PD-ABC-438
70204

A.I.D. EVALUATION SUMMARY - PART I

1. BEFORE FILLING OUT THIS FORM, READ THE ATTACHED INSTRUCTIONS.
2. USE LETTER QUALITY TYPE, NOT "DOT MATRIX" TYPE

IDENTIFICATION DATA

A. Reporting A.I.D. Unit:
Mission or AID/W Office: USAID/Senegal
(ES# ______)

B. Was Evaluation Scheduled In Current FY Annual Evaluation Plan?
Yes [ ] Slipped [X] Ad Hoc [ ]
Evaluation Plan Submission Date: FY 90 Q 1

C. Evaluation Timing
Interim [ ] Final [X] Ex Post [ ] Other [ ]

D. Activity or Activities Evaluated (List the following information for project(s) or program(s) evaluated; if not applicable, list title and date of the evaluation report.)

Project No.	Project /Program Title	First PROAG or Equivalent (FY)	Most Recent PACD (Mo/Yr)	Planned LOP Cost (000)	Amount Obligated to Date (000)
625-0958	OMVS Groundwater Monitoring	1983	06/90	6,501	6,501

ACTIONS

E. Action Decisions Approved By Mission or AID/W Office Director

Action(s) Required	Name of Officer Responsible for Action	Date Action to be Completed
Proceed with close-out procedures as planned	USAID/OMVS	3/91

(Attach extra sheet if necessary)

APPROVALS

F. Date Of Mission Or AID/W Office Review Of Evaluation: (Month) (Day) (Year)

G. Approvals of Evaluation Summary And Action Decisions:

	Project/Program Officer	Representative of Borrower/Grantee	Evaluation Officer	Mission or AID/W Office Director
Name (Typed)	William Egan	Mamadou Konaté	Seydou Cissé	Julius E. Coles
Signature	Egan 19 Feb 91		Seydou Cisse	Julius E Coles
Date	02/12/91		1/29/91	2/21/91

AID 1330-5 (10-87) Page 1

ABSTRACT

H. Evaluation Abstract (Do not exceed the space provided)

The project aims to help the Organisation pour la Mise en Valeur du Fleuve Sénégal (OMVS) establish and strengthen a self-sustaining groundwater unit, the Cellule des Eaux Souterraines, in Saint-Louis, Senegal. This final evaluation was conducted by a team of independent experts on behalf of USAID, on the basis of a review of project documents (including progress reports, maps, charts, field installation reports, and the Final Synthesis Report), interviews and conferences with project personnel and concerned officials of OMVS and USAID, visits to numerous sites important to the understanding of the context of the various components, and interpretation of the data in the light of the experts' varied and broad experience. The purpose was to identify significant lessons learned in the establishment of the groundwater monitoring unit, and to assess the impact of the project on OMVS institutional capabilities. The major findings, conclusions, and recommendations are:

- A network of piezometers was successfully installed, largely by a private-sector firm, and readings are taken regularly by project staff.
- The computer program is vastly better than could have been foreseen in the Project Paper. However, Gestion Eaux Souterraines (GES) is a new program and is not yet fully "debugged".
- The closing of the Senegal-Mauritania border has precluded the kind of contact, collaboration and inspection of work that is necessary for the complete success of this international project.
- It is strongly recommended that OMVS mobilize the financial and technical resources as needed for continuation of the Groundwater Monitoring Unit (GMV) of OMVS and its current activities beyond PACD.
- Some of the computer hardware should be replaced as soon as possible.
- The GMU should endeavor to publicize its work and the GES system through dissemination of reports of data and analysis to potential users in the three member states, and to other interested persons and agencies.

The evaluators noted the following lessons:

- Alternative methods may achieve as much or more success than those planned in the Project Paper. Flexibility is desirable.
- Computers and computer programs are welcome technology, but successful establishment and sustainability require time to get new programs debugged, and call for training and support not only for use but also for maintenance of equipment.

COSTS

I. Evaluation Costs

1. Evaluation Team

Name	Affiliation	Contract Number OR TDY Person Days	Contract Cost OR TDY Cost (U.S. $)	Source of Funds
Robert M. Reeser Stergios Dendrou	Development Economist Group, a subsidiary of Louis Berger International, Inc.	PDC-0085-I-05-9060-00 Delivery Order	$49,780	Project

2. Mission/Office Professional Staff Person-Days (Estimate) 30

3. Borrower/Grantee Professional Staff Person-Days (Estimate) 20

A.I.D. EVALUATION SUMMARY - PART II

SUMMARY

J. Summary of Evaluation Findings, Conclusions and Recommendations (Try not to exceed the three (3) pages provided)
Address the following items:

- Purpose of evaluation and methodology used
- Purpose of activity(ies) evaluated
- Findings and conclusions (relate to questions)
- Principal recommendations
- Lessons learned

Mission or Office:	Date This Summary Prepared:	Title And Date Of Full Evaluation Report:
USAID/Senegal	December 14, 1990	OMVS Groundwater Monitoring Project Final Evaluation, dtd May 1990

I. Purpose of the Project

The OMVS Groundwater Monitoring Project aims to help the Organisation pour la Mise en Valeur du Fleuve Sénégal (OMVS) establish and strengthen a self-sustaining groundwater unit, the Cellule des Eaux Souterraines, in Saint-Louis, Senegal. The task of this Groundwater Monitoring Unit (GMU) is the Collection and analysis of piezometric data from a network of some 1,150 observation points, including 569 piezometers and 582 village wells distributed in the Delta region; the lower, middle, and upper valleys; and the Manantali region. The three-fold objective is to improve knowledge and understanding of (1) recharge-discharge relationships resulting from new flooding conditions associated with operation of the Diama and Manantali dams; (2) the effects of irrigation development, and (3) the potential for developing irrigation using groundwater.

II. Purpose of the Evaluation and Methodology Used

The purpose of this evaluation is (a) to identify significant lessons learned in establishing within OMVS a system to monitor and investigate potential problems of groundwater related to the development of irrigation and the operation of the Diama and Manantali dams, and (b) to assess the impact of the project on OMVS institutional capabilities, given personnel and funding constraints of the technical agencies of the Member States and of the OMVS.

This final evaluation was conducted by a team of independent experts on behalf of USAID, on the basis of a review of project documents (including progress reports, maps, charts, field installation reports, and the Final Synthesis Report), interviews and conferences with project personnel and concerned officials of OMVS and USAID, visits to numerous sites important to the understanding of the context of the various components, and interpretation of the data in the light of the experts' varied and broad experience.

III. Major Findings and Conclusions

The major findings and conclusions are:

* A network of piezometers was successfully installed, largely by a private-sector firm, and readings are taken regularly by project staff.

* Information about the network of observation points and the readings taken from them is recorded in a computerized system comprising three linked computers and the software programs Groundwater, SURFER and GES.

* Groundwater readings are entered in an automated (computerized) data base system (called Gestion Eaux Souterraines or GES) that was developed especially for this project. The GES system is a powerful, user-friendly system for entering and viewing data, quality control, data management, analysis and report preparation. Coupled with the program Groundwater, which handles historical information about the network, and the mapping program SURFER, the program is vastly better than could have been foreseen in the Project Paper. However, GES is a new program and is not yet fully "debugged." (In this document, the acronym GES is frequently used to refer to the entire complex of computer software used by GMU.)

* The hardware to support the program is in place, but one of the three computers should be replaced as soon as possible. Support in the form of repair of computers and debugging of software is not available locally.

* A good level of analysis has been performed, and will be reported in the forthcoming Synthesis Report, for the Delta region and Manantali. Similar in-depth analysis for the river valleys is needed. The GES system in the Groundwater Monitoring Unit (GMU) has analytical and modelling capability that can make great contributions to planning of river basin development.

* Training of nationals in USA and in France has been successful in terms of skills acquired by the trainees, but only one of three in each of those programs is currently with the project. The other trainees are working with the National Service of Hydraulics.

* The GUMU has been incompletely staffed since July 1988. The staff shortage has resulted in less analysis being done than is desirable, and has reduced the project's impact on national staff capabilities.

* Good documentation has been compiled and maintained throughout the life of the project.

* The benefits to be derived from collection and analysis of groundwater data adequately justify continuation of the program, and OMVS is pledged to do so. Budgetary stringency is expected.

* The closing of the Senegal-Mauritania border has precluded the kind of contact, collaboration and inspection of work that is necessary for the complete success of this international project.

IV. Major Recommendations

The major recommendations are:

* OMVS should mobilize the financial and technical resources as needed for continuation of the GMU and its current activities beyond PACD. During a transition period, while OMVS is preparing to assume complete responsibility for the operation, the needs will include temporary Technical Assistance support by a senior hydrogeologist and a computer specialist.

* Some of the computer hardware should be replaced as soon as possible. Maintenance of all such equipment must be assured by enhanced repair capability within OMVS.

* Additional professional (analytical) and technical (equipment maintenance) staff are sorely needed and should be obtained. Hydrologists from the National Services of Hydraulics should be assigned to the Central Office for tours of perhaps two months, for training and indoctrination, and also for evaluation as possible future full-time employees.

* A program of analysis and modelling should be organized spelling out specific studies intended. High on the priority list should be the imminence of need for and design of drainage in the Delta, and the potential availability of water for irrigation from underground strata in the Middle Valley and the Manantali area.

* The core samples collected during drilling of piezometers should be analyzed, to provide insights into the geological complexities of the Basin.

* The GMU should endeavor to publicize its work and the GES system through dissemination of reports of data and analysis to potential users in the three member states, and to other interested persons and agencies. GMU staff should also seek publicity through publishing articles in scientific journals and the popular press.

* A series of seminars in the member states should be organized and presented as soon as possible. The seminars should feature demonstrations of the GES systems, and discussions of how GMU outputs of data and finding can be utilized to benefit the Senegal River Basin and the member states.

V. Lessons Learned

Lessons learned from this project include:

Alternative methods may achieve as much or more success than those planned in the Project Paper. Flexibility is desirable.

Computers and computer programs are welcome technology, but successful establishment and sustainability require time to get new programs debugged, and call for training and support not only for use but also for maintenance of equipment.

Coordination of a project's activities with other agencies, and integration of inputs and outputs with such other agencies, is not likely to happen automatically. Outside help and direction may be needed to maintain broad perspectives and proper orientation.

Decentralized control of a project is quite possible, given delegation of both responsibility and authority.

Trainees should be contractually obligated to return to serve with the project or to the national technical service or activity linked to the project.

Advance guidance and direction of administrative and accounting procedures may help to keep the project "on track".

ATTACHMENTS

K. Attachments (List attachments submitted with this Evaluation Summary; always attach copy of full evaluation report, even if one was submitted earlier; attach studies, surveys, etc., from "on-going" evaluation, if relevant to the evaluation report.)

Evaluation Report.

COMMENTS

L. Comments By Mission, AID/W Office and Borrower/Grantee On Full Report

USAID/Senegal and the Organisation pour la Mise en Valeur du Fleuve Sénégal (OMVS) are very satisfied with the overall quality of the evaluation report. The report meets the demand of the scope of work and provides answers to questions posed.

While we are in general agreement with the findings, conclusions, recommendations, and lessons learned as articulated in the evaluation report, we have the following comment:

- OMVS should be able to assume now complete responsibility for the continuation of the Groundwater Monitoring Unit (GMU) and its current activities after seven years of project implementation.

** FINAL REPORT **

OMVS GROUNDWATER MONITORING PROJECT

(Project 625-0958)

FINAL EVALUATION

Prepared for USAID / SENEGAL

by

Robert M. Reeser
Agricultural Economist

and

Stergios Dendrou
Civil Engineer / Hydrologist

Development Economics Group

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Under
IQC Contract No. PDC-0085-1-05-9060-00
Delivery Order No. 5

May 1990

OMVS Groundwater Monitoring Project Evaluation
Final Evaluation

EXECUTIVE SUMMARY

The OMVS Groundwater Monitoring Project aims to help the Organisation pour la Mise en Valeur du Fleuve Senegal (OMVS) establish and strengthen a self-sustaining groundwater unit, the Cellule des Eaux Souterraines, in Saint Louis, Senegal. The task of this Groundwater Monitoring Unit (GMU) is the collection and analysis of piezometric data from a network of some 1,150 observation points, including 569 piezometers and 582 village wells distributed in the Delta region; the lower, middle, and upper valleys; and the Manantali region. The three-fold objective is to improve knowledge and understanding of (1) recharge-discharge relationships resulting from new flooding conditions associated with operation of the Diama and Manantali dams; (2) the effects of irrigation development, and (3) the potential for developing irrigation using groundwater.

This final evaluation was conducted by a team of independent experts on behalf of USAID, on the basis of a review of project documents (including progress reports, maps, charts, field installation reports, and the Final Synthesis Report), interviews and conferences with project personnel and concerned officials of OMVS and USAID, visits to numerous sites important to the understanding of the context of the various components, and interpretation of the data in the light of the experts' varied and broad experience.

The major findings and conclusions are as follows:

* A network of piezometers was successfully installed, largely by a private-sector firm, and readings are taken regularly by project staff.

* Information about the network of observation points and the readings taken from them is recorded in a computerized system comprising three linked computers and the software programs Groundwater, SURFER and GES.

* Groundwater readings are entered in an automated (computerized) data base system (called Gestion Eaux Souterraines or GES) that was developed especially for this project. The GES system is a powerful, user-friendly system for entering and viewing data, quality control, data management, analysis and report preparation. Coupled with the program Groundwater, which handles historical information about the network, and the mapping program SURFER, the program is vastly better than could have been foreseen in the Project Paper. However, GES is a new program and is not yet fully "debugged." (In this document, the acronym GES is frequently used to refer to the entire complex of computer software used by GMU.)

* The hardware to support the program is in place, but one of the three computers should be replaced as soon as possible. Support in the form of repair of computers and debugging of software is not available locally.

* A good level of analysis has been performed, and will be reported in the forthcoming Synthesis Report, for the Delta region and Manantali. Similar in-depth analysis for the river valleys is needed. The GES system in the Groundwater Monitoring Unit (GMU) has analytical and modelling capability that can make great contributions to planning of river basin development.

* Training of nationals in USA and in France has been successful in terms of skills acquired by the trainees, but only one of three in each of those programs is currently with the project. The other trainees are working with the National Service of Hydraulics.

* The GMU has been incompletely staffed since July 1988. The staff shortage has resulted in less analysis being done than is desirable, and has reduced the project's impact on national staff capabilities.

* Good documentation has been compiled and maintained throughout the life of the project.

* The benefits to be derived from collection and analysis of groundwater data adequately justify continuation of the program, and OMVS is pledged to do so. Budgetary stringency is expected.

* The closing of the Senegal-Mauritania border has precluded the kind of contact, collaboration and inspection of work that is necessary for the complete success of this international project.

<u>Lessons Learned</u> from this project include these:

Alternative methods may achieve as much or more success than those planned in the Project Paper. Flexibility is desirable.

Computers and computer programs are welcome technology, but successful establishment and sustainability require time to get new programs debugged, and call for training and support not only for use but also for maintenance of equipment,

Coordination of a project's activities with other agencies, and integration of inputs and outputs with such other agencies, is not likely to happen automatically. Outside help and direction may be needed to maintain broad perspectives and proper orientation.

Decentralized control of a project is quite possible, given delegation of both responsibility and authority.

Trainees should be contractually obligated to return to serve with the project or to the national technical service or activity linked to the project.

Advance guidance and direction of administrative and accounting procedures may help to keep the project "on track."

