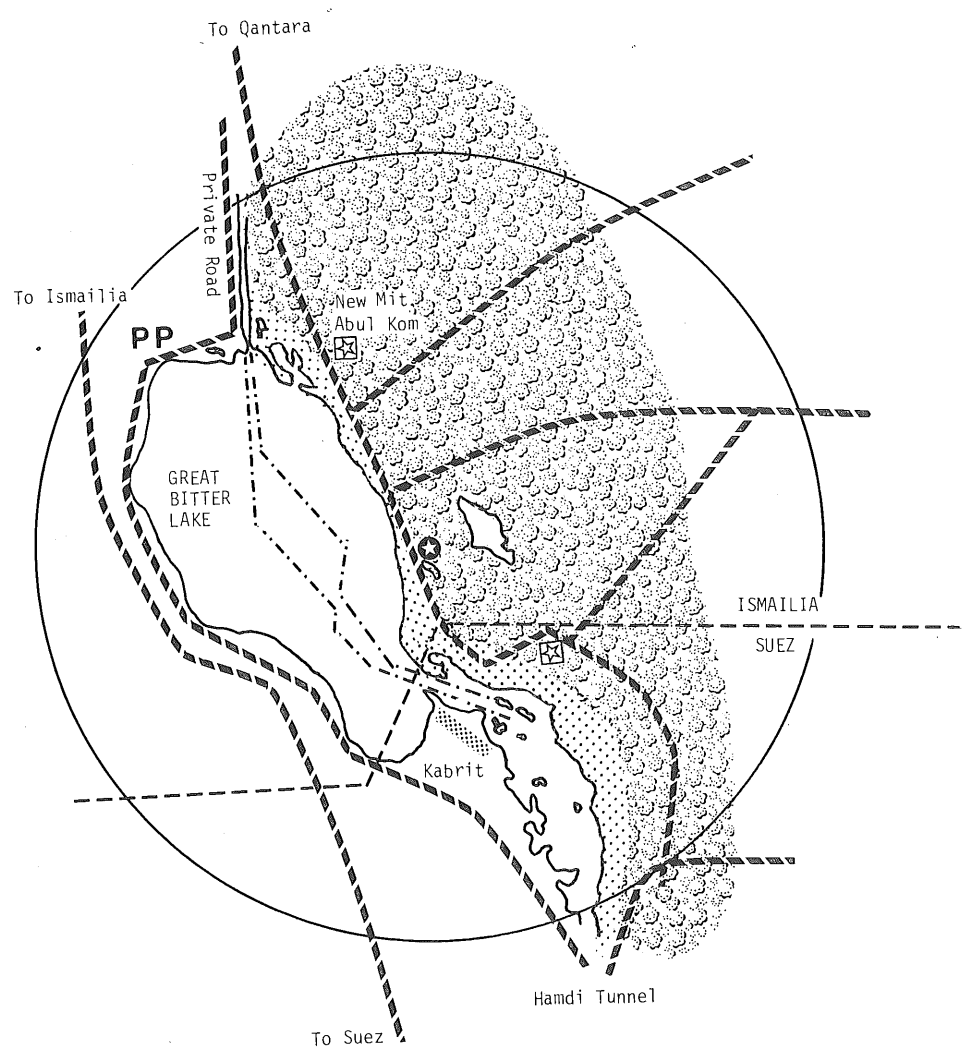
TABLE 4-3

LAND CAPABILITY WORKSHEET FOR: BITTER LAKES

Land Use	Land Character: Access	Soil	Coast	Coral	Slope	Flood	Higher Elevation	Infra-structure	Aquifer	Dunes	Rank
Industry											
P.S.	+	-	+	0	+	+	0	-	0	0	3
Locus A											
Locus B											
Agriculture											
P.S.	+	+	0	0	+	+	0	+	-	0	2
Locus A											
Locus B											
Residence											
P.S.	+	+	++	0	+	+	0	+	0	0	2
Locus A											
Locus B											
Tourism											
P.S.	++	+	++	0	0	+	0	+	0	0	1
Locus A											
Locus B											
Fishing											
P.S.	+	0	++	0	0	0	0	+	0	0	3
Locus A											
Locus B											
Admin.											
P.S.	N/A										
Locus A											
Locus B											
Shipping/ Warehousing											
P.S.	+	0	+	0	+	+	0	0	0	0	3
Locus A											
Locus B											
University											
P.S.	N/A										
Locus A											
Locus B											

CODE: P.S.: Present site (New Mit Abul Kom)
Locus A: To be determined
Locus B: To be determined

+ means site judged advantageous in terms of that criterion; ++ means very advantageous; - means disadvantage or problem; 0 means neutral or not applicable; ? situation uncertain. Coding is explained further in the middle of page 4-6.



LEGEND:

- Irrigated Agriculture (Partially Under Development)
- Tourism Area
- PP Power Plant
- Shipping Convoy Lanes
- Road
- Airfield
- Point from which 20km Radius Drawn
- Potential Town Site
- Governorate Line

KILOMETERS

25 20 15 10 5 0

FIGURE 4.5
BITTER LAKES: PRELIMINARY SKETCH TO ASSIST IN ZONING FOR FUTURE LAND USE

Dames & Moore

4.7.3 Ayun Musa (including El Shatt and Ras Misalla)

The area directly east of Suez (El Shatt, Ayun Musa, Ras Misalla) is included in Land Resource Unit H, which has relatively good potential for irrigated agriculture. The dunes to the northeast set a limit as do the hills to the east.

Analysis indicates that 30 percent of the LRU H should be subject to semi-detailed soil surveys and that about 30 percent of the areas surveyed will be appropriate for irrigation. Of the approximately 200 square kilometers between the Ayun Musa coast and the 100 meter elevation line, it is expected that about 6,000 feddans will be irrigable. The kinds of crops that could be grown in the coarse textured aeolian soils are figs, citrus, banana, tomato, onion, and cotton with drip and sprinkler irrigation. The location near Suez suggests agriculture for export.

Two other land uses are appropriate for this area: light industry and recreational tourism. The land capability of this area includes:

- flat land
- fair to good soils
- good access to Suez port and Hamdi tunnel
- sandy beach and shallow coral reef
- a shallow aquifer--slightly saline to fresh
- a few palm trees.

Table 4-4 considers three primary land uses (light industry, tourism and agriculture) with a single town at the center to serve all three. This suggestion is based on an analysis which rates Ras Misalla best for tourism and El Shatt best for industry. By and large, agriculture does not benefit as much as either tourism or industry from water and highway access and may be east of the highway.

Possible Land Capability Early Actions:

- set aside land for recreational tourism
- set aside land for industry
- plant date palms and/or other trees
- establish program to protect the shallow aquifer (including the springs)

4.7.4 The Ras Taba Area

Taba is ten kilometers from Aqaba port and Jordan's southern tourist zone, and five kilometers from the port and beaches of Eilat.

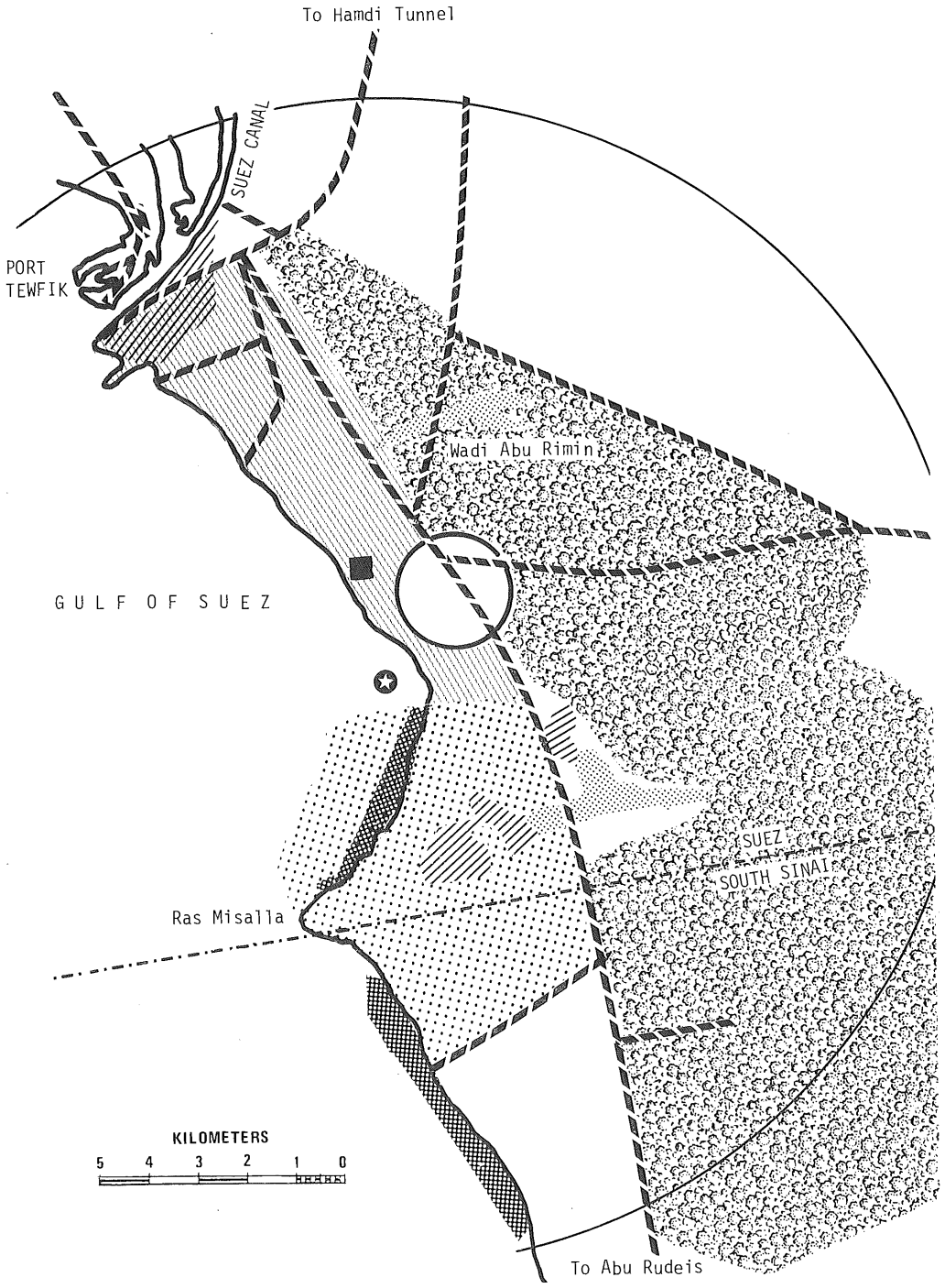
Table 4-4

LAND CAPABILITY WORKSHEET FOR: AYUN MUSA AREA

Land Use	Land Character: Access	Soil	Coast	Coral	Slope	Flood	Higher Elevation	Infra-structure	Aquifer	Dunes	Rank
Industry											
P.S.	-	+	+	0	+	+	0	-	-	-	2
Locus A	++	+	+	0	+	+	0	+	+	+	1
Locus B	-	-	-	0	+	+	0	-	-	0	3
Agriculture											
P.S.	-	-	0	0	0	0	0	-	+	-	2
Locus A	+	+	0	0	+	0	0	+	-	+	1
Locus B	+	0	0	0	+	0	0	-	+	-	3
Residence											
P.S.	-	0	-	-	+	+	0	-	-	-	3
Locus A	+	0	+	-	+	+	0	+	+	+	1
Locus B	+	0	+	+	+	+	0	0	-	0	2
Tourism											
P.S.	+	0	-	-	0	0	0	-	0	-	3
Locus A	+	0	+	0	0	0	0	+	0	+	2
Locus B	+	0	+	++	0	0	0	-	0	+	1
Fishing											
P.S.	-	0	-	0	0	0	0	-	0	0	2
Locus A	+	0	+	-	0	0	0	+	0	0	3
Locus B	+	0	+	++	0	0	0	0	0	0	1
Admin.											
P.S.	N/A										
Locus A											
Locus B											
Shipping/ Warehousing											
P.S.	-	0	-	0	+	+	0	-	-	-	3
Locus A	++	0	+	0	+	+	0	+	+	+	2
Locus B	+	0	+	0	+	+	0	-	-	+	1
University											
P.S.	N/A										
Locus A											
Locus B											

CODE: P.S.: Present Site (Ayun Musa and hinterland)
Locus A: El Shatt
Locus B: Ras Misalla

+ means site judged advantageous in terms of that criterion; ++ means very advantageous; - means disadvantage or problem; 0 means neutral or not applicable; ? situation uncertain. Coding is explained further in the middle of page 4-6.



LEGEND

- Possible Residential/Commerce Site
- Agricultural Land
- Tourism/Recreation
- Coral Reef
- Potential Light Industry
- Governorate Boundary
- Ephemeral Pond
- Salt Pan
- Road
- Point from which 15km Circle Drawn
- Quarentine Building

FIGURE 4.6
AYUN MUSA: PRELIMINARY SKETCH TO ASSIST IN ZONING FOR FUTURE LAND USE

Dames & Moore

Taba's development potentials include:

- Recreational and religious tourism
- Shipping (as adjacent to Aqaba)
- Industry (as adjacent to Aqaba and Eilat)
- Transport (road connections to Suez and El Arish; and air connections to the world via Ras El Nabq)
- Commerce for Southeast Subregion and international).

Taba's land capability is quite limited, as there is only a narrow strip of land along the rocky coast. Within ten kilometers of Taba are several possible small port sites and a coral island with an historic fort and a small harbor. Within 15 kilometers is an extensive (40 to 80 square kilometers) plateau at about 700 meters altitude. Here there is El Naqb, a fully equipped airport sufficient to handle 747s.

For Ras Taba to realize its potential and for Egypt to have a convenient transport link to its southeastern coast and to Jordan, Saudi Arabia, and Iraq and to join North and South Sinai, it may be desirable to organize the area in four parts:

- Taba Center
- Quay and ferry terminal
- Faraun Island
- Upper Taba.

Table 4-5 ranks the present site, Mersa Murakh and the airport site for several potential land uses. Agriculture was not considered although there is some potential in the two wadi beds. The principal constraint is the lack of availability of flat land; another is flood danger in two wadis. The possible solution is a road 700 meters up the mountain, which, although expensive, is necessary to give access to the Hadj highway, the airport and additional flat land.

The concept of land uses as ranked in Table 4-5 optimizes land capability in the area. Upper Taba is within 20 kilometers of Aqaba port by road and 30 kilometers by road and then ferry (in case the direct road is closed). It has enough space to handle a variety of possible urban land uses, including free zone activities related to the airport and Aqaba port. The customs clearance of religious tourists can be well handled here, as can commercial travellers' hotel needs. Lower Taba could then remain a pleasant tourist town, organized around the beach and Faraun island. (See Figure 4.4).

Water is now provided to the airport from Eilat. In the future it could come from wells near Kuntilla. During the hot summer Upper Taba, 700 meters in elevation, will be cooler than Taba Center. In winter, Taba Center will be warm compared to Upper Taba.

