

AGENCY FOR INTERNATIONAL DEVELOPMENT  
WASHINGTON, D. C. 20523  
**BIBLIOGRAPHIC INPUT SHEET**

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*Batch 72*

1. SUBJECT CLASSIFICATION	A. PRIMARY Food production and nutrition	AP10-0000-G218
	B. SECONDARY Water resources and management--Senegal	

2. TITLE AND SUBTITLE  
A program for ground water development, Senegal

3. AUTHOR(S)  
(101) Parsons (R.M.) Co., Los Angeles

4. DOCUMENT DATE 1963	5. NUMBER OF PAGES 31p.	6. ARC NUMBER ARC
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7. REFERENCE ORGANIZATION NAME AND ADDRESS  
Parsons

8. SUPPLEMENTARY NOTES (*Sponsoring Organization, Publisher, Availability*)  
(Addendum to Reconnaissance hydrologique, 127p.: PN-RAB-611)

9. ABSTRACT

10. CONTROL NUMBER PN-RAB-612	11. PRICE OF DOCUMENT
12. DESCRIPTORS Ground water Project planning Senegal	13. PROJECT NUMBER
	14. CONTRACT NUMBER AID/afr-116 GTS
	15. TYPE OF DOCUMENT

*A PROGRAM FOR*  
**GROUND-WATER DEVELOPMENT**  
**REPUBLIC OF SENEGAL**

*AN ADDENDUM TO*  
**HYDROGEOLOGIC RECONNAISSANCE**  
**REPUBLIC OF SENEGAL**

*A REPORT FOR*  
**THE UNITED STATES**  
**AGENCY for INTERNATIONAL DEVELOPMENT**

**CONTRACT No. AID/afc-116**

**PIO/T685-Y-52-AC-3-20002-1**

**NOVEMBER 1963**

**THE RALPH M. PARSONS COMPANY**

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*ENGINEERS-CONSTRUCTORS*



**LOS ANGELES  
NEW YORK**

A. I. D.  
Reference Center  
Room 1656 NS

# The Ralph M. Parsons Company

*Engineers • Constructors*

617 WEST SEVENTH STREET, LOS ANGELES 17, CALIFORNIA

February 19, 1964

Department of State  
Agency for International Development  
Washington 25, D. C.

ATTENTION of Mr. Thomas V. Leahy  
Project Engineer

SUBJECT Contract AID/afe-116-Senegal  
Ground-Water Development Project  
An Addendum to Final Report

Gentlemen:

In accordance with your instructions to prepare a scope of work and cost estimate for an alternate ground-water development project for Senegal, we are pleased to transmit herewith an addendum to our Hydrogeologic Reconnaissance report. The proposed development project is considerably smaller in scope than the one previously recommended and has been programmed to:

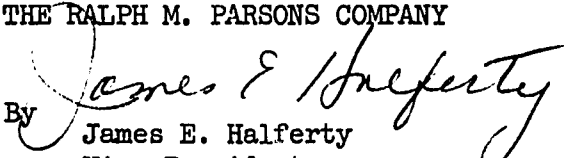
1. Provide the basic hydrogeologic data required for planning and implementing water development projects in those areas of Central Senegal where existing facilities are inadequate to provide for present and future water demands.
2. Provide an adequate sanitary water supply in those areas of Central Senegal where municipal, village, and livestock water shortages are most critical.
3. Provide the Republic of Senegal with the minimum necessary drilling equipment required for undertaking small exploratory drilling and water development projects.

We wish to thank you for the opportunity to carry out this assignment and we hope that we may be of further assistance in the development of water resources in Senegal. If you have any additional questions regarding our recommended development project, please contact us.

Very truly yours,

THE RALPH M. PARSONS COMPANY

By

  
James E. Halferty  
Vice President  
Foreign Operations

JEH:mm



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## INTRODUCTION

During November 1963, The Ralph M. Parsons Company submitted to the United States Agency for International Development a report\* presenting the results of field investigations in the Dakar-Cap Vert Peninsula, Central Senegal, and the Bakel-Kédougou areas of Senegal. The report contained a review of all hydrogeologic information pertaining to these areas, an evaluation of proposed work programs previously submitted to AID by the Senegal Government, and a recommended ground-water research and development project including a cost estimate for undertaking the project.

The scope of work previously recommended included exploration of the deep Maestrichtian and shallow phreatic aquifers in Central Senegal and construction of wells in those areas where municipal, village and livestock water requirements are most critical, utilizing those aquifers that could be developed most economically. Subsequent to submission of The Ralph M. Parsons Company report and recommended development project, recent developments in Senegal have indicated that assistance from USAID would not be needed for exploration of the Maestrichtian formation on the vicinity of Port-Thiès. As research and well construction costs associated with the Maestrichtian formation constituted a major portion of the total estimated cost of the

\* Hydrogeologic Reconnaissance, Republic of Senegal  
A Report for the United States Agency for International Development  
The Ralph M. Parsons Company, November 1963



