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Information Systems Assessment: End of Project

Report No. 55

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Information Systems Assessment: End of Project

A Deliverable in Support of Task #3: Equitable Allocation of Water Resources

Report No. 55

Prepared by:

Tom S. Sheng, Ph.D.
Senior Water Resources Information Systems Specialist
Computer Assisted Development, Inc.

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Acknowledgements

The LIFE Integrated Water Resources Management Project (LIFE-IWRM) was a joint activity of the Ministry of Water Resources and Irrigation (MWRI) and the United States Agency for International Development (USAID). Program implementation was the responsibility of International Resources Group, Ltd. (IRG) and Development Alternatives Inc. (DAI) working directly with the Integrated Water Resources Management Unit (IWMU) of the WRMI.

This report was prepared with assistance and support of staff members from the project and IWMU. The purpose of the information systems subtask under Task No. 3 was to provide technical assistance, equipment, and training to 27 Integrated Water Management Districts (IWMDs) and five Irrigation Directorates to develop information systems to support equitable allocation of water resources at the individual districts and directorates.

The Information Systems Team of the project consisted of Eng. Alaa Abbas Helmy Hassan (IWMU), Eng. Hisham Saber Hassan Ali Shehab (IWMU) and Dr. Tom S. Sheng (CADI). Additionally, Eng. Soha Mohamed Mostafa (West Sharkiya) and Eng. Mohamed Hamed (IWMU) implemented the Maintenance worksheets; Dr. M. A. Abdel Khalek implemented the Water Quality Database; Eng. Safaa Khoudary Osman (IWMU) provided general information technology support and Project website maintenance; Dr. Mohamed Rami Mahmoud (MWRI) assessed the role of the Ministry Information Center (MIC) in supporting IWMDs and supervised the MIC staff in developing and upgrading the Water Level, Complaint, and Valuation databases; Dr. Hanan Mahmoud (MWRI) implemented the GWS groundwater database; and Eng. Magda Hassan (MWRI) improved and provided support for implementing the Matching Irrigation Supply and Demand Database (MISD). The following MIC staff members also participated: Eng. Eid Ramadan with maintenance training, Eng. Sanaa Yahyaa with GIS and map preparation, Eng. Ebtisam Hassan with the development of the water level database; and Eng. Anmira Helmy with the preparation of the violation and complaints database.

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Acronyms, Abbreviations, and Measurements

AAU	Agricultural Administrative Unit
ADSL	Asymmetric Digital Subscriber Line
AED	Academy for Educational Development
BC	Branch Canal
BCWUA	Branch Canal Water User Association
CADI	Computer Assisted Development, Inc.
CDIAS	Central Directorate, Irrigation Advisory Service
DAI	Development Alternatives, Inc.
DEM	Digital Elevation Model
EGP	Egyptian Pound
EPADP	Egyptian Public Authority for Drainage Projects
EPIQ	Environmental Policy and Institutional Strengthening Indefinite Quantity Contract
EQII	Environmental Quality International, Inc.
ETM	Enhanced Thematic Mapper
GIS	Geographic Information System
GOE	Government of Egypt
GPS	Global Positioning System
GPSR	Greedy Perimeter Stateless Routing (wireless networking protocol)
GSM	Global System for Mobile Communications
GW	Groundwater
GWS	Groundwater Sector
IDS	Irrigation and Drainage System
IRG	International Resources Group
IS	Information System
IT	Information Technology
IWMD	Integrated Water Management District
IWMU	Integrated Water Management Unit
IWRM	Integrated Water Resources Management
IWRMP	Integrated Water Resource Management Project
LAN	Local Area Network
LIFE	Livelihood and Income from the Environment (project)
M&E	Monitoring and Evaluation

MALR	Ministry of Agriculture and Land Reclamation
MWH	Montgomery Watson Harza
MIC	Ministry Information Center
MISD	Matching Irrigation Supply and Demand
MS	Microsoft
MWRI	Ministry of Water Resources and Irrigation
O&M	Operation and Maintenance
RTU	Remote Terminal Unit
USAID	United States Agency for International Development
USB	Universal Serial Bus
UPS	Uninterruptible Power Supply
WQMU	Water Quality Management Unit
WUA	Water User Association

Measurement Units

Feddan	unit of land measurement = 4200 m^2
Kerat	unit of land measurement = 1/24 feddan = 175 m^2

Executive Summary

The LIFE-IWRM project provided technical assistance, equipment, and training to the Integrated Water Management Districts (IWMDs) and Irrigation Directorates to develop information systems to facilitate integrated water resources management activities and improve the quality of irrigation service. By the end of Year 4, all IWMDs have been established and equipped with computer hardware and software, GPS receivers, and digital maps. A number of database applications for measurement-based water management practices have been developed and put into place, including a water monitoring system with data loggers and databases for storing and retrieving information. Digital mapping was completed to support the IWMD boundary delineation and geo-referencing canal and drainage networks, monitoring sites, branch canals, and BCWUA service areas.

The specific accomplishments are:

- Installed a large number of computer systems (117) in 27 IWMDs and five Irrigation Directorates.
- Implemented seven water resources databases/worksheets (MISD, Water Level/Discharge, Complaint, Groundwater, Water Quality, Maintenance, and BCWUA) at 27 IWMDs and five directorates.
- Installed seven data loggers with sensors to provide near real-time water data at four districts and one directorate.
- Trained selected staff from the IWMDs and directorates on computer basics, hardware maintenance, database O&M, and GPS use.
- Built capacity for digital mapping at all IWMDs and directorates.
- Conducted a survey of branch canal command areas and supported an inventory of water structures at each IWMD using GPS receivers.
- Verified and finalized IWMD irrigable areas between MWRI and MALR based on the BC command areas GPS survey.
- Constructed and printed geo-referenced IWMD and directorate maps, including water objects such as canals, drains, water structures, pump stations, and groundwater wells.
- Supported the IWMD M&E program with data from the project supported databases
- Aggregated the IWMD water and agricultural data at each directorate using the built-in functionality of the project supported databases/worksheets.
- Linked some of the water resources tabular data to the geo-referenced map objects to provide additional analytical functionality and spatially distributed water information for the managers.

As of June 2008, digital water data are readily available via computerized information systems at all IWMDs and directorates. Data quality has improved over the four years; standards and quality control measures have been initiated. The information system tools supported the establishment of IWMDs, participation of the BCWUAs, and measurement-based water management practices. The IWMDs and directorates are using the tools to support their measurement-based irrigation management activities. All managers are able to quantify their water inflows and outflows and crop

water requirements via the water monitoring program and information systems, and use the data/information for making timely, informed management decisions to improve the quality of irrigation service.

