USAID/Jordan
Jordan Water Policy Planning

Water Quality Conservation and Improvement Project
Ministry of Water and Irrigation
The Hashemite Kingdom of Jordan

June 1999

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Prepared by
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For
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1. Introduction

Under USAID's EPIQ IQC Task Order No. 826, Science Applications International Corporation (SAIC) was requested to provide technical assistance and advisory support to the Jordan Ministry of Water and Irrigation (MWI). The primary purpose of SAIC's assignment was to provide continuity to specific critical MWI program elements previously supported by USAID's Water Quality Improvement and Conservation (WQIC) Project. Technical assistance under the EPIQ IQC task was provided primarily to the newly organized Water Resources Management and Planning Directorate of MWI.

SAIC's assignment began on 4 January 1999 and was limited to providing support to MWI for 13 person-days per month. The scope of SAIC's support to MWI was described in Annex III of USAID's EPIQ IQC Task Order Request, and was subdivided into three areas: (1) water information system databases; (2) upgrade and implementation of water monitoring system networks; and, (3) unified water monitoring system restructuring. In addition, SAIC had been requested to provide limited follow-on support for activities remaining from the WQIC Project relating to Central Laboratory and MIS program issues. SAIC's technical contribution for this assignment required the full participation of MWI staff in order to undertake and complete specific work activities. In many respects, SAIC acted as a catalyst for a variety of important developmental activities that enhanced or promoted the work completed by MWI with support of the WQIC Project. SAIC was able to provide direction and guidance in the performance of these work activities and also coordinated overall program support for the activities.

This final report provides an account of work activities completed during the period of performance for SAIC's assignment. In addition, activities which have been started and supported during the period of performance but which remain in progress are identified. Lastly, activities required for future development of the water information system, water monitoring networks, and the Water Resources Management and Planning Directorate, and related recommendations are presented. This report also provides documentation for the many data corrections to the WIS Databases completed during the assignment.

Attachment 1 is a summary listing of action items (activities) undertaken during the period of performance of SAIC's assignment under the EPIQ IQC Task Order.

2. Assignment Action Items

At the beginning of the assignment, SAIC met with MWI management and senior staff to identify and discuss essential activities required to support continued development of programs supported by the WQIC Project as well as the newly established Water Resources Management and Planning Directorate (WRMPD). The WRMPD had been discussed and debated for several years during the WQIC Project, but formal MWI action affecting reorganization of this Directorate including realignment of staff from the Water Authority of Jordan (WAJ) to MWI only occurred in early January 1999. Based on these discussions, numerous action items were identified for consideration during the EPIQ IQC assignment. Most of these action items represented further refinement of work and activities initiated under the WQIC Project. This was particularly true for action items related to the Water Information System (WIS) Databases. An objective in identifying and defining the action items was to bring basic program activities to a greater state of development and completion so that USAID's new project with MWI would be able to start at a higher programmatic level without needing to address more foundational issues.

Action items were grouped into five (5) major categories and a determination was made as to whether each action item was an activity that could be completed in the short-term or long-term. Action items were grouped into the following major program categories:

- Water Information System (ORACLE RDBMS) Activities
- Water Resources Monitoring Networks and Instrumentation Activities
- Water Resources Management Directorate and Program Activities
- Laboratory Issues Remaining from WQIC Project
- MIS Issues Remaining from WQIC Project

The remainder of this report discusses efforts toward completing activities supporting further development of these programs. A full listing of the action items is presented in Attachment 1. Long-term action items were identified but were not pursued because of the limited duration of SAIC's assignment.

2.1 Water Information System (ORACLE RDBMS) Activities

Water Information System (WIS) activities primarily were related to the WIS Databases developed by the WQIC Project. WIS related action items were divided into five subgroups:

- WIS Databases Design, Development, and Modification

- Database Administration (DBA) Development
- Data Entry and Populate Data Tables
- WIS Databases Cleanup
- WIS Technology Integration and Development

2.1.1 Database Tables Design, Development, and Modifications

Action items supported under the Database Tables Design, Development, and Modifications category were related to continued development and refinement of the basic structure of the WIS Databases. A full review of the data tables comprising the WIS Databases was completed to identify progress with expansion of the database since completion of the WQIC Project. Based on the review, changes or modifications were made to the actual design of several data tables and several forms used to access data in the WIS Databases. Primary changes included splitting the Discharge_Measurements table into two separate data tables, one for wadi/streams and one for springs.

Since completion of the WQIC Project, a new module (water uses data tables) had been added to the WIS Databases. The new module was reviewed for consistency with the original database structure and significant organizational changes were recommended and instituted. The data tables for the water uses module were separated into two modules, one for water uses and one for NWMP (National Water Master Plan) support. The resulting water uses module now is consistent in terms of data content with the original intent of the WIS Databases. The NWMP support module now represents a collection of data tables which are designed solely to support the water balancing module and related activities of the NWMP. Of the 20 data tables initially developed for the water uses module, 12 were moved to the NWMP support module.

Changes to several data entry and data query forms were made (primarily for the Daily_Climatological table and several water uses data tables) to better support user needs. In the case of the water uses tables, the forms for several tables had to be modified before data could be accessed from the tables. Modifications to the basic structure of a data table or to data forms required changes to other elements of the database (e.g., views, primary keys, look-up-table triggers, menu screen, access privileges, DBA functions). These changes were completed at the time a particular modification was made to a data table.

The design of the WIS Databases was intended to support use of calculated fields and data ranges. Both features are intended to promote greater reliability of data stored in the database by enhancing the data entry process. Calculated fields supported by the WIS Databases are summarized in Table 1. These fields must be programmed to be active and MWI was in the process of programming these fields at the completion of the EPIQ IQC assignment.

Table 1. Planned Calculated Fields for WIS Databases

Data Table	Calculated Field
Discharge_Measurements Table	• Area Field = Width Field x Depth Field • Discharge Field = Area Field x Velocity Field
Daily_Discharge Table	• Flood_Flow Field = Discharge Field - Base_Flow Field
Water_Levels Table	• Water_Level Field = Well_Summary.Measuring_Point Field - Water_Levels.Depth_to_Water Field
Aquifer_Tests Table	• P_Water_Level Field = S_Water_Level Field -Drawdown Field • Specific_Capacity Field = Yield Field/Drawdown Field
Reservoir_Volumes Table	• Reservoir_Volume Field = (Extracted from Reservoir_Capacities.Reservoir Volume Field based on Reservoir_Volume.Gauge_Height Field)

2.1.2 Database Administration (DBA) Development

Action items supported under the Database Administration Development category related to management and maintenance of the WIS Databases. These activities are intended to support database security, access to the database by authorized users, documentation of modifications to the database structure, updating of documentation publications, development of reporting options to support user requirements, and related management actions. Specific activities supported by SAIC are listed in Attachment 1.