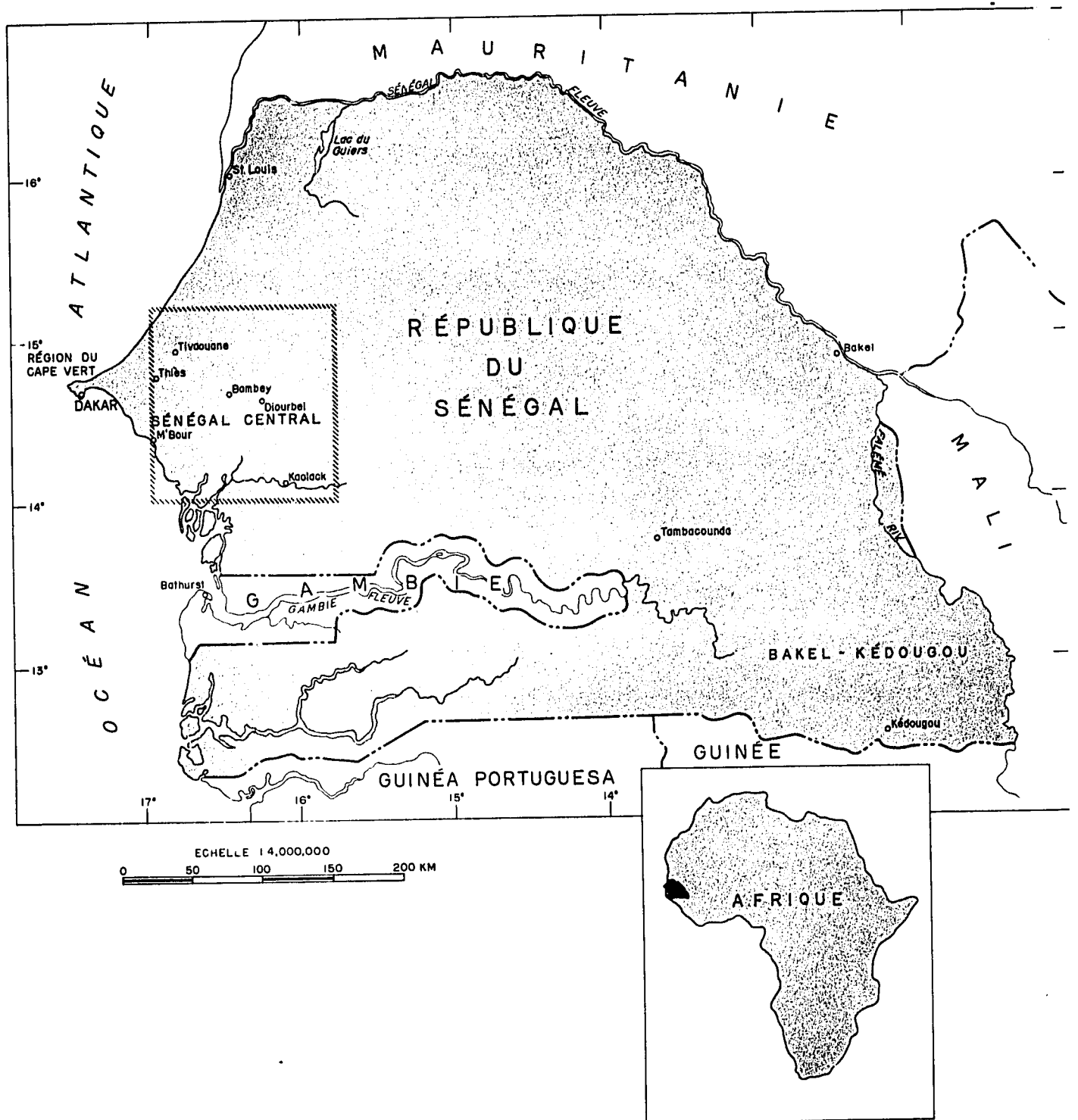
recommended project, which no longer would be applicable, USAID requested The Ralph M. Parsons Company to prepare a scope of services and cost estimate for an alternate project, excluding research and development of the Maestrichtian from further consideration.

The alternate development project for ground-water development in Central Senegal described herein is considerably smaller in scope than the previously recommended project. It has been limited to exploration and development of the shallow phreatic aquifers of Central Senegal, but includes some of the objectives included in the previously recommended scope of work.

#### DEVELOPMENT PROJECT

##### Applicant

The Ministere de Travaux Publics is, at present, the authority responsible for the administration of water resources research and development projects. However, the formation of a "Ministry of Water Resources" is now under consideration, and presumably the recommended project described in the following section would be carried out under the auspices of the "Hydraulic Division" of this government agency. Since Division functions have not been firmly established it has not been possible to include an organizational description of the "Ministry."



SENEGAL AND VICINITY



### Location and Description of Project Area

The recommended project is located in the area previously designated "Central Senegal" which is delimited by longitudes  $15^{\circ} 45'$  and  $17^{\circ} 00'$  west and by latitudes  $14^{\circ} 00'$  and  $15^{\circ} 15'$  north. This area can be divided into four physiographic units. The Thies cuesta and its back-slope, known as the Thies plateau, are two main units in the north-west part of the area. A portion of this sector bordering the ocean also includes an appreciable area of dunes and "niayes." The south-west part of the area east of the mouth of the Saloum forms a third unit, a network of salt-marshes in which tidal effects are felt for great distances. Here sea water invades wide areas barren of vegetation, known as "tannes," which appear to be increasing in areal extent. The fourth unit is a sandy plain of little relief whose elevation decreases southward and occupies over 60 per cent of the area.

There are no perennial streams, but in areas where stream channels have been eroded below the water table small ponds or "marigots" form during the dry season. However, by the end of the dry season effluent seepage ceases and ponded water evaporates.