1. Introduction

1.1 Authorization

Under the USAID/Egypt-funded Livelihood and Income from the Environment (LIFE) Integrated Water Resources Management (IWRM) Project (Contract No. EPP-I-802-03-00013-00 Task Order 802), International Resources Group (IRG), in association with the Academy for Educational Development (AED), Development Alternatives, Inc. (DAI), ECODIT, Inc., Environmental Quality International, Inc. (EQII), Montgomery Watson Harza (MWH), and Training Resources Group, Inc. (TRG), is responsible for assisting the Government of Egypt (GOE) to promote integrated water resources management. The period of performance for the contract is October 1, 2004 – September 30, 2008.

1.2 Purpose of Report

The purpose of this report is to present an assessment of the Information System (IS) activities carried out under Task No. 3.

1.3 Project Objective

Figure 1. LIFE IWRM Project Sites

The GOE is implementing an aggressive irrigated agricultural area expansion program, which will reduce the supply of water per feddan. Currently, the high cost of operating and maintaining the water delivery infrastructure places a serious strain on the national budget because farmers pay only a small portion of the actual costs; this is further compounded by decreasing water quality as the water conveyance system is increasingly used for waste disposal.

The objective of LIFE/IWRM is to provide technical assistance, training, commodities, and small grants in support of the decentralization of water management decision-making, and increased participation of all rural inhabitants in such decision-making in two priority geographical areas and five Irrigation Directorates: Zifta and West Sharkiya in the Middle Delta; and West Qena, East Qena, and Aswan in Upper Egypt, as shown in Figure 1.

With a decentralized and participatory approach, USAID expects greater civic responsibility in maintaining the water conveyance infrastructure resulting in improvements in the quality of local water resources through better management of locally generated liquid and solid wastes.

The objectives of the project will be achieved through the formation and development of functional and sustainable Branch Canal Water User Associations (BCWUAs) and Integrated Water Management Districts (IWMDs), and by developing the capacity of stakeholders to manage solid and liquid wastes in the targeted directorates.

SUB-OBJECTIVE 1. Rural inhabitants will accrue immediate and long-term economic benefits from participating in water-management decision-making and governance of the water conveyance infrastructure.

SUB-OBJECTIVE 2. Local communities and private associations will participate in water resources decision-making, accept responsibility for maintaining the water conveyance infrastructure, and adopt improved management practices for solid and liquid wastes.

Seven tasks, under three performance requirement categories, are to be implemented under the LIFE/IWRM Program:

1 Performance Requirement I: Decentralized Management of Water Resources

- Formation of IWMDs
- Formation of BCWUAs
- Equitable allocation of water resources

2 Performance Requirement II: Stakeholder Engagement in Water Resources Management

- Improved maintenance and upgrading of water management equipment
- Improved water quality management through better environmental services
- Improved wastewater reuse practices

3 Performance Requirement III: Capacity Building of MWRI staff

- Graduate degree training for MWRI staff

There are also a number of crosscutting issues that are common to all seven tasks, including: commodity purchases; workshops and training; monitoring and evaluation; donor coordination; public awareness through information, education, and communication; and gender considerations.

The LIFE/IWRM has worked closely with the MWRI Integrated Water Management Unit (IWMU), five directorate Undersecretaries and General Directors, 27 IWMDs, and other key stakeholders over the past 36 months. To facilitate project implementation, provide technical coordination at higher levels, and resolve any inter-sectoral issues, a steering committee was appointed by the Minister of the MWRI. Members of the steering committee include:

- Chairman (Eng. Gamil Mahmoud, MWRI Special Consultant to H.E. Minister)
- Head of Irrigation Department
- Egyptian Public Authority for Drainage Projects
- Chairman of M&E Department
- Head of Sector - Minister’s Office

- Director of Technical Office for Technology and Information – Minister's Office
- Head of Institutional Reform Unit
- Head of National Water Boards Project
- USAID representative
- LIFE/IWRM representative

1.4 Organization of Report

The remainder of this report is organized in five chapters:

2. Information Systems Component
3. Review of Tasks
4. Achievements
5. Lessons learned and Recommendations

2. Information Systems Component

2.1 Data Flow

In general, water data flows from the districts to their respective directorates. The directorates then review, aggregate, and summarize the data before forwarding the information to their respective water distribution regional offices and the MWRI departments in the Cairo headquarters. The MWRI departments carry out similar data management activities as the directorates, and use the data/information for central planning, operation, and analysis.

For most of the districts, staff members collect data mainly for others to make water management decisions for them. The MWRI uses the standard water duty as the basis for calculation of agricultural water requirements. An annual plan for water quota (including irrigation, municipal, industrial, and navigation requirements) is then developed for each directorate on a 15-day basis at each major inflow/diversion point on the canal. This plan is discussed with an irrigation directorate from time to time to account for any changes in climatic and/or agricultural conditions.

Water quota for each directorate is then distributed to districts on a rotational basis. Two types of rotations are implemented. The first is a three-turn rotation, which is implemented mostly in lower Egypt and consists of 5 days "on-period" and 10 days "off-period" giving an irrigation interval length of 15 days. The second type is a two-turn rotation that is implemented mainly in Upper Egypt, and consists of 7 days "on-period" and 7 days "off-period" resulting in an irrigation interval of 14 days. During the rice season in Lower Egypt, a two-turn rotation system is implemented for canals growing rice. This rotation is 4 days "on-period" and 6 days "off-period" giving an irrigation interval of 10 days.

With current practices, the districts do not prepare requests for water base on actual crop water requirements. Instead, irrigation directorates issue water to their districts according to an allocated water quota on a 15-day basis. Water allocation in Egypt, with the exception of the 27 IWMDs, is mainly a supply-driven system.