WIS Databases Documentation System

A documentation system for the WIS Databases was established by MWI. An electronic folder was created by the DBA administrator to maintain copies of all relevant electronic files supporting the WIS Databases. The folder was sub-divided into (1) script files; (2) database data table design; (3) look-up-table (LUT) contents; (4) database forms; (5) database menu; and, (6) database documentation. A script file for each data table and data view was created and saved in the appropriate folder. Script files make it possible to easily modify the design of a data table or data view and recreate the table or view in the database without having to re-key data fields, primary keys, triggers, and related commands and instructions for the entire table or view. Electronic copies of all documents supporting design and development of the WIS Databases, including user guides, were obtained and saved in the documentation system. A detailed Power Point presentation describing the purpose, design, development, and key features of the WIS Databases was developed.

WIS Databases Design Changes Documentation Tracking System

An electronic documentation control system for tracking completion of design changes and

modifications to the structure of the WIS Databases was developed. All design changes initiated for the WIS Databases will be specified as a task order in a Lotus Notes-based documentation control tracking system. For each task order, the design change will be identified and how the change will affect all elements of the WIS Databases will be specified. The tracking system then will be used to monitor and verify progress made toward completing the required design modification and all related changes in the WIS Databases. Figure 1 presents the basic information form for the tracking system.

In addition, a separate electronic documentation system was established to document data- related changes to the WIS Databases. Frequently, the WIS Databases administrator is requested to insert extensive sets of data into the WIS Databases or to correct data already entered into the WIS Databases. Often it is simpler to import historic data or general data into the WIS Databases as a data set using spreadsheets instead of key entering each data record. This is particularly an issue because of the relatively new status of the WIS Databases and the substantial capability the database brings to MWI in comparison to previous database systems. The documentation system for data-related changes permits MWI to keep an electronic record of these types of data record entries or modifications. Figure 2 presents the basic information form for the data-related documentation system.

WIS Databases Users

User access and privileges for the WIS Databases were identified and assigned. The initial list of users still is very small and primarily is limited to MWI staff. Approximately 25 MWI staff and supporting consultants now have varying degrees of access to data in the WIS Databases. Because of continued organizational development changes, WAJ and JVA staff have very limited access to the WIS Databases.

Figure 1. WIS Databases Changes Tracking System Form

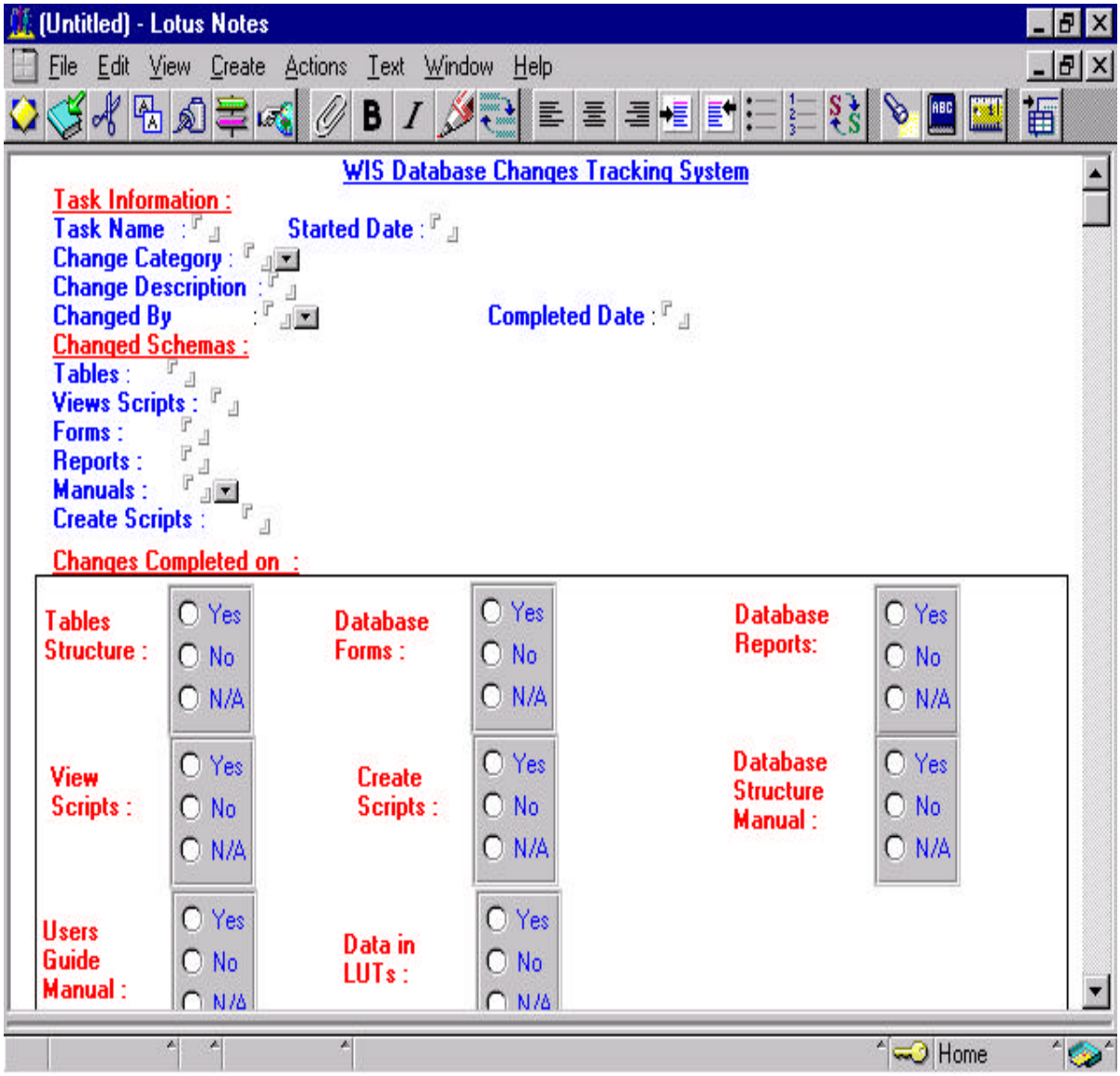
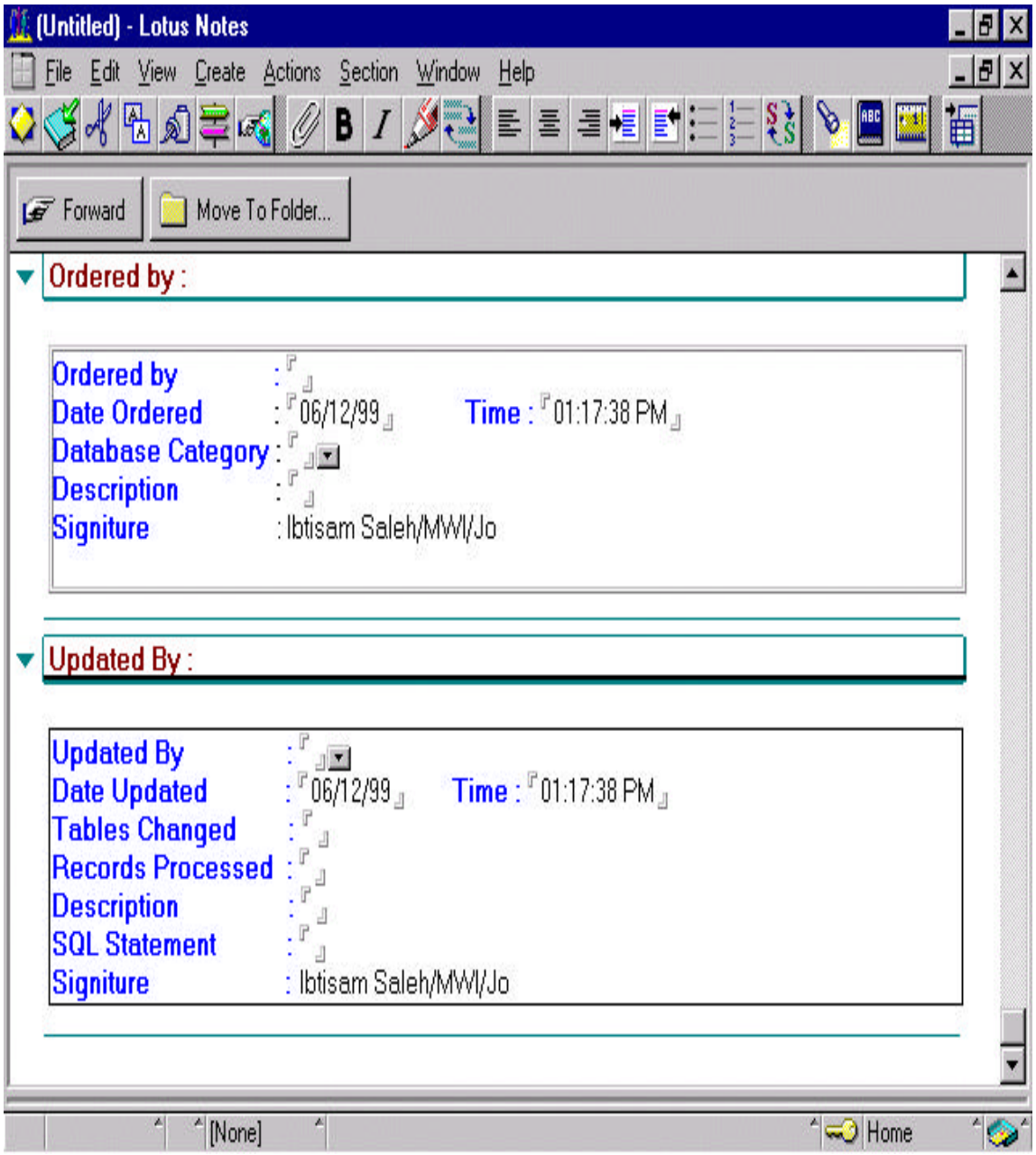