The <u>major recommendations</u> are:

+ OMVS should mobilize the financial and technical resources as needed for continuation of the GMU and its current activities beyond PACD. During a transition period, while OMVS is preparing to assume complete responsibility for the operation, the needs will include temporary Technical Assistance support by a senior hydrogeologist and a computer specialist.

+ Some of the computer hardware should be replaced as soon as possible. Maintenance of all such equipment must be assured by enhanced repair capability within OMVS.

+ Additional professional (analytical) and technical (equipment maintenance) staff are sorely needed and should be obtained. Hydrologists from the National Services of Hydraulics should be assigned to the Central Office for tours of perhaps two months, for training and indoctrination, and also for evaluation as possible future full-time employees.

+ A program of analysis and modelling should be organized, spelling out specific studies intended. High on the priority list should be the imminence of need for and design of drainage in the Delta, and the potential availability of water for irrigation from underground strata in the Middle Valley and the Manantali area.

+ The core samples collected during drilling of piezometers should be analyzed, to provide insights into the geological complexities of the Basin.

+ The GMU should endeavor to publicize its work and the GES system through dissemination of reports of data and analysis to potential users in the three member states, and to other interested persons and agencies. GMU staff should also seek publicity through publishing articles in scientific journals and the popular press.

+ A series of seminars in the member states should be organized and presented as soon as possible. The seminars should feature demonstrations of the GES system, and discussions of how GMU outputs of data and finding can be utilized to benefit the Senegal River Basin and the member states.

PROJECT IDENTIFICATION DATA

1. Countries: Senegal, Mauritania and Mali (OMVS)

2. Project Title: OMVS Groundwater Monitoring

3. Project Number: 625-0598

4. Project Dates:

   a. First Project Agreement: August 1983
   b. Final Obligation Date: FY 87 (June 30, 1988)
   c. Most Recent PACD: June 30, 1990

5. Project Funding:

a.	A.I.D. Bilateral Funding (grant)	US$ 6,501,000
b.	Other Major Donors:	US$ 0
c.	Host Country Counterpart Funds	US$ 650,000
	Total	US$ 7,151,000

6. Mode of Implementation:
   AID direct contract with ISTI (Technical Assistance)
   Personal Service Contract (Technical Assistance)
   PASA with USGS (Technical Assistance)
   Host Country Contract with SAFOR
   (Piezometer Network in Senegal and Mauritania)
   Force Account Contract with DNHE (Mali)
   (Piezometer Network in Mali)

7. Project Designers:
   AID/Dakar, River Basin Development Office, and
   REDSO/Abidjan

8. Responsible Mission Officials:
   Mission Directors: David Shear, Sarah Jane Littlefield, Julius Coles
   Project Officers: Hugh Smith, John Anderson, William Egan

9. Previous Evaluation:
   No previous evaluation of the project.
   Evaluation of Location, Construction and Installation of Piezometer Network, Feb.- Mar. 1989

Table of Contents

List of Figures

ACRONYMS AND ABBREVIATIONS USED IN THIS REPORT

AGOC	Agence de Gestion des Oeuvrages Communs (in OMVS)
BRGM	Bureau de Recherches Geologiques et Minieres
CEFIGRE	Centre de Formation Internationale a La Gestion des Ressources en Eau
CGA	Card for color on computer monitor
CIEH	Comite Inter-Etat d'Etudes Hydrauliques
CNRADA	Centre National de Recherche Agronomique et de Developpement Agricole (Mauritanian equivalent of ISRA)
CPI	Characters per inch
DNHE	Malian Direction Nationale de l'Hydraulique et de l'Energie
GERSAR	Groupement d'Etudes et de Realisation des Societes d'Amenagements Rurales
GES	Gestion Eaux Souterraines, a software program
GMU	Groundwater Monitoring Unit of OMVS
ISRA	Institute Senegalaise des Recherches Agricoles
ISTI	International Science and Technology Institute
IWME	Irrigation, Water Management and Engineering Office
KB	kilobytes
km	kilometer(s)
m	meter(s)
MB	Megabytes
mm	millimeter(s)
OJT	On-the-job training
OMVS	Organisation pour la Mise en Valeur du Fleuve Senegal
ORSTOM	Organisation de Recherche Scientifique et Technique Outre-Mer
PACD	Project Assistance Completion Date
PASA	Participating Agency Service Agreement
PC	personal computer
PIO/T	Project Implementation Order/Technical Services
SAED	Societe pour l'Amenagement et l'Exploitation de la Vallee du Fleuve Senegal
SAFOR	Societe Africaine de Forage
SONADER	Societe National d'Equipement Rurale (Mauritanian equivalent of SAED)
USAID	United States Agency for International Development
USGS	United States Geological Survey
WARDA	West African Rice Development Association

PREFACE AND ACKNOWLEDGEMENTS

In our evaluation of the Groundwater Monitoring project and in the preparation of this report, we have been aided in innumerable ways by a number of persons. We would like to express our thanks and appreciation to the following institutions and their personnel:

The USAID Mission in Dakar:- Irrigation, Water Management and Engineering Office: Mr. Gilbert Haycock, IWME Chief; Mr. William Egan, Project Officer; Mr. Jean Le Bloas, IWME Advisor; and Mr. Seydou Cisse, Program Office, for their support, assistance, encouragement, and confidence in our carrying out of this task.

The OMVS office in Dakar:- Mr. Babaly Deme, Director of the Departement des Infrastructures Regionales, and Mr. Bakary Ouattara, Deputy Director, for their kind assistance.

The Cellule des Eaux Souterraines, in Saint-Louis:- Mr. E. Ousmane Ngom, Chief; Mr. Denis Richard, Consulting Engineer, and Mr. Tim Rosche, Administrative Officer. Their help went beyond the call of duty.

All of these institutions and persons were fully cooperative and supportive, and their help greatly facilitated our work.

Robert M. Reeser
Stergios Dendrou

CHAPTER 1

INTRODUCTION

Final evaluation of the OMVS Groundwater Monitoring Project (625-0958) was undertaken in April and May, 1990.

PURPOSE OF THE EVALUATION.

The purpose of the evaluation was to follow USAID standard procedures in regard to closing out of projects of international assistance, but more specifically to identify significant lessons learned during the implementation of the project, lessons which may be of value in follow-on, related or other projects. A second purpose was to assess the impact of the project on OMVS and its several components in respect of their institutional capabilities, particularly with respect to the enhancement of those capabilities -- the underlying motivation for the original project.

QUESTIONS TO BE ADDRESSED.

The following questions indicate the concerns of the evaluation:

Has the project achieved what it set out to achieve? If not, why not? What constraints or problems were encountered? Were they foreseen or not? What steps were taken to accommodate or overcome them? With what success? Were the mitigating factors enough to rationalize or justify whatever shortfalls may have ensued? In retrospect, how could or should things have been done differently?

What lessons can be learned from this experience that can contribute to greater success and fewer problems for subsequent efforts or other projects, where some similarity such as subject matter, technology, target population, suggests transferability?

Of the original goals and purposes of the project, which of them remain to be accomplished? What should be done relative to these goals: should they be abandoned, or should some effort be made to achieve them? If the latter, then what should be done, and by whom? What roles should be played by USAID and other actors?

Are there circumstances or needs that have been brought to light by the work of the project which, although they may not have been a part of the project's original objectives, now appear to be important and worthy of follow-up effort? If so, what kind of activity, and by whom, is recommended to sustain the positive effects of the project to date, or to make use of resources or data made available by that effort? In other words, what follow-up actions need to be taken?

An alternative approach to the evaluation produces the following specific questions and topics to be addressed by the evaluation team:

- Review of the project's goals and objectives as set forth in the original Project Paper, and appraisal of the progress of the project toward achievement of those goals. Consideration of the relevance of those goals at the present time.

- Assessment of the effectiveness of the project and its current status, including what goals have been met or will be met by the Project Assistance Completion Date (PACD), and what goals will not be met. What action or support is needed, and by whom or what agency, to assure continuation of the activities undertaken and/or supported by the project?

- Regarding the aspects of the project that give it its unique place in the scheme of things -- the piezometer network, the data base, the trained personnel, the documentation, the institutional character -- evaluate and assess their adequacy and appropriateness, the efficiency of the project in achieving or providing them, their impact and their sustainability.

- Review the expenditure of funds, and recommend how any remaining and unexpended funds might best be utilized.

In this report, both sets of questions are addressed.

ORGANIZATION OF THE REPORT.

This Evaluation Report follows the format set forth in AID Handbook 3, Chapter 12, "Project Evaluation".

* Chapter 1 provides orientation as to purpose, questions to be addressed and report organization.

* Chapter 2 presents the context of the Groundwater Monitoring Project, including its economic, political, social, and technical aspects.

* Chapter 3 briefly introduces the members of the evaluation team and the methods used in the evaluation. .

* Chapter 4 contains the major technical findings of the evaluation, by task and according to relevance, effectiveness, efficiency, impact and sustainability.

* Chapter 5 presents the findings of the evaluation relative to project implementation and administration.

* Chapter 6 draws some conclusions from the evaluation findings, and points out some lessons learned.

* Chapter 7 provides general and specific recommendations to enhance the operation of donor programs in West Africa and to assist the development of the three nations, Mali, Mauritania, and Senegal.

* Appendices include reference material such as the Evaluation Scope of Work, the current Logical Framework, a list of all documents consulted, itinerary and list of pertinent contacts.

This evaluation report is written for the uninitiated in West African affairs; complete but succinct explanations are given when concepts are first encountered. Maps and figures are included so that the report is as self-sufficient as possible. Descriptions and explanations are based on project documentation and other authoritative material, on interviews with project personnel, and on-site visits. To the extent possible, the source of objective information is shown when it is presented; the evaluators do not pretend to have re-invented the wheel.

Interpretations and judgements in this report are those of the evaluating team, although, in some cases, by adoption or espousal.

Given the geographic, hydrologic, economic, political and social complexity of the Senegal River setting, some differences of opinion may be expected. An effort has been made to avoid basing major conclusions and recommendations of the study on controversial findings, and the authors believe that a strong base of support exists for the findings, conclusions and recommendations reported here.

CHAPTER 2

THE CONTEXT OF THE PROJECT

The original ideas for the Groundwater Monitoring Project are found in the recommendations of the Environmental Assessment Project (625-0617) in the late 1970s. This study, known as the OMVS environmental study by Garret Fleming, evaluated the overall environmental effects from the Senegal River Basin Development Plan. In particular, that study pointed to potential problems of "salination, changes in quantities of groundwater for recharge and contamination from pesticides and fertilizers." Further study and analysis are found in the report of George C. Taylor (October 1979), on the basis of whose recommendations this project was established.

A thumbnail sketch of the Senegal River and its tributaries is necessary here for a better comprehension of the political, technical, economic and social context of the project. A more detailed description of the Senegal River Basin and its geologic, hydrologic and climatic characteristics is pertinent to this evaluation and is included in Chapter 4.

The Senegal River and its longest tributary, the Bafing in Mali, have a combined length of 1,800 km. The system drains a watershed that covers an area of 218,000 square km in four countries, namely Guinea, Mali, Mauritania and Senegal (Figure 1).

Most of the rainfall and runoff occurs in the upper third of the watershed, in the Fouta Djalon Mountains of Guinea, and in Mali. The highest point on the river is at an altitude of 1,400 m. Upstream, the rivers have characteristics typical of mountain rivers, namely well defined banks in a narrow valley 1 or 2 km wide. Three tributaries serve to collect the waters of the upper watershed. The Bafing and the Bakoye join at Bafoulabe in Mali to form the Senegal River. The Faleme, which forms the boundary between Mali and Senegal, empties into the Senegal River near Bakel, where the borders of the three states join. Downstream from that point the Senegal River flows 800 Km to the ocean with a total drop in elevation from Bakel to the ocean of only 17 m. The lower basin covers only 1/3 of the area of the watershed and is mostly desertic. The middle and lower river valley is less well delineated and includes a floodplain that is up to 20 km wide.

The hydrologic regime of the river is driven by one rainy season per year, which may last from May through October in the upper watershed. The waters collected during that period are of a sufficient quantity over a relatively short period of time that a flood is generated. This flood, of variable strength and duration

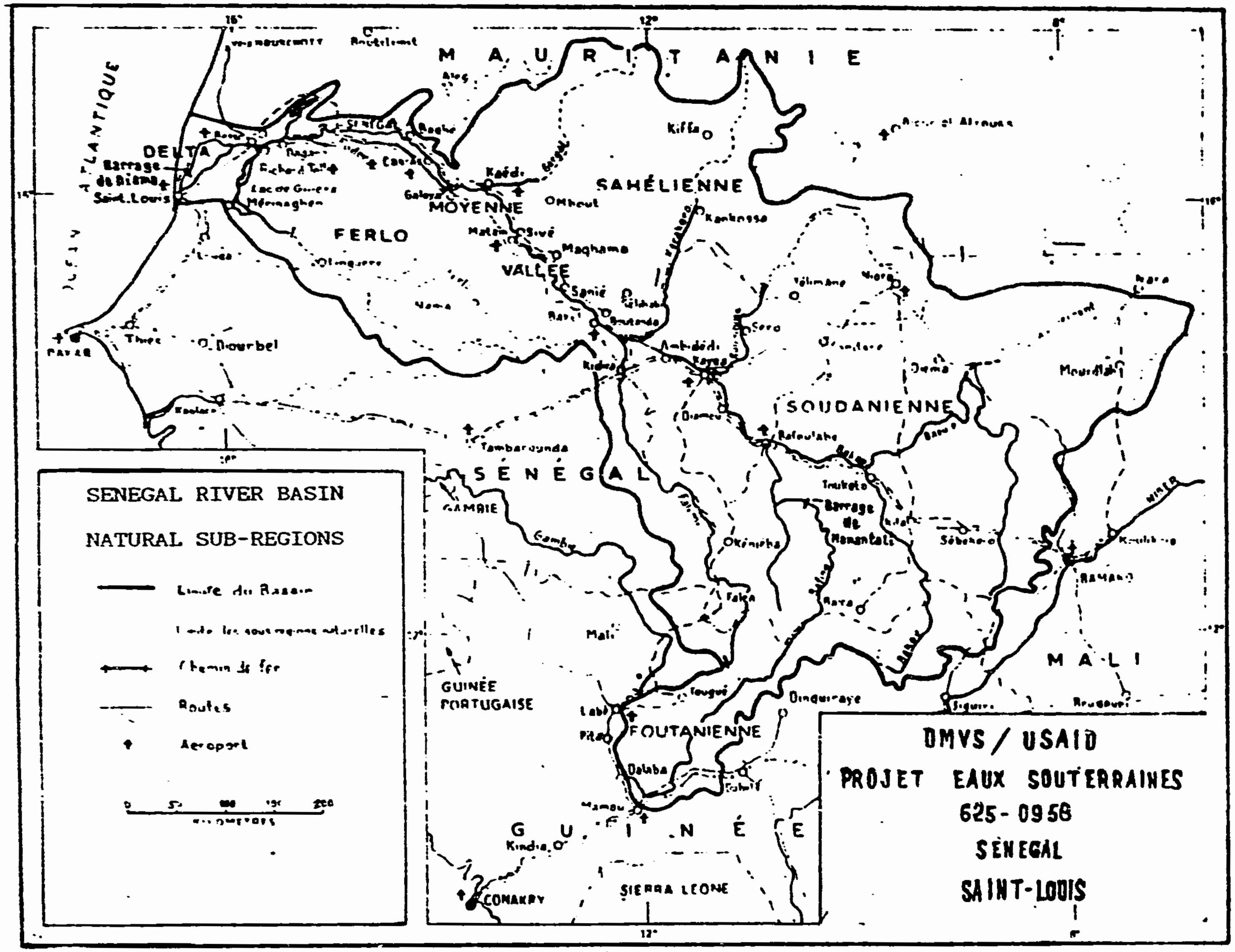

Figure 1. The Senegal River Watershed

Source: Files of Groundwater Monitoring Project depending on whether it is a wet, average or dry year, forces its way to the ocean at Saint-Louis. Along the way it fills all low-lying areas including the Lac de Guiers at the confluence of the Ferlo River, a seasonal stream in the desertic area of northern Senegal.