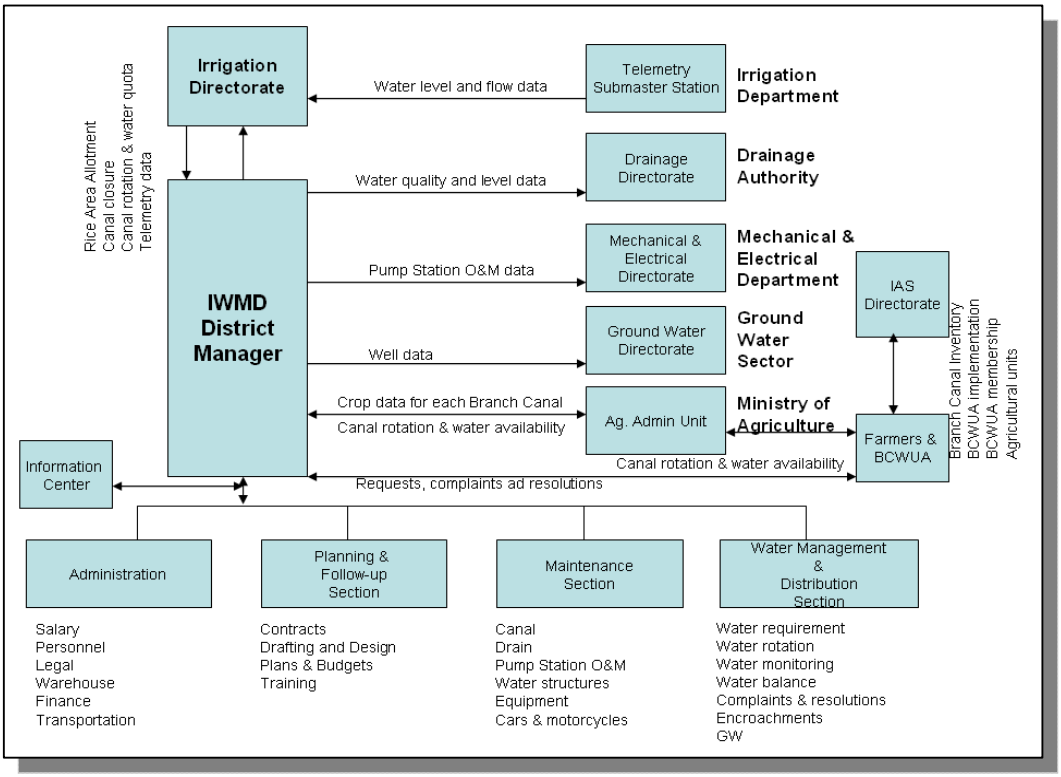
Under the LIFE-IWRM, the 27 IWMDs now have the authority to make district-level management decisions. Figure 2 (on the next page) shows the data/information flow in all directions, from the district, to the district, and within the district. The figure includes the four district sections (Water Management and Distribution, Maintenance, Planning and Follow-up, and Administration) and Information Unit, along with the data collection requirements. The district Information Unit is responsible for managing all of the data/information needed to support decentralized and integrated water management decisions.

Specifically, IWMD receives crop data from the Agricultural Administrative Unit (AAU) every 15 days. Crop water requirements are prepared fortnightly as a part of the matching irrigation supply to demand (MISD) program and the information is submitted to the respective directorate. For each directorate, a monthly water distribution meeting was established. The meetings are attended by water distribution engineers from the directorate, respective regional water distribution staffs (Lower Egypt only), and IWMDs. During the meetings staff members evaluate the computed MISD values for each IWMD, assess and examine the differences between the

demand and supply figures, and identify and suggest ways to resolve any water allocation issues.

Once water allocation issues are discussed and resolved, specific information such as 15-day water allocation amounts flows downward from the regional water distribution offices to the directorates. The directorates inform the districts and the districts inform the BCWUAs and AAU. In turn, the BCWUA and agriculture extension officers share the information with the farmers in the districts so they can coordinate and manage their pumping operations at the *mesqa* level. When farmers have minor problems with water delivery, they usually try to resolve them with the BCWUAs. For major irrigation issues, BCWUAs file complaints with the districts, and district managers consult with directorate staff members to resolve the problems.

Figure 2. Data/Information Flow



2.2 Concept

With the integrated water management approach, the main goals are to:

- Integrate all water management functions so the IWMD can manage all water supplies (i.e., Nile water, groundwater, and drainage water) within each district; and

- Decentralize water management so the district staff can match water supplies with water demands (agricultural, municipal, and industrial requirements) within each of the districts fortnightly.

To support the information requirements of decentralized management, district water, agricultural, and spatial data must be digitized and stored in computerized information systems that can be structurally organized, systematically maintained, freely accessed, and fully analyzed by staff members within each IWMD.

The IS component under the project consists of two major technologies: database management and digital mapping systems. While the database management and mapping systems evolved independently, both are integrating, analytical, and strategic technologies that are complementary to each other. The convergence of both technologies offers an extraordinary opportunity for producing information management tools that connect disparate, but indispensable, threads of spatial and non-spatial data across different information systems and management units. These tools create broader knowledge and understanding for decision makers at the district, directorate, and central levels. As of June 2008, the two systems are converging through shared unique canal identifiers established under the project.

2.3 Objectives

The specific IS objectives are to:

- Establish databases to support measurement-based water management practices and data/information-based decision making at the district and directorate levels;

- Provide specific information systems to support the MISD program matching water supply to demand from all sources (agricultural, municipal, and industrial requirements) within each of the districts;

- Establish IWMD and directorate digital mapping systems to prepare and provide geo-referenced maps with water objects for each of the districts and directorates; and

- Use satellite imagery (free NASA LandSat 7 ETM+) and GPS survey data to verify and/or calculate IWMD boundaries, irrigable areas, BCWUA service areas, canal and drain alignments, and water structure and monitoring locations to support the improved water management practices.

2.4 Approach

The overall IS development approach of the project consists of following major activities:

Year 1

- Installed computer hardware and software at the IWMDs and directorates;

- Installed MISD, Water Level, Discharge, and Complaint databases at all 27 IWMDs; and

- Trained selected staff from the IWMDs and directorates on computer basics, hardware maintenance, database operation, and general GPS use.

Years 2 and 3

- Introduced and install three additional databases/worksheets (Groundwater, Water Quality, BCWUA, and Maintenance) at the IWMDs.

- Established a total of seven functioning databases/worksheets (MISD, Water Level/Discharge, Complaint, Groundwater, Water Quality, BCWUA, and Maintenance) at the IWMDs;

- Introduced and installed MISD, Water Level/Discharge, Complaint, Groundwater, Water Quality, BCWUA, and Maintenance databases/ worksheets at the five directorates.

- Supported district and directorate implementation of MISD water management practices with the MISD Database;

- Supported district water monitoring activities with the Water Level/ Discharge Database;

- Built capacity for digital mapping at the IWMDs and directorates;

- Constructed and printed geo-referenced IWMD maps, including water objects such as canals, drains, water monitoring sites, structures, pump stations, and wells;

- Conducted a survey of branch canal command areas and support inventory of water structures at each IWMD using GPS receivers;

- Aggregated the IWMD water and agricultural data at each directorate using the seven project supported databases

- Introduced and supported the district M&E program with data from the seven databases; and

- Carried out corresponding training events.