Table 4-5

LAND CAPABILITY WORKSHEET FOR THE RAS TABA AREA

Land Use	Land Character: Access	Soil	Coast	Coral	Slope	Flood	Higher Elevation	Infra-structure	Aquifer	Dunes	Rank
Industry											
P.S.	+	0	+	0	-	0	0	+	0	0	1
Locus A	+	0	-	0	+	0	0	+	0	0	1
Locus B	-	0	+	0	-	0	0	-	0	0	2
Agriculture											
P.S.	N/A										
Locus A											
Locus B											
Residence											
P.S.	+	0	+	0	-	0	-	+	0	0	1
Locus A	+	0	-	0	+	0	+	+	0	0	1
Locus B	+	0	+	0	-	0	-	-	0	0	2
Tourism											
P.S.	+	0	+	-	-	0	0	+	0	0	2
Locus A	+	0	-	-	+	0	0	+	0	0	2
Locus B	+	0	+	++	-	0	0	-	0	0	1
Fishing											
P.S.	+	0	+	+	0	0	+	-	0	0	2
Locus A	-	0	-	-	0	0	-	-	0	0	3
Locus B	+	0	+	++	0	0	+	-	0	0	1
Admin.											
P.S.	+	0	+	0	-	0	0	+	0	0	1
Locus A	+	0	-	0	+	0	0	+	0	0	1
Locus B	-	0	+	0	-	0	0	-	0	0	3
Shipping/ Warehousing											
P.S.	-	0	+	0	-	0	0	+	0	0	2
Locus A	+	0	-	0	+	0	0	+	0	0	1
Locus B	+	0	+	0	-	0	0	+	0	0	1
University											
P.S.	N/A										
Locus A											
Locus B											

CODE: P.S.: Present site (Taba Center)
Locus A: Plain on Hadj Road at 700 meters (Upper Taba)
Locus B: Mersa Murakh and access road (Taba Port)
+ means site judged advantageous in terms of that criterion; ++ means very advantageous; - means disadvantage or problem; 0 neutral or not applicable; ? situation uncertain. Coding is explained further in the middle of page 4-6.

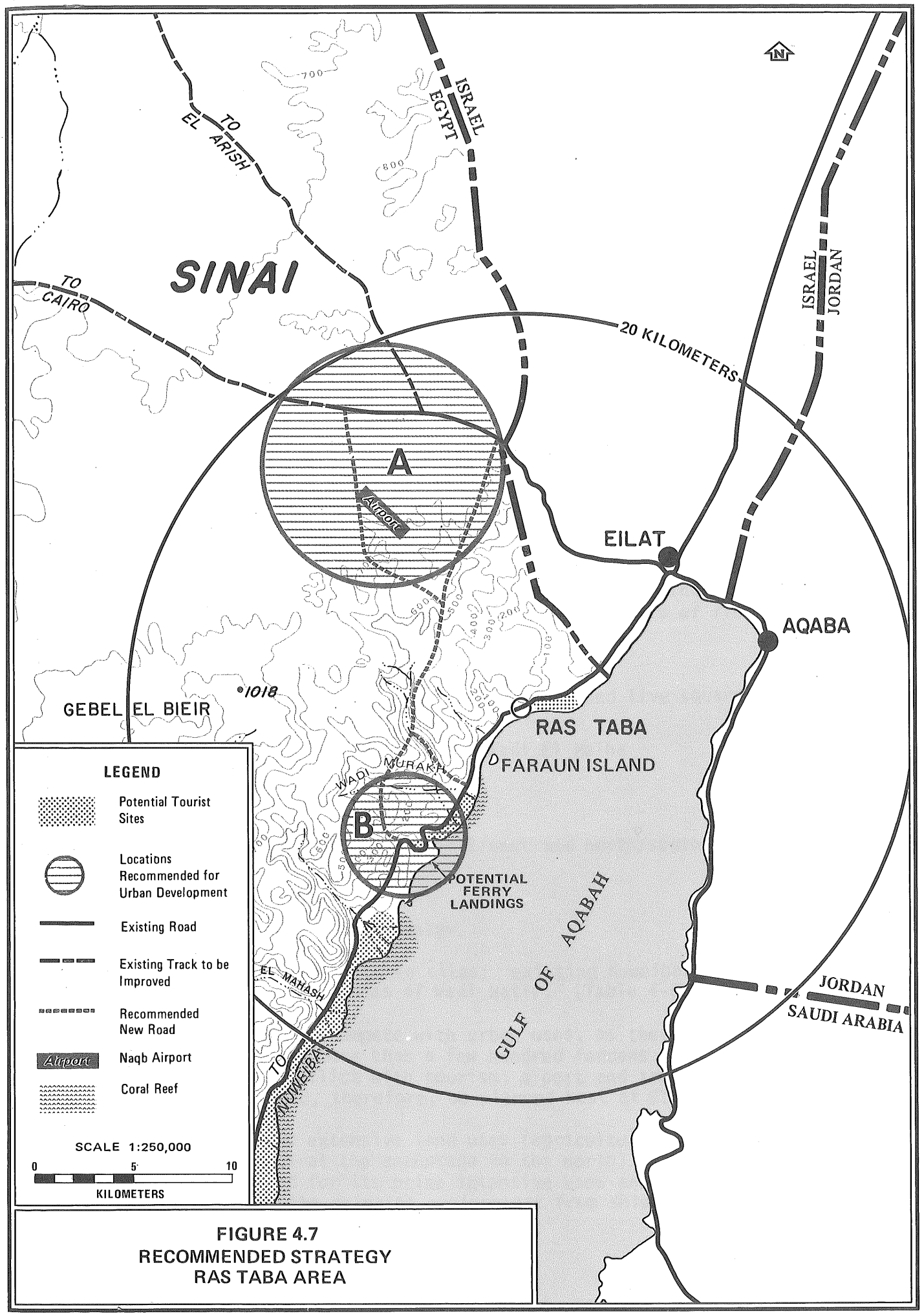


FIGURE 4.7
RECOMMENDED STRATEGY
RAS TABA AREA

Possible Early Land Capability Actions:

- drilling for groundwater
- construction of a ferry and lighter landing
- construction of a road from the airport to the coast
- conversion of the airport to civilian use.

4.7.5 Nuweiba

Along the entire Aqabah coast the mountains drop sharply into the deep gulf. This is particularly true just south of Nuweiba. At Nuweiba there is an outwash plain at the mouth of the Wadi Watir with about 20 square kilometers of flat land.

Nuweiba is sited close to the intersection of the Ras Taba/Sharm El Sheikh highway and the highway from Wadi Feiran and St. Catherine Monastery. It is about 70 kilometers south of Taba and north of Dahab, and 150 kilometers from Sharm El Sheikh. It is thus the place best situated to be the administrative center of the Southeast Subregion, a transition place for tourists between a cultural and mountain holiday to a sun and sea holiday, a truck trans-shipment point, and a small military base. Fifteen kilometers to the north is a small anchorage at the end of Wadi El Malha and at a break in the coral reef, comprising about five square kilometers of flat land.

Land Characteristics of Nuweiba include:

- steep slope except 20 square kilometers and five square kilometers of outwash
- some irrigable coarse soils in Wadi El Malha
- small beach, extensive coral
- plentiful building materials
- best access in subregion (east/west and north/south road plus anchorage)
- flood danger in wadis
- shallow and deep groundwater.

The SDS analysis ranked three sites: existing Nuweiba, Wadi El Malha anchorage, and the lower reaches of Wadi Watir. (Table 4-6.)

Agriculture need not compete with urban uses, as there is not enough groundwater to cultivate more than a few hundred feddans. Land or sea transport uses might conflict with tourism; a port and truck terminal warehouse location could, therefore, be planned best at El Malha.

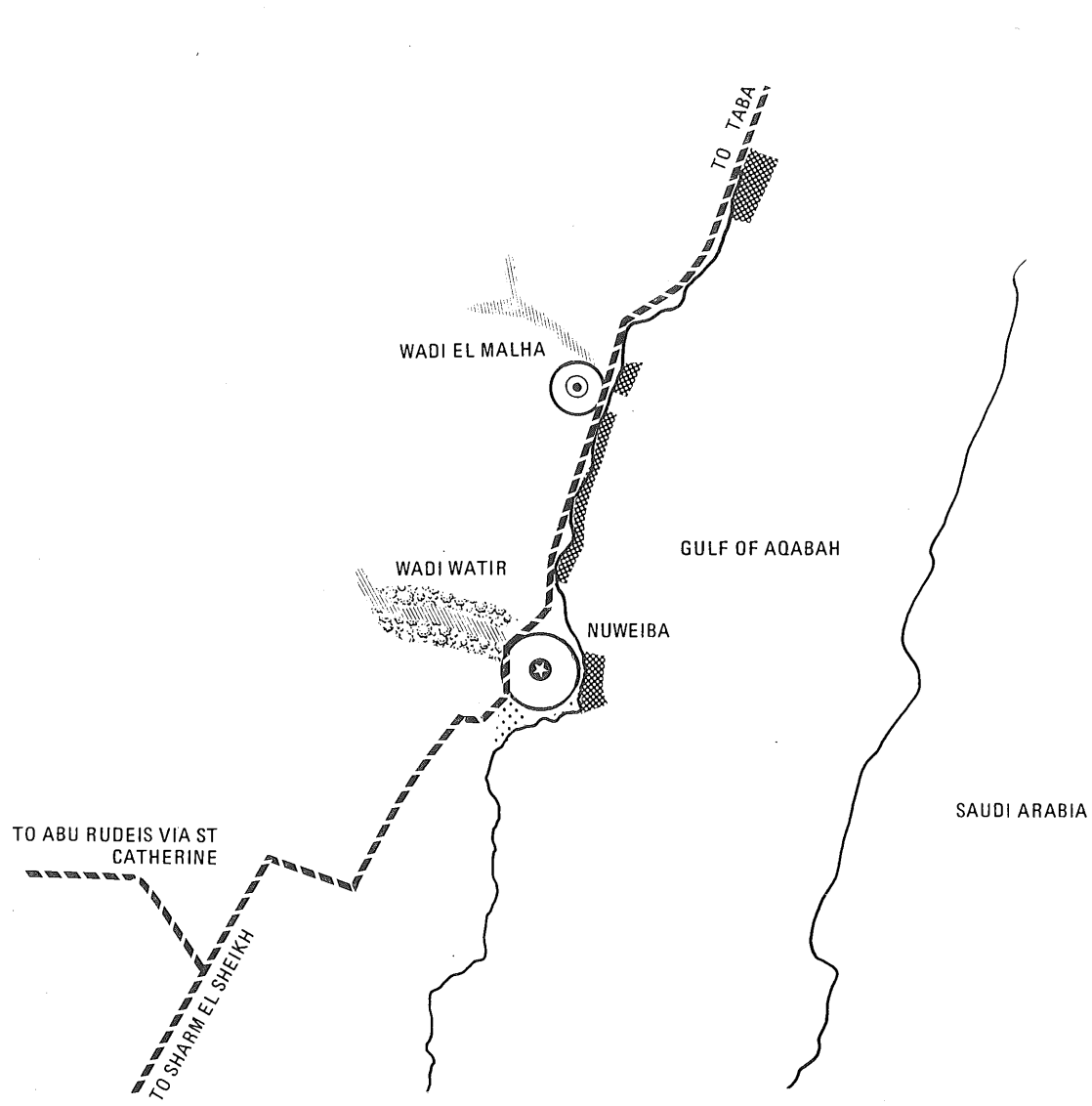
Siting of the two extensive land uses (agriculture in the wadi and the transport functions at the anchorage to the north) will permit use of all Nuweiba's flat land for its prime intensive uses and avoid possible damage to coral or to the pristine environment from shipping, trucking and/or tourist bus parking.

Table 4-6

LAND CAPABILITY WORKSHEET FOR: NUWEIBA

Land Use	Land Character: Access	Soil	Coast	Coral	Slope	Flood	Higher Elevation	Infra-structure	Aquifer	Dunes	Rank
Industry											
P.S.	N/A										
Locus A											
Locus B											
Agriculture											
P.S.	+	-	0	0	+	+	0	0	-	0	1
Locus A	+	0	0	0	+	0	0	0	0	0	2
Locus B	+	+	0	0	-	-	0	0	+	0	1
Residence											
P.S.	+	+	+	0	+	+	0	+	+	0	1
Locus A	+	+	+	0	+	0	0	+	+	0	2
Locus B	-	-	-	0	-	-	0	-	-	0	3
Tourism											
P.S.	+	+	+	+	+	0	0	+	-	0	1
Locus A	+	+	+	+	-	0	0	-	+	0	2
Locus B	-	-	-	-	-	0	0	-	+	0	3
Fishing											
P.S.	+	0	+	+	0	0	+	-	0	0	2
Locus A	+	0	+	+	0	0	+	+	0	0	1
Locus B	-	0	-	-	0	0	-	-	0	0	3
Admin.											
P.S.	N/A										
Locus A											
Locus B											
Shipping/ Warehousing											
P.S.	+	0	+	0	+	+	0	+	0	0	1
Locus A	+	0	+	0	+	-	0	+	0	0	1
Locus B	-	0	-	0	-	-	0	-	0	0	2
University											
P.S.	N/A										
Locus A											
Locus B											

CODE: P.S.: Present Site (Delta behind hotel)
Locus A: El Malha anchorage
Locus B: Wadi Watir
+ means site judged advantageous in terms of that criterion; ++ means very advantageous; - means disadvantage or problem; 0 neutral or not applicable; ? situation uncertain. Coding is explained further in the middle of page 4-6.



LEGEND

- Flood Potential
- Potential Agriculture
- Road
- Coral
- Salt Pans
- Point from which 20 sq km drawn
- Point from which 5 sq km drawn

KILOMETERS

25 20 15 10 5 0

FIGURE 4.8
NUWEIBA: PRELIMINARY SKETCH TO ASSIST IN LOCATING A TRANSPORTATION AND ADMINISTRATIVE CENTER

Dames & Moore

Possible early land capability actions:

- fishing port and quay at El Malha
- drilling for groundwater
- planting trees on soil reclaimed through the use of urban solid and liquid wastes
- prepare comprehensive plan for area within twenty kilometers

4.7.6 Abu Rudeis (including Abu Zenima and the mouth of Wadi Feiran)

There is considerable development potential near Abu Rudeis: petroleum, gas, coal, agricultural soils, minerals, and tourism (sea, history, mountains, hot springs). This location is more central to the Southwest Subregion than any other. Abu Zenima is situated on a small shelf and therefore has little room to expand. Abu Rudeis is on the hot, west-facing coastal plain surrounded by low hills, and it is spreading onto agricultural soil. Because of the limitations of both current sites and the recommended rural and urban development in the subregion, a careful search for a new site is recommended as a matter of high priority. This subject is also discussed in Volume VI.

At present Abu Rudeis is a classic example of urban sprawl. For 25 kilometers along a formerly beautiful coast there are many hundreds of temporary buildings used primarily for residence and including warehousing, assembly, offices and garages associated with the mining of petroleum. Land and marine resources are being spoiled unnecessarily. The considerable capital and organizational energy being expended could contribute to building a fine city.

Based on field surveys and map studies, it appears promising to study the uplands above the Wadis Sidri and Feiran within 15 kilometers. At about 300 meters there is some rolling land which is somewhat cooler than Abu Rudeis, away from the agricultural potential, close enough to catch sea breezes, having some groundwater. There is easy access from the north (minerals), south (petroleum), west (agriculture and airport), and east (St. Catherine and Nuweiba).

Figure 4.5 indicates the present site and two alternatives. Other sites might well be considered, possibly to the north. Table 4-7 indicates that the current site has the best potential of the three for industry, warehousing, fishing, and tourism, if pollution is controlled. The present site is also rated best for agriculture, and irrigated agriculture with Nile water is being recommended. Other uses seem better sited at either Wadi Sidri or Wadi Feiran pending more detailed studies, including in particular a microclimate analysis of alternative sites (discussed in Volume VI, Section 4.8).