Only once a year does the Senegal River have enough volume of flow to reach the ocean. During the dry season, recession flows and bank storage upstream are insufficient to sustain the river flow past Podor. Over the practically flat Delta and Lower Valley, the absence of flow permits the ocean (if unobstructed) to creep inland as far as 250 km, near Podor.

From this quick description it becomes apparent that this yearly flood of the Senegal River is a valuable natural resource. To be sure, this resource has long been tapped, as witnessed by the operation of the Lampsar Marigot, which supplies water to the city of Saint Louis, and the Lac de Guiers, which has long been the source of part of the water supply for Dakar and with projected development will supply a larger portion. A system of dikes and floodgates allows the flood to enter, then the gates are closed to prevent recession (return) flows to the Senegal River.

The present-day management of the Senegal River includes the operation of two dams, namely the Manantali Dam in Mali, a reservoir barrage built on the Bafing tributary, and the Diama Dam, near the mouth of the river. The recently-completed Manantali Dam, designed to regulate the river flow and to provide hydropower, is in the second year of filling the reservoir, now a little over half full; the planned hydropower station has not been constructed yet. The Diama Dam is designed to eliminate saltwater intrusion and to control the river levels in the lower valley and the Delta. Benefits from the operation of the dams will include water supply, hydropower, greater navigability of the lower reaches of the river, and most importantly, agricultural development through flood control and provision of water for irrigation.

Institutionally, the management of the Senegal River Valley is administered by the OMVS (Organisation rour la Mise en Valeur du fleuve Senegal), an international organisation of Mali, Mauritania and Senegal. OMVS had no pre-existing entity dealing with groundwater, although the member states had some groundwater capability in their respective Ministries of Hydraulics. The Groundwater Monitoring Unit (GMU; French name Cellule des Eaux Souterraines) was established in OMVS, with its headquarters in Saint-Louis, Senegal. The creation of this permanent structure within OMVS was a condition precedent to the start-up of the Groundwater Monitoring Project, and the Project was attached to the GMU. The GMU is to take over the monitoring project at the end of USAID's involvement, and to move forward in extracting the full potential offered by the monitoring system.

The major economic impact of the monitoring project will be the anticipated effect on agricultural development, natural resources and biological diversity in the valley and the Delta of the Senegal River, and in the expansion of use of the groundwater resource in the Manantali region in Mali as it is affected by the dam. Institutionally, the major contribution of the Monitoring project is its support for the "Cellule des Eaux Souterraines." The project did not create the GMU, but the project provided funding and a program that enabled the GMU to become established.

Finally, the social impact of groundwater monitoring will devolve from the favorable impact on the entire gamut of development along the river valley. This development includes not only irrigated agriculture but also recession cropping, salinity and water-logging, fisheries and the diverse fauna and flora of the region, and local drinking water supplies. The resulting increase in agricultural production is expected not only to reduce the national food deficit, but also to contribute to stabilization of the population in rural areas, away from metropolitan centers.

CHAPTER 3

TEAM COMPOSITION AND STUDY METHODS

The evaluation team was composed of Dr. Robert M. Reeser, agricultural economist and team leader, and Dr. Stergios Dendrou, hydrologist and hydrogeologist. Both members of the team are eminently qualified for this evaluation.

Dr. Reeser has accumulated 18 years of experience in international development, and has spent several years as analyst for irrigation and water development projects. His familiarity with the geographic area derives from long-term assignments in both Senegal and Mali, and short-term work in Senegal, Guinea-Bissau, Mauritania, and Niger. His assignments in West Africa and elsewhere have included, in addition to technical work as an economist, the design, administration and evaluation of projects.

Dr. Dendrou brings to this assignment twenty years of unique experience in all aspects of water resources systems, management and exploitation, surface water and groundwater. He is principal developer of a three-dimensional groundwater flow and mass transport model with quick, interactive input data preparation from maps on the screen. He has experience in groundwater projects including contamination from pesticides and fertilizers, and he is completely fluent in French.

The combination of backgrounds and skills of the members of the evaluation team assures a fresh look at this complex and challenging project.

The methodology followed in the evaluation included the following techniques:

* Review of all documents of the project, from the Project Paper through periodic progress reports, other mid-term reviews and project evaluations, through drafts of the final "Synthesis Report".

* Interviews and conferences with project personnel and concerned officials of USAID and OMVS.

* Visits to sites important to an understanding of the context and interrelationships of the project components, including both Diama and Manantali Dams, numerous piezometer and observation well sites, and agricultural areas in the Delta and Lower Valley regions.

* Analysis of maps, tabulated and untabulated data, and reports and other documentary evidence from alternative

sources, to perceive relationships not expressed in narrative portions of the reports.

* Interpretation of the data and observations in the light of a framework of understanding of agriculture, development, hydrogeology, meteorology, bureaucracy, projects and their operation, and human nature, derived from a background of varied and broad experience.

In addition, there was much interaction among the project personnel and the evaluation team members, who discussed thoroughly many aspects of the project's importance, history, and present and future status. Conferences with USAID personnel, midway through the assignment, permitted a useful interaction with project officers before the report was drafted. Reactions to and comments on the draft report by project personnel and OMVS and USAID staff were duly noted in preparation of this final report.

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CHAPTER 4

TECHNICAL FINDINGS OF THE STUDY

BACKGROUND

The Groundwater Monitoring Project is in concept a massive undertaking of groundwater data collection over the length of the entire Senegal River. The area encompassed is 1,200 km long, reaching from the mouth of the river, which forms a delta covering an area of 4,344 square kilometers, to Manantali Dam. It includes the lower, middle and upper valleys, which are of variable width, from 20 km downstream to a few (2 to 5) kilometers upstream. This global approach to data collection is dictated by the institutional organization for the Senegal River (OMVS), and it is unique in that it encompasses many geologic formations.

Traditionally, a monitoring exercise is designed around one particular geologic formation, either to study its extent or to evaluate its properties and potential. In this case, since many different geologic formations are at hand, they have to be identified and treated separately. The only thread connecting the various geohydrologic regions of the Senegal River is the river itself, whose yearly wet season flood affects the hydrology of each formation.

Roughly speaking there are three major geographic areas to consider. They are, starting from the top of the watershed, the region of the Manantali Dam, the valley (which may be subdivided into upper, middle and lower), and the Delta. The most extensive hydrologic and hydrogeologic study and analysis of the data collected has been done in the Delta. A brief description of each of the three areas is given here, to provide a better understanding of the object and setting of our evaluation. Following that description, the planned and actual outputs of the project and the achievement of project goals are discussed according to the criteria of relevance, effectiveness, efficiency, impact and sustainability.

The Delta Region of the Senegal River

The Delta Region of the Senegal River is fascinating: at places it looks desertic, with sand dunes and little or no vegetation; at others it is like an oasis, green with active vegetation. And then there is the river, which after flowing generally due west for 250 km turns south to finally reach the Atlantic Ocean some 25 km south of Saint-Louis, bordered on the west by that sand-spit the "Langue de Barbarie" which keeps growing longer every year. (See Figure 2; the sand-spit is barely distinguishable.)

The river up to the Diama Dam is really a saline estuary. Before the Diama Dam, it was an estuary all the way to a point between Dagana and Podor.

Understanding the evolution of the Delta in geologic times goes a long way toward explaining its present day behavior and properties. The highlights of the geologic history of the Delta are presented here. (Sources: Audibert, 1984; the project's Synthesis Report Vol.2; and observations of the consultants). Over the recent history of the region -- "recent", geologically speaking, being in the last thousand or so centuries -- there have been at least three episodes of sea water intrusion resulting from the rise of the level of the Ocean. Some 100,000 years ago, the Delta was part of a gulf. The Senegal River flowed due west into that gulf, and the depositions of river-borne particles of that time were greenish sands that formed a stratum called the Inchirien. After a partial retreat, the ocean engulfed the Delta a second time around 40,000 years ago, and there were similar types of deposition. This was then followed 10,000 years later by a rather intense dry period corresponding to the Quaternary Glaciation. The sea level dropped to about 100 m below present sea level, and the Delta, then dry land, was covered by red dunes (forming a stratum called Ogolien) of eolian (wind-borne) origin. It is likely that the prevailing winds were from the north-northeast.

With the end of the glaciation period the sea level rose again gradually, eventually reaching a level 2.5 m above present sea level. A particularly wet period around 10,000 B.C. caused, among other effects, the formation of some lakes, attested by typical deposits of calcium encountered in some areas.

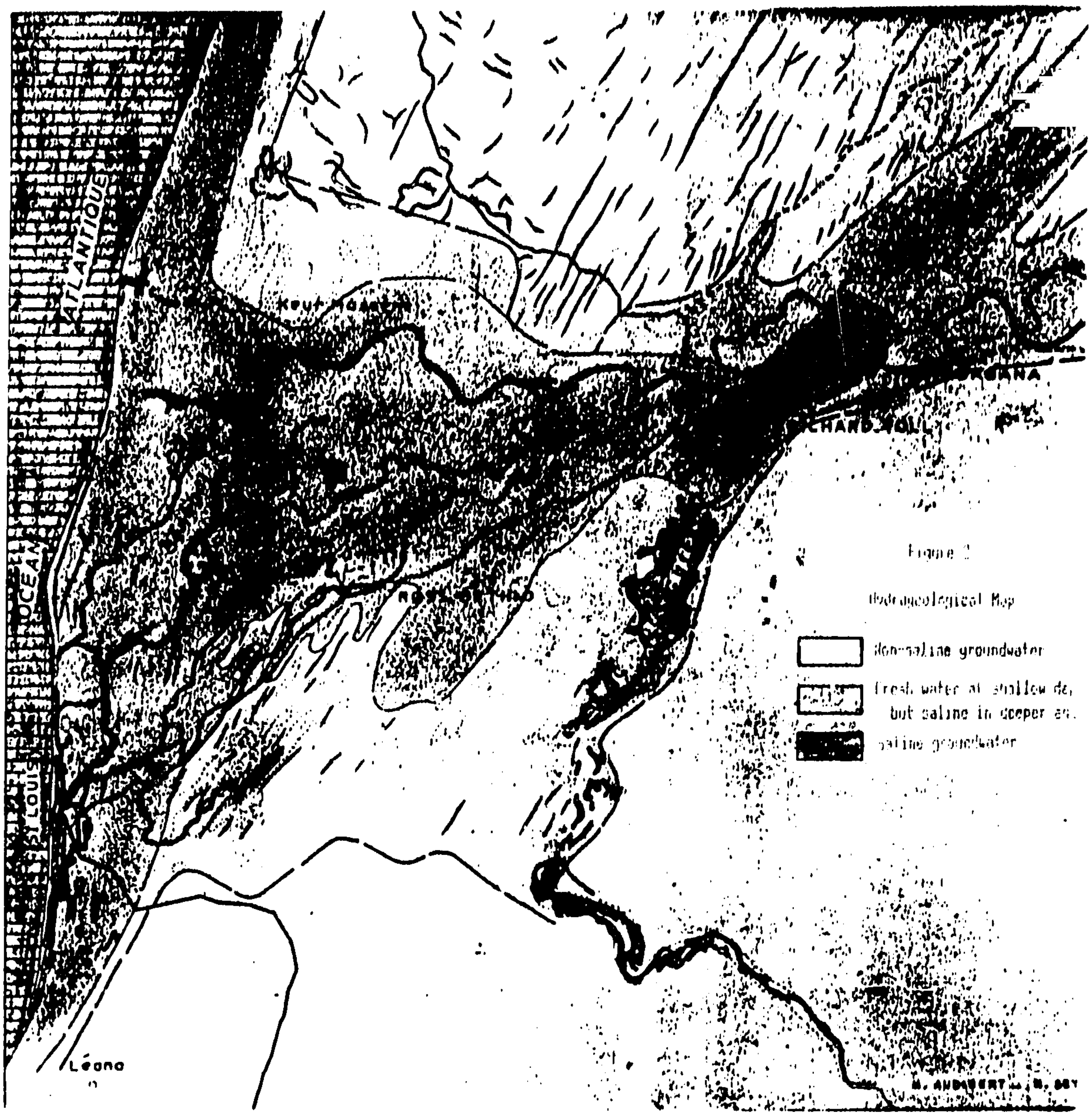
The last 2,000 years are particularly important in explaining the present-day landscape. During this period, the river's seasonal flood inundated much of the Delta, creating small lakes and other impoundments called "marigots". Silt and clay depositions helped stabilize these depressional areas, further isolating them from the underlying saline groundwater. In turn, further eolian deposition of sands from the Sahara to the north-east, along with strong northern littoral winds ("les alizes" or trade winds), caused the river to deviate to the south. The same forces created the Lampsar, the Gorom and the Djoudj Marigots, all aligned in a NE-to-SW direction.

The land area of the Delta can be separated into two zones: the zone that has been regularly inundated by the river, or Ouallo in the local language, and the zone outside that, which is called the Dieri. Clay layers, because of their river deposition origin, are found only in the Ouallo.

From this quick description of the historical evolution of the Delta, we can draw the following geohydrologic picture: the entire

Figure 2

Hydrogeological Map



Source:

Audibert, M. Delta du Fleuve Senegal: Etude hydrologique. 1970. (See Bibliography.)

Delta region, extending into the Ouallo, is underlain by saline water of marine origin. (The areas where groundwater is saline are shown in Figure 2.) Where evaporation acted freely, there resulted higher salt concentrations (in some places five times the concentration of the ocean). Some areas influenced by marigots and other surface waters are less saline. In a few places, isolated pockets of fresh water are found over clay lenses that are particularly impermeable (perched aquifers). However, trying to predict where those pockets (of small total volume) are, is tantamount to trying to perform magic; those found so far were found by accident or coincidence.

Potential evaporation in the Delta greatly exceeds the annual rainfall of less than 280 to 300 mm. Therefore, the entire system is driven by evaporation, and is influenced by the presence of surface waters which may be fresh if from the river, or more or less saline if they come from the drainage of irrigated perimeters. The effect of surface waters on groundwaters is very localized, the influence zone of the river, canals and marigots extending a few hundred meters according to an estimate by Audibert, or up to 2 km according to data collected in this study.

Water movement through the soil or through underground aquifers generally is more efficient vertically than horizontally. Underground water, like that on the surface, seeks its own level. However, within a few meters of the surface, evaporation of some of the water as it moves horizontally means that the front of underground water advancing outward from the river bed is at progressively deeper and deeper depths -- down to the bottom of the aquifer. This progressively greater depth to water is technically referred to as a decline of the piezometric level. When one views a cross section of the river and adjacent aquifers, the water present appears as a mound, with its highest point directly below the channel where it is fed or supplied. The use of the term "mound of water' refers to this phenomenon.

The difference in the estimated area of influence of surface water on recharge of aquifers is mostly one of definition, whether "influence" is considered to be a 10% or only 1% change in piezometric level. Fundamentally, evaporation tends to stabilize the progressing front of the mound of river water very quickly, within 200 m from the bank. Irrigation in an area reduces the normal evaporation losses of the local aquifer, permitting greater accumulation of water in the aquifer. Therefore, rise of the piezometric levels should be expected not only from the anticipated rise in river level behind the Diama Dam, but more importantly because of large scale irrigation.