Year 4

- Devised a way to systematically identify and correct all district spatial data errors (line and polygon overlap and gap issues) one-by-one to ensure high quality map products;

- Constructed and print maps based on district spatial layers using GIS tools with the support of the GIS mapping unit at each directorate;

- Linked the water resources tabular data to the geo-referenced map objects and symbolize and see them on maps with other data layers. The thematic map generation provides additional capabilities to analyze spatially distributed data/information for the managers at each directorate and IWMD; and

- Carried out corresponding training events.

3. Review of Tasks

3.1 Computer Hardware and Software Procurement

The IWRM team initiated the information system task by carrying out inter-related subtasks under the community procurement of the IT equipment. Over the project life, the IWRM team:

- Assessed hardware and software needs
- Prepared hardware and software specifications
- Solicited bids
- Selected suppliers
- Signed contracts
- Installed computer hardware and software at each of the IWMDs

By the end of Year 4, the IWRM team provided over 100 computer systems and IT equipment. All 27 IWMD, five directorates, CDIAS, Water Distribution offices, IWMU, Water Communication Unit, and Telemetry Department are equipped with the latest IT equipment. A summary of the equipment is presented below.

Each of the IWMDs received:

- 3 desktop computers with Windows XP, Office 2003, and Antivirus software
- 6 desktop computers with Windows XP, Office 2003, and Antivirus software (East Qena IWMD training room)
- 5 project supported water resources databases
- 1 black and white laser printer
- 1 color ink printer
- 1 A4 scanner
- 1 LAN system
- 2 GPS units with data cables
- 1 fax machine
- 1 copy machine
- 3 UPS'
- 4 voltage stabilizers
- 3 computer tables and 3 task chairs
- 1-2 USB 2.0 mobile 2.5" hard drives
- 1 USB 2.0 memory stick
- 1 ADSL/Dial-up Internet connection (25 of 27 districts)
- 1 data logger each for Quesna, Birket El Saba, and Deshna
- 2 data loggers for Luxor
- 1 GSM for Deshna
- 2 GSM modems each for Quesna, Birket El Saba, Aswan, and El Selcela,
- 3 GSM modem for Luxor

Each of the directorates received:

- 3 desktop computers with Windows XP, Office 2003, and Antivirus software
- 6 desktop computers Windows XP, Office 2003, and Antivirus software (East Qena Directorate training room)
- 4 desktop computers with Windows XP, Office 2003, and Antivirus software and 1 data projector (Aswan Directorate training room)
- 2 desktop computers with Windows XP, Office 2003, and Antivirus software and 4 scanners (East Qena document imaging activities)
- 2 laptops with Windows XP, Office 2003, and Antivirus software (East Qena)
- 1 laptop with Windows XP, Office 2003, and Antivirus software (Aswan and West Sharkiya)
- 1 ArcView 9.2
- 3-4 UPS'
- 3-4 voltage stabilizers
- 1 portable digital data projector (Aswan)
- 1 A0 ink plotter (3 of 5 directorates)
- 1 A3 color printer
- 1 black and white LaserJet printer
- 1 A3 scanner
- 4 A4 scanners (East Qena document imaging activities)
- 1 LAN
- 1 GPS receiver and 1 PC interface cable
- 2 USB mobile hard drives (3 of 5 directorates)
- 4 USB mobile hard drives (East Qena)
- 2-3 computer tables and 2-3 task chairs
- 1 ADSL/Dial-up Internet connection
- 2 data loggers for West Sharkiya
- 2 GSM modems each for New Zifta and West Qena
- 4 GSM modems for West Sharkiya
- 1 GSM modem for East Qena

CDIAS received:

- 3 desktop computers with Windows XP, Office 2003, and Antivirus software
- 3 black and white laser printers
- 2 color ink printers
- 1 GPS unit with data cable
- 3 UPS'
- 2 voltage stabilizers
- 2 computer tables and 2 task chairs

Water Distribution Directorates received:

- 2 desktop computers with Windows XP, Office 2003, and Antivirus software
- 2 black and white laser printers

- 4 GPS units with data cables
- 2 UPS'
- 2 voltage stabilizers
- 2 GSM modems

IWMU received:

- 5 desktop computers with Windows XP, Office 2003, and Antivirus software
- 3 laptop computers with Windows XP, Office 2003, and Antivirus software
- 1 ArcView 9.2
- 1 A3 color ink plotter
- 1 A3 scanner
- 2 black and white laser printers
- 6 GPS units with data cables
- 1 digital camera
- 1 portable digital data projector
- 1 A0 color scanner
- 5 external USB mobile 2.5" hard drives
- 5 USB 2.0 memory sticks
- 5 UPS'
- 1 ADSL Internet connection

Telemetry Central Directorate received:

- 4 desktop computers with Windows XP, Office 2003, and Antivirus software
- 5 UPS'
- 1 data logger
- 3 GSM modems

Water Communication Unit received:

- 2 desktop computers with Windows XP, Office 2003, and Antivirus software
- 2 laptop computers with Windows XP, Office 2003, and Antivirus software
- 5 UPS'
- 1 data logger
- 3 GSM modems
- 2 black and white laser printers
- 1 A4 scanner

3.2 Database Development and Implementation

The overall IS development approach used by the project was to introduce and implement the databases that have already been developed, tested, and used by the MWRI in the past. The databases included:

- Water Level/Discharge Database prepared by MIC under the Red Sea Sustainable Development and Improved Water Resources Management Project.
- Complaint Database prepared by MIC under the Red Sea Sustainable Development and Improved Water Resources Management Project.
- Violation Database prepared by MIC under the Red Sea Sustainable Development and Improved Water Resources Management Project.
- MISD Database developed under the Water Policy Reform Program.
- Water Quality Database developed by the Water Quality Management Unit.
- Groundwater Database developed by the Groundwater Sector.
- Maintenance worksheets developed by West Sharkiya Directorate.
- BCWUA Database developed by Central Directorate of Irrigation Advisory Service.

All eight databases have been further improved by the MWRI departments based on feedback from the IWMDs over the last four years. Seven of the eight databases are installed and functioning at all the directorates and IWMDs with only one exception. The Wady El Norkra and Wady El Saaida districts are equipped with the Water Level Database, but it is not yet used due to a lack of marble gauges in the canal network and gate keepers to read and report water levels. With the project's successful IS training program, all IWMDs have a number of competent IS/IT staff members, ranging from three to 13, with an average of six members, which is sufficient for district database and IT operations.