The space needed for the long-term future for a population of over 60,000 at a new site might be about 20 square kilometers, including 100 hectares for light industry, 100 hectares for a university, 25 hectares for the central business district, and 1500 hectares for residences, institutions, and recreation.

Table 4-7

LAND CAPABILITY WORKSHEET FOR: ABU RUDEIS

Land Use	Land Character: Access	Soil	Coast	Coral	Slope	Flood	Higher Elevation	Infra-structure	Aquifer	Dunes	Rank
Industry											
P.S.	+	+	+	0	+	-	0	+	-	0	1
Locus A	-	+	-	0	-	-	0	-	+	0	2
Locus B	+	+	-	0	+	+	0	-	-	0	1
Agriculture											
P.S.	0	++	0	0	+	0	+	0	+	0	1
Locus A	0	+	0	0	-	0	-	0	+	0	2
Locus B	0	-	0	0	+	0	-	0	-	0	3
Residence											
P.S.	-	-	-	0	-	0	-	++	+	0	2
Locus A	+	+	+	0	0	0	+	-	+	0	1
Locus B	0	+	+	0	+	0	+	+	-	0	1
Tourism											
P.S.	0	0	+	+	-	0	0	+	0	0	1
Locus A	0	0	-	-	+	0	0	-	0	0	2
Locus B	0	0	-	-	-	0	0	-	0	0	3
Fishing											
P.S.	+	0	+	+	0	0	+	+	0	0	1
Locus A	-	0	-	-	0	0	-	-	0	0	3
Locus B	-	0	-	-	0	0	-	-	0	0	3
Admin.											
P.S.	N/A										
Locus A											
Locus B											
Shipping/ Warehousing											
P.S.	++	0	+	0	+	0	0	+	0	0	1
Locus A	-	0	-	0	-	-	0	-	0	0	3
Locus B	+	0	-	0	+	0	0	-	0	0	2
University											
P.S.	0	-	+	0	-	-	-	0	-	0	3
Locus A	0	+	-	0	-	-	+	0	-	0	2
Locus B	0	+	-	0	+	+	+	0	+	0	1

CODE: P.S.: Present Site (at coast)
Locus A: Above Wadi Sidri
Locus B: Above Wadi Feiran

+ means site judged advantageous in terms of that criterion; ++ means very advantageous; - means disadvantage or problem; 0 neutral or not applicable; ? situation uncertain. Coding is explained further in the middle of page 4-6.

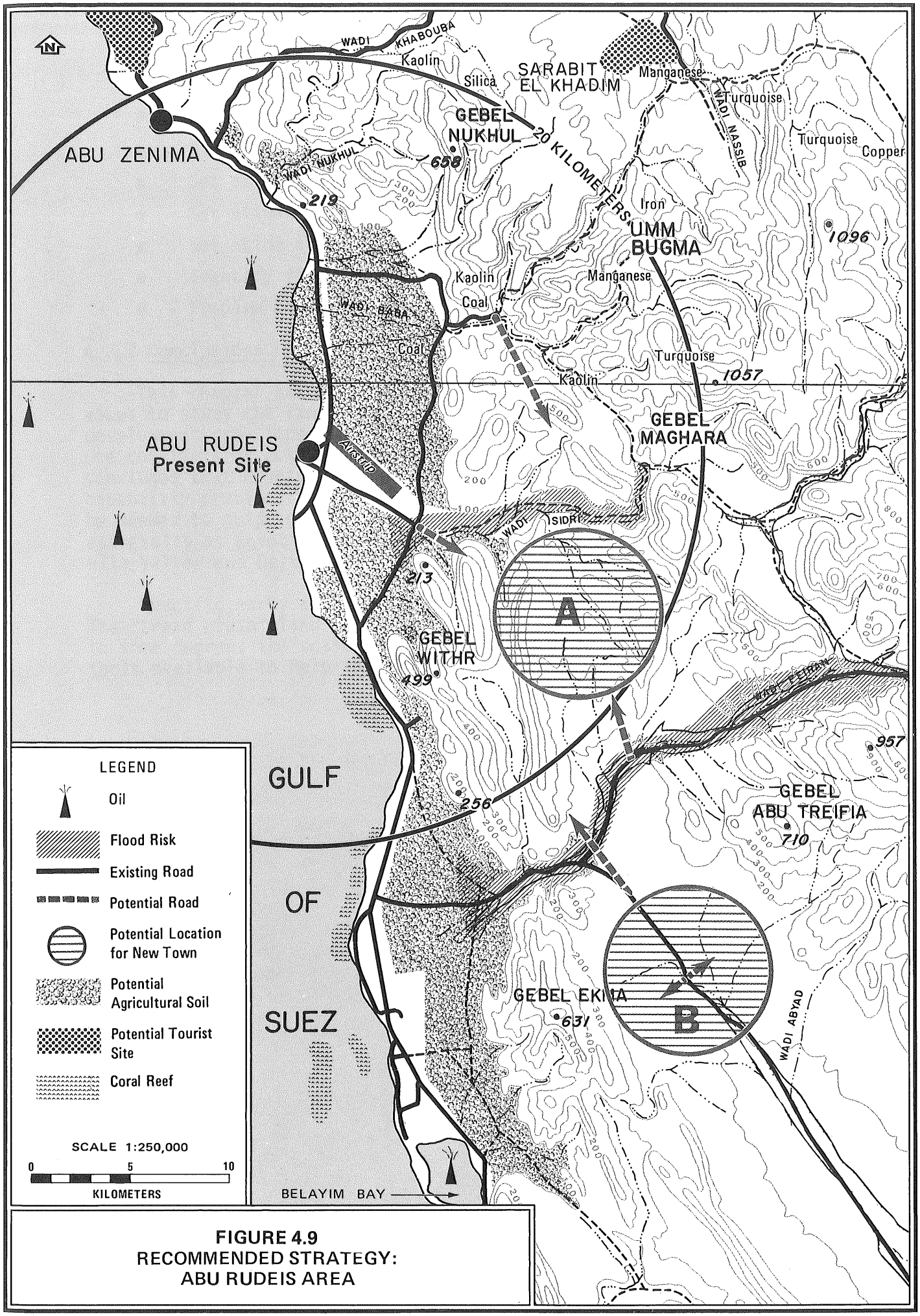


FIGURE 4.9
RECOMMENDED STRATEGY:
ABU RUDEIS AREA

Possible early land capability actions:

- Plan urban uses on the coast to forestall continued sprawl
- Set aside areas on coast for recreational tourism
- Set aside areas on coast for industry
- Set aside areas for irrigated agriculture
- Identify flood and pollution hazards
- Prepare comprehensive plan within 30-35 kilometer radius.

4.7.7 Conclusions

This chapter has used working papers, maps, field trips, and interviews to study the land capability of Sinai for non-agricultural development, the impact of infrastructure on land capability, and land use conflicts at both extensive and intensive levels. The Consultant concludes that development in Sinai will be fraught with many land capability problems. Considerable study, planning, and monitoring will be needed to guide growth that will not spoil the land and environment, especially as Egypt's long experience is with development in the lush Nile Valley and Delta more than in the desert.

Specific early actions have been listed for some special sites. The "broad brush" land capability analysis presented here has defined, to some degree, the scale and nature of the problems, and the research tools available to help in solving them.

5.0: ENVIRONMENTAL MANAGEMENT

5.1 INTRODUCTION

Before proceeding with major development projects in Sinai, four principal issues of environmental management need to be resolved:

- How are environmental impacts to be anticipated? In other words, how can planners systematically identify potential impacts of development proposals and compare them with the impacts of other proposals?

- How are major conflicts between proposed land uses to be resolved? By what planning and decision-making mechanisms can compromise be reached among environmental, social and economic values of competing or incompatible land use proposals? What options are there for conflict resolution?

- How are multiple-use areas to be managed? When land use conflict is resolved through a complex mix of land uses, how is a management plan to be devised and carried out?

- How are environmental factors to be monitored? What methods are to be used and who will be responsible for keeping track of environmental change brought about by development? How can the monitoring information be used to identify and redress problems at an early and/or timely stage?

The management system under which Sinai can best develop must be one which provides workable answers to the above questions. This chapter discusses factors involved in these management issues and provides a number of recommendations.

It may be useful to reiterate the overriding questions: What is likely to happen to the Sinai Peninsula when its arid wilderness is converted into an agricultural and industrial province of Egypt, supporting six times as many people as it now does, and relying on importation of huge quantities of Nile water and massive pumping of groundwater? What planning, management and monitoring mechanisms are needed to maximize the good effects and minimize the bad effects of Sinai's transformation?

5.2 IMPACTS OF DEVELOPMENT

Planners need a straightforward, systematic procedure for evaluating the potential environmental impacts of any development program or project. The easier the procedure is to understand and use, the more likely it will be effectively incorporated into the planners' routine. Such incorporation is in itself an important environmental goal for Sinai's development, because it would ensure that environmental concerns are factored into development decisions.

The initial environmental examination (IEE) procedure recommended here is based on posing a set of questions regarding basic environmental concerns. The questions are directed to specific projects or components of programs which can be located geographically. To answer the questions adequately, there must be adequate information about the intended site and its surroundings. The generalized version of each question reads: "What is the likely adverse impact?" The answer may be "no impact" (given a rating = 0), "some impact" (rating = 1), or "great impact" (rating = 2). The following ten questions were selected to facilitate identification of the major environmental problems that can be expected to result from development in Sinai.

5.2.1 Contamination of Surface Water or Groundwater

Question 1. Are wastes from the project likely to result in the contamination of surface water or groundwater?

Because water resources in Sinai are limited, every effort must be made to minimize the contamination of surface water and groundwater supplies. If contamination occurs, it will either necessitate costly mitigative measures or reduce the development potential of the contiguous area and the region.

Water contamination can result from a number of causes. Among the most common sources of contamination are improper disposal of industrial, agricultural and domestic chemicals and waste materials. For example, wastes from a mining operation might be disposed into a wadi where periodic drainage would wash heavy metals or other toxic substances into agricultural fields, thereby affecting the soil, plants and the food chain. The waste material also could seep into the groundwater, which is later pumped to the surface for agricultural or domestic use.

Another cause of groundwater contamination is overpumping of aquifers. If this happens, saline water may flow into a freshwater aquifer -- increasing its salt content and possibly making it unfit for agricultural or domestic use. Groundwater may also be salinized when saline soils are irrigated in ways that leach salts into the underlying aquifers.

5.2.2 Lowering of the Groundwater Table

Question 2. Is the project likely to result in substantial lowering of the groundwater table or to affect downstream users?

In implementing Sinai development projects, groundwater pumping should not exceed the maximum safe yields discussed in Volume V. Under some circumstances, development plans may call for some degree of mining of groundwater, effectively using up some of an aquifer to

achieve certain goals. It should be kept in mind, however, that groundwater mining and water table lowering generally have negative effects which should be considered before plans are finalized. These effects include increased pumping costs as depths increase, intrusion of lower quality groundwater or seawater, subsidence of land as groundwater is removed from underlying rock, and drying of shallow wells even at considerable distances from the deep well pumping stations. Such effects may also be found downstream, many kilometers from a project area.

5.2.3 Flooding and Shifting Sands

Question 3. Is the project likely to be affected by flooding or by shifting sand?

Much of the fresh water that falls on Sinai escapes through surface runoff. This runoff is a potential resource that may be diverted and used; it is also a potential hazard to development. During heavy precipitation in the winter and spring, flash floods can inundate a wadi with several or more feet of water, resulting in the destruction of roads, houses, bridges and other structures, and causing severe soil erosion. It is thus important to be aware of flooding potential and to recognize that flooding in Sinai can be severe.

Shifting sands can also pose a hazard to development. The concern is not so much that a project will cause dune instability, but rather that unstable dunes may encroach upon or bury a project. It is not uncommon to see dunes covering part of the main road between El Qantara and El Arish, and dunes can overwhelm an agricultural area, rendering it unfit for use. Areas with potentially unstable dunes and shifting sands should be considered for grazing and other agriculture that can be readily moved to a new location if a shift in dunes forces such a move.

5.2.4 Air Pollution

Question 4. Are significant quantities of SO_2, TSP, NO_x or other pollutants to be emitted, and is it likely that the dispersion would impinge on the surrounding terrain?

Air quality is an important concern at both the local and regional level. If significant quantities of sulfur dioxide (SO_2), total suspended particulates (TSP), nitrogen oxides (NO_x), or other pollutants such as carbon monoxide, hydrocarbons and lead are emitted, they can affect the growth of natural vegetation and crops over large areas, and can greatly reduce the value of a beach or other touristic attraction. Where toxic substances such as heavy metals are emitted into the atmosphere, they can have potentially serious effects if they enter the food chain.

Appropriate project location and design can alleviate the severity of air pollution. Proper smokestack height may help to lessen impingement of the plume and disperse the emissions. Careful site selection can ensure that the project is located suitably. The critical factors to consider in site selection are the prevailing wind directions by time of day and season of the year, the strength of the wind and the occurrence of inversions (which have opposite effects on mixing of air and hence dispersion of pollutants), and the distance and direction to human settlements, agricultural areas, tourist sites, conservation areas, and grazing areas which may be harmed by frequent exposure to the pollutants.*

5.2.5 Hazardous Wastes

Question 5. Is the project likely to necessitate the disposal of wastes or hazardous substances?

Proper disposal of industrial and domestic wastes and hazardous substances is necessary for the prevention of water and soil contamination and the maintenance of good public health. Improper waste management can result in the contamination of soil, surface water, and groundwater through runoff and percolation. The major consequences of soil and water contamination can be a deterioration of public health, loss of water and soil resources for agricultural and domestic use, and the destruction of fish and other animal habitat.

Hazardous substances such as radioactive, flammable, caustic, carcinogenic and poisonous agents and substances can be dangerous and cause serious problems of disposal. Industrial chemicals and agricultural pesticides are the most common problems. They require special treatment and handling, and must be disposed of at specially designed disposal facilities to avoid contamination of water, soil, and plant and animal life. Given its abundance of land and proximity to markets, it is possible that a few specialized sites could be developed in Sinai where hazardous wastes could be disposed of conveniently without danger to any other activity; identification of such sites will require careful study.

5.2.6 Dust Intrusion

Question 6. Is the project likely to produce significant levels of dust?

Since tourism is likely to be a major factor in the development of Sinai, it is important to consider obnoxious dust produced by mining, quarrying, industrial processes, agricultural processing and vehicular activity as potentially significant negative impacts on the environment. Tourists from wetter climates are quite annoyed by a dusty atmosphere, especially on beaches, at cultural sites, and in wildlife areas. Dust/particulate matter pollution is also a problem for the coral reefs that attract the tourists.

---

* The MOD/UNDP study of air pollution around Suez City may be referred to here, as inversions are a particular location-specific problem at the head of the Gulf of Suez.

Dust in an arid climate is a constant problem. One common source of dust in urban areas is vehicular movement. A number of mitigative measures can be employed to reduce dust:

- paving roads,
- sweeping roads,
- orienting structures to block the dusty winds (rather than accelerate them), and
- employing land use planning that considers high and low wind patterns diurnally and annually.

5.2.7 Damage to Scenic Areas

Question 7. Is the project likely to have a negative effect on the aesthetic value of scenic areas?