Fundamentally, the movement in the aquifer is vertical rather than horizontal, because of the flatness of the entire Delta, the absence of gradients, and the predominance of evaporation. Left on its own, the Delta would be a predominantly saline zone.

Before serious attempts were made to manage the river waters, the yearly flood of fresh water barely covered the entire surface of the Delta (over 4,000 square km) and served only to feed the marigots and some isolated pockets of fresh water above clay lenses. The management of surface waters, first by the dike along the left bank of the river (the dike on the right bank is under construction), then by the Diama Dam, is providing a reservoir of fresh water for intensive irrigation purposes. As demonstrated at the beginning of the century by the Frenchman Richard, of Richard-Toll fame (the term means "Richard's farms"), even the most saline of soils in the Delta, if washed out first, can be used for crop production. Irrigation has been going on ever since in various perimeters of the Delta, and at an intensifying pace. As a result of this activity, the danger of the rise of the saline groundwater looms great.

The problem in the Delta is fundamentally one of surface water management: a network of canals is put into place to bring fresh river water for irrigation. Efficient irrigation and control of soil salinity requires the use of drains. At present, the drained (and more saline) water is returned to the river. As the scale of operation increases, this contamination will eventually negate the whole purpose of the management.

A master plan is needed for the management of the Delta surface waters, to avoid the accumulating salinity t at would end economic production of crops. One possible solution is a dual network of canals: one to distribute fresh water for irrigation, another to collect and convey all drained waters to a discharge point downstream of the Diama Dam (a zone entirely condemned to be saline). A draft master plan for surface water management of the Delta (Plan Hydraulique pour le Delta) has been proposed by GERSAR in 1989. A comprehensive Master Plan study should begin from and build on the findings of that study.

Two clay layers exist, one at an approximate depth of 0 to 5 m, the other deeper at 10 to 15 m. The thickness of these layers varies, and at places they thin out to extinction (where clay and silt were never deposited by the river floods). Clay layers tend to isolate water-bearing formations from one another. An interesting approach to control of salination would be to take advantage of the presence of this top layer by systematically flushing out the upper saltwater stratum (the one that would eventually salinate the root zone) with the excess water in wet years. The result would be a reduced need for drainage. The feasibility of the approach has not been tested, and the small horizontal transmissivity of the formations may render this approach impractical.

The Lower and Middle Valleys of the Senegal River
(from Richard-Toll to Bakel)

An excellent presentation of the upper valleys of the Senegal River is included in a document prepared by GMU Chief Ngom and Consulting Engineer Richard for presentation to the OMVS-CEFIGRE conference in France in April 1989. Some highlights are as follows:

The subdivision into Lower Valley (from Richard-Toll to Dagana), Middle Valley (from Dagana to Bakel), and Upper Valley (upstream from Bakel) shown in Fig. 3, is based on planning considerations for agricultural developments by the OMVS Cellule d'Evaluation et de Planification Continue. The division between the Middle and Upper Valleys is 25 km downstream from Bakel. At that point the river has the maximum sustained flows. Variation of the geology along the river valley is gradual. Most of the valley is underlain by an alluvial aquifer, 40 m deep on average and interspersed with clay lenses.

The after-effects of marine transgression are found up to Boghe. At one time the ocean reached that far inland, and from Richard-Toll to Boghe the groundwater, being partly of marine origin, is more or less saline. Analysis of the data shows that this aquifer alternatively rises and falls, being recharged by the rising waters in the River during rainy season flows, and then draining the excess water back to the river at low flow. This effect extends only to about 500 m from the river bank. Beyond that point, the progression of the front of the mound is counter-balanced by evaporation losses. In the lower parts of the Valley, the rainfall is less than the potential evapotranspiration. Upstream in the valley,, the amount of rainfall increases, and higher ground elevation puts the surface to the aquifer further underground, which reduces the effect of evaporation.

Intense agricultural development (through irrigation) can modify this picture: evaporation losses from the aquifer would be reduced, therefore the mound could progress farther away from the banks. If irrigation water were pumped from wells, then a piezometric head gradient could be maintained away from the river which would result in more rapid recharge of the aquifer.

Of course irrigation water could be pumped directly from the river. One potential advantage of pumping the aquifer is the reduced distance over which the water has to be transported. Another is the reduction of evaporation losses from canals, by avoiding long-distance conveyance of water by canals. Also, by maintaining lower piezometric levels, evaporation directly from the aquifer is reduced. This is because evaporation ceases at a certain depth, on the order of 4-5 m, depending on the soil.

Figure 3

Subdivisions of the Senegal River Valley

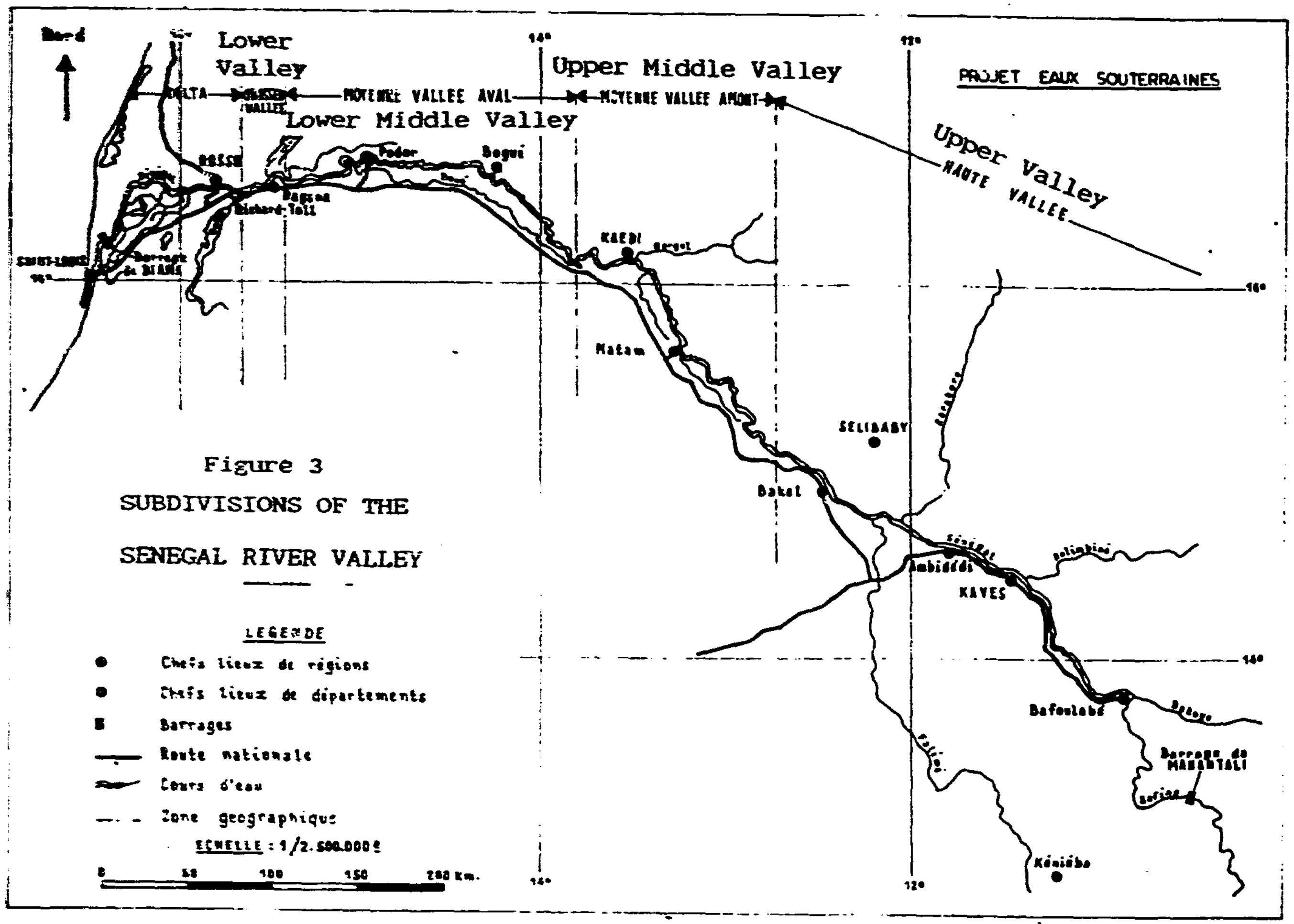


Figure 3
SUBDIVISIONS OF THE
SENEGAL RIVER VALLEY

Source: Files of Groundwater Monitoring Project

In sum, irrigation from groundwater, as was proposed by a Bechtel study in 1976, appears to be particularly promising for the river reaches between Bakel and Kaedi. Areas with sufficient transmissivity must be identified before embarking on a massive evaluation study.

Below Boghe the aquifer is more or less saline. Flushing out the saline water from the upper layers of the aquifer and replacing it with excess waters from the river during wet years may be a feasible and desirable alternative to consider.

All these alternatives seem worthy of investigation. A model should be used for that purpose, as outlined in the recommendations section. It would be the best way to maximize the returns from the extensive investment that the piezometric network represents.

The Manantali Dam Area

The Manantali Dam is built on the Bafing River. Bafing means black in the local language, and the river is so named because of the dark color of the water, derived from the iron-rich rock formations of the watershed and banks. The Bafing provides over half of the flow of the Senegal River, and collects its waters in the Fouta Djalon mountains, in Guinea, at an altitude of 800 m.

Hydrogeologically, in the Manantali area there are three aquifer formations: one layer situated above the future maximum reservoir level (which must have been feeding the Bafing through springs); a second, artesian formation (fractured pelites) with a typical piezometric head 1 m above the below-dam river level (which also feeds the river); and the alluvial aquifer below the river proper.

Unlike the Lower Valley of the Senegal River (at least below Kaedi), the aquifers in the Manantali Plateau are replenished by rainfall.

The network of 20 piezometers installed by the Malian Ministry of Hydraulics and Energy proved to be extremely efficient. All piezometers reached the targeted two upper aquifer layers. Data collected from these piezometers over the last two years have already shown that the effect of the waters in the reservoir, rising as it is being filled for the first time, has not propagated downstream of the dam. These data show a good response of the piezometric head to river level, corroborating the mechanism of aquifer replenishment from rainfall in the upper plateaus, and gradual draining into the river. Data collected from the three piezometers situated on the reservoir banks upstream of the Dam will show the amount and extent of bank storage. This bank storage will contribute to the storage capacity of the reservoir. On the other hand, evaporation losses will be important. At the dam, a figure was supplied of 1.8 m of water depth to be lost to evaporation annually, over a reservoir area of some 400 square km); other estimates are higher, over 2 m.

As a side remark, it can be conjectured that the increased evaporation will result in increased rainfall and therefore runoff. Such rainfall would not necessarily occur over the reservoir or the watershed of the Bafing River, but it might feed another tributary, for example the Bakoye or the Faleme, and thus not be completely lost to the system.

The network of piezometers is excellent and it is magnificently maintained and operated. Readings are taken every two weeks instead of the requisite monthly, and the network is operated at minimal cost as a one-man operation. It should be maintained in the foreseeable future.

On a more general level, it can be observed that groundwater is abundant in the region. A simple modeling exercise can show the extent and best location of wells to supply villages, including wells for villages recently relocated from zones that are now flooded. Abundant groundwater would also support irrigated agriculture, although marketing problems related to the distance from urban centers make the idea less attractive.

Other factors also favor development of this area. With the planned completion of the hydropower station in 1996, there will be plenty of cheap energy available locally. A canning industry, tied to irrigated farming, or some other industry that would benefit from cheap power, could be envisioned in the area. Eventually, of course, transmission lines will be built to carry electric power to the three capitals of Bamako, Dakar, and Nouakchott, but power should be cheaper at the source.

ACCOMPLISHMENTS OF THE PROJECT

The project output can be grouped in three major categories, namely the groundwater monitoring system, the set-up and training of staff for data collection and management, and the development of the capability for groundwater data compilation and management. The original Scope of Work was adapted and modified over the course of the study, as dictated by encountered "field" conditions, new technology that became available, and adjustment of study goals. The variance of actual from planned outputs and its documentation is discussed in Chapter 5. Here, two of the major products of the project are described and discussed: the piezometric network that was established, and the computerized database system GES that was developed for the management and analysis of the piezometric data.

The Piezometric Network

The observation network covers some 1151 spatial data points, of which approximately one half are newly-installed piezometers and the rest are selected pre-existing wells in villages. Determination of the location of the piezometers was based on the specifications of the Project Paper. The criteria were the following:

1/ a density of 1 piezometer per 100 hectares in the zone of the largest agricultural perimeters (shallow piezometers).

2/ along 10 transects of the Senegal River Valley (shallow, medium, and average depth), spaced at a distance of 10 km and above.

3/ average general density of 1 set of piezometers (all three depths) per 100 square kilometers.

4/ along transects a few hundred meters apart, near the Diama Dam.

5/ pre-determination of target aquifer formation that piezometer was to reach.

All criteria were satisfactorily met. Given the size of the study area (1,200 km long), this is a very representative network that can be useful for many years to come.

This sample is representative of the study area in another way that has not been exploited. The drilling of over 500 bore-holes produced the same number of core samples, which reveal -- or would reveal if properly studied and analyzed -- the geology of the sample area. The availability of these core samples gives the potential for a textbook-quality study of the geology of the Senegal Valley, without the problems and the cost of first taking samples. It would be a shame to discard a resource of such interest and potential value, without first extracting from it any further benefits that are available. These samples should be analyzed.

The network of piezometers was very carefully evaluated by Bolke (1989). He ran tests on several randomly selected piezometers, and was satisfied that they were properly installed and providing valid data. Vandenbeusch (1988) also evaluated the network and found it satisfactory. Visual inspection by the evaluation team at various sites concurs with the above findings.

The question has arisen as to the possibility of defining a limited size network for the purpose of reducing long-term operating costs. The preoccupation with cost is serious, and the idea merits some thought. It would be a pity to completely abandon any portion of the network. The entire network should be kept operational, including the networks of the upper valleys and the Manantali area.

It would appear that some cost savings can be achieved by training the crew of monthly inspectors (also known as Network Monitoring Agents) to achieve more with fewer people.

The Data Management System GES

The computerized data management system of the GMU comprises three elements: Groundwater, SURFER, and GES.

The program Groundwater records historical information about the observation points: location, depth, geological strata, etc.

The data management system GES (for Gestion des Eaux Souterraines) is of particular interest because of its unique features and its newness. Developed specifically for the GMU, it is written in the CLIPPER data base language. CLIPPER is a derivative of the well-known language dBase III+, but it is faster. The reason for selecting a higher order language (as opposed to BASIC, FORTRAN, PASCAL, or C) is that it already incorporates a family of standard functions for creating relational data bases, thus making the development of a system faster, more systematic, and therefore less prone to error.

The basic data are piezometric heads, streamgage elevations, meteorologic data (rainfall, temperature, wind), results of permeability tests, list of maps (the maps themselves are not saved in the computer, for example in raster form, but vectorized maps generated by the software SURFER are saved in the database), data of geologic formations and others. These data bases are interrelated by origin, e.g. piezometer identification number, date of data collection, range of level of observed value and others. Thus, these sources of information can be accessed for direct intercomparison and report presentation.