Figure 2. WIS Databases Data Records Documentation Form



Updated WIS Databases Users Guide

An addendum to the Water Information System (WIS) Databases Users Guide prepared by the WQIC Project (report 3114-98-1c-046; October 1998) was issued by MWI for the water uses and NWMP support modules of the WIS Databases. The addendum brings the user guide documentation for the WIS Databases up-to-date with the current development of the WIS

Databases.

FoxPro Database Phase-Out

To date, MWI still maintains two database systems for water resources related data, ORACLE RDBMS and FoxPro. With completion of the activities presented in Section 2.1 of this report, particularly the WIS Databases Cleanup activities (Section 2.1.4), there no longer is justification to continue maintaining the FoxPro database. Beginning with the current water year (October 1998), time series data no longer are entered into the FoxPro database. The ORACLE RDBMS WIS Databases provide substantially greater data management capability both in terms of the types of monitoring data which can be stored and the design and organization of the data tables. The more quickly the FoxPro database is removed from use, the more quickly continued enhancements, particularly reporting, will be completed for ORACLE RDBMS.

WIS Databases Design Update Document

At the end of the EPIQ IQC assignment several DBA development activities still were in progress. An addendum to the Water Information System (WIS) Databases Design Update Document (report 3114-98-1c-044; August 1998) prepared by the WQIC Project was in preparation. The addendum would document the design of the water use and NWMP support related data tables and look-up-tables and would include other modifications that had been made to the WIS Databases.

DBA Development

One action item for the assignment focused on the identification and development of DBA staff responsibilities and assignments. This action item still is in progress but is proceeding slowly because of limited MWI staff time which can be devoted to this activity. In addition, unsettled organizational issues within MWI and the Water Resources Management and Planning Directorate, which is responsible for the WIS Databases, continue to adversely affect overall development of the WIS Department. Policy and procedures for managing the WIS Databases as well as the spatial data associated with MWI's GIS and related responsibilities for the WIS Department still must be established. DBA staff must be relieved of the data entry and data importing and cleanup activities expected of them. DBA activities alone are a full-time responsibility.