One of Sinai's greatest attributes is its magnificent scenery, especially the mountain, plateau and wadi landscapes of the interior, and the beaches, headlands and shallow waters of the coasts. Some outstanding examples are the St. Catherine area, the Sarabit El Khadim area, and the Ras Mohammad area. Damage to the aesthetic value of an area can come from such obvious sources as oil spills on beaches and coral reefs, and from more subtle sources such as obtrusive buildings that clash with the appearance of their natural surroundings. The primary concern is that tourist sites, especially those with great cultural significance or natural beauty, not be marred by thoughtless construction projects that may damage the sites' aesthetic value to visitors.

Moreover, the aesthetic appeal of the architecture, layout and landscaping of settlements will affect potential settlers' decisions about moving to Sinai.

5.2.8 Impact on Cultural Heritage

Question 8. Is the project likely to impact any known historical, archaeological or religious site of significance?

Egypt has a long, rich past, and the preservation of significant historical, archaeological and religious sites is obviously very important. These cultural resources are not only important for their intrinsic and educational value, but also as a tourist attraction. A listing of the more significant cultural sites is given in Appendix D; these are also shown on Figure 4.1.

5.2.9 Impact on Natural Heritage

Question 9. Is the project likely to result in the loss of wetlands or other critical natural areas?

Of concern are barrier beaches, saltwater marshes, lagoons, coastal dunes, coral reefs, mangroves, oases, high plateaus, mountains and shallow aquifers that play important roles in maintaining the structural integrity and primary productivity of ecosystems and provide substrate, water, breeding areas, nursery areas, wintering areas and migration pathways of critical importance to survival of certain animal and plant species. The most significant natural areas of Sinai are listed in Appendix D and mapped on Figure 1.2. Several of these critical areas provide habitat for rare and endangered species of plants and animals.

5.2.10 Land Use Conflicts

Question 10. Is the project likely to result in the displacement of other potentially more important land uses?

The development of an area for a particular purpose can result in the displacement or preemption of other uses of the land. For example, agriculture is limited to land that can be irrigated or rainfed; much potential agricultural land is still undeveloped, but it is important to take early steps to retain it for eventual agricultural use. It is therefore preferable to locate nonagricultural developments on land that is unsuitable for agriculture.

Tourism as a land use is most demanding in terms of both site and accessibility. The full development of tourist potential in Sinai may well require 20 years or more. Therefore, only under the most demanding circumstances should other activities be allowed to use sites suitable for future tourist use.

5.2.11 Summary and Conclusions

These ten questions may be added to, expanded upon, or revised from time to time to suit the particular needs and concerns of the planners and managers of Sinai's development.

Having answered these questions with a rating (0, 1 or 2) for each project, the planner can sum the ratings to get an overall rating of the proposed use for comparison with other projects. This system allows for some objective comparison and analysis of alternative projects, or of the same project at alternative sites. In other words, the planner can choose the project with the least negative impact on a particular site or choose a site where a particular project will have the least negative effect on the environment.

Having chosen a particular project for a particular site, the manager then makes a "threshold decision" about the need for more

detailed environmental impact assessment. In the initial environmental examination (IEE) procedure recommended here, the decision might be that a project which receives a rating of 2 in any of the 10 questions should have further environmental assessment in the problem area(s) where there is likely to be "great impact." This threshold decision can often be made even when only reconnaissance-level information is available. Further environmental assessment usually requires more detailed data collection and analysis for the proposed site, which can be incorporated into prefeasibility or feasibility studies of particular proposals. Thus, the IEE procedure is a technique for identifying needs for more detailed information about Sinai.

Summing of impacts, or using any simple "decision rule" for IEE threshold decisions, are simplifying techniques that can lead planners astray; these techniques are not substitutes for informed judgment. One project may have a summed rating of only 2, but this 2 may come from one answer of "great impact" which requires further assessment. Another project may have no impact ratings above 1, but there may be so many slight impacts that the cumulative effects merit further study.

When several projects occur in one locality, each may mitigate or exacerbate the environmental impacts of the others. For example, smoke from a single small factory may quickly dissipate, but the smoke from several factories in an industrial estate may cause severe air pollution in surrounding residential areas. Conversely, measures taken to increase the efficiency of fishing gear and boats may lead to irreversible reduction of fish populations, but not if a new licensing program limits the number of boats in operation and the length of the fishing season. These examples underline the need to consider projects in spatial clusters.

There are two general types of impact considered in environmental assessment. One type includes those impacts which affect the viability of the project itself. One example would be the deterioration of soils under long-term irrigation; another would be the collapse of a fish population due to over-fishing. In both examples, not only do the projects bring about their own demise, they leave the areas poorer, often permanently poorer, in development potential; future options are reduced or lost.

The other type of impact includes those which affect people and places outside the project. Air pollution and groundwater contamination are two examples. The environmental costs of the project are borne by people and areas that do not necessarily gain from the project benefits. Internal impacts are often considered in technical feasibility studies, because they are of immediate concern to the project's success (unless short-term gain is considered far more important than longer-term sustainability). The external impacts can also be factored into feasibility studies even though

their costs are usually diffuse and outside the project. The IEE procedure emphasizes the external impacts precisely because there is no other "automatic" or self-enforcing means to account for them.

The above discussion refers repeatedly to planners and managers of development. It is critically important to the success of environmental evaluation of projects, programs and strategies that the IEE procedure be carried out by the people working closely with those who do the regular planning and management tasks for Sinai. It is tempting to shunt aside environmental evaluation as a task for specialists; however, it should be obvious from the ten IEE questions that even a generalist planner can make the judgments that lead to threshold decisions, and that these questions are vital to the future development of Sinai.

5.3 LAND USE CONFLICTS

5.3.1 Introduction

The issue of incompatible land uses is discussed in Chapter 4. It was pointed out that land use conflicts are most likely to occur in spatial clusters of resources, such as around El Arish, Lake Bardawil, the east bank of the Suez Canal, around the Abu Zenima-Abu Rudeis complex, and others.

There are particular areas of ecological, cultural and/or scenic value which can tolerate only limited and carefully regulated use. The most notable areas are around St. Catherine Monastery, the coasts and offshore waters around Ras Mohammad, and the eastern shore and islands of Lake Bardawil. While the conservation of these areas has received considerable international and Egyptian interest, there are other areas deserving conservation. An illustrative list might include the following:

- the flamingo nesting grounds on the eastern shore of Lake Malaha,
- the wildlife and plants of the Gebel El Maghara and surrounding plains,
- the higher elevations of the El Tih and El Igma Plateaus,
- the fortress of Qalat El Gindi,
- the area around and the ruins of Sarabit El Khadim,
- the fortress of Faraun Island (off Ras Taba),
- the coral reefs along the Gulf of Suez coast south of El Tor and along most of the length of the Gulf of Aqabah coast, and
- the mangrove swamps around Nebq.

A major land use conflict will arise in Sinai as some of the best grazing areas are taken over by more intensive land uses, especially agriculture. The problem is most likely to become serious in the northeast corner of Sinai, where rainfall and prospects for both agriculture and grazing are highest. It may also become serious in the mountain wadis of southern Sinai, which have traditionally been the grazing refuge of the Bedouin; the wadis possess most of what little usable soil exists in southern Sinai. The traditional Bedouin pastoralists will not necessarily be displaced by non-Bedouin. Many Bedouin, who are already farming, may seize opportunities provided by Sinai development to expand their operations at the expense of pastoralist neighbors. These displaced pastoralists will be forced to overgraze less viable grazing areas, thereby accelerating desertification.

In summary, there are three types of land use conflict that can be foreseen:

- between development activities in the spatial clusters of resources found mainly on the northeastern coast, the eastern bank of the Suez Canal, and the southwestern coast,
- between environmental and cultural conservation and most other land uses, and
- between traditional Bedouin pastoralism and expanding settled, more intensive agriculture.

Options exist to avoid or resolve these conflicts, but each type of conflict requires a distinctive approach.

5.3.2 Zoning

Zoning may be the best option for avoiding conflicts in the spatial resource clusters of the coasts. As part of the strategic planning process, zoning would give priority to those activities which have the highest long-term value at the location in question. For example, outstanding oil fields just offshore would have priority over a good tourist beach which is likely to be polluted occasionally by spills from the drilling and pumping rigs. Rather than let investors develop the beach for tourism only to meet financial ruin after a major oil spill, the zoning plan would direct the investors to another beach unlikely to be affected by oil spills, or include beach clean-ups as a public service or tax credit. Similarly, areas subject to frequent air pollution from existing industrial areas would be zoned against residential settlement and sensitive agriculture. Conversely, areas with promising agricultural soils would be reserved primarily for agriculture, while industry and settlement would be kept small by the zoning plan.

Zoning plans are designed to be altered in response to discoveries of new resources or changing circumstances which affect

the value of each location for alternative land uses. They are therefore mechanisms for keeping development activities from interfering with each other, but they are not necessarily meant to preserve the existing situation, favor one type of development over another, or tie the hands of government. The consultants have recommended, on a preliminary basis, that sites suitable for tourism be given priority over other land uses in Sinai.

5.3.3 Reserves

Related to zoning is the concept of reserves. Reserves are meant to preserve or conserve the existing situation and give definite if not exclusive preference to one type of land use, usually maintenance of areas, features, and/or sites of major ecological or cultural significance such as examples mentioned above (section 5.3.1). Two types of reserves may be distinguished.

5.3.3.1 Preservation Areas. These areas may be called sanctuaries, wildlife reserves, national parks or given other labels depending on their purposes. They are dedicated to the total protection of ecosystems, species and/or historical/archaeological sites. Special efforts may be made to restore the area or sites, and provisions may be made for visitors (with emphasis on unobtrusive facilities). All other land uses, however, are strictly prohibited. Candidate areas and sites for preservation status are:

- the area around St. Catherine, to protect the natural landscape, the monastery, and the wildlife and plants in the surrounding mountains and wadis,

- Ras Mohammad and vicinity, to protect the rock formations on the shore, the vistas of mountains and sea, the mangrove swamp, raptor nesting areas, and the exquisite coral reefs, and

- the eastern shore and islands of Lake Bardawil, to protect the wetland landscape and ecological role of the area as a major resting ground for migrating birds traveling between Europe, Asia and Africa.

These three candidates are world class treasures of natural and cultural heritage which deserve priority attention.

5.3.3.2 Conservation Areas. Conservation areas are the second type of reserve. Like preservation areas, they are dedicated to protection of ecosystems, species and/or historical/archaeological sites. Other land uses which are compatible with the primary goal are, however, permitted within the framework of a management plan. In other words, conservation areas are operated under a multiple-use concept with a primary goal -- protection of certain features. There is great diversity of conservation areas, depending on the features to be protected and other resources of the area which

permit compatible land uses. Often a preservation area serves as the core of a conservation area: the conservation area can therefore serve as a buffer area around the preservation area. This arrangement is useful in allowing long-standing residents to continue their traditional way of life rather than forcing their eviction. At the same time, the local people can develop an interest in the protection of the valued features as a means to protect their own traditions. An excellent candidate for this kind of conservation area is St. Catherine, which is inhabited by monks and by Bedouin pastoralists, some of whom serve the monastery. The area is under increasing pressure by tourism development; this can be compatible with protection of the area's valued features, but only under a careful management plan that regulates the location and type of development allowed. A conservation area's most critical characteristic is its multiple-use management plan.

Lake Bardawil is another candidate for conservation area status. The eastern shore and islands could be the preservation area core of a larger conservation area including the whole lake: its shore, barrier beach and inlets. The management plan would need to balance many development activities and proposals, such as inlet management, lagoon fishing, aquaculture, oil/gas exploration, salt production, tourism (boating and birdwatching), and the existing shoreline villages (Najila, Ruag and Tulul).

The Gebel El Maghara, El Tih/El Igma Plateaus, and the coral reefs of the Gulfs of Suez and Aqabah coasts are also prime candidates for conservation area status.

5.3.4 Hema System

The best option for managing conflict between expanding agriculture and traditional grazing, and between competing pastoralists, may be revival of traditional cooperative management systems. One example is the hema system, as revived in Syria, Saudi Arabia and the Sahel. In the hema, pastoralists are organized into cooperative grazing units that set aside grazing land in blocks for specific time periods and purposes. The cooperatives, which may reflect tribal structures, also raise forage crops on other blocks of land, using water harvesting methods, wells and cisterns. Currently, there is a proposal to develop a hema system on 200,000 feddans between El Arish and Rafah. The result of the traditional management system is similar to zoning, but with more flexible rotation or alternation of land uses based on cooperative decision-making in response to weather and land conditions (e.g., grazing may be disallowed while bees are on the flowers.)

5.3.5 Summary

To some extent, land use conflicts can be avoided by good land use planning. A planning authority can make decisions to favor particular land uses in designated areas through zoning and dedication of preservation and/or conservation areas. These mechanisms reduce the potential for land use conflict, but they never eliminate

it. Conflict avoidance or resolution depends for real success on consultation and collaborative decision-making by land users themselves.

It is tempting to regard the Sinai Peninsula as an empty land wherein the Government of Egypt can do what it will. The reality is quite different. There are many people and organizations in Sinai or concerned with Sinai who must be consulted before agreement or consensus is achieved. Experience with land use planning and conflict resolution indicate that the intermediate-level authorities, such as governorate administrators, are more effective than national-level bodies or local organizations in recognizing the diverse interests of the range of current and potential land users, be they Bedouin pastoralists or multi-national firms.

In Volumes I, II and VI conservation areas are recommended as a practical step toward establishing nature reserves. Administratively, it may be more reasonable to establish the conservation area first and the preservation area within it at a later date. Exclusionary zoning for major land uses and re-establishing the hema system clearly should be part of an immediate action agenda.

5.4 MANAGING RESERVES AND ZONING

Given that a general zoning plan is established in each governorate and that certain areas are dedicated as conservation areas, the governorates and supporting central government agencies may develop management plans and enforcement procedures.

The management plans can be developed on the same basis as the initial decisions to zone and dedicate--a consultative process involving representatives of all current and potential users of the land in question, mediated by the governorate or regional administration. It is important in this process that the goals be clearly formulated and accepted at the outset, and that all participants understand what a management plan should include. It is also important to develop a separate, individualized management plan for each zoned resource cluster or conservation area. For example, the management plan for the Lake Bardawil conservation area must be very different from the management plan for the St. Catherine conservation area, because the resources and the current and potential land users are very different.

Part of each management plan is enforcement. In Sinai control of water supplies will be a very effective enforcement tool. Linking decisions to drill wells or lay pipelines to compliance with the management plan for the area can control the activities of most land users. There may be greater difficulties in controlling small-scale activities which are less dependent on major water works, but the major land use conflicts will arise from large-scale land users who depend on imported Nile water or on pumping from expensive deep wells. In this arid region control of water means control of land use. Control of water is a separate management topic taken up in Volume V.

Another part of each management plan is personnel. The lack of trained personnel for administering conservation and preservation areas is a particular problem. The Egyptian Wildlife Service may be the best source for such administrators. With assistance from the U.S. Fish and Wildlife Service, the Egyptian Wildlife

Service was established in 1979 to provide a corps of resource management professionals. More recently, there have been proposals for funding to train such professionals for Sinai reserves, under the auspices of the U.S. Fish and Wildlife Service and/or other U.S. and international agencies. The most workable arrangement for deploying these professionals may be to second them from the Wildlife Service (part of the Ministry of Agriculture) to the individual governorates. Effectively, each governorate would have its own staff to mediate the dedication of reserves and the development of management plans by the consultative process recommended above. The resource management professionals could then assume responsibility for administration of the management plans for the governorate's reserves.