Exposures of older rocks in the area are relatively rare and only those of Paleocene age or younger are to be found. Coarse Paleocene limestones are exposed along the foot of the Thies cuesta scarp and in the vicinity of M'Bour. Thickness is estimated to be of the order of 20-30 meters. In the rest of the area the Paleocene is covered by Eocene and younger sediments, which are the most extensive, and comprise the shallow phreatic aquifers.





Continental Terminal formations overlie the middle and upper Eocene in the southeast corner of the area.

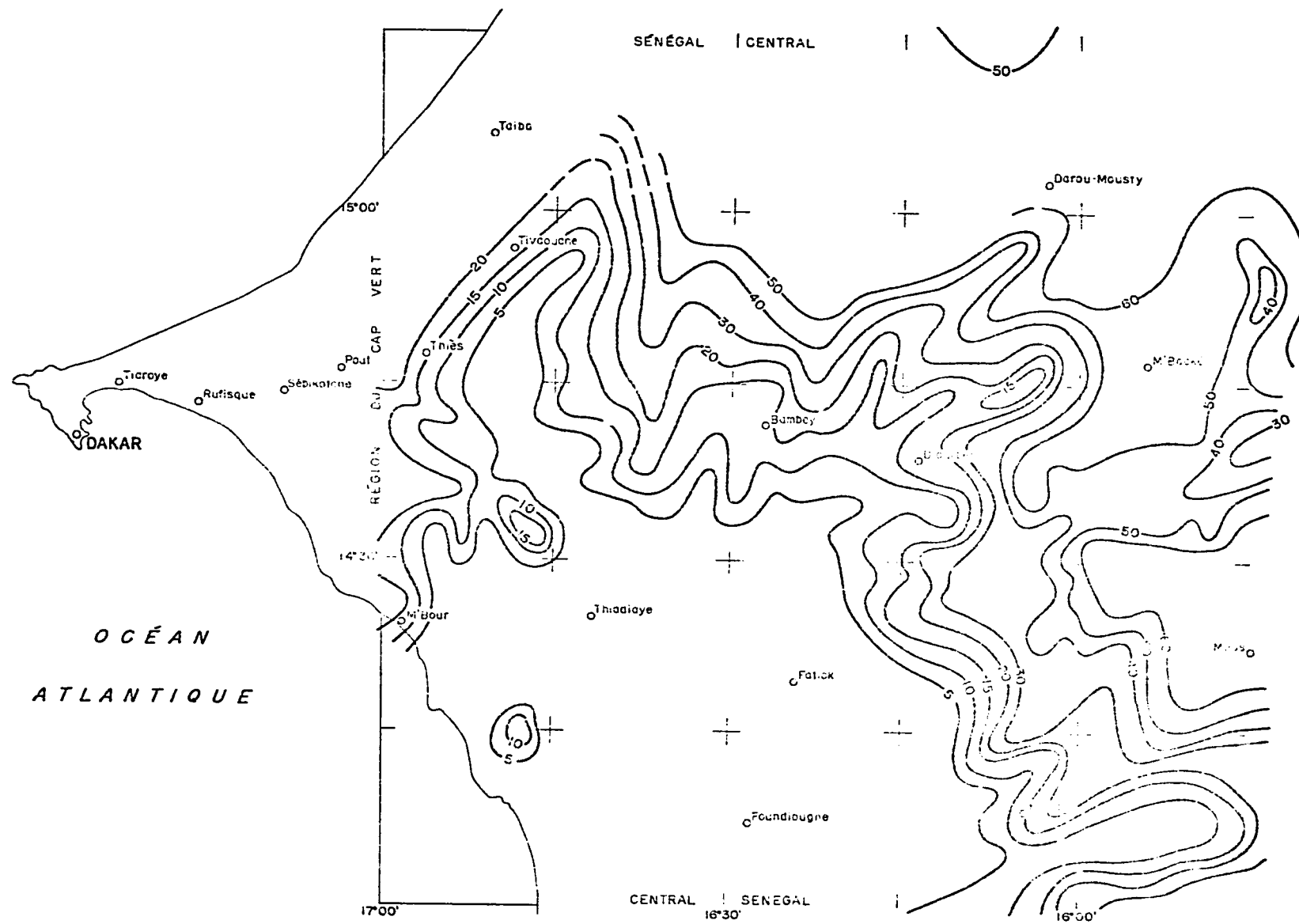
Phreatic aquifers vary considerably in lithologic character and include sands, marly sandstones, marls, limestones, and interbedded marly limestones, varying in age from lower Eocene to Pliocene. The more permeable water bearing deposits are located west of Diourbel where sandy aquifers and permeable limestones occur. East of Diourbel shallow wells penetrate less permeable marls and limestones.

Replenishment occurs primarily from the direct infiltration of rainfall, and streams are believed to contribute very little recharge to the aquifers. Depths to the water table vary from 5 meters in the western part of the area to 60 meters in the north-east part as shown on the following map. Subsurface movement of ground water is generally eastward from the Thies cuesta.

Quality of water is generally very good throughout most of the area. West of Diourbel total dissolved solids vary from 300 to 600 parts per million. East of Diourbel quality is somewhat poorer. In this area total dissolved solids vary from 500 to 1200 parts per million.