Water Level/Discharge Database is an MS-Access, Visual Studio and .Net software application used for storing technical details of water structures (canals, drains, pumps, siphons, and barrages), average daily water level measurements (i.e., upstream and downstream water levels) and discharges. The database provides water level/discharge statistics and irrigation system schematics. The main purpose of the database is to compute daily and fortnightly water deliveries to each IWMD and directorate.

Complaint Database was developed with MS-Access, Visual Studio and .Net software. It is used for storing, classifying, and reporting farmer complaints in a district. The database also tracks actions taken to resolving farmer's complaints. The directorate version can enter complaints filed directly with the directorates plus import, store, review, edit, consolidate, and report the complaint data from districts.

The M&E team reported that recent queries of complaint data produce different results, depending on whether the data comes from the paper records of the Districts, the electronic database at the district level, or the centralized database of the MIC. This problem may be caused by lack of a standard procedure for reporting complaints. Currently, all complaints filed at the directorate and undersecretary level might not be reported to the relevant districts. If managers expect to continue to use complaints data in the management process, the procedure for reporting complaints should be reviewed and standardised.

Violation Database was developed with MS-Visual Studio and .Net software and deals with Law No.12 - 1983, and Law No.48 - 1982. The database contains violation records (responsible engineer's name, location, day, date, subject, violator's name, etc.). The system also tracks each violation in every stage including warning, removal, court, and jurisdictional verdict.

The Violation Database has encountered technical difficulties of tracking the complex violation mitigation process. Even though the database has been revised several times, it must still be refined. As of June 2008, the latest version has been installed at East Qena Directorate and its four IWMDs, and West Sharkiya Directorate and its five IWMDs, for further testing.

All three databases (above) were initially developed using MS-Access and later constructed with MS-Access, Visual Studio and .Net. The end result is a "closed/complied" database application with stringent security measures. This change made upgrading the databases and fixing programming errors only possible at MIC office in Cairo. On several occasions, district data were lost when upgrading the databases. The Director in East Qena stated in March 2008 that these databases will not sustain unless MIC is willing to "open" the databases to provide access to the internal database tables. Due to the difficulties encountered with the database, Birket El Saba has decided to build its own violation database. Wady El Saaida also constructed a water user database that tracks complaints.

MISD Database is an MS-Access application that is used for storing bi-weekly crop data from MALR and computing bi-weekly water requirements. It uses the cropping pattern information provided by MALR to compute the near real-time crop water needs for both the "current" and "expected" half-month time periods. The "expected" need covers the water requirements for the crops expected to be in the district one half month in the future. The computed current and expected water requirements are then submitted every two weeks to the directorate. The directorate imports the bi-weekly water demands into the MISD and summarizes the district demands by canal for scheduling water deliveries.

The MISD Database was installed and tested during Year 1 and Year 2. During Year 3 and 4, IWMU staff members worked closely with the IWMDs to check and verify crop water requirement calculations in MISD and have fixed database programming errors. The database has been improved with options to set the conveyance efficiency value for each BC, rather than using the hardwired efficiency factor of 0.7 to incorporate differences from one BC to another, and one IWMD to another. Two of the IWMDs in Upper Egypt have changed some of the BC efficiency values to match the field conditions in order to provide more realistic water demand estimates. However, the "flexible" system efficiency concept is not yet fully accepted by MWRI water distribution and all staff members on the project.

Water Quality Database is an MS-Access application that was customized from the MWRI central level version based on the needs of the IWMD quality monitoring program so that district staff can use it for field data management and analysis. The database consists of two parts. The first part is a description of sites of which water quality parameters are observed and measured, and the second part is to store,

retrieve, and report on water quality data. A total of five parameters (temperature, conductivity, pH, dissolved oxygen, and turbidity) are measured and reported to the directorate monthly. Directorates import, compile, and monitor the district data using the Water Quality Database tailored for the directorates.

Groundwater Database is an MS-Access application. The database is divided into two major components. The front-end of the database has forms, queries, reports, modules and macros. The back-end contains only tables for storing groundwater data. In multi-users environments, this reduces network traffic and allows continued front-end development without affecting or interrupting users and data tables. The GW database stores data from observation points like wells, tanks, dams, trenches, springs, and desalination plants. For the IWMDs, wells are the main observation points. The GW database was customized to meet requirements of the 27 IWMDs and their directorates. It includes data items such as location, ownership, use, borehole depth, well depth, water levels, discharge, drawdown, TDS, and chemical analysis. For the directorate version, the district GW data can be imported and consolidated. As of June 2008, groundwater data for more than 9,000 points has been entered in the district databases. The GW database has been excluded from Aswan (directorate and its districts) due to the lack of groundwater wells in each of the IWMDs.

Maintenance worksheets track the status of canal and drain maintenance contracts, store the design data of canal and drain cross sections, and survey results of the water structures. The worksheets are linked via the unique canal code developed by the project and the drain code from EPADP. The same worksheets are used by the IWMDs and directorates.

BCWUA Database has been converted from MS-Access to MS-Excel worksheets by the IWMU staff. There are total of four worksheets used to cover the main steps in BCWUA formation. The first worksheet is for BCWUA baseline data including branch canal details, water user information, population, and villages within each BC service area. The second worksheet is for tracking BCWUA establishment by entering vital information about water users involved in BCWUAs; this worksheet is updated monthly during the establishment phase to reflect progress with regard to the BCWUA developed workplan. The third worksheet is for tracking activities during the activation phase which includes (1) signing a memorandum of understanding with the MWRI, (2) introducing and adopting the Internal Regulations by BCWUA, and (3) holding regular internal and external meetings. The last worksheet is used to monitor and track the BCWUA participatory management activities in district water distribution, waterways and structures maintenance, solid and liquid waste management, conflict resolution, and BCWUA-IWMD meetings.

New directorate versions of all seven databases were developed and installed by the IWMU and MIC staffs with additional options to import, consolidate, and store the district water data in the last 18 months. Simultaneously, the seven databases for the IWMDs were upgraded with data and report export options to meet the data consolidation requirements at the directorate level.

3.3 Digital Mapping

Digital mapping has supported multiple project tasks and district measurement-based water management activities. The project equipped each district with a digital

mapping system with computer hardware and software, handheld GPS units with software, paper maps (printed by the Egyptian Survey Authority) and a scanned digital version, DEM, Landsat ETM+ images, and Google Earth images. Each district also has a trained mapping team able to use the mapping system. For the five directorates, the same approach was implemented.