WIS Database Reports

A critical activity for the WIS Department is the development of standard reports for data stored in the WIS Databases. MWI requires that periodic data reports (e.g., monthly wadi/stream (or spring) discharge for a station, monthly precipitation data for a station) be prepared for water resources planning and management purposes. This is a major activity. MWI has discussed subcontracting of this activity for more than eight (8) months, but has not been able initiate a contract. The primary tasks of this activity would include:

- Determine/update the types of reports required and linkages back to WIS

Databases menu system
- Define report format guidelines and standards
- Prioritize report preparation activities
- Program and test of reports
- Link and incorporate report options into WIS Databases menu system
- Complete user training

While a dynamic (i.e., user selects query options) programming approach would provide the greatest flexibility to the user, it also would require much more development time and testing. Consequently, the option of standard reports would allow MWI more immediate capability to issue reports. MWI recently was informed that it may be possible to generate standard reports using an ORACLE RDBMS report building feature which can be accessed through an ORACLE package available with Netscape's Internet browser. Once the data report is programmed using the step-by-step guide of the report building feature, the program can be saved as part of the WIS Databases. At the end of the EPIQ IQC assignment, the Ministry was attempting to work with this feature to try to build some basic data reports which then could be accessed through the WIS Databases.

2.1.3 Data Entry and Populate Data Tables

The WIS Databases provide substantial data management capability to MWI for water resources and quality related data. Many of the data tables created for the WIS Databases are new to MWI's data management systems. Initially, these data tables did not contain data even after migration of data from the FoxPro database to the ORACLE RDBMS-based WIS Databases. In addition, time-series data from the 1997-1998 water year had not been entered into the FoxPro database at the time of migration and these data still needed to be entered into the WIS Databases. Consequently, the focus of these activities was to populate data tables created in the WIS Databases. In addition, water resources time-series monitoring data for water years 1997-1998 and 1998-1999 were entered into the appropriate WIS Databases data tables. The action items summarized below and listed in Attachment 1 do not include the extensive work undertaken by GTZ during this period to populate the water uses and NWMP-support related data tables as well as some of the facilities related data tables.

The Facilities table was populated initially with locational and general information about Jordan's municipal wastewater treatment facilities and later with the same information for major industries. In addition, data tables related to the Facilities table (e.g., Facility_Pipes, Facility_Standards, Facility_Production_Data) also were populated with relevant information about each facility.

JTM (Jordan Transverse Mercator) coordinates for all stations and facilities in the WIS Databases were computed by MWI using a translation algorithm based on the Palestine Grid coordinates for the respective monitoring station or facility. These JTM coordinates are being re-verified prior to being imported into the appropriate WIS Databases data tables and corresponding data fields.

JTM has been designated as the official coordinate system in Jordan for GIS-related applications.

Water resources and quality time-series data for the 1997-1998 water year were entered into the WIS Databases. These data included: surface water daily discharge; springs discharge; ground water level; precipitation; several evaporation parameters; and ground water and spring quality. In addition, production data for the period prior to the 1997-1998 water year also were entered into the WIS Databases. Entry of time-series data for the 1998-1999 water year was initiated and largely completed through May 1999 (i.e., into the third quarter of the current water year). At the end of the EPIQ IQC assignment, entry of time-series data for the 1998-1999 water year was continuing on a regular basis. However, entry of production data for the 1997-1998 and 1998-1999 water years had been stopped because of difficulties in obtaining the data in a useable format and due to changes in the WAJ programs which usually provided these data to MWI. In summary, MWI has made substantial progress with the data management process. Historically, data entry would not be initiated until almost one year after completion of the respective water year.

Stations table records were created for each of the reservoirs located in Jordan. This is a first step toward using the reservoir module of the WIS Databases. Full use of the reservoir module data tables requires close coordination between MWI and JVA, the agency responsible for operating and maintaining the reservoirs.

2.1.4 WIS Databases Clean-Up

This section presents a summary of the continuation of validation analyses for the FoxPro to ORACLE RDBMS migration for different types of ground water data as well as general database cleanup activities. Migration of data from the FoxPro database to the WIS Databases programmed in ORACLE RDBMS was completed by WQIC Project. However, limitations in the FoxPro database, particularly relative to aquifer designation, prevented accurate migration of these data automatically. Consequently, the aquifer designation information for each well had to be validated manually. The validation process identified substantial inaccuracies in the original data sets and these could not be fully corrected within the scope of the WQIC Project.

A summary of the FoxPro to ORACLE RDBMS data migration effort is presented in WQIC Project document 3114-98-1b-05 (May 1998). Post-migration analysis and clean-up were completed for surface water flow, springs discharge, springs water quality, rainfall, and evaporation data, and the findings were presented in WQIC Project document 3114-98-1c-042 (July 1998). A separate WQIC Project document (3114-98-1c-045; September 1998) was prepared summarizing the post-migration analyses which has been completed for ground water related data (e.g., water levels; water quality; aquifer information; and aquifer test) information. The information documented in these reports presented the post-migration analyses conducted to validate completion of the FoxPro to ORACLE RDBMS data migration activity. These post-migration analyses were intended to ensure consistency of the ground water data between the FoxPro and ORACLE RDBMS databases. However, the analyses were not intended to validate the accuracy

of each data set.

2.1.4.1 General Activities

Since the date of migration of the FoxPro data to the ORACLE RDBMS-based WIS Databases, MWI had been accumulating lists of data corrections primarily for ground water related data records in the FoxPro database. The corrections had not been made to the WIS Databases. In addition, many new ground water stations and their associated records in related data tables had been added to one or the other of the database systems. All of these accumulated corrections and additions were reviewed with respect to both the FoxPro and WIS Databases, and records in the two systems were corrected to be consistent with correct data and each other. Problems created by the practice of continuing to use these two databases and ensuring data completeness and reliability presents a strong argument for fully phasing out the FoxPro database.

Many data records in the FoxPro database contained blank data fields or data fields that had been set to a value of zero "0". This convention was used to represent "no data" for the data field. Also in FoxPro, the convention of a sequence of "9"s (e.g., 9999.999) had been used to represent blank data for time-series records. This practice substantially complicated the data retrieval process and more importantly analysis of these data. In the WIS Databases programmed in ORACLE RDBMS, it had been decided that a zero "0" would only mean a value with the numerical equivalent "0" and not a blank datum. In addition, in ORACLE RDBMS no conventions would be used to represent blank data for time-series data; only measured values (including "0") would be entered into the database. Consequently, it was necessary to check all values of "0" (zero) in the ORACLE RDBMS data tables.