#### Purpose

The western-half of Central Senegal is the most densely populated part of Senegal. Although some of the larger towns that obtain ground water from wells penetrating deep Maestrichtian aquifers do not have a critical water supply problem, many of the towns and

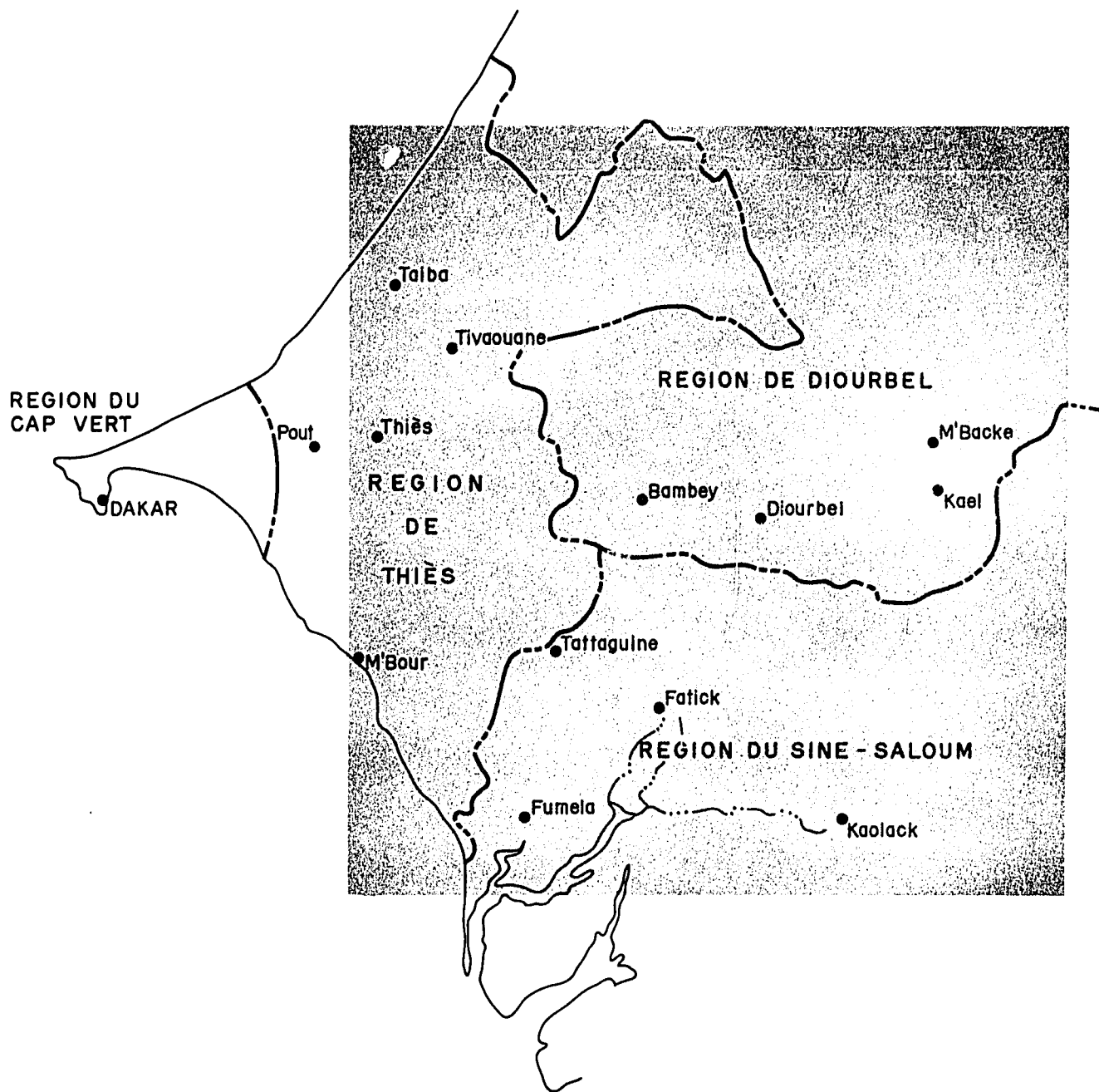




small villages that obtain water from shallow hand dug wells penetrating the phreatic aquifers do not have an adequate water supply, particularly during the dry season when surface water is not available. In some areas water problems are more acute because of the additional supply needed for livestock.

Within the Region de Thiès, local authorities have determined that seven large capacity wells and about 140 small capacity wells are required to supplement existing facilities. Within the Regions of Diourbel and Sine-Saloum in the Central Senegal area, the Director of Génie Rural has prepared an inventory of additional water supply facilities required that includes some 28 large capacity wells for municipal and livestock use and about 110 small capacity village water supply wells.

Although some of the hydrogeologic parameters of the phreatic aquifers have not been determined, previous studies have shown that the phreatic zone, particularly west of Diourbel where Eocene limestones occur, could provide additional water supplies. The purpose of the proposed project is to provide supplemental sanitary water supplies in those areas of Central Senegal where municipal, village and livestock water deficiencies are most critical. The location of the proposed project is shown on the following plate.