5.5 MONITORING THE ENVIRONMENT

Environmental monitoring can be discussed on at least two levels. The first is the technical level of detecting changes in particular features of the environment, such as water quality, air quality, soil degradation, groundwater depths, migratory bird populations, number and movements of an endangered species of animal, and the density and composition of natural vegetation. The second is the administrative level of monitoring enforcement of environmental and land use regulations and compliance by local land users.

A good rule of thumb is to keep separate the role of administering plans and regulations and the role of monitoring. The same people should not be trying to do both jobs, lest there be a conflict of interest. While the administrator is a servant of the government, the monitor should be an adviser to decision-makers. A good precedent was set by the Governor of North Sinai when he established the 'Office of Conservation' with a director; however, the roles of administrator and monitor may be mixed in this office. It would be best to designate an environmental monitor who would have primary responsibility for measuring both environmental change and the effectiveness of enforcement efforts. The monitor should have direct access to the Governor to report important findings. A contract relationship with a university to carry out some of the technical monitoring might also be a practical approach.

The work of environmental monitoring would be made more effective by the voluntary activities of concerned citizen groups. At present there is only a small constituency for environmental protection in Egypt; however, new groups such as the Ornithological Society of Egypt may eventually play an important watchdog role in monitoring, supporting the official monitors, and making direct proposals to the appropriate authorities. Effective monitoring of Sinai's environment requires that a diversity of interests be represented, perhaps through the collaborative interaction of government officers, university personnel, and citizen groups.

APPENDIX A

RECONNAISSANCE SOIL CAPABILITY ASSESSMENT FOR IRRIGATED AGRICULTURE ON THE SINAI PENINSULA

A.1 INTRODUCTION

The first objective is to describe the process of soil capability assessment carried out for the Sinai Development Study, Phase I (SDS-I). A step-by-step description is given to show how the interpretation presented in Volume IV was derived. Following the procedure, interested agencies or individuals can reinterpret existing soil information using alternative criteria of capability. They can also incorporate new information into the assessment and derive more accurate maps and recommendations.

The second objective is to caution the reader of Volume IV about the limitations of the data base and assumptions from which soil interpretations were made. These problems point to needs for field work in particular areas. The maps of Volume IV illustrate the distribution of soil characteristics but do not pretend to indicate exact locations or sites.

A.2 PROCEDURES USED IN SOIL CAPABILITY ASSESSMENT

A.2.1 Step One: Delineation of Land Resource Units: The assessment began with a division of the Sinai Peninsula into map units that represent distinctive landscapes. The components of a landscape need not be similar to each other in their physical and biological characteristics, but together they form a distinctive ensemble. Providing a commonplace example: the paths, yards, and houses of a village represent very different resources, but in combination they are a single, distinctive landscape easily recognized as "village." To inventory these landscape components separately would miss the characteristic village pattern. In the same way, an alluvial plain covered in patches by wind-blown sand and dissected here and there by wadis forms a recognizable landscape composed of different but interrelated landforms. The distinctive landscapes of Sinai are called "Land Resource Units," (LRUs). Each is composed of different landforms and their associated soils.

The delineation of the LRUs (Fig. 3.1) was based on interpretation of Landsat imagery (scale 1:250,000) of Sinai, aided by various written reports of field work, especially by the Desert Institute (1981).

A.2.2 Step Two: Field Data for Land Resource Units. Soil data from scattered sample points were used to describe the map units (LRUs) delineated in Step One. The reports of the Desert Institute (1981), General Organization for Groundwater (REGWA) (1981), and Enterprise for Applied Geophysics (1963) surveys provided detailed soil data for sample points in selected areas

of Sinai. These sample points were located in reference to the LRUs and their component landforms. An important assumption is made in this step: that the data for the sample points located within a LRU be extrapolated to the whole of the land resource unit, even those parts for which there is no direct field data.

A.2.3 Step Three: Data Reduction. From the data in the three reports, cited above, a representative soil profile was selected for each landform in the LRU. This profile may be an actual profile recorded in the field, or it may be a composite of several profiles. Selection of a "representative" profile is a process of informed, experienced judgment: the more profiles available for study for a particular landform, the more confidence there may be in the judgement.

A.2.4 Step Four: Data Presentation. The data from these representative profiles and the calculations and interpretations made from the data are presented in LRU Data Tables which are in the SDS-I files. The data are listed by the standard categories used in soil surveys, with a focus on properties relevant to irrigated agriculture in arid areas. The description and significance of these properties for irrigated agriculture in Sinai are presented in Appendix B.

A.2.5 Step Five: Agricultural Capability Assessment. The data which are relevant to agriculture are summarized in Table A-1 at the end of this appendix. This table forms the basis of the agricultural soil capability assessment. Limitations for irrigated agriculture are used as the criteria for capability. Certain critical limitations are effectively impossible to overcome. Others can be overcome with large investments in unusual and difficult reclamation techniques. A third class of limitations can be dealt with effectively by relatively familiar and less costly reclamation and management practices. The three classes of limitation are listed in Table A-2 (at the end of this appendix). Soils subject to the first and second classes of limitation are regarded initially as inappropriate to recommend for irrigated agriculture. Soils subject to the third class of limitation are scored for the number of such limitations present. Each limitation is given a score of 1. Erodibility of soil was not considered as one of the scored limitations, because susceptibility to wind and water erosion problems is widespread among the Sinai soils and therefore not useful for ranking their relative capabilities.

Soils subject to five or more of the third class limitations are (somewhat arbitrarily) considered as marginal for irrigated agriculture. Soils with less than five limitations, therefore, are considered candidates for irrigated agriculture (Table A-3 at the end of this appendix).

A.2.6 Step Six: Mapping Candidate Areas. At this reconnaissance level of capability assessment, it is not possible to map precisely the locations of sites of the candidate soils. However, they are associated with particular landforms in certain Land Resource Units. For each LRU, the percentage of the unit occupied by the particular landforms has been estimated as part of Step One. Areas of the LRUs are obtained from the map by use of a planimeter. Areas of the component landforms (and their associated soils) were obtained by calculating with the appropriate percentages. These areas are listed in Table A-3.

Candidate areas for irrigated agriculture are mapped in Figure 3.4, which shows those LRUs which contain candidate soils. Candidate areas with only one third-class limitation (see Table A-2) are distinguished from those with two-to-four limitations; Land Resource Units are scored in terms of the component soil with the least limitations, so a Unit with "one limitation" may have other components with three or even six limitations. Areas outside those Units are excluded from further consideration at this time. Figures 3.5 and 3.6 show areas the Consultant has proposed for development as part of the Recommended Strategy.

A.2.7 Cautionary Notes.

Note One: Use of Reconnaissance Surveys. The user of reconnaissance soil survey results can not draw definitive conclusions from the sparse data base. The reconnaissance map indicates the general distribution of soil characteristics rather than specific locations and qualities. Delineation of candidate areas for agriculture is meant to show where more detailed field investigations should be carried out. The candidate areas are general locations within which usable soils are most likely to be found. Non-candidate areas may also have small parcels of usable soil -- perhaps even some very good soil -- but usable soils are much less likely to be found there than in the candidate areas. In short, the reconnaissance survey is primarily a guide to further work.

Note Two: Estimates of Feddans of Usable Soil. Table A-3 gives areas in feddans of the candidate areas for irrigated crop cultivation. These figures represent very rough estimations which depend on the accuracy of the boundaries of the LRUs as they were mapped. They also depend on the accuracy of the estimates of the percentage of each LRU which is occupied by each of the component landforms. At this reconnaissance stage, both the LRU boundaries and the percentage estimates for the component landforms are subject to major errors due to the lack of field data. Therefore, the feddan estimates should be used very cautiously. A suitable rule of thumb would be to assume that at most 50 percent of the feddan estimate is actually usable soil and that at most 60 percent of the actually usable soil can ever be irrigated due to factors such as scattered

distribution of usable soil. In other words, 30 percent of each feddan figure is probably the largest area of irrigated crop cultivation that can be developed within the component landform of the candidate area.* The area required for infrastructure such as houses, roads, footpaths, windbreaks, pipes or canals, has also been subtracted.

Note Three: Assumptions in Each of the Steps of the Assessment. At every step of the soil capability assessment, there was at least one critical assumption or judgement made by the analyst. A different analyst might make different assumptions or judgements. These assumptions or judgements are made explicit in the previous description of procedures so that the user of the capability assessment can be fully informed of the analyst's choices. If the user wishes to make different choices, the description of procedures should be sufficiently detailed to allow another analyst to perform the assessment again using alternative assumptions and judgements.

In Step One, the delineation of LRU boundaries is a matter of analyst judgement, based on field experience, evaluation of written reports, and aerial or space imagery. Most of the boundaries probably would not be moved more than a few kilometers by another analyst.

In Step Two, it is assumed that the data from the few sample points can be extrapolated to the whole LRU. However, there are many LRUs, especially those which are broken into two or more discontinuous parts, for which this assumption may not hold true. When there are large parts or sections of an LRU without a single sample point, there is less confidence in the validity of the assumption.

In Step Three, a representative soil profile is selected for each landform component of each LRU. The analyst must use informed judgement in making this selection. Another analyst may disagree with the choice.

In Step Four, data presentation focuses explicitly on properties relevant to irrigated agriculture in arid areas, which is broadly construed as including all forms of irrigation with water from any source (Nile water, groundwater, or runoff water which may be delivered by flood, sprinkler, drip or other irrigation systems).

*The most notable exceptions to this "rule of thumb" are the Lower Wadi El Arish (LRU G) and the El Qaa Plain (LRU N). In both these locations the Consultant feels confident that more than 30 percent of the area will be found to have soils suitable for irrigation and has therefore included a larger feddanage when listing "candidate areas" (for example, in Table 3-9). In short, the 30 percent "rule" is to be applied flexibly; it offers a first approximation which must be modified to take into account actual field conditions as soon as the results of more detailed studies make it possible to do so.

In Step Five, evaluations of the limitations for agriculture (Table A-2) constitute judgements about the "practicality" of remedial action. Soils subject to second class limitations were ruled out for further consideration on the assumption that remedies were (if not known in Egypt) either technically unlikely to work or too expensive to carry out, or both, prior to year 2000. However, practical remedies may be found. Dune stabilization in Land Resource Unit 'J' and poldering in LRU 'I' are good examples of remedial actions for serious limitations that might be implemented effectively, albeit at considerable expense.

Also in Step Five, all the third class limitations of Table A-2 are given equal weight in scoring the number of limitations and using these scores to compare the capability of different soils. This is appropriate at the reconnaissance level. However, more sophisticated assessment based on more detailed information and more specific soil management objectives would give different weights to the different limitations. Furthermore, the distinction between candidate soils and marginal soils on the basis of a cutoff at <u>four</u> limitations, regardless of which limitations are involved, is also appropriate only to the reconnaissance level of capability assessment. These are assumptions that can easily be changed in later assessments with more and better data.

In Step Six, the estimation of areas of different soils in Table A-3 is based on assumptions about the homogeneity of the LRUs, the accuracy of the landform percentages, and the association of soils with landforms. See Note Two above (page A-3).

<u>Note Four: Being Too Cautious</u>. Planning cannot wait until a completely adequate data base is assembled. In fact, one role of planning is to decide which data are worth collecting and assembling in order to support further planning and development implementation. Therefore, the user of this reconnaissance soil capability assessment of the Sinai Peninsula should not be discouraged by the drawbacks of the data base or the frequent use of judgement and assumption in the assessment procedures. Awareness of drawbacks and conflicting opinions of the judgements and assumptions in the assessment help the user make better use of the assessment without drawing unsupported conclusions.

Table A-1. Land Resource Units of the Sinai Peninsula - Landforms and Soil Characteristics

LRU	Component Landforms	Slope	Texture	Salinity	$CaCO_3$	Sodium	Gypsum	Special Problems
A	floodplain (80%)	0-2	medium	high	high	--	trace	wind erosion
	active wadi beds (20%)	0-2	medium	low	high	--	trace	wadi flooding
B	alluvial plain (35%)	0-8	coarse	high	high	high	nil	shallow to bedrock
	alluvial plain (eroded) (25%)	8-30	coarse	high	high	high	low	shallow to bedrock
	small swales and wadis (20%)	0-8	coarse	high	high	--	low	shallow to hardpan and flooding
	rock outcrop (20%)	15-80	bedrock	--	--	--	--	rock outcrop
C	alluvial plain (40%)	0-8	coarse	high	low	low	nil	shallow to bedrock
	sand sheet (40%)	0-2	coarse	low	low	low	nil	wind erosion
	active wadi beds (20%)	0-8	medium	low	low	low	trace	wadi flooding
D	alluvial sand deposits (40%)	0-8	medium	low	high	--	--	wind erosion
	sand dunes (30%)	2-15	coarse	low	low	--	--	mobile dunes
	alluvial plain (15%)	0-8	medium	high	high	--	--	shallow to bedrock
	active wadi beds (15%)	0-8	medium	low	high	--	--	floods/surface stones
E	rock outcrop (70%)	8-25	bedrock	--	--	--	--	rock outcrop
	residual soil (20%)	0-25	medium	high	high	high	--	shallow to bedrock
	small swales and wadis (10%)	0-8	coarse	high	high	--	--	shallow to bedrock
F	rock outcrop (90%)	>15	bedrock	--	--	--	--	rock outcrop
	aeolian sand (10%)	8-25	coarse	low	low	low	nil	shallow to bedrock
G	aeolian sand sheet and dunes (40%)	0-8	coarse	low	low	low	nil	mobile dunes
	alluvial soil on lower terraces (40%)	0-8	medium	high	low	--	--	erodible soil (but good drainage)
	alluvial soil on higher terraces (20%)	0-2	medium	high	low	--	--	extremely saline soil

Table A-1. (continued)

LRU	Component Landforms	Slope	Texture	Salinity	$CaCO_3$	Sodium	Gypsum	Special Problems
H	aeolian sand sheet (30%)	0-8	coarse	low	low	low	nil	wind erosion
	mobile sand dunes (30%)	8-30	coarse	low	low	low	nil	mobile dunes
	coastal beach and wet sabkha (25%)	0-2	coarse	high	low	--	low	shallow to saline water table
	sandy dry sabkha (10%)	0-2	coarse	high	low	--	high	shallow to saline water table
	lagoonal sediments (5%)	0-8	medium	high	low	--	--	extremely saline soil
I	deltaic and lacustrine deposits (very poorly drained (40%)	0-2	medium	high	low	--	--	very shallow to saline water table, tidal and seasonal flooding
	deltaic and lacustrine deposits (poorly drained) (30%)	0-2	medium	high	low	--	--	very shallow to saline water table
	wet sandy sabkha (20%)	0-2	coarse	high	low	--	low	shallow to saline water table
	dry sandy sabkha (10%)	0-2	coarse	high	low	--	high	shallow to saline water table
J	mobile dune and inter-dune sand (100%)	8-30	coarse	low	low	low	nil	mobile dunes
K	alluvial plains (50%)	8-30	coarse	high	high	high	low	gravel and surface stones
	active wadi beds (40%)	0-8	medium	high	high	low	low	shallow to water table & flooding
	wet sabkha on wadi deltas (10%)	0-2	medium	high	high	low	nil	shallow to water table & flooding
L	alluvial plains and active wadi beds (60%)	0-8	coarse	low	low	high	nil	surface stones and flooding
	coastal plain (40%)	0-2	coarse	high	low	high	nil	gravel and surface stones
M	mountain front alluvial fans (50%)	0-25	coarse	low	low	high	nil	gravel and surface stones
	alluvial plains (30%)	0-8	coarse	high	low	high	nil	gravel and surface stones
	active wadi beds (15%)	0-8	coarse	low	low	high	nil	gravel, surface stones & flooding
	coastal strip (5%)	0-2	coarse	high	low	high	nil	gravel and surface stones

Table A-1. (continued)

LRU	Component Landforms	Slope	Texture	Salinity	$CaCO_3$	Sodium	Gypsum	Special Problems
N	alluvial plain (45%)	0-2	coarse	high	low	high	low	gravel
	playa (45%)	0-2	medium	high	low	high	low	shallow to hardpan & erodible
	active wadi beds (10%)	0-2	coarse	high	low	high	nil	flooding
O	active wadi beds (90%)	0-8	coarse	low	low	high	nil	gravel, surface stones & flooding
	terraces (10%)	0-8	medium	high	low	low	nil	hardpan at 150-300 cm depth
P	rock outcrop (98%)	>8	bedrock	--	--	--	--	rock outcrop
	active wadi beds (2%)	0-30	coarse	low	low	high	nil	gravel, surface stones & flooding

Table A-2. Limitations for Crop Cultivation Under Irrigation

First Class Soil Limitations: (Nearly impossible to remedy)	--	Exposed bedrock
	--	Shallow depth (less than 1 meter) to bedrock
Second Class Soil Limitations: (Impractical or Costly to remedy)	--	Mobile dunes
	--	Shallow depth (less than 1 meter) to good quality water table
	--	Shallow depth (less than 3 meters) to saline water table
	--	Extremely saline soil (greater than 100 mmhos/cm)
Third Class Soil Limitations: (Manageable with standard techniques)	--	Slope (8-30%)
	--	Gravel (more than 20% through profile)
	--	Surface stones, including boulders (covering more than 10% of soil surface)
	--	Hardpan (less than 3 meters below surface)
	--	Flooding likely following rain
	--	Coarse texture (rapid permeability throughout profile)
	--	High salinity (10 mmhos/cm or greater)
	--	High calcium carbonate (30% or greater)
	--	High exchangeable sodium (20% or greater)

NOTES: 1. For greater detail about limitations and possible remedies, see Appendix 2.