A systematic review of all ORACLE RDBMS data tables was completed and zero ("0") values were corrected in each table. This review was conducted using SQL (standard query language) commands to query each data table for blank and conventioned values for time-series data. In some cases of general data, each record in the data table was reviewed. The following summarizes the general findings of the review process and the corrective actions taken:

- Stations table - Zeros ("0") in the Map_Scale (67 records), Vertical_Accuracy (66 records), Horizontal_Accuracy (67 records), and Jordan_North and Jordan_East (69 records) data fields were replaced by blanks (representing no data).
- Facility table - Zeros ("0") in the Map_Scale, Vertical_Accuracy, and Horizontal_Accuracy data fields (110 records were replaced by blanks). These data were not migrated from FoxPro, but are new data entered manually into the WIS Databases. Discussions with the staff performing data entry for these records were held to educate them about the data table and data field requirements.
- Surface Water Daily_Discharge table - Of 4,862 records with zero ("0") values or "999 type" values, only one (AL 0065; 28 February 1995; flood discharge) was determined to be in error and was corrected from "99.9999" to zero ("0").

- Spring Discharge_Measurements table - 1,681 records had a value of "9999.999" in the Discharge_Spring data field. These records were checked against the original data sheets and were corrected. In most cases, the records were deleted from the data table because the "9999.999" value represented no data.
- Daily_Rainfall table - 1,074 records had a value of "999" or greater in the Daily_Rainfall data field. These records were checked against the original data sheets and were corrected. In most cases, the records were deleted from the data table because the "999" value represented no data.
- Well_Summary table - Several fields in the Well_Summary table contained zero ("0") values: Well_Depth (605 records); Measuring_Point (5101 records); Reference_Point (5102 records); Riser_Pipe_Length (69 records); Development_Time (4054 records). All zero values were changed to blank values (representing no data).
- Well_Borehole table - The Base_Borehole_Diameter data field for 228 records had a zero ("0") value. All zero values were changed to blank values. The Borehole_Diameter data field for 18 records had a zero ("0") value (Attachment 2); the zeros were deleted, but the correct borehole diameter must be determined and corrected in the data table.
- Well_Casing_Screen table - The Base_Casing_Screen data field for 77 records had a zero ("0") value. All zero values were changed to blank values. The Casing_Screen_Diameter data field for 42 records had a zero ("0") value (Attachment 3); the zeros were deleted, but the correct casing_screen diameter must be determined and corrected in the data table.
- Water_Levels table - 97 records had Water_Level data field values not equal to zero ("0") (Attachment 4). The values for this data field should be equal to zero ("0") at the present time; all records were corrected to the zero value. One record (CD1106; 1 December 1992) had a Depth_to_Water data field value of zero ("0"). This record was deleted.
- Aquifer_Test table - 3,704 data records had inappropriate zero ("0") values in one or more data fields. These values were corrected to blanks.
- Formation table - 261 records had zero ("0") or blank values for the Base_Formation data field. Each record was reviewed and the appropriate data value was determined based on geologic maps and well depth data. Attachment 5 presents a summary of the original and corrected data for these records.
- Lithology table - More than 1,700 empty records were deleted from the data table. In addition, 798 records were corrected. A listing of the original records requiring correction is presented in Attachment 6.

At the end of the EPIQ IQC assignment, several identified action items of low priority had not been initiated. These include: updating and activating the new settlement list; validating the governorate and village (settlement) for each monitoring station and facility; validating the coordinates and altitude of each monitoring station and facility; completing an update of the data type records for ground water stations; and, checking on the use of lead zeros ("0") for decimal values in the WIS Databases. These activities ultimately must be completed if these data in the WIS Databases are to be reliable. Validation of the coordinates and altitudes of each monitoring station and each facility will be a major undertaking worthy of a separate project or a task of a major project.

2.1.4.2 Springs Record Corrections

The aquifer associated with each of Jordan's 836 springs listed in the WIS Databases was reviewed and validated by MWI. Corrections were made to the WIS Database records, as needed. The status (e.g., used, dry, etc.) of each spring was reviewed and corrected in the WIS Databases.

2.1.4.3 Ground Water Record Corrections

Aquifer Designation and Related Data

As part of the post-migration analysis conducted under the WQIC Project, a well-by-well review of the aquifer summary information was completed. This was necessary because more than 900 aquifer test records (i.e., approximately 25 – 30 % of the data) in the Aquifer Table of the FoxPro database could not be migrated to ORACLE RDBMS. These records could not be migrated because no aquifer designation was specified in the FoxPro database {Well Table; Aqpen(x) data fields (x=1,2,3,4)} for the ground water well associated with these records. ORACLE RDBMS would not accept aquifer data (e.g., top, bottom, static water level) and aquifer test data during the migration process unless the aquifer code (Aqpen(x) data) for the well in question was specified. In addition, the aquifer type code (e.g., confined, flowing, unconfined) often was not specified in the FoxPro.Fullith Table, and in these cases aquifer data (e.g., top, bottom, and static water level) also could not be migrated to ORACLE RDBMS.

The most complete process for assuring all aquifer data (i.e., top, bottom, static water level, aquifer type code) were migrated from FoxPro to ORACLE RDBMS was to conduct a well-by-well review of the aquifer summary information and compare data in both databases. This process was completed for all ground water stations (i.e., more than 4,500 wells) by the WQIC Project. While the comparisons were performed by the WQIC Project, only about 50% of the necessary corrections to the records in both databases could be completed by the Ministry and WQIC Project staff during the WQIC Project.

The remaining corrections were made to the two databases under the EPIQ IQC assignment. In addition, more than 600 ground water stations were added to the ORACLE RDBMS based WIS Databases during the period 1 January through 31 May 1999. Currently there are more than 5,200 wells listed in the WIS Databases. In some cases, the actual historic files for wells had to be consulted to verify aquifer summary information. In many cases, geologic and hydrogeologic maps and reports were consulted to verify questionable data and to determine the correct aquifer(s) penetrated by a well. As each well was reviewed, any required corrections were made simultaneously in the FoxPro and ORACLE RDBMS databases. In some cases, corrections also were made to the geologic formation and aquifer test data tables in each database. However, the geologic formation corrections were not within the scope of the post-migration analysis and could not be done for each well. A thorough review of these data is recommended after the post-migration analysis has been completed.

Attachment 7 presents an updated summary of the corrections made to the aquifer summary records in both ORACLE RDBMS (Aquifer_Summary Table) and FoxPro (Fullith Table) as a result of this well-by-well review of the database records. The process to complete this task took more than nine months and resulted in substantial corrections to the aquifer summary records as can be noted in the attachment. It is believed that as much as 20% of the original database with respect to ground water aquifers has been modified through corrections of data.