**PROJECT LOCATION**



### Objectives

The objectives of the project include undertaking a program of limited hydrogeologic research and exploratory drilling for the purpose of establishing necessary hydraulic parameters and design criteria for the construction of water wells in those areas where needs are most critical, and the construction of a limited number of wells in those areas where the development of ground water can be undertaken on a technically and economically sound basis. The specific objectives of the project include:

1. Determine those geologic and hydrologic parameters of the shallow phreatic aquifers required for the construction of producing water wells in those areas of Central Senegal where previous studies have indicated the presence of a substantial ground-water reservoir.
2. Determine aquifer transmissibility, storage coefficients and other hydrogeologic parameters of the phreatic aquifers in those areas of Central Senegal where data necessary for the planning of specific water development projects is either absent or inadequate.
3. Construct water wells in those areas of Central Senegal where municipal, village and livestock water requirements are most critical, by utilizing those phreatic aquifers that can be most economically developed.



4. Provide the Republic of Senegal with the minimum necessary drilling equipment required for undertaking limited exploratory drilling and water development projects that cannot be undertaken economically by private organizations.

#### Scope of Work

The achievement of project objectives will require the services of an engineering and construction contractor who is well qualified by previous experience in similar hydrogeologic research and groundwater development projects. The project will also require the participation of those government agencies of the Republic of Senegal responsible for the planning and administration of hydrogeologic research and water development projects who will assist the contractor in implementing the project and provide some of the project facilities. Since about 40 per cent of the project objectives include basic research and exploratory drilling, a specific work program and project schedule cannot be precisely outlined and planned. However, it is believed that the following items of work can be accomplished with a 12-month period.

1. Review previous hydrogeologic reports and available data and, in consultation with participating agencies of the Republic of Senegal, select specific sites for constructing water production wells. 10 mos  
17 mos



2. Drill about 10 exploratory test and observation wells to a maximum depth of 150 meters to determine geologic and hydraulic characteristics of the phreatic aquifers. About 5 of these wells will be of sufficient diameter to permit the installation of a production test pump.

20 to 200 m

10 for pumps

3. Design and prepare specifications for permanent water supply wells.

Same

limited: 700 meter wells

phreatic only

4. Construct 10 water supply wells for either municipal or livestock use. For purposes of cost estimating it is assumed these wells will yield 60 to 120 cubic meters per hour.

Same  
low capacity

5. Construct 30 village sanitary water supply wells equipped with hand pumps or small engine driven pumps capable of yielding about 3 cubic meters per hour from depths varying from 5 to 50 meters. Well depths will vary from about 10 to 60 meters.

same

6. Prepare a final report which will include an evaluation of those hydrogeologic factors that affect the occurrence, movement and replenishment of the phreatic aquifers in Central Senegal based on new information acquired during the course of the project. The report also will include a recommended program for the further exploration and development of ground water in the phreatic aquifers of Central Senegal.

not worth any way  
Determine 5  
1) investigation (water supply study)  
2) create drilling design w/ in  
3) plan wells accordingly

work in  
Machakos



## PROJECT SCHEDULE

About four months will be required for processing project personnel and the procurement and shipping of required equipment and materials, prior to the commencement of the project. A total of 12 months will be required to complete the project commencing with the arrival of the hydrogeologic and drilling staffs and project equipment in Senegal. The first phase of the project will require about five months to obtain the necessary information for the design of production wells and procurement of additional well construction materials. During this phase the contractor will prepare specifications, purchase, and arrange for shipment of all required materials from point of origin to Senegal. Hydrogeologic studies will commence upon the staff's arrival and continue through all phases of the project. The second phase will require about seven months and consist essentially of constructing water supply wells. At the conclusion of well construction activities the hydrogeologic staff will prepare a final report for submission to participating agencies.