The GES system is entirely menu driven, so that all applications can be accessed from the screen with appropriate guidance and help-screens to elucidate the proper way of proceeding. An innovation in this regard consists of allowing the user to edit the help-screen and add his or her own remarks or instructions, thus making the help-screen more effective. A foolproof feature is included which prevents the user from accidentally erasing the already existing text. Some graphical software was also written in the PASCAL language specifically for this project. Data management and some analysis modules are incorporated in the system. No groundwater flow simulation module exists at this time in GES.

The software SURFER was installed on the recommendation of the consultant Hollway of USGS, who also provided training in the program's use. This is another instance where the broad-spectrum capability of USGS contributed importantly to the project. SURFER, as one element of GMU's computerization, provides the capability of making and printing maps showing the location of water data.

The entire system runs on a set of three computers, a Northgate 386 and two IBM XTs, each performing as an autonomous work station

and linked by way of the LAPLINK software. The hardware requirements are as follows:

1/ Central memory, 640 kB (preferably 1 MB)
2/ Graphics Card CGA
3/ Printer 17 cpi, 15 inches wide
4/ Hard disk 120 MB, to accommodate the ever-expanding database.

For recompiling and linking the program, the system should have the CLIPPER and PASCAL compilers.

Considering the adequacy of the equipment now in use by the GMU, one of the IBM XT computers shows signs of terminal wear; it should be replaced as soon as possible. In this replacement, consideration should be given to upgrading to a 386 machine, fully compatible with the Northgate computer. In the resulting setup, the Northgate could be dedicated to data management, data entry, and upkeep of the GES system, with the new computer dedicated to analytical work. In particular, it would be used to access SURFER and other application software.

The old IBM XT has minimal salvage value. If replaced, it should be turned over to OMVS, where it could be used for training purposes. Any intensive professional use is likely to result in early breakdown and termination of the machine's usefulness.

The system as thus upgraded should be able to carry the operations in the foreseeable future (1 to 2 years). Any future upgrades should be carefully examined in relation to future project needs, numerical modeling capability, graphical (map) interfaces and other conditions that will arise from a future study effort.

The GES system overall is efficient, robust (has fail-safe features), and extremely useful. It is also easy to use. Anyone who can learn the instructions of a word-processor should be able to learn this system also. It renders the product of this project, i.e. the vast set of data, alive and attractive. If properly disseminated (or advertized) it can create quite a following of interested parties from numerous other national agencies (for example, SAED, SONADER, DNHE, ISRA) or institutions like ORSTOM, CIEH Ouagadougou, etc.

The foregoing statement about GES is to a certain extent a statement of the goal, the target, rather than the reality. GES is a new program, and was developed for this specific use. It does not have the long history of user feedback and experienced-based refinement that necessarily goes into a computer program to make it entirely care-free. It can become everything good that has been said about it, but at present it is still a fragile system and it occasionally reveals problems in use. For example, during the visit of the evaluation team, a problem developed that the local staff (unassisted) was unable to resolve. Telephone contact with the designer of the program brought instructions that led to resolution of the difficulties, but this sort of thing can be expected to happen again, perhaps repeatedly, over the next several months. Access to the program's designer or someone with equivalent skills and knowledge of the program should be assured, so that GMU will be able promptly to cope with such difficulties, if and when they arise.

While several separate and distinct software programs are used by the GMU, they are commonly spoken of collectively as "the GES system." That usage is reflected in this report, which also uses the acronym GES to refer to the GMU's combination of programs.

QUESTIONS ADDRESSED BY GROUNDWATER STUDIES

The Project Paper describes (on page 16) the aim "to establish within the OMVS a system for monitoring and investigating potential groundwater problems.... The system will address:

a. Recharge/discharge relationships... (between the Senegal River and the aquifers);

b. Changes in the groundwater regime... (from the operation of the Diama and Manantali Dams);

c. Irrigation potential from groundwater in the Matam-Boghe sector.

d. Water quality in domestic and livestock wells, resulting from changes in river flow, irrigation and use of fertilizers, pesticides and other materials; and,

e. Groundwater dynamics, including water-logging and salination, in and around irrigated perimeters."

Neither these research topics nor results of the studies are mentioned as outputs of the project. The evaluation team construes this to mean that there was no obligation to perform the studies, but only to establish a system capable of doing so. The list of research topics constitutes a very ambitious program of studies, rendered even more formidable by the extent of the study area, from the Delta to Manantali some 1,200 km away.

The project has in fact made a great deal of progress toward answering these questions, and the tools have been developed to continue improving on the answers in the years to come. Each topic is discussed separately in the following section, and in the next section some recommendations for future work are offered.

Recharge/Discharge Relationships

This question is of primary importance in the Delta region, but it is also important in the Matam-Boghe sector. The major finding is that the effect of the river on the surrounding aquifers is limited to a narrow zone extending 200 to 500 m from the river banks. This should calm fears that the saline aquifers would rise as a result of increased levels in the river from operation of the Diama Dam. However, this appeasement or calming should not lead to complacency. The entire system, especially in the Delta, is controlled by vertical exchanges and by evapotranspiration. Increased irrigation will cause rise of the aquifer. Effective drainage of the perimeters must be provided. Further details are given in the discussion of studies needed for the future, in this chapter.

Changes in Groundwater Regime from Diama and Manantali Dams

The foregoing discussion leads to and supports the conclusion that the changes in the groundwater regime are not a direct consequence of the operation of the dams, but rather are a result of the increased irrigation. Expansion and proliferation of irrigated perimeters should be in compliance with a comprehensive master plan for the management of surface waters and groundwaters of the Delta. Such a plan should include a network of canals for irrigation, and canals for the evacuation of drained (saline) waters.

Irrigation Potential from Groundwater

Other than the fact that the limit of influence of the river on the aquifer does not extend beyond 500 m, the study did not further establish the potential for irrigation in the Matam-Boghe sector. The question, involving as it does not only water resources but also soils, topography, weather, human resources, markets, etc., is too complex to be appropriate for the scope of this study. The feasibility of irrigation using groundwater would be a very interesting topic for a future study, but the study should be of restricted geographic scope in order to be of manageable proportions. A Pilot Project approach is suggested.

Water quality considerations

The study of water quality in domestic and livestock wells, and changes resulting from changes in river flow, irrigation and use of fertilizers, pesticides and other materials is an aspect of the project that should also be left for future study. Such an effort, like the foregoing one, should be of manageable dimensions; a pilot study would be a reasonable way to start.

Groundwater Dynamics, Salination and Water-logging near Irrigated Perimeters

This is among the most crucial problems affecting agricultural development in the Delta, and the importance of its being properly and adequately addressed can hardly be overstated. The problem needs to be addressed both at the level of individual perimeters and at the level of the overall water supply and evacuation framework for the Delta. The first of these concerns can be addressed by GMU, as is further discussed under Modelling. An integrated Master Plan is needed for water management in the Delta, addressing the supply of fresh water via a system of canals, and also the disposal of the drained, more saline water. Development of such a plan should involve diverse viewpoints and multiple agencies. Ideas on the formulation of such a study are given in another section of this chapter.

STUDIES NEEDED FOR THE FUTURE

Environmental Impact of the Dams.

The consequences of raising the level of the lower reaches of the Senegal River include inundating certain areas now above water level -- except where protected by dikes. The world-famous bird refuge at Djoudj is one area that will be affected. Concerns are being expressed that the flooding of additional land now used as nesting sites will have an adverse impact greater than was foreseen earlier. A comparable park in Mauritania will be similarly affected. Such concerns should be put to rest, or else corrective action taken, depending on the findings of a study. Both the effect on nesting sites and probable bird population, and the consequences for agriculture and the quality of life if bird populations are decimated, should be investigated.

Analysis of Core Samples.

While the geology of the valley is of far less concern to this study than the hydrogeology, the core samples produced in the drilling of more than 500 bore-holes represent a resource of both academic and practical interest. Effort should be made to locate an interested institution, and to arrange for the analysis and interpretation of these core samples and the reporting of the geological cross-section of the Senegal Valley which they represent.

Groundwater Modelling.

Modeling was suggested by BRGM in 1988, and the use of a specific model was proposed. Later, a USGS consultant recommended against modelling on the grounds that the proposed model was inappropriate and that insufficient time remained to develop a suitable model.

There are two fundamental prerequisites for a successful modeling effort, in addition, of course, to the time and resources for it: a good understanding of the physical system at hand, and a good understanding of the problems or questions that the model will be called to answer. Both elements are very important, because the level of understanding of the physical system dictates the choice of model, while the level of detail required and the questions asked determine which processes must be included in the model.

In view of the level of understanding of the hydrogeologic environment reached from the data collected of this project, and with a clear perception of the problems that need to be addressed, the evaluation team recommends that a systematic modeling effort be undertaken. As a first step, fence diagrams can be drawn, to give a pictorial representation of the various stratigraphic formations.

The modeling effort should be the object of a comprehensive study directed by the OMVS (with funding from any reliable source or combination of sources). The study should address all areas of the Senegal River valley, so as to achieve economies of scale. Each of the three major areas of the river basin has its own set of physical processes and relevant questions. These are as follows:

For the Delta: The scale of groundwater influence is small, the size of one or two irrigation perimeters. The predominant movement is vertical. The model should be three-dimensional and should include the processes of evapotranspiration, percolation (with perhaps the need to incorporate the unsaturated zone), and the capability of simulating the effect of drains. The model will be used to determine optimal location and size of drains in relation to depth of irrigation, so as to control the rise of the saline water table.

The larger scale problem in the Delta is that of the management of surface waters, irrigation waters, and the more saline waters from the drains. A master plan should be drawn to determine the network of canals for irrigation, and its mirror image for the disposal of the drained (saline) water. The appropriate scale for this model would be, for example, the entire left bank. The detailed groundwater models of the various perimeters will provide the flows that the network would be designed to evacuate. A larger-scale groundwater model may also be used to evaluate the feasibility of flushing out a portion of the saline aquifer where it is underlain by an impermeable clay layer.

The Delta is an area whose potential has been proven since the beginning of this century. Uncoordinated, piecemeal development, however, will reach, and probably has already reached, a point of diminishing returns. A large scale modelling effort such as is outlined here should be a top priority.

The modelling effort suggested here is not the same as an integrated master plan for water management in the Delta. Modelling and groundwater expertise should, however, be major components and contributors to such a plan. Cellule Apres Barrage (CAB) should be involved, and possibly would be an appropriate agency to coordinate and direct the development of such a plan. The suggested plan has features in common with the 1989 proposal of GERSAR for a "Plan Hydraulique pour le Delta". The effort of GMU along this line should be complementary rather than competitive with other planning efforts.

For the Upper, Middle, and Lower Valleys. The hydrogeologic scale here is larger. The processes are predominantly transverse to the river axis, with (in general) small expected variation longitudinally.

A model would encompass a reach about 10 km long, and a width up to 5 or 10 km, in order to include most of the land suitable for irrigation development. The question that this model will be used for is the feasibility of pumping water for irrigation from the aquifer. The aquifer will be replenished from the river by maintaining an outward gradient. The advantage of this scheme is reduced distance of transportation of the water for irrigation, and reduced evaporation losses.

Many such models can be set up in the valleys, starting in the most promising sector between Matam and Kaedi. Below Podor, the aquifer's salinity increases. The feasibility of flushing out the upper layers should be investigated -- again, by the technique of modelling.

For the Manantali Area. Groundwater is plentiful in the Manantali area. It is replenished, seasonally, by the abundant rain. A model would encompass an area large enough to include the upper plateau where most of the recharge takes place (an area of the order of 100 square km). The model could be used to determine best location and amount of water supply from wells for the various villages (recently relocated from the flooded zones). It could also be used for the determination of larger scale water use for agriculture or industry that the future availability of cheap energy may attract.

An evaluation should also be made of the bank storage resulting from the higher levels of the reservoir. This storage can offset some of the important evaporation losses (estimated at 1.8 m over approximately 400 square km of the reservoir). As an aside, the flows from tributaries such as the Bakoye and the Faleme should be monitored to detect any eventual increase in rainfall (and therefore runoff) from the increased evaporation.

This global approach to modeling has many merits. Institutionally, it is a proven way of carrying out large scale studies. It will allow economies of scale: one set of model software will be installed to be used in many applications. The repetitive character of the exercise offers the best means for efficient technology transfer: initial model set-ups will be carried out by experienced personnel, later applications can be entrusted to nationals (with appropriate supervision). Most important of all, the study will be designed to give real and practical answers to important questions about the development of the Senegal River.

Selection of the appropriate software is also a matter of importance. In the old days, data setup was manual and very time consuming. Weeks could be spent in data preparation only to find out that if it was possible to start over, things could have been done better. A model is no longer the solution algorithm alone; it is also the environment in which the data are prepared and the attendant graphical interface, because that dictates how easily a model can be used.

Finally, let us note that no technology is too advanced for a developing nation, especially as far as computer technology is concerned, because the problems and the questions are real, and the latest technology allows to find better answers more reliably and more economically.

The modelling effort envisaged by the evaluation team would no doubt involve and justify an entire project, inasmuch as an expatriate team and a multi-year effort would be required. It is recommended that the process of identification of a project and study of its feasibility, as steps to obtaining funding, should be undertaken without delay.

CHAPTER 5

PROJECT IMPLEMENTATION FINDINGS: OUTPUTS AND PROBLEMS

PLANNED AND ACTUAL OUTPUTS

The purposes and outputs to be achieved by the Groundwater Monitoring Project, as they were indicated in the Project Paper and the Grant Agreement, were as follows:

(1) a comprehensive master plan,
(2) a management information system for OMVS,
(3) a data compilation and analysis system,
(4) trained staff for implementation of the Comprehensive Master Plan, and
(5) a network of piezometers and observation wells.

The project was to supply long- and short-term technical assistance, technical and office equipment and construction materials, and was to support the overall program with personnel (including, specifically, the salaries of local staff of the project at the central office in Saint-Louis and the three sector offices), and operating costs of drilling the piezometers and establishing the observation wells.

In general, the project has achieved significant outputs and has been satisfactorily timely. In some cases changes were made in the outputs required, as time passed and the situation evolved. The five output categories are discussed in more detail below.

Master Plan.

The project output mentioned first in the list of outputs in the Grant Agreement was "A comprehensive master plan for monitoring and solving problems created by hydro-agricultural developments in the Senegal River Basin." That commitment, in retrospect, was excessive; monitoring was and is feasible, but to provide a plan for solving any number of as-yet-unidentified and unspecified problems, and that within the structure of the project, was overly ambitious, and as such it should not have been a part of the contract.

Work on the monitoring system went on apace; understandably, nothing was done on the master plan. A consultant from BRGM recommended that modelling be undertaken, and proposed a specific model. A contract amendment with ISTI was signed on 31 December 1988 which promised six reports; these reports apparently were to be in lieu of the Master Plan. The Bolke report, based on a consultancy in early 1989, recommended preparation of an interpretative report on hydrology of the basin as Phase II of the project. Bolke also supported elaboration of a groundwater model, as recommended by BRGM, as Phase III on the condition that it be found feasible in Phase II. The Weiss report, in draft later in 1989, recognized that too little time remained to achieve a master plan, or to undertake any serious modelling effort. Weiss recommended combining all technical analyses into one "synthesis report."

As for the six reports that were promised by ISTI in the contract amendment signed on 31 December 1988: less than a year later and with some nine months remaining before PACD, it was seen as "impossible in the project time remaining to do the extensive analysis and interpretation necessary to write six reports" (quoted from September 1989 draft version of E. Weiss' report of January 1990). Instead, a major report would be done which would have chapters addressing, perhaps in abbreviated form, the topics of the promised reports.