Drilling Data Consistency

Several types of drilling data were found to be inconsistent in the FoxPro database during the data migration process to ORACLE RDBMS completed by the WQIC Project. For example, the ending date of drilling was earlier than the starting date. However, corrections could not be made due to time limitations. During the period 1 January through 31 May 1999, these data were reviewed against original file records, as available, and corrections were made in the ORACLE RDBMS-based WIS Databases. More than 5,200 well records were reviewed for drilling date information and corrections were made. If information was not available, approximate drilling dates were established based on aquifer test or water level data records.

Well Completion Consistency

The FoxPro database contained two data fields (WF1, WF2) which described how a well was completed (e.g., cased, open-hole, screen). During design of the ORACLE RDBMS-based WIS Databases, it was determined that only one such field was needed because generally only one field in the FoxPro database actually contained data. For approximately 450 of the more than 5,200 data records in the FoxPro database, both WF1 and WF2 data fields contained data. In many cases, the same code was used for each data field implying that there was only one field of legitimate data. During the period 1 January through 31 May 1999, these records were reviewed and corrections were made to the ORACLE RDBMS and FoxPro databases. Attachment 8 lists the wells listed in FoxPro having data in both WF1 and WF2 data fields. Based on this review, the well finish codes/descriptions in the look-up-table supporting the Well_Summary table of the WIS Databases were modified slightly.

Summary

Based on the post-migration analyses of the ground water data conducted by the WQIC Project and the EPIQ IQC assignment, a comprehensive program to correct ground water related data inconsistencies and inaccuracies in the ORACLE RDBMS-based WIS Databases is recommended. The program should be conducted with the goal of ensuring data accuracy and consistency among the lithologic records, geologic formation records, aquifer summary records, aquifer test records, and location data for each ground water well in the WIS Databases. As part of this program, all wells in the Kingdom should be fixed with a label to the well casing. The label should include the correct well identification number for the well.

A couple of minor activities remain to be completed as listed in Attachment 1.

2.1.5 WIS Technology Integration and Development

A number of technology integration and development action items associated with the Water Information System were identified at the beginning of the assignment. These were listed as long-term activities and are presented as recommendations in Section 3.0 of this report.

2.2 Water Resources Monitoring Networks and Instrumentation

With support from the WQIC Project, monitoring networks were defined and associated monitoring plans were developed for each of Jordan's surface water basins and ground water aquifers. Both water resources and water quality monitoring networks were developed for the basins and aquifers. In addition, water resources and quality monitoring networks and plan were developed for the more than 800 springs found in Jordan. A separate monitoring network and plan also was developed for MWI's precipitation and evaporation data needs. A listing of the monitoring plans is presented in Table 2, below. Each plan includes a table listing the planned monitoring stations for the basin or aquifer described in the plan.

Table 2. List of Water Resources and Water Quality Monitoring Plans Prepared with Support of the WQIC Project

Ground Water Networks

- Amman-Wadi Sir (B2/A7) Aquifer Ground Water Quality Monitoring Program in Zarqa River Basin (3114-95-1c-04, Volume 5). October 1995.
- Amman-Wadi Sir (B2/A7) Aquifer Ground Water Level Monitoring Program in Zarqa River Basin (3114-95-1c-04, Volume 6). October 1995.
- Amman-Wadi Sir (B2/A7) and Rijam (B4) Aquifers Ground Water Level Monitoring Program Plan for the Yarmouk Basin (3114-96-1c-06). September 1996.
- Amman-Wadi Sir (B2/A7) and Rijam (B4) Aquifers Ground Water Quality Monitoring Program Plan for the Yarmouk Basin (3114-96-1c-07). September 1996.
- Amman-Wadi Sir (B2/A7) and Rijam (B4) Aquifers Ground Water Level Monitoring Program Plan for the Azraq Basin (3114-96-1c-08). September 1996.
- Amman-Wadi Sir (B2/A7) and Rijam (B4) Aquifers Ground Water Quality Monitoring Program Plan for the Azraq Basin (3114-96-1c-09). September 1996.
- Amman-Wadi Sir (B2/A7) Aquifer Ground Water Level Monitoring Program Plan for Mujib, Dead Sea, Hasa Basins (3114-96-1c-14). October 1996.
- Amman-Wadi Sir (B2/A7) Aquifer Ground Water Quality Monitoring Program Plan for Mujib, Dead Sea, Hasa Basins (3114-96-1c-15). October 1996.
- Amman-Wadi Sir (B2/A7) and Rijam (B4) Aquifers Ground Water Level Monitoring Program Plan for the Jafr Basin (3114-96-1c-21). December 1996.
- Amman-Wadi Sir (B2/A7) and Rijam (B4) Aquifers Ground Water Quality Monitoring Program Plan for the Jafr Basin (3114-96-1c-22). December 1996.
- Ground Water Aquifers Water Level Monitoring Program Plan for the Jordan River & Rift Side Wadis Basins (3114-97-1c-23). January 1997.
- Ground Water Aquifers Water Quality Monitoring Program Plan for the Jordan River & Rift Side Wadis Basins (3114-97-1c-24). January 1997.
- Rijam (B4) Ground Water Aquifer Water Level Monitoring Program Plan for the Sirhan & Hammad Basins (3114-97-1c-25). January 1997.
- Rijam (B4) Ground Water Aquifer Water Quality Monitoring Program Plan for the Sirhan & Hammad Basins (3114-97-1c-26). January 1997.
- Alluvium Aquifers Water Level Monitoring Program Plan for the Wadi Araba Basins (3114-97-1c-28). April 1997.
- Alluvium Aquifers Water Quality Monitoring Program Plan for the Wadi Araba Basins (3114-97-1c-29). April 1997.
- Hummar (A4), Naur (A2), and Kurnub Aquifers Water Level Monitoring Program Plan for Jordan (3114-97-1c-30). May 1997.
- Hummar (A4), Naur (A2), and Kurnub Aquifers Water Quality Monitoring Program Plan for Jordan (3114-97-1c-31). May 1997.
- Ram (Rum) Aquifer Water Level Monitoring Program Plan for Jordan (3114-97-1c-39). December 1997.
- Ram (Rum) Aquifer Water Quality Monitoring Program Plan for Jordan (3114-97-1c-40). December 1997.