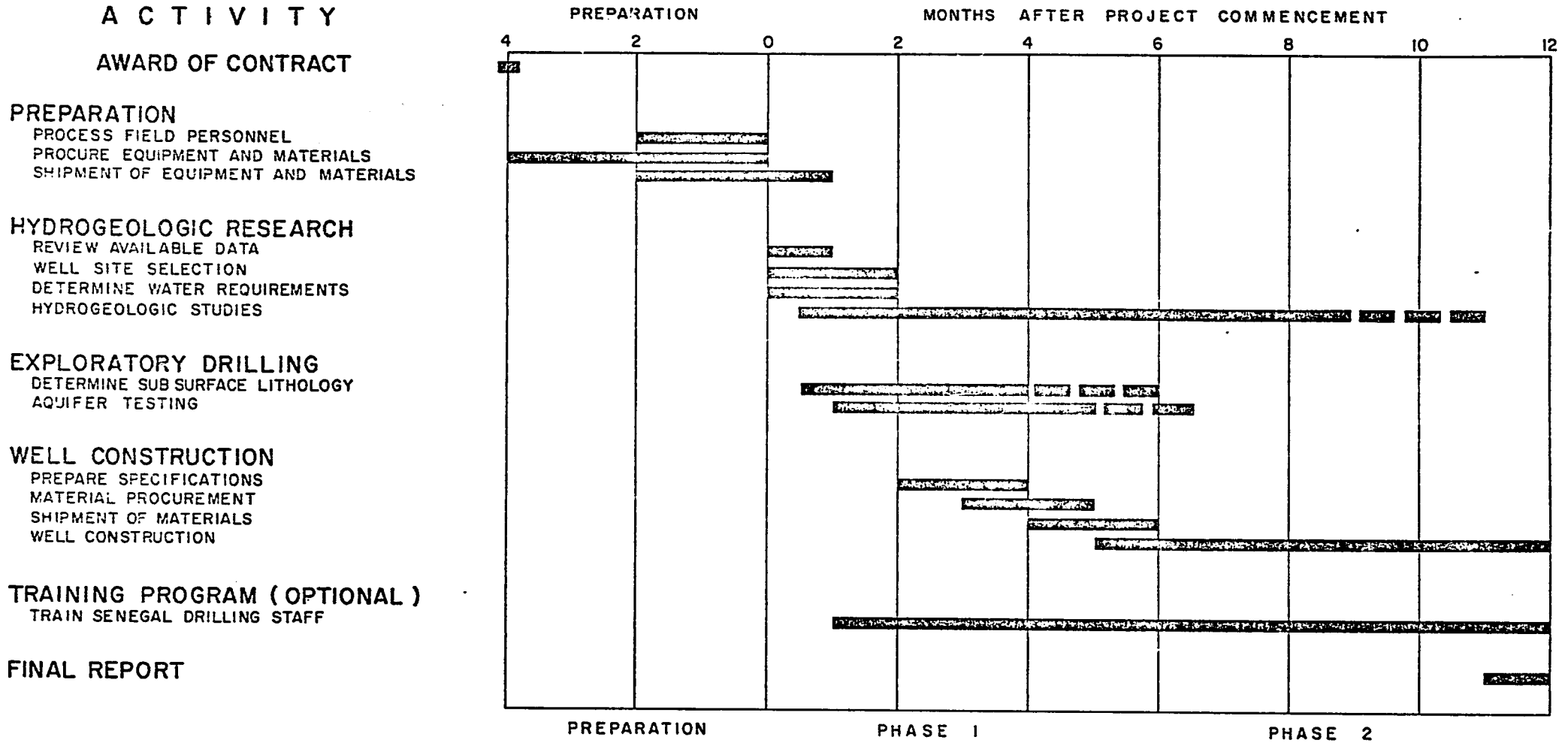
## SCOPE OF SERVICES

### Hydrogeologic Research and Drilling Services

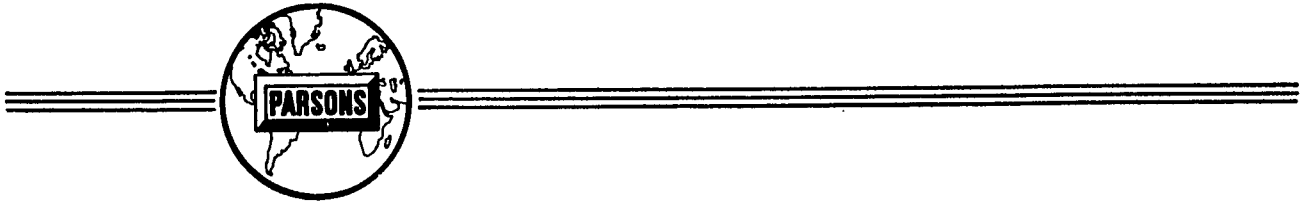
The contractor will provide all personnel required for general administration, hydrogeologic research, and supervision of exploratory drilling and well construction in order to achieve the objectives of



# SCHEDULE OF PROJECT ACTIVITIES



## PROJECT SCHEDULE



the project and accomplish those items of work included in the Scope of Work. The contractor's field staff will consist of the following members:

1. Project Manager-Hydrogeologist
2. Senior Hydrogeologist
3. Driller
4. Pump Installer-Mechanic

Members of the contractor's field staff shall be well qualified in their respective professions and vocations. At least one member of the hydrogeologic staff and one member of the drilling staff shall speak fluent French.

The contractor also will provide all personnel required for maintaining a field office and mobile field camp. Personnel employed in these activities shall be well qualified and selected from local residents of Senegal.

The contractor also will provide all technical and supporting services required to carry out the hydrogeologic research, exploratory drilling and well construction activities of the project.

#### Procurement

The contractor will provide all services for the preparation of specifications, purchasing, and procurement of all equipment and materials required for the project. One cable tool drilling rig capable of drilling water wells to depths of 200 meters will be included in equipment purchased.



### Training

In the event the participating agency of the Republic of Senegal wishes to assign trainees to the project, the contractor will train assigned personnel in the operation and maintenance of all drilling equipment for the purpose of continuing the exploration and well construction activities at the termination of the project. The trainees will perform all work required by the contractor that is associated with the drilling, testing and construction of exploratory borings and water supply wells. It is desirable that the trainees have some previous experience in well drilling and possess the physical ability and mechanical aptitude required for the vocation. The trainees should also be capable of reading and writing French. The contractor will participate in the selection of each trainee and the contractor will be authorized to dismiss any trainee whose services are unsatisfactory.

### Warehouse, Field Office and Storage Facilities

The participating agency of the Republic of Senegal will provide the warehouse and storage facilities required for the stock-piling and warehousing of all equipment and materials required for the project. In addition, the agency will provide an office, located in Dakar, for the contractor's field staff and the necessary utilities and services required for the operation of the office, including electricity and water.



#### Exemptions and Right-of-Way

The Republic of Senegal will exempt the contractor as well as members of his field staff and their families from the payment of all taxes, levies and duties on personal possessions, salaries, profits, materials, equipment and fuels during the course of the project. In addition, the participating agency will provide for the access and use of all lands required for achieving the project objectives.

#### Operation and Maintenance

The participating agency of the Republic of Senegal will assume the responsibility of operating and maintaining all works constructed during the course of the project. In the event water storage or distribution facilities are required for constructed wells, they will be provided by the Republic of Senegal.