These recommendations were approved and adopted at project, OMVS and USAID levels in 1989, and the agreement was made official at GMU headquarters on January 30, 1990. This agreement constitutes a de facto deletion of the requirement of preparing a comprehensive master plan, substituting a Syntheses Report that would focus on the Delta. Thus, the Synthesis Report, when finally completed and submitted (it was still in draft at the time of evaluation), will meet the contractual obligations for the ISTI reporting requirements, as well as the requirements of preparing a comprehensive master plan.

With the Master Plan requirement deleted and its replacement requirement met, the first-listed Output is fulfilled.

__Management Information System__.

The term and the requirement for a "management information system" is somewhat ambiguous and subject to alternative interpretations: a "systeme de gestion" or a "systeme d'information." Whichever was meant, the requirement has been met.

A management system would be a sustainable, easily verifiable, probably manual, administrative and accounting system, meeting high standards and acceptable to USAID. Inasmuch as the GMU was a newly-created entity, starting out with an efficient and effective system was important.

This kind of a system of information for management has been installed. The system that is in use is basically a traditional accounting and record-keeping system, built around the "Accounting and Administration Procedures Manual," prepared by USAID. While computerization of records was attempted early in the project's history, that approach was abandoned because of competition for the limited computer capability. The decision to use a traditional, manual system was wise, given that the system installed should be continued by local personnel after the departure of the TA personnel. The system has worked well, and the fact that audits by USAID's Controller reveal no major problem corroborates that statement.

An alternative and more commonly-accepted interpretation of the required management information system is a "systeme d'information," a mechanism whereby information (data, analysis, interpretation) collected or developed by the GMU is transmitted or passed on. Transmittal to other entities for which that information is of potential use or interest (such as Hydraulics Ministries, SAED, ISRA, WARDA, Cellule Apres Barrage, etc.) would be ideal, especially if the information system included (a) widespread awareness within the development community as to just what type of information is available through the GMU, and (b) feedback from recipients of information, that could help the GMU orient their analyses around the needs of their "clients."

Direct dissemination of information by GMU was undertaken, with distribution of information to the member states, but was not continued. Currently, GMU submits all technical reports and periodic progress reports to OMVS headquarters in Dakar, thus satisfying the second-listed output. Distribution beyond that point, to the member states and/or other agencies and organizations, is handled by headquarters rather than by the GMU. It is doubtful that maximum availability or utility of information to the potential users is being achieved. A parallel distribution system, with expectation of feedback to GMU, should be investigated and if possible undertaken.

Data Compilation and Analysis System.

The Data Management System GES was described and discussed in some detail in Chapter 4. Its adequacy for the task and its general suitability can hardly by questioned. A comment on this output, relative to what was foreseen at the time the project was planned, may be appropriate.

Recording of monthly readings on level and characteristics of water, taken from over a thousand observation points, would soon add up to a formidable data compilation and management problem. The requirement that the project establish a system for coping with this problem certainly was appropriate. However, it apparently was envisioned that the system would be based on manual record-keeping, for the Project Paper and Grant Agreement make no reference to or provision for a computer or a computerized data base such as has been installed and is in use. This was no doubt largely because then-available computer technology for such a system required larger and more costly equipment than the desk-top computers that, thanks to evolving technology, now accommodate the system. In this instance, the project output is much better and far more powerful than could have been foreseen.

An incident that occurred during the final evaluation provides a commentary on the GES system. The system broke down, in the sense that certain important functions could not be performed. Telephone communication with Louis Brunelle, who developed the software program, brought a FAXed message with instructions for resolving the difficulty. This scenario, which could happen again, suggests a need to keep open present channels of communication or to establish new channels, because local staff need support and are likely to continue to need it.

__Trained Staff__.

The fourth-listed output in the Grant Agreement is "Trained staff for implementation of the Comprehensive Master Plan." A requirement to train staff to meet unspecified and unknown needs would be unreasonable and perhaps unenforceable; like the master plan, it should never have been required. It can also be claimed that training for the needs of the master plan is irrelevant, given that there is no master plan.

What should have been required instead, and what the project has accomplished and provided, is trained staff for carrying out of the program of the GMU: maintaining and taking readings from the piezometer network, compiling and entering the data in the management information system, and analyzing and reporting the data.

The training program and the training inputs provided in achieving this level of output are worthy of comment.

The project inputs for training specified in the Project Paper were as follows: Long-term academic training in the U.S for three participants, long-term third country training for six participants (later reduced to three, for reasons of cost), and short-term training for research assistants and support personnel.

Training on-the-job was also to be provided, and the trained personnel were to be integrated into the project prior to its completion.

Following is a list of the persons who received long-term overseas training:

__In United States__: Graduate programs in Hydrogeology at Utah State University:

- Ousmane Ngom (Senegal), October 1985 - June 1988
- Soungalo Togolo (Mali), July 1986 - August 1988
- Moulaye Driss Ould Guih (Mauritania), Sept. 1985 - August 1988

Ousmane Ngom had another month of training in USA in July-August 1989, when he attended a week-long seminar on computer applications for groundwater and three weeks OJT in modelling at USGS.

__In France__, Training by BRGM, August - December 1986 in France, followed by on-the-job training January - April 1987 in country of origin:

- Toumane Diakite (Mali)
- Mouhamed Fadel Ould Saad Bouh (Mauritania)
- Mamadou Sarr (Senegal)

The hydrometristes were given a month of training and the controllers (who oversaw the installation of piezometers) 1 1/2 months in late 1986, in the respective sector offices. Lamine Sangare, sector chief in the Delta, and the Central Office secretary received 50 hours of training in Lotus and WordPerfect in Saint-Louis. The accountant received a week's training on office machines in Dakar and 40 hours on Lotus on the project computers. The photocopy man had two weeks of Xerox training in Dakar. English lessons have been provided for the secretary and the former Chef de Projet. For many employees, formal or informal on-the-job training has been provided.

Of the recipients of long-term training in USA, only Ousmane Ngom is currently attached to the project. Soungalo Togolo and Toumane Diakite are working with Ministry of Hydraulics in Mali. Mamadou Sarr is with Ministry of Hydraulics in Dakar. Mouhamed Fadel Ould Saad Bouh has been assistant sector chief in Rosso, Mauritania since June 1987.

Certainly, the training provided by the project has benefitted the trainees, and their improved capabilities have benefitted the project. However, it is to be regretted that so low a proportion of trainees has been retained in project service. The objectives of USAID include contributing to the trained national cadre, whether retained by the project or not. Clearly, those trainees who are serving in responsible administrative or technical posts in the governments of their countries, whether in or out of the project, are performing services useful to their countries. It has been accepted policy that even where returnees are contractually required to serve the project -- which was not the case here -- they will normally be released to work elsewhere in the government.

From the narrow and selfish viewpoint of this project, the training component of the project might be considered less than completely successful, because the needs of the GMU for more trained people in the Central Office was not met by the training program. In fact, however, it was not the intent that all the trainees should return to the project; GMU would not have been able to accommodate all of them. The current understaffing of GMU is more a function of needs of the national services of Hydraulics and/or budgetary stringency than it is a function of training.

However, strings tied to the training or clauses inserted into the contracts, to assure that the project's need for trained persons would be met, should be carefully considered by donors. It is far easier to relax those requirements, and to permit a trainee to take other employment, than it is to require him to return if that wasn't part of the original bargain.

Piezometric Network.

The network for observation of piezometric levels was described and discussed in Chapter 4. In view of multiple evaluations attesting to the adequacy of distribution, installation, quality control, etc., no more needs to be said; this output has been fully achieved.

With these interpretations and modifications of some of the original contractual obligations, it appears that all of the required outputs have been satisfactorily achieved.

CHANGES IN METHODS AND INPUTS

Although the planned outputs of the project were satisfactorily achieved, some of the means or the techniques by which they were achieved were at variance from those planned and described in the Project Paper. This section discusses the principle variances.

Source of TA Personnel.

The Project Paper was very specific about obtaining the long-term technical assistance personnel from USGS under a PASA agreement. However, it was not done that way. When the USGS person arrived, he could speak no French, and it became clear that he was not prepared to live and work in Saint-Louis. He returned to USA within a couple of weeks. USGS was unable to provide a replacement, so another source of personnel was sought. The contract was awarded to International Science and Technology Institute, which provided the services of Mr. Denis Richard, who served from January 1985 until the end of the project.

The Administrative/Finance Officer was to be supplied by USAID under local direct-hire arrangements. This procedure was effective. Mr. James Onofrey served from the inception of the project (June 1984) until March 1987. Mr. Timothy Rosche took over the post in May 1987, to serve until PACD. There was a two-month gap between the assignments of the two officers, but there is no evidence that the gap caused any serious problems, due in part to interim assistance provided by Alfred Schultz of USAID's Agricultural Research Project.

Short-term consultants were to have been supplied by USGS. Some 10 man-months of consultant time were supplied by ISTA (Brunelle, Migneault, Fortin), 6 by USGS (Bolke, Hollway, Weiss), and 1 1/2 by BRGM (Vandenbeusch). Use of ISTI as the primary source of short-termers was reasonable, given that the principal adviser was from that company, but several of the USGS consultancies provided inputs that were crucial, and more extensive participation by USGS would have been welcomed.

As to the qualifications and capability of the consultants who were brought to serve the project, considerable difference of opinion exists. In view of USAID's standard procedures for selection of personnel, whereby the qualifications of the candidates are circulated and the successful candidate must be found acceptable to all parties, all parties must accept a share of the responsibility for selection. Hindsight, of course, permits comparisons; naturally some consultants were better and more productive that others. It is pointless to dwell on the personalities, work habits, etc. of individuals.

One feature of the use of consultants appears at first examination to be out of balance. Several of the consultants made multiple visits to the project, staying for short periods and returning for another visit after only modest intervals. On closer examination, the multiple trips appear to be not junkets but visits fully justified by such considerations as progressive availability of data or computer equipment or trainee time, implementation of proposals made on earlier visits, etc.

A common criticism of USAID's personnel selection system, regarding the length of time required to define the need, draft the necessary documents, find the right person and to get him approved by all parties, and get him on board, applies to this project as well. As an example, from the brief visit of USGS' candidate for the Consulting Engineer post to the arrival of Denis Richard, nearly seven months elapsed. On the other hand, turnover in personnel, another common difficulty, definitely was not a problem in this project.

Vehicles.

The original plan and budget provided for rehabilitation of vehicles already possessed by OMVS. However, these vehicles were found to be in such condition that rehabilitation was not economic,
and new vehicles were obtained instead. Proper maintenance of these vehicles during the life of the project has resulted in their condition at PACD being such that, when they are turned over to OMVS, there will be a reasonable expectation of another couple of years of useful life before they need to be replaced -- assuming continuation of proper maintenance.

Piezometer Installation.

The original intention, expressed in the Project Paper, was that the network of piezometers would be installed by the OMVS using equipment supplied by the project, with crews and materials financed from the same source. Subsequently it was decided that the objectives of effectiveness and efficiency would be better met if the drilling and installations were done under contracts. That meant, in the cases of Senegal and Mauritania, contracts with private-sector firms. This decision was approved and supported by OMVS and USAID. The private-sector firm SAFOR was selected, and carried out the piezometer installations in Senegal and Mauritania. In Mali, the DNHE (Direction Nationale d'Hydraulique et de l'Energie) has conducted well-drilling operations for years, and was fully competent to perform the needed work, which they did with success.

The decision to do the work under contract was sound. The administrative burden on project personnel was thereby reduced significantly from what it would have been, and the private sector enterprises (drilling companies) were enabled to develop rather than state-supported entities. The impact on employment occurred in the private rather than the public sector, but its magnitude probably was not much different. The flexibility and pragmatism of OMVS and USAID in accepting such a change is to be applauded.

The decision to use contractors for installing piezometers came after the new vehicles were bought. More vehicles had been obtained than would have been essential for supervision of construction and subsequent operation of the network. As a result, the project had fewer transport problems than normal, and the vehicles at PACD are probably in better condition, given their age, than usually happens.

Staffing.

The staffing pattern of the project and the organization within which it operates has evolved over time; this was revealed by organigrams examined in Saint-Louis. The changes are for the most part related to modifications already mentioned, especially the contracting-out of piezometer installation and attendant reductions in need for directly-employed staff, or to normal rearrangements to improve efficiency.

One major staffing change came about in mid-1988 which deserves comment. There was long-standing disagreement over technical and other matters among the Consulting Engineer and the three Chiefs of the Central Office, such that these four technical persons in the project were not functioning as a team. To resolve the impasse, the head of the GMU and the Chiefs of Operations and of Data Collection were sent back to their home institutions by the OMVS High Commissioner. Ousmane Ngom was assigned as Chef d'Operations a few months later, and subsequently he was named as Chef de Cellule. The other posts were not and still have not been filled.

Inasmuch as the program of installing piezometers was largely complete by that time, dispensing with the services of the supervisor of that work was not completely unreasonable. Unfortunately, more was at stake than possible redundancies. Momentum was lost, and staffing has not been up to proper strength at any time since.

Before the High Commissioner's action was taken, the deterioration of working relationships resulted in virtual cessation of the technical advancement of the project. For several months, an expatriate served as project director. The new Chef de Cellule, when he arrived, had to "learn the ropes," and the Consulting Engineer's coaching him interfered with other duties. Institution-building effects were dealt a serious blow by reduction of qualified national professional staff of the central office, to only one person. Benefits to individuals, in terms of training from the experience of serving as counterparts to expatriate professionals, have been reduced, and the number and quality of analyses that could be done during the life of the project have also suffered. More difficult to appraise is the loss of momentum, loss of institutional presence, perhaps even loss of the critical mass necessary for survival of the GMU.

The Central Office of GMU has been able to function with an abbreviated local staff while it was fleshed out with two long-term expatriates and often one or two more short-termers; progress could be and was made. In the future, without the expatriate staff, important analytical work and the dissemination of technical information, which will be seen as the "raison d'etre" of the GMU, can hardly be accomplished with the staff that will be available. This is because of the priority that is given to administrative matters, which will leave insufficient time for analysis of data and preparation of reports. The ability of the GMU to continue to function, and its viability as an operational unit, are both in question because of the limited staff.

The GMU needs to have additional national personnel assigned. Long-term assignment of at least one more professionally-qualified person to the central office is seriously needed. In addition, or as an alternative if budgetary stringency dictates, hydrologists from the Nationmal Servicces of Hydrologists could be sent to the Central Office of GMU for periods of perhap[s two mopnths,durng which time they would learn about GES and how the data are processed and analyses propduced. Not only would this permits them to return to their home institutions as supporters of the utility and boosters for the use of GMU outputs, but they could be evaluated as potential full-time GMU staff members, for the time in the future when finances permit and demand requires more staff and increased output.

Expenditures

It is not within the competency of the evaluation team to do an audit of project financial records, but only to review and comment on more general aspects of costs.

The original budgetary allocation for the OMVS Groundwater Monitoring Project was US$ 4,651,000. This was later increased to US$ 6.501.000, as shown in the table, ure 4. Actual funds obligated for the project have been in line with the revised budget, and the amount remaining (unspent) as of the time of evaluation is approximately US$250,000.

The original budget was for a four-year project; the actual LOP will have been 6.5 years. Thus the cost per year has been less than foreseen: 1.0 million per year rather than 1.16 Million. On a per-year basis, actual costs for Technical Assistance were slightly higher that originally budgeted. Actual Operating Costs were somewhat less than budgeted, probably due at least in part to the under-staffing of the Central Office since July 1988.