A series of mapping activities were carried out by the districts, directorates, and IWMU under the project to support the water management activities as follows:

- Procuring, scanning, and geo-referencing the 1:25,000 paper maps (141) covering all 27 districts (by IWMU).
- Digitizing (on-screen) district boundaries, canals, and drains based on the scanned 1:25,000 maps and Landsat ETM+ images using Autodesk Map software (by all districts).
- Marking the exact location of groundwater wells and water monitoring points using the handheld GPS units (by all districts).
- Creating a point for each BCWUA at the head end of its BC using ArcGIS software; if a BCWUA covers more than one BC, the point was created at the head of the largest BC. Individual BCWUA attribute data from the BCWUA worksheets are linked to the respective BCWUA points on the district map (by IWMU).
- Surveying BC areas, canals, and drains using the handheld GPS units (by all districts).
- Digitizing and computing urban areas based on Google Earth images using Autodesk Map (by all districts).
- Marking the exact location of water structures - aqueduct, gate, covering, regulator, siphon, bridge, and tail escape (by all districts).
- Computing and finalizing the BC net area for each district (by all districts and IWMU).
- Marking the exact locations of the 27 district and five directorate offices using the GPS units (by all districts).
- Marking the exact locations of all BCWUA offices (600) using the GPS units (by all districts).
- Building a geodatabase for each district with all the available vector and raster layers (by all directorates and IWMU).
- Print irrigation district and directorate maps (by all directorates).

As of June 2008, all 27 districts have successfully completed the digital mapping work using Garmin GPS receivers and Autodesk Map software. The results of the mapping activities provided each IWMD with 16 geo-referenced map layers (plus attribute tables) as follows:

- GPS district boundaries
- GPS office location
- GPS canals
- GPS drains
- GPS water structures (i.e., aqueduct, gate, covering, regulator, siphon, bridge, and tail escape)
- GPS groundwater wells

- GPS BC gross areas
- Urban areas (digitized from Google Earth images)
- BC net areas (BC gross areas – urban areas)
- GPS flow monitoring points
- GPS water quality sampling sites
- BCWUA (point file)
- BCWUA service areas (built from BC gross areas)
- GPS BCWUA office locations
- DEM (digital elevation model) data (downloaded from Internet)
- Landsat ETM+ 7 satellite images (downloaded from Internet)

The above spatial data provides: baseline information for accuracy delineation of the IWMDs in each directorate; visualization of irrigation system layout, BC areas, BCWUA service areas, water structure locations, groundwater wells, monitoring sites, and IWMD and BCWUA office locations; and the computed BC, urban, BCWUA, district, and directorate areas.

One of the outcomes of the mapping activities is the MWRI-MALR approved irrigable area for each district. Using GPS survey data, the Irrigation and Agricultural Administration at the directorate level was able to reconcile the irrigation and agricultural area differences by agreeing mainly on the GPS net area (irrigable), which incorporated the GPS official and unofficial irrigable areas for each IWMD. The new set of approved area figures has been incorporated in the MISD Database and should provide more precise water demand figures in 2008.

3.4 Data Consolidation and Integration

In the past 18 months, the project focused on building directorate databases with built-in functions to import and consolidate district data. In order to consolidate and mange the district data in a systematic way, a canal coding system was established that assigned each canal with a unique identification number. The codes were added to the MISD Database, Maintenance worksheets, and canal spatial layer so water data such as water demands from the districts can be aggregated by canal to facilitate water distribution at the directorate level. Additionally, the project adopted the GWS, WQMU, and EPADP coding systems for the Groundwater, Water Quality, and Maintenance databases respectively. Other databases such as water level/discharge, complaints, and violations are using a similar approach but with different coding systems.

With these unique identifiers, most of the data in the databases can be linked to relevant locations via GIS software for spatial analysis, such as finding the number of BCWUAs in each agriculture district. Maintenance data from the database can be linked to the water structures and visualized via thematic maps, showing total money spent for each water structure over the last 12 months for example. With that information, the mangers of the BCWUAs can establish maintenance priorities, prepare new budgets, and plan for the next year.

Most of the district data has a location component. Linking location to information is a process that applies to many aspects of decision making in water management. GIS is one of the ways to integrate different systems to save valuable resources, visualize

an organization's assets, and streamline workflow processes. Several GIS applications have been initiated at East Qena Directorate and IWMU. The other four directorate GIS groups will need more technical support and training in order to carry out the data consolidation and integration activities.

3.5 Training

A comprehensive training program was designed and completed by the Task 3 Team over the past four years as shown in Table 1.

Table 1 Information System Training Courses

No	Course	No. of Event	Year	Days	No. of Participants	Female
Year 1						
1	Basic Computer Skills	11	1	132	246	92
2	Computer Maintenance	5	1	20	83	32
3	Software Installation	3	1	4	43	19
4	GPS Training Course	3	1	4	67	7
Total		**22**		**160**	**439**	**150**
Year 2						
1	MISD	7	2	20	307	33
2	Operation of Data Logger & Software	1	2	1	7	4
3	Water Level & Complaint Database	6	2	12	87	38
4	ERDAS GIS	1	2	5	6	2
5	Water Flow Calibration	6	2	12	76	22
6	Water Quality & Ground Water	6	2	28	115	16
7	WL & Complaint Database Installation	6	2	12	81	33
8	Digital Mapping	6	2	24	111	31
9	Introduction to GIS	2	2	10	12	0
Total		**34**		**124**	**802**	**179**
Year 3						
1	Assessment of BC Areas	6	3	12	106	25
2	Water Quality Database Consolidation	3	3	9	79	34
3	Ground Water Database Consolidation	3	3	6	46	19
4	Computer Maintenance	5	3	15	71	35
5	MISD	4	3	4	107	15
6	Operation of Data Logger & Software	5	3	11	77	25
Total		**26**		**46**	**486**	**153**
Year 4						
1	Digital Mapping Refresher Training	6	4	18	63	34
2	Violation of Data Base	2	4	4	22	16
Total		**8**		**22**	**85**	**50**
Project Total		**90**		**352**	**1812**	**532**

The project, with the assistance of IWMU, MIC, WQ Management Unit, GW Sector, and Telemetry staffs successfully trained a total of 1,609 participants in the following subject areas: computer basics, computer hardware maintenance, MISD Database O&M, Water Level and Complaint databases O&M, Violation Database O&M, digital mapping, GPS survey, BCWUA worksheets, Water Quality Database O&M, Groundwater Database O&M, data logger and Logger Net software, and GIS. Almost all the courses were offered in multiple locations and were well supported by the project regional offices. Only a few short courses (computer basics and GIS) were conducted by private service providers.