### PROJECT COST ESTIMATE

#### Basis for Preparing Cost Estimate

The proposed project has been divided into six major cost categories: Contractor's personnel services, local personnel, local project facilities and services, equipment, drilling and well construction materials, and shipping expense.

The contractor's personnel services will consist of providing four field technical men, expenses related to their subsistence and travel costs, and home office services that will include general administration, specification preparation, clerical work, purchasing



and inspection. It is assumed that three of the four field men will be on single status as they will work continuously in the field.

The contractor's local staff will consist of Senegal residents who will be employed to assist on well drilling, maintain the mobile project field camp, and assist the Project Manager in the Dakar office.

Local project facilities and services include those items required to operate the Dakar office, support the drilling program, and technical services that cannot be provided economically by the contractor.

Equipment and material costs include all equipment and materials required to support and carry out the exploratory drilling and well construction program. Most of the equipment and materials will be purchased in the United States, however, some of the materials such as fuel, gravel and cement will be purchased in Senegal.

Shipping expense includes the cost of shipping all equipment and materials required for the project from point of origin to Dakar.

#### Summary of Costs

The estimated total cost of the proposed project is about \$421,000, which includes the cost of all personnel, equipment, materials and services required, with the exception of office and warehouse facilities at Dakar. If housing, subsistence, and local personnel costs could be provided by the Senegal Government or paid for with



local currency, the total dollar cost would be reduced to about \$361,000. Project cost items may be summarized as follows:

<u>Item</u>	<u>Description</u>	<u>Amount</u>
I	Contractor's Personnel Services	\$ 184,000
II	Local Personnel	41,000
III	Local Project Facilities and Services	17,000
IV	Equipment	58,000
V	Drilling and Well Construction Materials	104,000
VI	Shipping Expense	17,000
	Total Estimated Cost	\$ 421,000

203,000  
OK  
69,500  
111,000  
19,000

COPY EXACT



ESTIMATE OF U.S. DOLLAR COSTS

I. Contractor's Personnel Services

	<u>Monthly Salary</u>	<u>Man Mos.</u>	<u>Sub- Totals</u>	<u>Totals</u>
<u>A. Field Personnel</u>				
Hydrogeologist (Project Manager)	1500	14	\$21,000	
Hydrogeologist	1100	12	13,200	
Driller	900	12	10,800	
Pump Installer-Mechanic	900	<u>12</u>	<u>10,800</u>	
		50	55,800	
			<u>8,370</u>	
Overseas Differential (15%)				\$64,170
 <u>B. Home Office Personnel</u>				
Project Manager	1200	3	3,600	
Administration	750	2	1,500	
Clerical and Miscellaneous	400	2	800	
Engineering (spec. preparation)	1000	2	2,000	
Purchasing and Inspection	1000	4	<u>4,000</u>	
				11,900
 <u>C. Payroll Costs and Welfare Benefits</u>				
Field Salaries (\$55,800 x 20%)			11,160	
Home Office Salaries (\$11,900 x 20%)			<u>2,380</u>	
				13,540
 <u>D. Transportation (round trip)</u>				
5 adults, 2 children (6 fares - \$1100)			6,600	
Personal effects (air freight) 600 lbs. @ \$4.00/lb.			2,400	
Household goods (ocean freight) 2000 lbs. @ \$1.25/lb.			2,500	
Per diem 50 travel days @ \$8/day			<u>400</u>	
				11,900
 <u>E. Housing and Subsistence</u>				
Family (1) @ \$500/month			6,000	
Single status personnel (3) @ \$300/month			10,800	
Schooling, 2 children @ \$100/month			<u>2,400</u>	
				\$19,200



	<u>Subtotals</u>	<u>Totals</u>
<b>F. <u>Out-of-Pocket Expense</u></b>		
Miscellaneous travel and preparation expense 7 individuals @ \$50 each	\$ 350	
Postage and cables @ \$100/month	1,200	
Miscellaneous supplies @ \$50/month	<u>600</u>	
		\$ 2,150
<b>G. <u>Overhead</u></b>		
Field salaries (\$55,800 x 67%)	37,400	
Home Office salaries (\$11,900 x 75%)	<u>8,900</u>	
		46,300
<b>H. <u>Fee</u></b>		
50 man-months @ \$300/man month		<u>15,000</u>
<b>Total Cost of Contractor's Personnel Services</b>		<b>\$184,160</b>





II. Local Personnel

	<u>Monthly Salary</u>	<u>Man Mos.</u>	<u>Sub- Totals</u>	<u>Totals</u>
<b>A. <u>Local Office Personnel</u></b>				
Office Manager	400	12	\$4,800	
Secretary	325	12	3,900	
Warehouseman	350	12	4,200	
Laborer (1)	30	12	<u>360</u>	
				\$13,260
<b>B. <u>Field Personnel</u></b>				
Driller helper (2)	200	24	4,800	
Driver	300	12	3,600	
Cook	40	12	480	
Cook's assistant	30	12	360	
Laborer (2)	30	24	<u>720</u>	
				9,960
<b>C. <u>Welfare Benefits</u></b>				
47% of \$23,220				10,900
<b>D. <u>Subsistence</u></b>				
Local field personnel 7 men @ \$3/day				<u>6,900</u>
				Total Local Personnel Expense \$41,020