2. El Tina Plain is recommended for reclamation despite second class soil limitations because of ready access to Nile water, good highway access, and techniques, well established in Egypt, for overcoming those specific limitations.

Table A-3. Areas of Land Resource Units and Their Landforms

Land Resource Unit	Component Landforms	Approximate Area (000 feddans)	Candidate for Irrigation
A	floodplain (80%)	462	yes
	active wadi beds (20%)	117	yes
B	alluvial plain (35%)	984	no
	alluvial plain (eroded) (25%)	703	no
	small swales and wadis (20%)	563	marginal
	rock outcrop (20%)	563	no
C	alluvial plain (40%)	699	no
	sand sheet (40%)	699	yes
	active wadi beds (20%)	349	yes
D	alluvial sand deposits (40%)	198	yes
	sand dunes (30%)	149	no
	alluvial plain (15%)	74	no
	active wadi beds (15%)	74	yes
E	rock outcrop (70%)	2,270	no
	residual soil (20%)	649	no
	small swales and wadis (10%)	324	no
F	rock outcrop (90%)	442	no
	aeolian sand (10%)	49	no
G	aeolian sand sheet and dunes (40%)	14	no
	alluvial soil on lower terraces (40%)	14	yes
	alluvial soil on higher terraces (20%)	7	no
H	aeolian sand sheet (30%)	220	yes
	mobile sand dunes (30%)	220	no
	coastal beach and wet sabkha (25%)	183	no
	sandy dry sabkha (10%)	73	no
	lagoonal sediments (5%)	37	no
I	deltaic and lacustrine deposits (very poorly drained) (40%)	55	yes*
	deltaic and lacustrine deposits (poorly drained) (30%)	41	yes*
	wet sandy sabkha (20%)	28	no
	dry sandy sabkha (10%)	14	no

* See Table A-2, note 2.

Table A-3. (continued)

Land Resource Unit	Component Landforms	Approximate Area (000 feddans)	Candidate for Irrigation
J	mobile dune and interdune sand (100%)	1,485	no
K	alluvial plains (50%)	185	marginal
	active wadi beds (40%)	148	no
	wet sabkha on wadi deltas (10%)	37	no
L	alluvial plains and active wadi beds (60%)	51	yes
	coastal plain (40%)	34	marginal
M	mountain front alluvial fans (50%)	268	marginal
	alluvial plains (30%)	161	marginal
	active wadi beds (15%)	81	marginal
	coastal strip (5%)	27	marginal
N	alluvial plain (45%)	23	yes
	playa (45%)	23	yes
	active wadi beds (10%)	5	yes
O	active wadi beds (90%)	120	marginal
	terraces (10%)	13	yes
P	rock outcrop (98%)	1,926	no
	active wadi bed (2%)	39	marginal

LITERATURE CITED

Bower, C.A. 1959. Chemical Amendments for Improving Sodium Soils. Agriculture Information Bulletin 195, U.S. Department of Agriculture, 9 p.

Desert Institute, 1981. Agriculture and Water Investigations of Sinai. Final Contract Report to Dames & Moore from the Desert Institute, Cairo.
List of Volumes:

I	Geology		
II	Hydrogeology	A:	Text and Chemical Data
		B:	Information Sheets
III	Soils	A:	El Arish
		B:	El Bardawil & El Bruk
		C:	El Gifgafa & El Giddi
		D:	Nakhl & Sudr
		E:	El Qaa, Feiran & East of Suez Canal
IV	Ecology		
V	Plant Production		
VI	Animal Production		

Enterprise for Applied Geophysics. 1963. Report on Investigation of Water and Soil Resources in the North and Central Part of Sinai Peninsula. Geofizika. Enterprise for Applied Geophysics, Zagreb, Yugoslavia; Contract report to the General Development Organization, Cairo.

Food and Agriculture Organization of the United Nations. 1973. Sandy Soils. Soils Bulletin 31. FAO, Rome.

____. 1979. Soil Survey Investigations for Irrigation. Soils Bulletin 42. FAO, Rome.

Lunt, O.R. 1963. Sensitivity of Plants to Exchangeable Sodium Percentage. (Compiled from literature), University of California Report No. 5, Agricultural Water Quality Research Conference, Appendix B.

REGWA. 1981. Reconnaissance Soil Survey of North Sinai. Ministry of Development and State for Housing and Land Reclamation, Cairo.

Richards, L.A. et al. 1954. Diagnosis and Improvement of Saline and Alkali Soils. Agriculture Handbook 60, U.S. Salinity Laboratory, U.S. Department of Agriculture, Riverside, California.

USDA - Soil Conservation Service. 1978 Predicting Rainfall Erosion Losses. Agriculture Handbook No. 537. USDA-SCS, Washington, D.C.

____. 1982. Aids for Estimating Soil Properties Significant to Interpreting Land Use. Arizona. USDA-SCS. Phoenix.

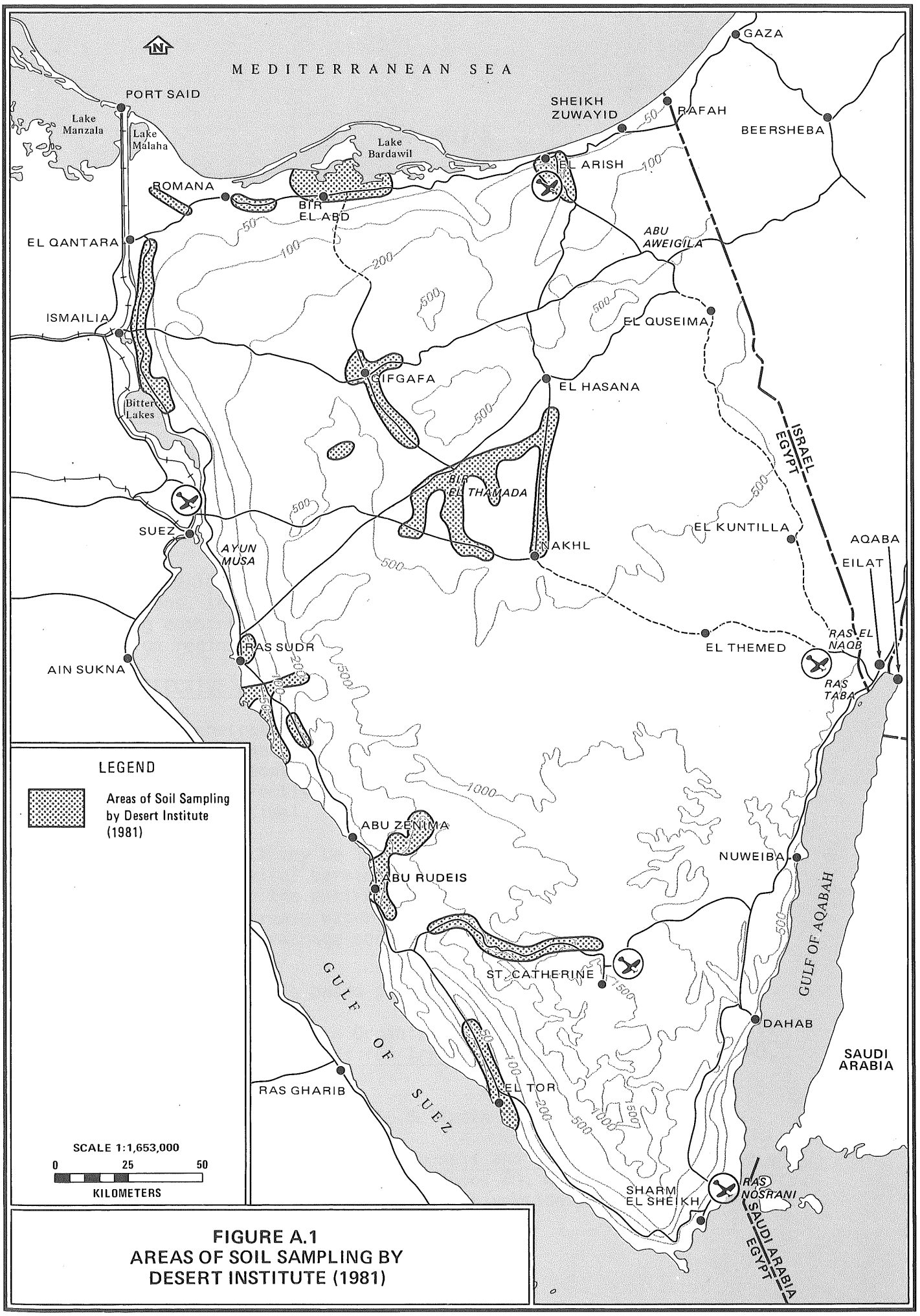


FIGURE A.1
AREAS OF SOIL SAMPLING BY DESERT INSTITUTE (1981)

APPENDIX B

SOIL PROPERTIES RELEVANT TO IRRIGATED AGRICULTURE IN SINAI[1/]

B.1 SLOPE

The degree of slope influences irrigation, infiltration, and runoff characteristics. While irrigation is practical on steeper slopes, 8 percent was selected as the maximum acceptable slope without downgrading capability. A guide for selecting irrigation method in relation to slope is included in Appendix C.

B.2 WATER TABLE

Good quality water should not percolate more than about 90 centimeters below the surface in any 24-hour period after irrigation has begun. Pre-irrigation water tables must be lower than 90 centimeters. Saline water tables should never be higher than 3 meters below the surface.

Where it is necessary to utilize soils with perched groundwater conditions, they may be drained using tile drains. Shallow well pumping combined with water removal from the area can be utilized for high regional water tables; this is highly efficient.

B.3 EFFECTIVE ROOTING DEPTH

Root penetration is inhibited by physical factors such as bedrock, cemented pans, or poor drainage. Chemical factors such as high calcium carbonate and gypsum concentrations also limit root penetration. Effective rooting depth greater than 90 centimeters is considered optimal.

Rooting depth may be increased by deep plowing in the case of physical and chemical barriers. Care must be taken not to destroy the usefulness of the entire profile. Drainage procedures may be undertaken to decrease water table levels and thus increase rooting depth under poor drainage conditions.

1/ This appendix is based primarily on the following sources:

Food and Agriculture Organization of the United Nations, Soil Survey Investigations for Irrigation, Soils Bulletin 42, FAO, Rome, 1979.

_____, Sandy Soils, Soils Bulletin 31, FAO, Rome, 1973.

L.A. Richards, et. al., Diagnosis and Improvement of Saline and Alkali Soils, Agriculture Handbook 60, U.S. Salinity Laboratory, U.S. Department of Agriculture, Riverside California, 1954.

B.4 PARTICLE SIZE DISTRIBUTION

Texture influences infiltration, moisture and nutrient retention, and susceptibility to erosion. Its effect on these qualities may be modified by soil structure, nature of the clay minerals, organic matter, and calcium carbonate content. Soils of all textural classes, except perhaps coarse sand, are irrigable by an appropriate method. In Sinai, fine textured soils tend to be high in soluble salts, and coarse textured soils are subject to rapid permeability and low water-holding capacity; thus, medium textured soils were favored in the capability system. High salt concentrations in fine textured soils may be controlled by careful leaching (see Salinity, Section B.8 below). Coarse textured soils are common among the more useful soils of Sinai. Their low water and nutrient holding capacity can be increased by incorporation of organic matter or synthetic soil amendments (see FAO, 1973, for a complete discussion of reclamation procedures for sandy soils). Frequent, low-quantity irrigation such as drip irrigation should be utilized.

High gravel content (greater than 20 percent) decreases water and nutrient holding capacity and should be treated with the same procedures as coarse textured soils. High gravel content is a major limitation to highly mechanized agriculture because of gravel abrasion to farm machinery. It is of smaller concern to less industrialized agriculture.

Surface stones and gravel may be an indication of comparable levels below the surface. Where they are due to concentration by wind erosion, they indicate an old soil which may have expandable clays and the high salt contents associated with them. In other words, high levels of surface stones and gravel indicate that a close investigation should be made of other soil features before decisions are made about its capability.

B.5 PERMEABILITY

The permeability of a soil profile is used to determine subsurface drainage and to evaluate the possibility of perched water table conditions developing, which may injure crop roots. Soil morphological features that influence or reflect permeability include texture, structure and structure stability, color and mottling, visible pores and depth to impermeable strata such as bedrock and hardpan. A moderately rapid permeability allows the greatest flexibility for water and salinity management.

Rapid permeability may be controlled using organic or artificial soil amendments. If slow permeability is due to impermeable strata which are not greater than about 30 centimeters, the strata can be 'ripped' using deep plowing techniques. Occasional deep plowing should be incorporated in a farm management plan. If slow permeability is due to high sodium content (see ESP, Section B.7 below)

extreme care must be taken in reclamation of these soils. Procedures described in the salinity section, below, should be followed for reclamation.

B.6 AVAILABLE WATER CAPACITY

Readily available water is that portion of the water in the soil that can be readily absorbed by plant roots (about 50-75 percent of the total available moisture). The 'total available moisture' is usually defined as the difference between the soil moisture contents at 'field capacity' and 'wilting point.' The capacity of a soil to retain water available to plants has a direct bearing on required depth and frequency of irrigation and is important, therefore, in judging the suitability of a soil for irrigation.

The importance of available water capacity cannot be overstated. Coarse soils having low clay content have low available water capacity. This can be increased by addition of organic matter and artificial soil amendments (see FAO, 1973). Soils with high levels of finely divided calcium carbonate have low available water capacity which should be treated with the same procedures.