Regional computer training centers were established and equipped with PCs and audio-visual equipment in Zifta (New Zifta Directorate Office), Zagazig (Zagazig Irrigation Complex, Telemetry Building), Qena (East Qena Directorate Building), and Aswan (Aswan Irrigation Directorate Building).

As a result of the training program, each district and directorate has a minimum of 3-4 capable staff members, who are actively engaged in the electronic database and digital mapping activities.

4. Achievements

The project has successfully accomplished tasks that have changed how the 27 IWMDs and the five directorates manage, analyze, use, and communicate their water data. The major achievements by year are:

Year 1 (FY 2005)

1. A computer unit was established with assigned IT staff at each district.
2. Eighty-five (85) computer systems with Windows XP and Office were installed at the districts and directorates. All systems are functioning properly.
3. Five (5) databases (MISD, Water Level, Discharge, Complaint, and Violation,) were introduced and installed at each district.
4. A digital mapping unit was established with one GIS computer system and one GPS receiver, in addition to the scanned maps (1:25,000) and LandSat images at each district.
5. Four (4) IS training courses were conducted in five separate locations (Tanta, Zagazig, Luxor, Qena, and Aswan): Basic Computer Skills course with 246 participants, Computer Maintenance course with 83 participants, Water Flow Monitoring - GPS course with 67 participants, Software Installation course with 43 participants for a total of 439 participants.

6 The trained district staff members developed additional computer applications to better manage data and information in the districts.

7 Designed, built, and deployed an HTML website for the LIFE-IWMP (www.iwrmg.org) to share project information and reports.

Year 2 (FY 2006)

8. A total of 94 computer systems with Windows XP and Office were installed and functioning at the 27 districts and five directorates.
9. Internet connections (dial-up or ADSL) established at 25 of 27 IWMDs and all five directorates. Email addresses assigned by MIC via MWRI system for all 27 IWMDs.
10. Five (5) project supported databases (MISD, Water Level/Discharge, Complaint, Groundwater and Water Quality) have been installed and are used by a majority of the IWMDs. Violation Database was dropped because it was not working properly.
11. BCWUA worksheets were introduced and installed as a tracking tool at the IWMD and directorate levels.
12. ArcGIS software was introduced and provided as a mapping tool at the directorate level; IWMU and directorate staff members were trained to use the software.

13. Nine (9) training courses (MISD Database, Water Level/Discharge and Complaint Databases, ArcGIS, ERDAS GIS, Digital Mapping, Water Quality and Groundwater Databases, and O&M Data logger) with 802 participants were successfully conducted in Upper and Lower Egypt.

14. The trained IWMD staff members developed additional worksheets and databases (i.e., employee database and canal maintenance worksheet) to better manage administrative and water objects data and information in the districts.

15. Twenty-seven (27) digital district maps (draft) with canals, drains, water monitoring points, and water quality sampling sites have been produced by the IWMDs with the assistance of East Qena, MIC, and IWMU.

16. An M&E database was designed, constructed, and used by the M&E team in Cairo. The district water and agricultural data from the 2004 and 2005 seasons have been entered in the database.

17. The project website was updated to meet USAID requirements.

18. One (1) CSI CR 510 data logger was installed at the Meit Bera intake in the Quesna district and is providing hourly water level data via low cost GSM/GPSR communication system.

19. A digital mapping unit was established with GIS computer hardware and software and GPS receivers in addition to the scanned maps (1:25,000) and Landsat images at each of the five directorates. The one in East Qena is providing technical assistance to all IWMDs in Upper Egypt.

Year 3 (FY 2007)

20. A total of 117 computer systems with Windows XP and Office were installed and functioning at the 27 districts and five directorates.

21. IWMU linked BCWUA data to 600 BCWUA locations on IWMD maps per USAID request.

22. Six (6) additional CSI data loggers were installed and are providing hourly water levels and pumping hourly data (Luxor IWMD only) to five IWMDs, four directorates, Water Distribution/Cairo, and Telemetry/Cairo via a low cost GSM/GPSR communication system.

23. All IWMDs are using the six databases/worksheets (Water Level/Discharge, Complaints, MISD, Water Quality, Groundwater, and BCWUA) to support measurement-based water management practices and data/information-based decision making at the district and directorate levels.

24. Three (3) project supported databases (MISD, Water Quality, and Groundwater) have been modified for the directorates and installed but are not yet used by five directorates as of August 2007.

25. Six (6) training courses in GPS field surveying & digital mapping, water quality, ground water, computer maintenance, MISD, & data loggers were developed and conducted at the directorates in Upper and

Lower Egypt with 486 participants.

26. The 27 IWMDs have capable staff members to operate and maintain the IS, and to share their IS experience and expertise with other irrigation districts. Two persons from each district have been assigned to take the lead on the IS: one for the databases and the other for the digital mapping.

27. The IWMD staff members have developed additional computer applications and databases (e.g., violation and water user databases) to better manage administrative and water data and information at some of the IWMDs.

28. The IWMD mapping staff members have productively applied their digital mapping skills to complete the BC GPS survey and compute the irrigable area for each BC and IWMD.

29. Canals, drains, BC areas, water monitoring points, and water quality sampling sites have been surveyed using GPS receivers and geo-referenced by the IWMDs with the assistance of IWMU.

30. One of the five directorate digital mapping centers (East Qena) is in full operation and providing technical assistance to all IWMDs in Upper Egypt

31. The project website was updated with project reports and success stories. A web counter was added to keep track of visitors and provide real-time website hit statistics

32. Computer maintenance sections were established at the IWMDs and directorates with trained IT staff members.

Year 4 (FY 2008)

33. Maintenance worksheets were introduced and implemented at the IWMDs and directorates. Water Level/Discharge, Complaint, Violation, BCWUA databases/worksheets were introduced and installed at the five directorates.

34. All directorate databases/worksheets have been improved with functionality to import and append data from IWMDS; a few of databases can consolidate IWMD data by canal.

35. Twenty seven (27) IWMDs and five directorates have been equipped with seven functional databases (MISD, Water Level/Discharge, Complaint, Groundwater, Water Quality, Maintenance, and BCWUA). As of June 2008, the latest Violation Database has been installed at two directorates and nine IWMDs (East Qena Directorate and its four IWMDs and W. Sharkiya Directorate and its five IWMDs) for testing.

36. All district water resources databases and worksheets have been upgraded with new functionality to enable each IWMD to export data to its directorate.