Table 2. List of Water Resources and Water Quality Monitoring Plans Prepared with Support of the WQIC Project (cont'd)

Surface Water Networks

- Zarqa River Basin Surface Water Quality Monitoring Program (3114-95-1c-04, Volume 3). August 1995.
- Zarqa River Basin Surface Water Resources Monitoring Program (3114-95-1c-04, Volume 4). August 1995.
- Surface Water Resources Monitoring Plan for the Yarmouk Basin (3114-96-1c-10). October 1996.
- Surface Water Quality Plan for the Yarmouk Basin (3114-96-1c-11). October 1996.
- Surface Water Resources Monitoring Plan for the Dead Sea Side Wadis, Wadi Mujib, and Wadi Hasa Basins (3114-96-1c-12). October 1996.
- Surface Water Quality Monitoring Plan for the Dead Sea Side Wadis, Wadi Mujib, and Wadi Hasa Basins (3114-96-1c-13). October 1996.
- Surface Water Resources Monitoring Plan for the Wadi Araba Basins (3114-96-1c-16). November 1996.
- Surface Water Quality Monitoring Plan for the Wadi Araba Basins (3114-96-1c-17). November 1996.
- Surface Water Resources Monitoring Plan for the Jordan River and Rift Side Wadis Basins (3114-96-1c-18). November 1996.
- Surface Water Quality Monitoring Plan for the Jordan River & Rift Wadis Basins (3114-96-1c-19). November 1996.
- Surface Water Monitoring Plan for the Azraq, Jafr, Hammad, and Sirhan Basins (3114-96-1c-20). November 1996.

Springs Monitoring Network

- Springs Monitoring Plan (3114-97-1c-037). December 1997.

Hydrometeorology Monitoring Network

- Hydrometeorological Monitoring Plan (3114-98-1c-041). April 1998.

Although substantial work had been completed under the WQIC Project, MWI had not been able to secure local currency funds required to construct/install the various networks. In addition, several types of instrumentation procured by the WQIC Project to support the monitoring networks had not been shipped from the United States and delivered to MWI. Consequently, activities under the Water Resources Monitoring Networks and Instrumentation category primarily related to promoting further development, construction, and activation of the monitoring networks, receipt of instrumentation procured by the WQIC Project, and installation of monitoring instrumentation. These action items were divided into three subgroups:

- Monitoring Station Installation
- Equipment Receipt and Installation
- Stations and Equipment Operations and Maintenance

2.2.1 Monitoring Station Installation

Activities under the Monitoring Station Installation category focused on installation of stations for the ground water, surface water, and hydrometeorology monitoring networks.

Ground Water

Under the WQIC Project, about 25 new wells planned for inclusion in the upgraded ground water monitoring network were drilled and installed in 1996 and 1997. Sixteen (16) additional wells had been drilled in 1997, but casing was not available to complete installation of all of these wells. Drilling of approximately 20 new wells (the remainder planned for Jordan's upgraded ground water monitoring networks) had been delayed pending receipt of local currency funds. These funds were secured in late 1998 and MWI worked with WAJ to procure services for both well casing for the wells already drilled and drilling/well casing for the wells still to be drilled. The well casing subcontract was awarded in March 1999 and MWI was awaiting receipt of the casing at the end of the EPIQ IQC assignment. Once received, the WAJ Drilling Department is supposed to install the casing and complete construction of the wells. Pending completion of the construction work, instrumentation procured by the WQIC Project will be installed.

A subcontract was awarded in February 1999 to a local drilling contractor to drill and install the approximately 20 wells to complete the upgraded ground water monitoring network. Unfortunately because of the severe water crisis expected for the summer of 1999, MWI retained the services of all available well drillers in Jordan to install large production wells. Consequently, no work has been completed by the drilling subcontractor for the ground water monitoring network. This work is expected to be initiated after the production wells are installed sometime during the summer of 1999. Pending completion of the construction work, instrumentation procured by the WQIC Project will be installed.

Surface Water

At the initiation of the WQIC Project only a handful of surface water monitoring stations previously maintained by MWI still were operational. In 1996, the WQIC Project was able to rehabilitate/construct six (6) monitoring stations specified for the Zarqa River Basin. Construction and rehabilitation of monitoring stations for the upgraded surface water monitoring network in the remainder of Jordan's basins had been deferred until local currency monies could be secured. These funds were secured in late 1998 and MWI worked with WAJ to procure services for design and construction of surface water monitoring stations. During the process, WAJ management decided that WAJ engineers would design the surface water monitoring stations for the Yarmouk River Basin. The design work was completed, and in March 1999 a subcontract was awarded for construction of these stations. Actual construction work was to begin in May 1999. Problems have been encountered with the selected construction contractor and remain to be resolved. Pending completion of the construction work, instrumentation procured by the WQIC Project will be installed.

In March 1999, WAJ began design work for surface water monitoring stations requiring construction or rehabilitation in the Dead Sea Basin (Wadi Mujib, Wadi Wala) and Wadi Araba Basins. This work has been delayed due to staffing changes and reassignments to other WAJ offices, but is expected to be completed in July 1999. At that time, options for construction of the stations will be considered.

During the WQIC Project, planned surface water monitoring stations for the Jordan River Valley were discussed with the KFW funded project supporting JVA programs. Based on this coordination, the KFW funded project would be responsible for most of the construction related activities with these planned stations. A couple of the stations still must be designed and construction by MWI. Table 3 summarizes the roles of JVA/KFW and MWI for these stations. All listed instrumentation for these stations has been procured and delivered to MWI and JVA by the WQIC Project.

Table 3. Jordan River Valley Surface Water Monitoring Stations

Monitoring Station	Status	Comments
King Talal Reservoir	**Station completed**	**Constructed and instrumented by WQIC Project**
Wadi Rajib	**Planned**	**KFW Project to construct; instrumentation provided by WQIC Project**
Wadi Kufrinja	**Planned**	**KFW Project to construct; instrumentation provided by WQIC Project**
Wadi Yabis	**Planned**	**MWI to construct; instrumentation provided by WQIC Project**
Wadi Jurum	**Planned**	**KFW Project to construct; RTU instrumentation provided by KWF Project**
Wadi Ziglab Reservoir	**Planned**	**KFW Project to construct; RTU instrumentation provided by KWF Project**
Wadi Ziglab - upstream	**Planned**	**MWI to rehabilitate existing station; instrumentation provided by WQIC Project**
Wadi Waqqas	**Planned**	**MWI to construct; instrumentation provided by WQIC Project**
Wadi Arab Reservoir	**Planned**	**KFW Project to construct; RTU instrumentation provided by KWF Project**
Wadi Arab- downstream	**Planned**	**MWI to rehabilitate existing station; instrumentation provided by WQIC Project**
Muheibeh Wells	**Planned**	**MWI to install staff gauge**
Adasiya Intake to KAC	**Planned**	**KFW Project to construct; RTU instrumentation provided by KWF Project**
Wadi Shueib Reservoir	**Planned**	**KFW Project to construct; RTU instrumentation provided by KWF Project**
Wadi Shueib - upstream	**Planned**	**KFW Project to construct; instrumentation provided by WQIC Project**
Wadi Kafrein Reservoir	**Planned**	**KFW Project to construct; RTU instrumentation provided by KWF Project**
Wadi Hisban	**Planned**	**KFW Project to construct; RTU instrumentation provided by KWF Project**
Wadi Abu Ziad	**Planned**	**KFW Project to construct; RTU instrumentation provided by KWF Project**