The decision to install the piezometer network under contract, rather than by governmental agencies equipped and supplied by the project, led to changes in the cost structure. Under the original plan, equipment and materials would have been furnished by the project as Commodities, and other costs of the installation would be paid under Construction. Under contract installation, materials furnished by the contractor were included in Construction costs. This had the effect of reducing Commodity expense while expanding costs in the Construction category. The two categories combined show an increase of about 50%. Somé of this increase was due to unforeseen increases in the cost of materials -- increases that would have applied to US purchases of materials had the piezometers been done by project crews.

In the aftermath of staff reductions in 1988, is was seen as desirable to evaluate the work done and to review the project accounting to date. A USGS consultant (Bolke: see bibliography) inspected the piezometer network, and Price-Waterhouse reviewed the accounts of the SAFOR contract. Both reviews concluded on a positive note, with no major discrepancies or problems found.

The USAID Controller has periodically reviewed various aspects of accounting and administrative procedures of the project. The representative of the Controller's office stated that no complete audit or review had been done -- evidently because the level of review that was used revealed no justification for deeper inquiry.

As can be seen from Figure 4, amounts remaining in the pipeline and unliquidated as of the time of evaluation approach a million dollars, but much of this will be used up. Even an outsider can recognize that salaries are to be paid and the costs of the evaluation remain to be billed. The contract with SAFOR and certain other matters will not be finally settled until after

Figure 4

EXPENDITURES FOR
OMVS GROUNDWATER MONITORING PROJECT
(US$ 000)

Category	Original Total (4 yrs)	Budget Per Yr	Revised Total (6.5 yrs)	Budget Per Yr	Unliquidated May 25 '90
AID INPUTS					
Technical Assistance	938	235	1,640	252	297
Commodities	1,154	*	630	*	98
Construction	968	*	2,539	*	232
Other/Operating Costs	1,271	318	1,245	192	212
Training	320	*	387	*	15
Evaluation	0	*	60	*	57
Total	4,651	1,163	6,501	1,000	911
OMVS INPUTS					
Project Costs	551	138	650	100	
TOTAL INPUTS	5,202	1,301	7,151	1,100	

* Not meaningful on an annual basis

Sources: Project Paper
USAID/Dakar, Controller's Office

PACD, and it is not possible at this time to state with precision how much money will remain. The Project Administrative Officer estimates that it could be as much as $289,000, but only about $25,000 is now certain.

If enough time remains for accomplishment of further purchases, it is desirable that some of the funds that would otherwise go unused be spent to meet two already-identified needs: to replace one of the project's aging computers, and to bring in a computer technician for one last session of training of local staff in the GES software program. If that is impossible because of insufficient time remaining, so be it.

Another well-justified use of funds would be to support planning and staging of seminars in the member states. These seminars would provide an opportunity for GMU to disseminate figures and reports generated to date, to demonstate GES and what it will do, and to receive feedback in discussion groups on how the data and analyses can be used. The publicity generated by such an activity, and general and international recognition of the usefulness of GMU and GES, would help to generate support and to assure funding for future activities. Support needed for such seminars, however, includes: planning; determining the target audience and the list of invitees; arranging the venue, accommodations, and logistics; scheduling speakers, etc., as well as paying for travel costs, facilities and accommodations, and related expenses. Planning and staging such affairs is a skill in its own right, and GMU needs to have that kind of technical assistance provided to it.

Whatever amount remains after all project accounts are settled is subject to deobligation, but continued support of the project as described above would be a use of the funds that approximates much more closely the original concept and purpose of the project, if it can be arranged.

ADDITIONAL PROBLEMS ENCOUNTERED

Every project encounters problems, and this project is no exception. Some of the problems have already been mentioned; several others remain that are worthy of mention.

Vandalism.

The Project Paper foresaw a problem of vandalism. It is hard to understand why anyone would want to break open the locked cap of a piezometer; there is nothing inside than can be stolen or used, nor can water be obtained from it. Nevertheless, the caps are broken open, and sometimes materials such as sand are put into the wells, effectively destroying their utility. Continuation of a program of education is probably the only feasible solution; hopefully, when everybody understands why the piezometers are there and what their purpose is, the vandals will leave them alone.

Computer Repairs.

Computers, like other machines, break down occasionally. Usually they can be fixed, but repairs to a complicated thing like a computer cannot be handled by the local witch-doctor or auto mechanic. There are other computers in Saint-Louis, but not very many of them, and there is no local capability for repairs. The GMU's reliance on computers makes the Cellule very vulnerable. This vulnerability should be reduced or eliminated by taking steps to assure better computer repair capability.

The other user of computers in Saint-Louis, SAED, faced with the same problem, may have a solution that could be shared if the costs thereof are shared. Failing such a solution or the possibility of developing one, the only recourse would be to develop in-house capability: hire it, or train your own.

At this stage, it is not realistic to think of "in-house" as being within GMU; even OMVS/Dakar does not have full capability, although theirs is better than that of GMU/Saint-Louis. Their maintenance problem is largely resolved by the combination of their in-house computer specialist, Mr. Pape Sarr, and the local availability of computer specialists (private companies) in Dakar.

Mr. Sarr's qualifications should be upgraded by training on the hardware and software in use at GMU, and means should be found to get him to the scene promptly when his services are needed. It may be necessary to find an alternative to Mr. Sarr. Certainly it would be desirable, although perhaps impossible at this time, to have repair capability in Saint-Louis. In view of the almost-total breakdown of functioning of the GMU that would result from a breakdown of the computer system, high priority should be given to establishing a "lifeline" in the form of a system for coping with hardware problems.

Use of GES Software Program.

The software program GES that was developed especially for the GMU is a good program, and it has been functioning well. However, it is a new program, and the probability is high that there are still imperfections or "bugs" in it. Therefore, it can be expected that, over the next several months or years, problems will arise in the use of the program. The point here is not hardware, already discussed in the previous paragraph, but software. An operators' manual for the user of GES has been prepared, and it will be helpful, but given the size and level foreseen for the manual, there probably will be problems beyond its scope. Access to someone who can solve such difficulties will be needed when those problems arise.

An arrangement is needed whereby GMU can obtain advice and find solutions to computer software problems, lest the great potential benefit of the program be lost to the GMU. The difficulty of such arrangements serves to underline the importance of using standard "off the shelf" computer software wherever possible, and of installing special programs, where they are necessary, early in the life of the project, to permit thorough "debugging" while project staff are on hand.

Problems Resulting from Border Conflicts.

OMVS is an international organization, and the GMU to which the Groundwater Monitoring Project is attached is also an international unit. However, of the three countries that make up the OMVS, Senegal and Mauritania are currently involved in disputes that closed their common border a year ago. The regular contact that existed between the Central Office and the sector office at Rosso, Mauritania was possible to a limited extent for a while, but in recent months, no direct contact at all has been possible. Indirect contact, through postal service, has been less than satisfactory. All levels of administration have suffered, from personal contacts through submission of reports, to delivery of spare parts and supplies, to payment of salaries.

It is not even possible to determine the real extent of the problem, because personal visits and on-site inspections in Mauritania have not been possible. Even the close-out of the project at PACD will be complicated enormously. Yet, there is little or nothing that project personnel can do to resolve the problem, other than to be patient and do the best possible under the circumstances.

CHAPTER 6

CONCLUSIONS AND LESSONS LEARNED FROM THE FINDINGS

From the outset, the Groundwater Monitoring Project appeared to the evaluating team to be a good project, with a solid record of accomplishments and few problems. Increasing familiarity with the project and its history tempered the original optimism. The project is still a good project, and some of its achievements are excellent. However, there have been problems, and certain cautions remain for the future.

The conclusions presented in the chapter are derived directly from the findings, which are extensively discussed in Chapters 4 and 5.

The grouping and summarization here is intended to provide ease of reference. The Lessons Learned follow the Conclusions.

CONCLUSIONS

* The long-term Consulting Engineer was not supplied by USGS as foreseen in the Project Paper, but rather by ISTI. This change deferred the start-up of the project by about seven months. ISTI also supplied more than half of the short-term personnel.

* The project has successfully installed and operates a network of piezometers throughout the study area, from which readings are taken regularly.

* The installation of piezometers by a private-sector contractor in Senegal and Mauritania, although contrary to the intentions expressed in the Project Paper, was a sound decision and it was successfully carried out.

* Evaluation by consultants in 1989 confirmed that the piezometers were well located and properly installed.

* Core samples resulting from the drilling of piezometer bore-holes constitute a resource that would reveal much geological information is analyzed.

* The chronic problem of vandalism and damage to the piezometers is being addressed by a program of teaching. Villagers are being taught about the nature and purpose of the pipes and the holes, and how the program will benefit the villagers.

* The long-term training of nationals in USA produced qualified professional hydrogeologists, but only one of the three so trained is now with GMU. The trainees were not required by their contracts to return to serve the project, and it was not expected that the project or the GMU would be able to accommodate them.

* Third-country training (in France) has raised the skill level of the trainees, but only one of three persons receiving that training is now with the project. The other two are serving their National Services of Hydraulics, which as acceptable to the donor.

* The Central Office of GMU is inadequately staffed, and has been since July 1988 when three national engineers were sent back to their home countries, to resolve a problem of disharmony involving those three and the Consulting Engineer.

* Adding to the GMU staff, particularly at the professional (analytical) level, is very important to the unit's success and perhaps even to its survival.

* Good documentation has been compiled and maintained through the project.

* A powerful and user-friendly automated (computerized) data base system (Gestion Eaux Souterraines or GES) has been developed and installed, that is useful for entering data, viewing data and quality control, data management, analysis, and report writing. This program is supported by the other programs in use: Groundwater for geographic and historical data, and SURFER for mapping.

* Problems have been encountered with "bugs" in this new software program, and these problems are likely to recur for some time. Establishment of a system to cope with such problems, is sorely needed.

* A good level of analysis has been performed, and will be presented in the Synthesis Report, for the Delta region and Manantali. Similar in-depth analysis for the river valleys is needed.

* Data and analytical findings generated by the GMU are passed to OMVS, thus satisfying the basic requirement for an information system. Further dissemination is handled by OMVS. Interest in and need for the GMU's findings is known to exist. More active dissemination of data and findings will help to generate support for the GMU's work, and action to this end should be taken by OMVS.

* The hardware to support the computer-based information and analysis system is in place. Locally, computer repair service is not available. One of the three computers should be retired in favor of a new machine.

* The permanent groundwater monitoring capability represented by the Groundwater Monitoring Unit (GMU; the French name is Cellule des Eaux Souterraines) is a very important institutional contribution of this project. In the future, GMU should be tied to the agency in charge of management of the dams, AGOC.

* It is important that the network of piezometers be maintained and that the program of readings be continued, as the longer series of readings enhances the value of the data already acquired. The program should remain in place.

* The program of maintaining and reading the piezometers can be carried out with a limited crew and at relatively modest cost. Some further cost savings probably can be effected.

* While OMVS has pledged to continue the GMU and its activities, and plans to support it from revenues to be earned from water use charges and other income, a period of transition of perhaps two years can be expected before that system is in place. OMVS will need external support during that period.

* The computerized automated data base GES (for Gestion des Eaux Souterraines) in itself represents an important element of the success of this project. It is far better than the system foreseen in the project design.

* The GES system has analytical capability to address many questions and problems of Delta and Valley agriculture, and has already supplied some useful findings:
  -- Serious salinity problems are imminent in the Delta.
  -- Raising the river level will in itself have very little effect on the underlying aquifer, and that only in a rather narrow zone, but additional irrigation will raise the water table.
  -- Irrigation from pumped groundwater may be feasible in the Matam-Boghe sector.

* Further study and analysis using modelling would produce additional information of even greater detail and thus greater utility.

* The Synthesis Report, now in preparation, has replaced the Comprehensive Master Plan as a required output of the project.

* Other significant outputs contributing to project success include the piezometer network and the capabilities of trained personnel.

* The USAID-developed Accounting and Administration Procedures Handbook facilitated the establishment and following of a system of project administration that avoided problems and confrontations with the USAID Controller.

* The closing of the Senegal-Mauritania border has prevented normal contacts between the GMU's Central Office at Saint-Louis and the Mauritanian Sector Office at Rosso, and has resulted in serious inefficiencies at all levels of administration.

* The project, having achieved all its project outputs according to (revised) plans, must be adjudged a success.

LESSONS LEARNED

* Departure from even the most carefully laid plans may be not only necessary but also a wise choice. An example is the installation of piezometers by contractors rather than by attempting to develop institutional capability.

* The development and installation of a specialized software program (GES) took place in this project despite that there was no mention of it in the Project Paper and that it was not foreseen in the early stages of the project. The lesson is not that it can be done easily, for it cannot, but rather that major inputs of human and other resources are needed, and that such an effort should come early in the project, to give time to "work the bugs out" before PACD.

* Automated computerized systems are the kind of technology that would always be welcome, whether provided by USAID or another agency.

* Consultants and similar TA personnel must carry out their duties and discharge their responsibilities in a professional fashion. Technicians who depart from post of assignment without having completed the task for which they were sent there endanger the credibility of themselves, their employers, the project and the donor, and bring embarrassment on all concerned.

* The transfer of technology to nationals is of vital importance. Furthermore, the technology of use and the technology of repair must be linked; both must be provided if either is to continue for long. The technology of repair and maintenance for computers is likely to be ignored and left behind, but it is of vital importance that it be available on a level comparable to the capability for use of the machines.

* Coordination among projects having similar goals or otherwise related actvities is usually a good thing, regardless of the sources of funding. Such coordination is not automatic. Common goals of increased incomes and food production in the Senegal River Basin and similar sub-goals regarding irrigation, hydropower and navigation might have suggested coordination with other agencies/projects such as other OMVS entities, SAED, SONADER, CNRADA, ISRA, Technical Services of Hydraulics, ORSTOM, etc. Little or no such coordination happened in this case. It should be encouraged, and compartmentaliztion of projects discouraged, from the very beginning.

* Decentralization works. The GMU is managed from Saint-Louis, despite OMVS' headquarters being in Dakar. Delegation of responsibility and authority to personnel at the project site make it quite feasible for a project to be physically apart from top management, and to be successful.

* If the objective of training is to provide qualified personnel for the institution supported by the project, trainees should be contractually required to return for service with that institution after training.

* Qualifications of expatriate Technical Assistance personnel, for both long and short-term assignments, should be carefully examined for personal compatibility and language skills as well as technical competence.

* Good administration is very important to the success of a project. It can be fostered by careful selection of personnel and by establishing a good system of administration and record-keeping, as was done in this case with the use of USAID's Administrative and Accounting Handbook.

CHAPTER 7

RECOMMENDATIONS

One of the most serious tasks of any evaluation is to formulate a set of recommendations. They are serious business because they go beyond the operational details of the particular project at hand. They concern the continuation of the effort and the achievement of goals, after the end of USAID's involvement. They also may concern fundamental ideas for future studies or projects for the future, to facilitate the full development of the Senegal River corridor, and to extend to other areas or projects the technology that has been successful here.

The recommendations presented here derive from the findings of this evaluation. Most of them are discussed in some detail at the points where they are first encountered, in Chapters 4 and 5, so they are summarized here. Those that have not been mentioned previously are treated at greater length.

1. **Continuation of Program.** The monitoring of groundwater in the Senegal River Valley should continue for the foreseeable future.

2. **Functional Continuity.** The GES databases should remain under the present administrative arrangement, with a trained local OMVS expert in charge.

3. **Institutional Continuity.** The present Groundwater Monitoring Unit should be retained and continued as the institution charged with execution of the monitoring program. Within the OMVS organization, the GMU should be linked to the structure in charge of operation of the dams: AGOC, Agence de Gestion des Ouvrages Communs.