37. The unique canal identifiers were created by the project and added to the MISD Database, the Maintenance worksheet and the canal map layers. The national drain codes from EPADP were added to the Maintenance worksheet and drainage map layers. With these unique identifiers, most of the data in the databases can be linked to relevant locations via GIS software for spatial analysis.

39. All districts have more accurate and current data to make informed decisions and are preparing 15-day, monthly and seasonal water resources reports based on data from the project supported databases.

40. Almost all of the IS tools are used in the districts (99%). Only the Water Level database is not yet used by Wady El Norkra and Wady El Saaida districts due to lack of marble gauges in the canal network and gate keepers to read and report water levels.

41. Ninety-two percent (92%) of IS tools in the directorates are used. The GIS mapping system is installed but not yet utilized by Aswan, West Qena, West Sharkiya, and New Zifta.

42. Each directorate, with the assistance of IWMU, has built directorate maps by consolidating district map layers (i.e., canals, drains, wells, water monitoring points, BC boundaries, district boundaries, BCWUA locations, etc.) with Autodesk Map and/or ArcGIS.

43. Using the GPS survey data, the Irrigation and Agricultural Administration at the directorate level was able to reconcile the irrigation and agricultural area differences by agreeing mainly around the GPS net area (irrigable),

44. Email addresses were established via Gmail by IWMU for all 27 IWMDs and five directorates. Gmail system is more reliable and easier to use than the MWRI system, especially in the offices located away from Cairo.

45. All seven Campbell data loggers are working properly and providing near real time water data via Vodafone GSM/GPSR communication system.

46. A total of 21 IS courses were conducted with 1,812 participants (29% female) over the past four years.

The project has successfully implemented the databases, mapping systems, and training programs. All the IWMDs have populated and utilized the seven databases, surveyed BC areas, built digital maps, computed 15-day crop water demand values and actual water supplies, and compared and analyzed the water supply vs. demand figures to support the MISD program. Furthermore, directorate mangers and engineers have been working with the IWMD and regional water distribution engineers on the MISD program and adjusting water allocation to each IWMD; all are eager to learn and do more with the newly installed water resources databases and the GIS system in the future.

5. Lessons Learned and Recommendations

The following lessons learned and recommendations resulted from working closely with the IWMDs and directorates over the past four years. The recommendations are an attempt to objectively identify items that will move the existing and future IWMDs and directorates closer to achieving equitable allocation of water resources through decentralized information systems for improved data collection, quality, management, analysis, and use.

1. Three computer systems and two GPS receivers should be provided for each new IWMD and directorate (see Section 3.1 for the hardware and software details) and 600 EGP/month for the equipment maintenance and replacement. The recommended equipment is sufficient for the nine databases and one mapping system based on feedback from the IWMDs and directorates. The equipment maintenance and replacement budget is an average of figures reported by the managers from the 27 IWMDs and five directorates in March 2008.

2. Continue to have MWRI central level support the IS systems of existing IWMDs, but at a lower intensity (refresher courses and database upgrades). It is always a good idea to keep empowering the IWMDs and directorates to continue using the information system tools to support the decentralize water management objective.

3. Ensure that IS systems upgrades are fully compatible with existing systems at IWMDs and directorates. There are potential software issues with MS-Access 2003 vs. 2007 and should be considered when upgrading the existing databases and developing new database application.

4. Implement data quality assurance measures and procedures. Currently, the districts do not exercise quality assurance measures for data collection and storage systems. Most of data from the field are unchecked. It is recommended that a procedure to systematically identify and fix errors at both district and directorate levels be established to provide high quality data. The information systems will only be useful if there is widespread trust in the accuracy of the data.

5. Unlock all existing databases and ensure that all future IS tools be "open source". The Water Level, Complaint, and Violation databases are too difficult for the IWMDs to maintain. IWMD staff members have experienced many problems (i.e., lost data and database functionality) upgrading the databases from one version to another and it is difficult, if not impossible, for the MIC staff to fix programming errors in the field due to the advanced software (Visual Studio and .Net) they used for the databases. The result is long turn around times for error fixes because most of the programming issues need to be fixed and re-compiled in Cairo by the MIC staff. In the future, all IWMD databases should be "open-source" systems based on standard MS-Access database software.

6. Implement IS activities at both district and directorate levels at the same time. The project did not implement the information systems at the five directorates until Year 3. The current evaluation of IS performance shows overall the districts are out performed the directorates. Four of five directorates will need more time to learn how to apply the GIS mapping software and database consolidation operations.

7. Implement three to four databases at a time, not all seven of them at the same time, perhaps with a 4-6 months gap. With the experience from other projects, the stepwise approach was implemented under this project and the results were positive. It is recommended to introduce MISD, Water Level/Discharge, and Complaint database first.

8. Upgrade the digital mapping system with the most recent high resolution images (1mx1m). The GPS canal, drain, and boundary survey work took about 12 months to complete, which was untimely for IWMD formation. One of the problems is the existing Landsat ETM+ image is seven years old and no longer reflects what is on the ground. With the high resolution images, the mapping teams would able to delineate district, BC, and urban boundaries in a much shorter time (3-6 months).

9. Initiate GPS district boundary and water resources and structure surveys early to support the IWMD formation task. The data are necessary for the IWMD formation, which is one of the first tasks under the integrated water resources management program. It was not done early under this project.

10. Conduct GPS BC area surveying in each district with local MALR staff. The MWRI decree area for most of the districts are outdated and should be updated with the GPS survey data through a process of review and reconciliation involving the MWRI, districts, and the local AAU. This procedure was carried out by the project with great success.

11. Purchase and install more electronic data loggers to support the MISD program. Experience shows that the data logger is a practical and inexpensive way to collect continuous flow data. The data should be integrated in the Water Level/Discharge Database and used by the district.

12. Provide the IS training program to the new IWMDs. Additional courses in MS-Access application and GIS spatial analysis should be considered. The IS training courses were excellent and successfully carried out by the MWRI staff members.

13. Continue to have directorates assist the IWMDs with all IS activities. This approach has proven effective over the past four years.

14. Establish computer maintenance sections at new IWMDs and directorates. IT staff members in the IWMDs will be responsible for computer maintenance activities under the supervision of IT persons from the directorate IT maintenance sections. The directorate IT staff members shell visit the IWMDs weekly and prepare monthly reports on the status of the IWMD computers. The project used the same

approach and procedures with excellent results at each of the 27 IWMDs.

15. Backup data files on a CD at each IWMD and submit a copy to respective directorates monthly for archiving.

16. Submit specific water data monthly from IWMDs to relevant directorates as shown in Fig. 2, except MISD 15-day water demand should be sent to the Irrigation Directorate fortnightly.