B.7 EXCHANGEABLE SODIUM PERCENTAGE (ESP)

The exchangeable sodium percentage is the degree of saturation of the soil exchange complex with sodium. ESP is usually a good indication of the structural stability of a soil and of its physical response to irrigation water. Most soils containing expanding type clay minerals exhibit unfavorable physical properties at ESP greater than 15 percent (described as moderate in this text). In general, physical properties become increasingly unfavorable with increasing ESP. Expanding 2:1 clay minerals are more strongly affected than non-expanding clays. In sandy soil, sodium-induced clay dispersion may favorably increase water-holding capacity.

In addition to possible deleterious effects that ESP levels may have on physical properties of a soil, some crops have a low tolerance for exchangeable sodium. A table showing tolerance of various crops to ESP is presented in Appendix C.

Reclamation of soils with high ESP (alkali soils) is discussed at the end of the salinity section below. Where soils have both high ESP and high levels of finely divided calcium carbonate or gypsum, danger of dispersion is less than in those lacking these minerals.

B.8 SALINITY

An excess of soluble salts is probably the most widespread soil quality adverse to crop growth in arid areas when irrigated. It is fortunate that, owing to their solubility, such salts are mobile and can be removed by leaching where drainage conditions are satisfactory.

The primary deleterious effect of excessive salinity is to raise the concentration of the soil solution. The flow of water into the plant by osmosis is reduced or reversed and the plant is starved of water even though the soil is moist. Some ions, particularly sodium, chloride and sulfate, have specific toxicity for certain crops. The variation among plants in their tolerance to salinity (Appendix C) affects the choice of cropping pattern when evaluating the possible effects of salinity.

Inadequate drainage and a rising water table after a few years of irrigation may lead to the entry of saline water into the root zone. The salinity level and sodic conditions at the time of sampling are not stable characteristics of the soil, and both can be changed with irrigation, salinity being the easiest and cheapest to correct. Important considerations in the evaluation of saline or sodic (alkali) soils include:

- quality of water to be used for irrigation,
- infiltration and permeability rates of the soil,
- leveling required to provide a suitable surface for leaching,
- ability of substrata to transmit the necessary leaching water,
- the level of salinity or sodic conditions, and
- availability or absence of gypsum to replace sodium in sodic soils.

The U.S. Department of Agriculture has developed a classification system for salt affected soils and has described methods of reclamation for each class. This material is summarized below.

B.8.1 Saline Soils

The electrical conductivity (EC) of the saturation extract is in excess of 4 mmhos/cm, ESP is less than 15, and pH values are less than 8.5. Chloride and sulfate are the principal soluble anions, bicarbonate content is relatively low, and carbonate is absent. Soluble sodium content may exceed those of calcium plus magnesium. Gypsum and calcium and magnesium carbonates are common constituents of saline soils. Salinity levels are sufficiently high to adversely affect growth of most plants.

Reclamation of these soils requires leaching with good quality irrigation water. It must pass through the root zone and be carried away either by deep percolation or tile drainage systems. Salinity levels are reduced to one-fifth of their original value by the

passage of a unit depth of water per unit depth of soil. For example, to reduce the average salinity in the top 60 centimeters of soil to one-fifth its original value would require passage of about 60 centimeters of water through the soil. Reduction of salt content to 10 percent of its original value would require about twice as much water.

It is sometimes impossible to leach all the soluble salts: for example, if drainage facilities are not adequate or if the amount of water required for complete leaching is not available. In other cases irrigation water contains soluble salts as well. In these instances, soils can be cropped with some loss in production by adopting special management practices. These include: (a) selection of salt-tolerant crops, (b) use of special planting procedures, such as sloping bed configurations, to minimize salt buildup in the immediate vicinity of plant roots, and (c) more frequent irrigating.

B.8.2 Nonsaline-Alkali Soils

ESP of these soils exceeds 15, but the soluble salt contents are low. Usually the pH values are greater than 8.5, but they may be lower if the ESP does not greatly exceed 15 or if calcium and magnesium carbonates are absent. Gypsum seldom occurs in these soils. Sodium is the dominant soluble cation and appreciable amounts may be present as the bicarbonate and carbonate salts.

Reclamation of these soils requires the removal of most of the exchangeable sodium and its replacement by calcium. A common procedure is application of gypsum followed by leaching to remove the salts, mostly sodium sulfate, derived from the reaction of gypsum with the sodium. Soils containing moderate-to-large amounts of finely divided calcium chloride or iron pyrites can release calcium or magnesium to replace sodium.

B.8.3 Saline-Alkali Soils

Soils of this class are characterized by high soluble salts and high exchangeable sodium. The EC of the saturation extract is greater than 4 mmhos/cm, and the ESP exceeds 15. The pH reading may vary considerably but is commonly less than 8.5. The soluble salt composition is similar to that of saline soils, except that sodium makes up a greater percentage of soluble cations.

Both replacement of soluble sodium and leaching of soluble salts are required to reclaim these soils. Sodium should be removed first, followed by leaching of the soluble salts. This will insure against rapidly increasing pH values and possible clay dispersion.

B.9 CALCIUM CARBONATE

Calcium carbonate commonly accumulates in soils developed under arid and semiarid climates. It is especially prevalent in the soils formed on alluvium from the calcareous dome mountains in the north, El Igma and El Tih Plateaus in central Sinai, and the Umm Bugma formation in the southwest.

The accumulations may be diffused throughout the soil profile, or may take the form of soft concretions, or nodules, or may be concentrated in a continuous horizon of varying hardness and at varying depths below the surface. The amount of carbonate present, the form of its distribution in the profile, and the depth to the carbonate-rich horizons are all important factors in judging the suitability of a calcareous soil for irrigated agriculture.

The presence of calcium carbonate affects both the physical and chemical characteristics of a soil. Continuous horizons of carbonate accumulations may not restrict water movement severely, but may prevent root penetration. The presence of carbonates reduces the ability of calcareous soils to retain moisture, especially at high concentrations.

Up to 10 or 15 percent calcium carbonate (designated as low in this text) may assist formation of stable aggregates associated with relatively large pores and rapid water movement. With an increased carbonate content to 20 or 25 percent (moderate in this text), precipitation of carbonate within the plant capillary tubes tends to increase the proportion of very small pores and reduce diffusivity.

Surface crusting can be a serious problem in newly irrigated calcareous soils, especially those of low organic matter content. Crusts not only affect infiltration and soil aeration, but also impede or prevent the emergence of seedlings. Heavy applications of water on soils with a high content of fine-grained carbonate encourages the formation of thick crusts upon drying. Soils which have a tendency to crust will therefore require a frequency of irrigation sufficient to prevent drying and hardening of the surface.

The physical characteristics of calcareous soils often change when they are irrigated. From a favorable virgin condition the soils become more coherent and resistant to root penetration, especially in the part of the profile subjected to wetting and drying. The effect is likely to be more marked if the organic matter content of the soil is low. Careful timing of tillage operations and careful seedbed preparation may be needed. The optimum moisture range for plowing calcareous soils is very narrow and occurs within four to five days after irrigation, whereas seven to eight days after irrigation the plowing operation is often rather difficult.

Nutrient deficiencies of phosphorus, iron, and micronutrients are common in plants grown on calcareous soils. High calcium carbonate content usually results in a need for larger inputs of fertilizers and is a dilutant factor for roots seeking nutrition. Accordingly, a highly calcareous soil can be expected to be less productive than slightly calcareous soils if all other factors are equal.

In summary, the primary effects of high levels of finely divided calcium carbonate are the following:

- nutrient deficiencies caused by chemical precipitation of phosphorus, iron, and some zinc,
- low nutrient and water holding capacities,
- susceptibility to pan formation, and
- surficial crusting.

Control of nutrient deficiencies requires foliar applications of iron and zinc and fertilization with phosphoric acid or other acid phosphate compounds. Substantial amounts of magnesium carbonate in the soil may lessen precipitation of iron and zinc. Research should be conducted to find desert adapted crops which have physiological mechanisms for nutrient extraction from these soils.

Low water and nutrient holding capacities require greater frequency of fertilization and irrigation. Incorporation of organic matter is the most effective procedure for counteracting these problems.

Pan formation can be controlled by varying leaching depths and using occasional deep leachings. Deep plowing to break up incipient pans is also recommended. If soils have calcium carbonate segregated into thick pans (less than 30 centimeters thick), they can be ripped by deep plowing. However, it is seldom cost effective to reclaim these soils for agriculture.

Surface crusting may be controlled by addition of organic matter or substitutes and frequent irrigation.

B.10 GYPSUM

Soils containing gypsum are widespread in arid and semiarid areas. A small amount of gypsum is favorable to crop growth in that it serves as a relatively soluble source of calcium to replace sodium in the exchange complex and thus acts to preserve soil structure. Sodic soils containing gypsum are relatively easy and inexpensive to reclaim. High percentages of gypsum in the soil, however, can cause serious problems, especially in irrigated

agriculture. The content of gypsum must be regarded as an important criterion in judging the suitability of soils for irrigation.

If gypsum levels are high (greater than 4 percent), they may be reduced by deep plowing and large applications of irrigation water. As with calcium carbonate there is danger of pan formation by continued irrigation to the same specific depth. Varying irrigation depths and incorporating deep leaching is the best way to counteract this problem.

APPENDIX C

LAND CAPABILITY INTERPRETATION AIDS

Table C-1: TOLERANCE OF VARIOUS CROPS TO ESP

Tolerance to ESP and range at which affected	Crop	Growth responses under field conditions
Extremely sensitive (ESP = 2 - 10)	Deciduous fruit, nuts avocado, cassava	Sodium toxicity symptoms even at low ESP values
Sensitive (ESP = 10 - 20)	Green beans	Stunted growth at low ESP values even though the physical condition of the soil may be good
Moderately tolerant (ESP = 20 - 40)	Clover, oats, tall fescue, most rice, dallis grass	Stunted growth due to both nutritional factors and adverse soil conditions
Tolerant (ESP = 40 - 60)	Wheat, cotton, alfalfa, barley, tomatoes, beet-root, some rice	Stunted growth usually due to adverse physical conditions of soil
Most tolerant (ESP more than 60)	Crested and fairway wheatgrass, tall wheat-grass, rhodes grass	Stunted growth usually due to adverse physical conditions of soil

Source: FAO (1979) from Bower (1959).

Table C-2: INFLUENCE OF ESP ON CROP REDUCTION

50% Crop reduction at ESP of 15 or less	50% Crop reduction at ESP of 15-25	50% Crop reduction at ESP 35
(Sensitive)	(Intermediate)	(Tolerant)
Avocado	Kidney beans	Alfalfa
Green beans	Red clover	Barley
Maize	Cotton	Beetroot
Tall Fescue	Lemon	Carrots
Peach	Most lettuce	Dallis grass
Sweet orange	Oats	Onion

Source: FAO (1979) from Lunt (1963).

Table C-3: RELATIVE TOLERANCE OF VARIOUS CROPS TO SOIL SALINITY

Fruit Crops		
High salt tolerance	Medium salt tolerance	Low salt tolerance
Date palm $EC_e x10^3 = 8$	$EC_e x10^3 = 8$ Pomegranate Fig Olive Grape Cantaloup $EC_e x10^3 = 4$	$EC_e x10^3 = 4$ Pear Apple Orange Grapefruit Prune Plum Almond Apricot Peach Strawberry Lemon Avocado $EC_e x10^3 = 2$
Vegetable Crops		
$EC_e x10^3 = 12$ Garden beets Kale Asparagus Spinach $EC_e x10^3 = 10$	$EC_e x10^3 = 10$ Tomato Broccoli Cabbage Bell pepper Cauliflower Most lettuce Maize Potatoes Carrot Onion Peas Marrow Cucumber $EC_e x10^3 = 4$	$EC_e x10^3 = 4$ Radish Celery Green beans $EC_e x10^3 = 3$
Field Crops		
$EC_e x10^3 = 16$ Barley (grain) Sugar beet Rape Cotton $EC_e x10^3 = 10$	$EC_e x10^3 = 10$ Rye (grain) Wheat (grain) Oats (grain) Most rice Sorghum (grain) Maize Flax Sunflower Castorbeans Soybeans $EC_e x10^3 = 6$	$EC_e x10^3 = 4$ Field beans Sugar cane Cassava

Table C-3: (Continued)

Forage Crops		
$EC_e x10^3 = 18$	$EC_e x10^3 = 12$	$EC_e x10^3 = 4$
Alkali sacaton Saltgrass Nuttal alkali grass Bermuda grass Rhodes grass Fescue grass Canada wildrye Western wheatgrass Barley (hay) Birdsfoot trefoil	White sweetclover Yellow sweetclover Perennial ryegrass Mountain brome Strawberry clover Dallis grass Sudan grass Hubam clover Alfalfa (Calif.common) Tall fescue Rye (hay) Wheat (hay) Oats (hay) Orchardgrass Blue grama Meadow fescue Reed canary Big trefoil Smooth brome Tall meadow oatgrass Cicer Milkvetch Sourclover Sickle milkvetch	White Dutch clover Meadow foxtail Alsike clover Red clover Ladino clover Burnet
$EC_e x10^3 = 12$	$EC_e x10^3 = 4$	$EC_e x10^3 = 2$

Source: FAO (1979) from Richards *et al.* (1954).

Table C-4: GUIDE FOR SELECTING A METHOD OF IRRIGATION

Irrigation method	Topography	Crops	Remarks
Widely spaced borders	Land slopes capable of being graded to less than 1% slope and preferably 0.2%	Alfalfa and other deep rooted close-growing crops and orchards	The most desirable surface method for irrigating close-growing crops where topographical conditions are favorable. Even grade in the direction of irrigation is required on flat land and is desirable but not essential on slopes of more than 0.5%. Grade changes should be slight and reverse grades must be avoided. Cross slope is permissible when confined to differences in elevation between border strips of 6-9 cm.
Closely spaced borders	Land slopes capable of being graded to 4% slope or less and preferably less than 1%	Pastures	Especially adapted to shallow soils underlain by clay pan or soils that have a low water intake rate. Even grade in the direction of irrigation is desirable but not essential. Sharp grade changes and reverse grades should be smoothed out. Cross slope is permissible when confined to differences in elevation between borders of 6-9 cm. Since the border strips may have less width, a greater total cross slope is permissible than for border irrigated alfalfa.
Check back and cross furrows	Land slopes capable of being graded to 0.2% slope or less	Fruit	This method is especially designed to obtain adequate distribution and penetration of moisture in soils with low water intake rates.
Corrugations	Land slopes capable of being graded to slopes between 0.5% and 12%	Alfalfa pasture and grain	This method is especially adapted to steep land and small irrigation streams. An even grade in the direction of irrigation is desirable but not essential. Sharp grade changes and reverse grades should at least be smoothed out. Due to the tendency of corrugations to clog and overflow and cause serious erosion, cross slopes should be avoided as much as possible.
Graded contour furrows	Variable land slopes of 2-25% but preferably less	Row crops and fruit	Especially adapted to row crops on steep land, though hazardous due to possible erosion from heavy rainfall. Unsuitable for rodent-infested fields or soils that crack excessively. Actual grade in the direction of irrigation 0.5-1.5%. No grading required beyond filling gullies and removal of abrupt ridges.