III. Local Project Facilities and Services

<b>A. <u>Local Facilities</u> (to be provided by Senegal Government)</b>				
Office				
Office utilities				
Warehouse and storage				
<b>B. <u>Local Office Operating Expense</u></b>				
Cables, postage			1,000	
Equipment			1,000	
Consumable supplies			<u>500</u>	
				2,500
<b>C. <u>Project Services</u></b>				
Surveying			5,000	
Electric logging			2,000	
Water analyses			1,000	
Equipment rental (heavy duty)			3,000	
Material transportation			2,000	
Material handling			<u>1,500</u>	
				\$14,500
Total Cost of Local Project Facilities and Services				\$17,000



#### IV. Equipment

	<u>Subtotals</u>	<u>Totals</u>
<b>A. <u>Drilling Equipment</u></b>		
Speedstar 71 (or equal) trailer mounted	\$ 12,000	
Tools and accessories	3,000	
Welder	2,000	
Test pump with diesel engine driver	7,000	
Miscellaneous spare parts	<u>2,000</u>	
		\$ 26,000
<b>B. <u>Transportation Equipment</u></b>		
Medium duty truck with A-frame and winch	14,000	
Pickup truck	3,100	
Jeep	2,100	
Station wagon	<u>3,000</u>	
		22,200
<b>C. <u>Field Camp Equipment</u></b>		
Portable office	3,000	
Generator	1,000	
Air conditioner	300	
Tents	1,500	
Refrigerators	700	
Furniture, bedding and cooking equipment	<u>1,500</u>	
		8,000
<b>D. <u>Technical Equipment</u></b>		
Hydrogeologic equipment	1,500	
Drafting equipment	<u>500</u>	
		<u>2,000</u>
Total Cost of Equipment		\$ 58,200

#### V. Drilling and Well Construction Materials

<b>A. <u>Consumable Drilling Materials</u></b>		
Bits	3,000	
Drilling mud and chemicals	1,000	
Welding rod	3,500	
Fuel and lubricants (drilling)	3,500	
Fuel, lubricants, maintenance (automotive)	<u>8,000</u>	
		\$ 19,000



	<u>Subtotals</u>	<u>Totals</u>
<b>B. <u>Well Construction Materials</u></b>		
Well casing	\$ 25,000	
Well screen	5,000	
Pump and motor assemblies	50,000	
Gravel, cement	<u>5,000</u>	
		\$ <u>85,000</u>
Total Cost of Drilling and Construction Materials		\$104,000
<b>VI. <u>Shipping Expense</u></b>		
<b>A. <u>Ocean Freight</u></b>		
Equipment and materials (including preparation)		10,000
<b>B. <u>Rail Freight</u></b>		
Equipment and materials		3,000
<b>C. <u>Air Freight</u></b>		
Equipment	1,500	
Emergency supplies	<u>2,000</u>	
		<u>3,500</u>
Total Shipping Expense		\$ 16,500



### TECHNICAL AND ECONOMIC SOUNDNESS

Previous hydrogeologic research has adequately demonstrated the technical soundness of proposed water development objectives. In fact, many of the project objectives are essentially the same as those recommended in previous reports. Previous studies have not included an hydrologic balance or determinations of aquifer coefficients, however, these limitations are not considered particularly significant as there is ample evidence suggesting that present water use generally does not exceed replenishment. Furthermore, a substantial number of wells have been constructed in the past that demonstrate the water yielding capacity of the phreatic aquifers. In any event, the magnitudes of proposed additional withdrawals of ground water are relatively small in comparison to present water use.

One of the primary factors that appears to have delayed the implementation of water development projects in Senegal is the very high cost of drilling exploratory test wells and constructing water supply wells. The cost of employing one of the local drilling contractors for well drilling is approximately 3 to 5 times domestic United States costs. Although the estimated cost of the proposed project would appear rather high if expressed in terms of unit drilling costs, the cost of constructed wells should be somewhat less than they would be if local drilling contractors were employed. Unit costs could be substantially reduced by extending the well



construction phase of the project for another year and employing an additional drilling rig. It would be most desirable also for the participating agency of the Senegal Government to assign drilling trainees to the project in order to insure a continuance of well construction activities and thereby achieve maximum benefit and utilization of equipment purchased for the project. There is, however, some doubt that the participating agency could undertake large exploratory drilling or well construction projects more economically than local contractors, but a small trained drilling staff could probably undertake small drilling projects more economically if objectives are sufficiently limited in scope.

#### BENEFITS

Tangible benefits resulting from the limited hydrogeologic research portion of the project may not be realized for many years. However, results of research studies would be of significant value in planning for further development of the phreatic aquifers which, in some areas, could probably be developed more economically than the deeper Paleocene and Maestrichtian aquifers.

Since there is little marketing of livestock, it would be difficult to appraise the benefits that would arise from providing additional water for livestock use and a thorough study of Senegal's livestock grazing and marketing practices should be made before undertaking



any large livestock water supply projects. However, the primary benefits of the village water supply program are more apparent. Many of the existing hand dug wells have insufficient yields, are unsanitary, and during summer months, yield very little water. In those areas where villagers obtain their water supply from springs and small streams, water borne parasites are most common. The proposed program should immeasurably contribute to minimizing this public health hazard.

The proposed project does not attempt to provide all villages with small capacity sanitary wells, but rather to introduce a more reliable method of providing a dependable sanitary water supply. The cost of constructing these wells by cable tool drilling is probably about equal to cost of traditional construction.



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