4. **Transition Period.** A transition period of perhaps two years may be recognized during which OMVS will attempt to establish funding and administrative arrangements with promise of continuity.

5. **External Support.** During the transition period, continued external support to OMVS will be needed. Such support should be supplied in three areas:
   - Maintenance and repair of computers.
   - Application and trouble-shooting of the GES software program, by supplying the services of a computer specialist.
   - technical assistance to the Cellule des Eaux Souterraines, in the form of a short-term expatriate senior adviser in hydrogeology.

6. **Increasing the size of staff.** At least one additional professionally-qualified person, a hydrologist or hydrogeologist, should be added to the staff of the Central Office, to assist with data analysis and report preparation and dissemination.

7. **Temporary Staff.** As a means of expanding and expanding public awareness of the work, outputs and potential contributions of GMU, the Central Office should receive hydrologists of member states' Services of Hydraulics who would be sent to Saint-Louis by their agencies, on a temporary duty or detached service basis, for periods of perhaps two months. Some training could take place, and candidates could be identified and evaluated for possible future employment at the Central Office, when financing permits.

8. **Hardware for the GES System.** One of the two IBM XT computers should be replaced as soon as possible. If possible, the replacement should be a 386 machine, fully compatible with the Northgate computer. The old IBM XT, if replaced, should be turned over to OMVS, to be used for training purposes.

9. **Maintenance of Computers.** The GMU's use of computer technology has its "downside" in that the entire operation can be paralyzed by a breakdown of the computer equipment. This vulnerability should be reduced to the extent possible by provision of repair capability. All options should be investigated; the best possibilities appear to be joint arrangements with other computer users in Saint-Louis, and upgrading the capabilities of OMVS/-Dakar's best employee(s) while also arranging for expeditious service from Dakar when it is needed.

10. **GES Software Program.** Every effort should be made to resolve residual difficulties in the operation and use of the GES software program, so that as of PACD the program will be fully operational.

It would be tragic if the showpiece that has been called "the major accomplishment of the project" were not even operational when the project ends.

11. **Groundwater Modelling.** Modelling is a useful tool, but it should be included in the activities of GMU as a tool, addressed to specific and relevant questions, rather than as a prestige-building exercise.

12. **Priorities in Modelling.** Fence diagrams constitute the first step in all areas. For the Delta, a three-dimensional model should be used to determine optimal size and location of drains. For the valley, models for areas of perhaps 50 to 100 square km should be used to study of the feasibility of pumping groundwater for irrigation. In the Manantali area, modelling could (a) determine best location and potential supply from village water wells; (b) evaluate the potential of groundwater for large-scale supplies for agriculture or industry, and (c) evaluate bank

storage for its possible contribution to the storage capacity of the reservoir.

13. **Planning for Modelling.** The modelling effort envisaged by the evaluation team would no doubt involve and justify an entire project, inasmuch as an expatriate team and a multi-year effort would be required. It is recommended that the process of identifying and describing a project and studying its feasibility should be undertaken without delay.

14. **Use of GMU Output in Planning Development.** The groundwater data and analyses already available and those to be forthcoming in the future can make real contributions to planning of agricultural development in the Basin, including the much-needed master plan for water management in the Delta, and the design of a pilot project/feasibility study of irrigation from groundwater upstream. Such use must be encouraged, by wider dissemination of data and findings, and the program of dissemination should begin with GMU initiative.

15. **Seminars.** A practical device for obtaining publicity and enhancing the popularity of and demand for the GES program and its output would be a series of seminars. Such seminars might feature presentation of the results of the study, demonstration of the model and how it is used, and thoughtful papers and discussion groups on application of this technology to problems of the Senegal River Basin. Seminars should be given at several locations, and in each of the member states: at Saint-Louis, Dakar, Bamako, and Nouakchott. Development of plans for such seminars should be a feature of the interim support to GMU by external sources of funding, and unspent funds from Project 625-0958 should be allocated to support of this activity if possible.

16. **Publications.** Another way to bring the GES program and its capabilities to the attention of potential users is through publications. Professional papers and popular articles alike should be used. The GMU should consider contributions to professional publications such as the National Bulletin Meteorologique, Bulletin Hydrologique, and others. Regular contributions could highlight recent findings, especially those related to season or other events.

APPENDIX A

Scope of Work for the Evaluation

2. Tasks:

A. Primary orientation for the evaluation team will come from an in-depth familiarity with the Project Paper, in particular Section III Project Description, Part C Project Components, Annex A Technical Analysis, and Annex D Logical Framework. The team will be responsible for reviewing the project's goals and objectives as set forth in the Project Paper and then appraising the project's progress toward the achievement of these goals.

B. In order for the evaluation team to be able to effectively perform their tasks, they will need to become familiar with the following:

(a) Piezometer network: criteria for placement and quality of construction to determine if the network is a viable tool to meet the technical objectives of the project.

(b) Data Base: State of computer capability and quality of data to evaluate its effectiveness as a tool for the storage, consultation and analysis of the data collected,

(c) Personnel: Degree of expertise and level of effort required by project staff member to determine if data collection and analysis is being conducted in an efficient and cost effective manner that will allow for its continuity (either through the Member-States or OMVS) after PACD.

(d) Documentation: Review all available documentation including the technical reports issued by project staff, quarterly progress reports, Bolke, Brunelle and Vandenbeush reports, etc..

(e) Implementing Agency: An understanding of the structure, administrative and political functions, and operational procedures of the Organisation pour la Mise en Valeur du Fleuve Sénégal (OMVS).

C. The evaluation team will carry out the following tasks:

* assess the overall current status of the project, and the progress made towards the achievement of objectives;

* determine what project goals have been met, what goals will be met by the PACD, and determine what goals require an extension of the PACD, for how long;

* identify the reasons for delays, and make recommendations for full achievement of all project objectives;

* recommend how the remaining project funds (after PACD) can be most effectively utilized;

• determine what recommendations can be made to help ensure the project's continuity after PACD;

D. In addition, evaluation team members should expect to conduct a field trip to visit several piezometer sites, conduct visits to the Saint-Louis and Rosso sector offices, and, if possible to fly to Manantali to visit the sector office there, as well as to fly over a large part of the Senegal River Valley to get an aerial perspective of the project area.

E. The evaluation report is to provide empirical findings to answer the above-mentioned questions, conclusions (interpretations and judgements) that are based on the findings, and recommendations based on an assessment of the results of the evaluation exercise. The evaluation report is also to provide lessons learned emerging from the analysis.

APPENDIX B

CURRENT LOGICAL FRAMWORK

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ANNEX D

PROJECT DESIGN SUMMARY

LOGICAL FRAMEWORK

Life of Project :
From FY 83 to FY 86
Total US Funding : $4.8 million
Date Prepared June 1982

PAGE 1

Project Title & Number Groundwater Monitoring Project (625-0-58

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Program or Sector Goal : The broader objective to which this project contributes : Goal: Increased incomes and food production in the Senegal River Basin.	Measures of Goal Achievement Goal: a. Income and production level targets based on OMVS projections (data collection will be facilitated by AID-financed IDP project).	Goal: a. Check of statistics compiled by OMVS and Member-States (data collection will be facilitated by AID-financed IDP project). b. At the beginning and end of project, socio-economic survey to be undertaken in project zone	Assumptions for Achieving goals targets : 1. OMVS will continue to command political and financial support from Member-States. 2. That USAID/RMDO and OMVS Member-States recognize constraints inherent to institutional-building and USAID financed advisor arrives as planned. 3. That competent nationals are recruited to fill all posts.
Sub-goal: Execution of projects in the OMVS Basin Development Plan, involving irrigation perimeters, dams hydroelectric power generation, ports and navigation.	Sub-goal: a. number of project implemented b. 85% of projects in accordance with basin development plans. c. 65% of projects achieving stated objectives by 1990.	Sub-goal: a. Copies of six-month Joint Review Program. b. Review of related Basin projects to insure application of data collected	

ANNEX D

PROJECT DESIGN FRAMEWORK

LOGICAL FRAMEWORK

Life of Project :
From FY 83 to FY 86
Total US Funding $4.6 million
Date Prepared June 1982

Project Title & Number : Groundwater Monitoring Project (625-[illegible]

Page 2

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Project Purpose:	Conditions that will indicate purpose has been achieved : End of project status :		Assumptions for achieving purpose :
To establish an effective monitoring and early warning system to identify current and potential problems and possibilities related groundwater development and management and to distribute information to Member-States.	a. Data compiled and analysed concerning water-logging, salination, water-quality, recharge-discharge, changes and irrigation potential and brought to attention of appropriate parties by completion of project (1987). b. Problems (e.g. pesticides and fertilizers) in groundwater identified and brought to attention of appropriate parties by 1987. c. Solutions to problems developed and tested as they are discovered.	a. Site visits b. Copies of reports; recordings and water analysis data collected. c. Site visits reports OMVS and hydrogeological evaluations.	a. Continued support for OMVS from Member-States and international donors. b. Systematic implementation of all planned monitoring and evaluations conducted as necessary. c. Planned monitoring and evaluations conducted as necessary. d. Criteria and personnel review for all project maintained. e. USAIDs and OMVS recognize realistic constraints and make necessary adjustment as work progress.

ANNEX [illegible]

PROJECT DESIGN SUMMARY

LOGICAL FRAMEWORK

Life of Project :
From FY 83 to FY [illegible]
Total US Funding $[illegible] mil.

Project Title & Number : Groundwater Monitoring Project (625-[illegible])

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Outputs: 1. Comprehensive Master Plan for monitoring and solving problems created by hydro-agricultural developments in the SRB. 2. Management Information System for OMVS. 3. Data compilation and analysis system. 4. Trained staff for implementation of Comprehensive Master Plan. 5. Network of piezometers and observation wells established in the Senegal River Basin.	Magnitude of Outputs : Outputs Indicators (by end of Project) Magnitude of outputs: 1. Plans established for the eight work components. 2. Data compilation for three work components and analysis for four work components. 3 Central staff of about 10 and field staff of about 30 technicians trained in US in-country. 4. [illegible] piezometers constructed by OMVS, 10 wells and 45 piezometers by contractor, and 20 piezometers constructed by the Malian DHNE.	a. Grants Agreement contracts between OMVS Member-States-site visits b. OMVS Saint-Louis Documentation Center Workshop Reports, records, correspondence and institutional visits; c. Deputy Director's reports, development plans, social and technical specifications.	Assumptions for achieving Outputs. a. TA and training programs effectively establish OMVS staff capabilities for project. b. Effective management of all activities of project c. All inputs supplied in a timely manner.

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ANNEX D

PROJECT DESIGN SUMMARY

LOGICAL FRAMEWORK

Life of Project :
From FY 83 to FY 86
Total US Funding $4.8 million
Date Prepared June 1982

Project Title and Number Groundwater Monitoring Project (625-0568)

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NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Inputs:	Implementation Target (Type and Quantity) :		Assumptions providing inputs
1. Technical Assistance			
2. OMVS Personnel	See Chapter V "Financial Plan"	OMVS Member-States and AID Records	AID Funds made avai.
3. Member-States Personnel			OMVS Budget receives continued support
4. Construction Materials			
5. Participant Training			No change in other donors' support.
6. Commodities			
7. Operating Expenses			
8. Evaluation personnel			

APPENDIX C

LIST OF DOCUMENTS CONSULTED

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No. 4:	20 Decembre 1986	-	27 Mars 1986
No. 5:	29 Mars 1986	-	28 Juin 1986
No. 6:	29 Juin 1986	-	30 Septembre 1986
No. 7:	1 Octobre 1986	-	5 Janvier 1987
No. 8:	6 Janvier 1987	-	30 Juin 1987
No. 9:	1 Juillet 1987	-	31 Decembre 1987
No. 10:	1 Janvier 1988	-	31 Mars 1988
No. 11:	1 Avril 1988	-	30 Juin 1988
No. 12:	1 Juillet 1988	-	30 Septembre 1988
No. 13:	1 Octobre 1988	-	31 Decembre 1988

No. 14: 1 Janvier 1989 - 31 Mars 1989
No. 15: 1 Avril 1989 - 30 Juin 1989
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APPENDIX D

ITINERARY AND LIST OF CONTACTS
In Senegal and Mali, April 25 - May 29, 1990

Wed. Apr. 25 Arrival in Dakar of Dr. Reeser and Dr. Dendrou

Thur. Apr. 26 In Dakar. Briefing in USAID/Dakar: William Egan, Project Officer; Gilbert Haycock, Director IWME; Jean LeBloas, Project Manager; Seydou Cisse, PRM. Meeting at OMVS: Babali Deme, Director of DIR, and Bakary Ouattara, Chief Hydrogeologist. Travel by car to Saint-Louis.

Fri. Apr. 27: In Saint-Louis: Meetings in OMVS, Cellule des Eaux Souterraines. Meeting with Jean LeBloas, USAID/Dakar; Ousmane Ngom, Chief, OMVS/DIR/Cellule Eaux Souterraines; Denis Richard, ISTI Hydrogeologist and Principle Adviser; Tim Rosche, USAID Administrative and Financial Officer; Louis Brunelle, ISTI computer expert; Emanuel Weiss, USGS expert in Hydrogeology.

Sat-Sun. Apr. 28-29: Study of project documentation

Mon. Apr. 30 AM: Demonstration of GES software program by Louis Brunelle.
PM: Visit to Diama Dam and inspection of piezometers
with Lamine Sangare, Sector Chief at Saint-Louis

Tues. May 1 Holiday: International Labor Day. Studied project documents and began outline of report.

Wed-Fri. May 2-4: Discussions with project staff, study of documents, progress on organization of report. Interview with Mr. Ouattara of OMVS/Dakar.

Sat-Sun. May 5-6: Trip to Manantali, Mali and return to Saint-Louis via chartered aircraft. Meetings with Mr. Garan Konare, OMVS, Chief of Dam Operation, and Moustafa Toure, Sector Chief, Monitoring Project. Visit to dam site and inspection tour of dam. Inspection of piezometers.

Mon-Tues. May 7-8: In Saint-Louis. Discussions with GMU staff. Drafting, printing and review of preliminary summary of findings.

Wed. May 9: Field trip to Podor by car, with Tim Rosche, Admin. Officer, and Lamine Sangare, Saint-Louis Sector Chief. Inspection of piezometers; observation of agricultural areas and development of irrigated perimeters. Return to Saint-Louis.

Thur. May 10: Trip to Dakar. Discussion in USAID office of preliminary Findings, Lessons, Conclusions, and Recommendations, with Haycock, Egan, LeBloas; Return to Saint-Louis.

Fri-Tues. May 11-15: In Saint-Louis. Drafting, review and discussion, revision of report.

Wed. May 16: Printed and made copies of Draft Final Report. Travel to Dakar.

Thur. May 17: In Dakar: Debriefing at OMVS for Deme and Ouattara.
Debriefing of USAID.
Discussion of program for finalization and translation of report.
Dr. Dendrou departed for USA.

Fri. May 18: Returned to Saint-Louis. Review and discussion of draft report.

Sat-Tues. May 19-22: In Saint-Louis. Review and discussion of draft report. Collection of additional information. Preparation of maps, completion of forms, etc. for inclusion in final report. Intensive revision and editing of draft report.

Wed. May 23: Travel to Dakar. Sessions with USAID personnel on technical aspects of the report.

Thur-Sun. May 24-27: In Dakar. Further sessions with USAID. Editing, preparation of executive summary, finalization of forms, maps, etc.

Mon-Wed. May 28-30: Receipt and incorporation of comment from OMVS. Printing, copying, binding and submission of Final Report.