Table C-4: (Continued)

Rectangular checks	Land slopes capable of being graded so single or multiple tree basins will be level within 6 cm	Orchards	Especially adapted to soils that have either a relatively high or low water intake rate. May require considerable grading.
Contour checks	Slightly irregular land slopes of less than 1%	Fruit, rice, grain and forage crops	Reduces the need to grade land. Frequently employed to avoid altogether the necessity of grading. Adapted best to soils that have either a high or low water intake rate.
Contour ditches	Irregular slopes up to 12%	Hay, pasture and grain	Especially adapted to foothill conditions. Requires little or no surface grading.
Portable pipes	Irregular land surface	Hay, pasture on small scale	Minimum preparation of land surface required.
Subirrigation	Smooth-flat	Shallow rooted crops such as potatoes or grass	Requires a water table, very permeable subsoil conditions and precise levelling. Very few areas adapted to this method.
Sprinkler	Undulating 1->35% slope	All crops	High operation and maintenance costs. Good for rough or very sandy lands in areas of high production and good markets. Good method where power costs are low. May be the only practical method in areas of steep or rough topography. Good for high rainfall areas where only a small supplemental water supply is needed.
Contour bench terraces	Sloping land - best for slopes under 3% but useful to 6%	Any crop, but particularly well suited to cultivated crops	Considerable loss of productive land due to berms. Require expensive drop structures for water erosion control.
Subirrigation (installed pipes)	Flat to uniform slopes up to 1% surface should be smooth	Any crop, row crops or high value crops usually used	Requires installation of perforated plastic pipe in root zone at narrow spacings. Some difficulties in roots plugging the perforations. Also a problem as to correct spacing. Field trials on different soils are needed. This is still in the development stage.
Drip	Any topographic condition suitable for row crop farming	Row crops or fruit	Perforated pipe on the soil surface drips water at base of individual vegetable plants or around fruit trees. Has been successfully used in Israel with saline irrigation water. Still in development stage.

Source: FAO (1979) from Richards *et al.* (1954)

APPENDIX D

NATURAL AREAS AND CULTURAL/SCENIC SITES

D.1 NATURAL AREAS*

The Sinai Development Study, Phase I team identified several natural areas in Sinai as being particularly sensitive to development:

- Lake Bardawil
- Lake Malaha
- Gebel El Maghara (North Sinai)
- Mitla Pass
- East Suez
- Ras Sudr
- El Tih Plateau
- St. Catherine area
- Ras Mohammad
- Coral reefs along the Gulf of Aqabah

D.1.1. Lake Bardawil

Lake Bardawil, a saline lagoon and wetland complex bordering the Mediterranean Sea, is an important stopover point for birds migrating between Africa and Eurasia during the spring and fall. It is about 74 kilometers long and up to 20 kilometers wide. The lake is fringed by the highly saline marsh land of El Tina Plain at the western end, is an open water lagoon in the central area, and has a series of low sand islands at the eastern end. The narrow semicircular barrier beach that forms the northern boundary of Lake Bardawil also separates it from the Mediterranean. Artificially maintained inlets are located at two or three points along the sandbar separating the lake from the Mediterranean.

The influx of water from the Mediterranean through these inlets is very important to the ecology of Lake Bardawil because it maintains the salt concentration at tolerable levels. The lake's eastern island-cove complex is an internationally recognized breeding, resting and feeding area for wintering and migratory birds. The lagoon in the central area is a good source of fish, and the western marshes provide an excellent habitat for wintering flamingo, avocet, shoveler, shelduck, and other waders.

Inlet stabilization at Lake Bardawil should be incorporated into a comprehensive lake and wetland habitat protection program for this major environmental resource.

---

* See Figure 1.2.

D.1.2 Lake Malaha

Lake Malaha is a shallow saline lake that fluctuates with the level of the Mediterranean. The Suez Canal bypass, which was constructed recently to alleviate congestion at the Mediterranean end of the canal, passes through a portion of Lake Malaha. Much of the bypass dredge material was disposed of in the lake, effectively reducing the nesting, feeding and resting habitat it provides to numerous migratory shorebirds, including the flamingo.

D.1.3 Gebel El Maghara (North Sinai)

The Gebel El Maghara area, one of the few mountains in northern Sinai, has been identified as a habitat for sensitive vegetation and perhaps the ibex. The fennec fox has been reported to inhabit the open sandy areas west of El Maghara, but it is very unlikely that this species would be disturbed by modest development. It appears possible to develop the coal reserves at El Maghara, in which case an assessment of the environmental impact from mining will be required.

D.1.4 Mitla Pass

There are a number of sensitive plants growing in the vicinity of Mitla Pass. This pass has been the scene of many military battles, and land mines are still present in portions of the area.

D.1.5 East Suez

The sandy area on the Sinai side opposite Suez is historically the range of the fennec fox. This fox is known in only a few areas in Sinai.

D.1.6 Ras Sudr

Bustards are known to inhabit the environs of Ras Sudr.

D.1.7 El Tih Plateau

Two areas in central Sinai located within the El Tih Plateau support sensitive vegetation (one area straddles the El Igma escarpment). Both of these areas are remote, have no roads leading to them, and are located in a region that is not expected to be developed to any great degree.

D.1.8 St. Catherine Area

The high mountain area in southern Sinai that includes Gebel Katherina, Gebel Serbal and Gebel Musa presents a landscape of exceptional flora and fauna and contains important archaeological and historical attractions. The area surrounding St. Catherine supports a variety of rare plants and wildlife. The present status of the

endangered Sinai leopard is uncertain; its former range included the St. Catherine area, and field investigations must be conducted to determine if this rare species still exists. The area also supports desert hedgehog, hare, ibex and rock hyrax, as well as a large number of endemic plant species, some of which are endangered.

The Sixth Century St. Catherine Monastery is located in a valley near the mountain of the same name. Its more than 2,000 priceless icons represent the entire development of this art form, and the monastery library contains rare manuscripts and early theological works. Gebel Musa is the traditional mountain of "the giving of the law" in Judeo-Christian belief and provides a spectacular view of the surrounding granite mountains, especially at sunrise. Gebel Serbal, long regarded as a holy mountain, caps a strikingly beautiful ridge of mountains and can be seen from long distances.

D.1.9 Ras Mohammad

Ras Mohammad is composed of several finger-like projections of land that form an unusually beautiful contrast between barren land and sea, set against a backdrop of mountains of southern Sinai and the meeting of the Gulfs of Suez and Aqabah at the head of the Red Sea. Ras Mohammad is made up of ancient uplifted coral; at one of its extremities, a high bluff overlooks the sea and provides an ideal lookout point. Mangroves are found growing in an inlet among the hills at the tip of Ras Mohammad, an unexpected sight. The mangrove that grows in this area and along the Aqabah coast is at the northernmost extension of its range.

Ras Mohammad also provides a habitat for a number of birds. Ospreys nest on the westernmost lobe, and sooty falcons nest among the cliffs overlooking the Gulf of Aqabah to the east. The coral reef that encircles Ras Mohammad at the water's surface contains many kinds of coral and is the home of a number of brightly colored fish. Because of its unusual beauty, Ras Mohammad is a popular tourist spot.

D.1.10 Gulf of Aqabah Coral Reefs

The western shoreline along the Gulf of Aqabah contains some of the most spectacular coral reefs in the world. The reefs extend the entire length of the shoreline from Eilat to Ras Mohammad. Skin-diving and viewing the coral through glass-bottomed boats are very popular activities. Spearfishing is also a popular sport.

D.2 CULTURAL AND SCENIC SITES

The Sinai Peninsula contains nearly 300 specific places of cultural or scenic interest, many of which have high potential as tourist attractions. Included are areas with antiquities, historical or religious interest, beaches or resort potential, and locations

with special scenic value (coastal regions, mountainous areas, and oases). The sites have been characterized according to the following eight categories (elaboration may be found in Chapter 4, Section 4.3):

- Aesthetic
- Archaeological
- Cultural
- Historical
- Military
- Scenic
- Recreational
- Religious

Of the 295 places of cultural or scenic interest identified in Working Paper, Tourism Volume, at least 17 major sites seem to justify consideration for conservation or preservation status. These are marked on Figure 4.1, and brief descriptions are provided below.

D.2.1 Dahab Lighthouse

The Dahab Lighthouse, located on a shallow, rocky surface fringed with bush-like corals, is a landmark for a beach area along the Gulf of Aqabah.

D.2.2 El Arish

El Arish is the largest city in Sinai (population 70,000) and the regional capital of North Sinai. It has a beautiful beach lined with palm trees and offers perfect weather for year-round recreational activities. A large Bedouin market is held every Thursday, and along the coast is an active fishing village with a large fleet of boats. Several tourism developments are planned for El Arish, which include a plaza commemorating Sadat's raising of the flag after the second-stage Israeli withdrawal and a plaza and tourist center near the old Allenby railroad.

D.2.3 El Tor

El Tor has been the main town of southern Sinai since the Byzantine period until the present; known in church sources as Raieto, it was a center for monks and pilgrims; Some of the hermits lived in the caves of Bir Abu Suweira (north) and in Gebel Umm Shomar (east). While it was the base and marine connection to St. Catherine Monastery until 1967, most of its buildings were the quarantine station for Moslem pilgrims returning from Mecca. El Tor's pilgrims' port, also a fishermen's anchorage, adds a picturesque quality to the beach. El Tor has a church, two mosques and several coral-stone buildings; In 1982, El Tor became the capital of South Sinai. El Tor is also a markaz capital; a Bedouin market is open on Thursdays.

D.2.4 Faraun Island (Gezira Faraun)

This is a small island in the northern Gulf of Aqabah, near Ras Taba. On its two hills are ruins of Crusader and Mamluk citadels, with walls and towers of an earlier period. Some identify the ruins with King Solomon. The Crusaders called it Ile de Graye, and it is also known as Pharoah's Island and El Qaria Island.

D.2.5 Gebel Musa (Mount Sinai)

This elongated granite mountain with numerous ravines, at an elevation of 2,285 meters, is composed of volcanic rock. It is traditionally recognized as Mount Sinai; Christians located many holy sites on the mountain and its surroundings. On the summit is a chapel built over ruins of an older church, and next to the chapel is a mosque. On the shoulder of the mountain is the chapel of the prophet Elijah, who fled to the desert after his dispute with the prophets of Baal on Mount Carmel. There are 750 steps leading from this chapel to the summit.

Man-made paths on the mountain lead to small hidden valleys. West of Elijah's chapel, in a valley abundant with vegetation, is the chapel of John the Baptist. A valley nearby has a large building, a well, and a large almond tree from which the valley got its name, Wadi El Lusa.

On the west in Wadi Safsafa is a large "safsafa" (willow) tree, from which the western summit was named. The valley has a chapel known as "Kanisat Safsafa," Chapel of the Virgin's Girdle.

At the top of the path leading down Wadi Shereis to the southwest is "Kanisat El Akhmar" (the Red Church), known as the Chapel of Saint Panteleimon. Along Wadi Shereis are chapels, iron crosses fixed to rocks, rock inscriptions, and hand-built paths and orchards, all produced by hermits.

The panorama from the summit is fantastic, especially at sunrise or sunset. From Ras Safsafa, one can see the El Rakha Plain, traditionally the place of the Israelites' encampment when waiting for Moses to descend with the Tablets of the Law.

D.2.6 Hammam Faraun

Hammam Faraun is a hot spring off the Gulf of Suez. According to legend, the Israelites crossed the sea at this point, and here Pharaoh and his chariot sank into deep water.

D. 2.7 Hammam Saidna Musa

This hot water spring runs into an indoor bathing pool. Next to the stone building of the pool is a date palm plantation that belongs to St. Catherine Monastery and is cultivated by local Bedouins.

D. 2.8 Marsa Bareika

This inlet of the large bay north of Ras Mohammad has sandy beaches and fine coral reefs.

D. 2.9 Marsa El Att

Marsa El Att is a spacious sandy bay north of Sharm El Sheikh, with a fine beach and coral reef. The northern edge drops 10 to 40 meters and has large fan-like corals. This site (which was once called Na'ama) has been improved as a resort, with bathing and diving facilities, restaurants, a snack bar, hotels and glass-bottomed boats.

D. 2.10 Qalat El Gindi

Qalat El Gindi is at the entrance to Wadi Sudr, through which runs the ancient road, Darb Esh Shawi. Saladin built a large fortress, surrounded by a high wall, to provide travelers with protection against marauding Bedouin. Below the mosque in the fortress courtyard is a large underground cistern with pointed Moorish arches.

D. 2.11 Rod El Eir

These inscriptions and drawings in rock date back to the ancient Egyptians, and include drawings of boats and animals. The incriptions are located at Wadi Rod El Eir (Path of the Donkey), near Bir Nasib, and the site can be reached by foot up the wadi or from Sarabit El Khadim.

D. 2.12 Sarabit El Khadim

Dating back about 4000 years to the 12th Dynasty, these ruins of an ancient Egyptian temple are in the Umm Bugma region. The temple was built in honor of the goddess Hathor, and contains the tomb of an important mine official. It is decorated with hieroglyphics that contain information about the operation of the mines. In 1906, Petrie found many more rock drawings and inscriptions in the mining area; he also discovered two inscriptions using the Proto-Sinaic alphabet, similar to the old Hebrew alphabet.

D. 2.13 Wadi Feiran

Wadi Feiran drains a wide basin of the high mountain region of southern Sinai into the Gulf of Suez. Its continuation above Naqb Buweib is called Wadi El Sheikh, where it runs mainly through

metamorphic rock. Feiran Oasis is eight kilometers long with wells, palms, gardens and houses of Bedouins who represent all the tribes of southern Sinai. On the side of the wadi are terraces of chalky marl deposits that prove the existence of ancient lakes dammed in by dikes. The terraces still contain underground water reservoirs refilled by seasonal floods. Tell El Makhrad in Feiran was a flourishing town during the Byzantine period, identified as biblical Rephidim. The new church (1969) and gardens belong to St. Catherine Monastery. On the sides of the wadi are caves dug into the marl, which were used by monks in ancient days. These caves gave the valley its name, which translates as "Valley of Mice."

The highway starts at the Abu Rudeis-El Tor road and runs along the wadi to St. Catherine, with side roads branching out to Wadi El Akhdar, Wadi Sahab, Wadi Solaf and Wadi Gharba.

D.2.14 Wadi Hebran

Wadi Hebran descends from Gebel Tarbush to the El Qaa Plain. In the 1860's, the Egyptian Abbas Pasha ordered the construction of a "chariot" road (Sikkat Abbas Pasha) from El Tor to St. Catherine Monastery, parts of which can still be seen. The oasis and tomb of Sheikh El Irdasiya and the canyon of gardens with its springs make Wadi Hebran a recommended route for walking or camel riding.

D.2.15 Wadi Isla

Wadi Isla gradually descends from Gebel Umm Shomar to the El Qaa Plain. From the Byzantine period, the wadi served as a camel caravan route to St. Catherine. Near the springs are palm groves, canes, juncus, mint, and cane huts belonging to the Awland Said tribe. Distant tribes come to Wadi Isla to collect cane.

D.2.16 Wadi El Maghara (South Sinai)

Wadi El Maghara descends into Wadi Sidri at Sheikh Soliman Nafia. In the 1840's, Major MacDonald rediscovered the old turquoise mines in the wadi and tried unsuccessfully to renew operations. Ruins of his camp's stone building are at the mouth of the wadi. Across the mouth of the wadi is a wall built by the ancient Egyptians. In 1905, Petrie removed from the canyon walls about 40 ancient Egyptian inscriptions which were sent to the Cairo Museum. Only one inscription has remained, with some short, mostly Nabatean inscriptions.

D.2.17 Wadi Mukattab

This sandy upper tributary of Wadi Sidri is approachable from Wadi Feiran (old road to Abu Rudeis). In the wadi are many drawings and inscriptions cut into the rock.