Hydrometeorology

Four (4) automatic weather stations, 10 automatic precipitation recorders, and 100 standard precipitation gauges had been procured by the WQIC Project to support the upgraded hydrometeorology monitoring network for Jordan. The automatic instruments had been delivered to MWI in late 1998, but it wasn't until several months later that receipt of all items of equipment could be verified and the vendor could come to Jordan. In April 1999, the vendor for the automatic instruments traveled to Jordan and installed four (4) weather stations and four (4) precipitation recorders complete with the full array of sensing instruments. The stations were installed at MWI sites located in Siwaqa, Mushaqqar (near Madaba), Khirbat al Samra, and the Jordan University of Science and Technology (near Irbid). The remaining automatic precipitation recorders will be installed following resolution of organizational and staff resources issues. One hundred (100) standard rainfall gauges were received by MWI in June 1999 and slowly are being installed at locations throughout Jordan.

2.2.2 Equipment Receipt and Installation

Activities under this category focused on working with DAI, the WQIC Project prime contractor, to secure delivery of numerous types of monitoring instrumentation procured by the WQIC Project. Several shipments of equipment were received in Jordan after completion of the WQIC Project. These shipments were examined against the procurement orders and delivered to MWI. Problems with the shipments were communicated back to DAI for resolution. In one case involving the hydrometeorology instrumentation, a quotation and packing inventory had to be obtained from the vendor to verify receipt of all instruments, sensors, and parts. The latest shipment (standard precipitation gauges) was received and delivered to MWI in June 1999. Receipt of miscellaneous parts for the Stevens surface water recorders (the last outstanding items) is pending.

Using local currency monies, MWI had procured 100 instrumentation boxes to provide for the security of ground water monitoring recorders at rehabilitated and new monitoring wells. These boxes were delivered in January 1999 and are slowly being installed throughout Jordan. MWI also advertised for and procured 25 vehicles using local currency monies. These vehicles were to be used exclusively by the water resources monitoring organizations to conduct their work. The vehicles have been delivered but distribution of all vehicles to the monitoring function is being reconsidered by the Ministry. Local currency monies were to be used to procure 25 SIAP clocks required to maintain existing automatic precipitation recorders (Italian origin). This procurement was cancelled, but is now proceeding using monies budgeted to the Water Resources Management and Planning Directorate.

As noted above, the automatic weather station and precipitation instrumentation procured by the WQIC Project were installed in April 1999. Installation of standard rain gauges received in June 1999 is in progress. Ground and surface water monitoring station instrumentation has been delayed due to difficulties encountered in constructing the stations.

An updated listing of monitoring instrumentation procured by the WQIC Project and delivered to MWI is presented in Attachment 9.

2.2.3 Stations and Equipment Operations and Maintenance

Prior to completion of the WQIC Project, WAJ had begun operating the upgraded water resources monitoring networks to the extent that new stations had been constructed, existing stations had been rehabilitated, and instrumentation had been installed as resources permitted. When these WAJ staff were reorganized within MWI's Water Resources Management and Planning Directorate, operation of the basic networks continued. However, further expansion and enhancement of the networks as established in the upgraded monitoring network plans prepared with support from the WQIC Project has been delayed, as discussed above.

Major additional portions of the upgraded ground water monitoring network could be activated if MWI had the resources (primarily vehicles and some more staff). Until these resources are secured, the full monitoring networks cannot become operational. Substantial development of the water resources monitoring organization and establishment of an on-going maintenance program also will be required before full operation of the networks is achieved. Attachment 10 presents a listing of the planned surface water resources monitoring stations for Jordan. Attachment 11 presents a listing of the planned ground water resources monitoring stations for Jordan. Attachment 12 presents a listing of the planned ground water quality monitoring stations for Jordan.

2.3 Water Resources Management Directorate and Program

The WQIC Project had provided substantial support to MWI for improving the organization and operations of the water resources and water quality monitoring functions during the life of the Project. A WQIC Project expert had participated in the planning process for integrating all water resources and related water monitoring activities into a single organization based in MWI instead of being subdivided among MWI, WAJ, and JVA. At the request of MWI, the WQIC Project completed a detailed evaluation and analysis of the Ministry's water resources monitoring function and organization. The resulting Water Monitoring System Program Plan (report 3114-97-1c-32; 1997) presented an evaluation of the proposed and designed upgraded water monitoring system networks for Jordan, the resources required to operate and manage the networks, organizational and administrative options for operating the networks, and long-term development issues. Formal recommendations for unifying the MWI's overall monitoring functions and organizations into a single function were presented in a subsequent summary document for MWI action.

In the fall of 1998, the WQIC Project LTTA formally was appointed to a committee to re-evaluate this issue and associated MWI functions related to water resources studies, water resources planning, WIS Databases management, and well licensing. Recommendations and a detailed plan of action for restructuring these functions into an integrated organization were developed and presented to MWI in the draft Water Resources Functions and Organizations Assessment

Document (report 3114-98-1c-047; 1998).

In January 1999, MWI formally moved the water resources monitoring and studies functions maintained by WAJ to MWI's Water Resources Management and Planning Directorate (WRMPD). Most (but not all) of the staff associated with the WAJ water resources monitoring and studies functions were reassigned to MWI. Water quality monitoring functions maintained by the WAJ Central Laboratory remained within WAJ. These MWI actions began the process of integrating the water monitoring organizations within MWI as presented in these documents.

Action items supporting organizational and program development of the WRMPD during the EPIQ IQC assignment were grouped into the following categories:

- Re-Organization
- Operations
- Equipment Management
- Training Program
- Studies and Analyses

Based on the list of action items, those activities relating to equipment management, training program, and studies and analyses were considered to be of a long-term nature and would not be supported in detail by the EPIQ IQC assignment.

2.3.1 Re-Organization

Although MWI formally announced re-alignment of the water resources monitoring programs from WAJ to MWI about 1 January 1999, selection of staff and re-assignment to MWI was not formally completed until February 1999. At the completion of the EPIQ IQC assignment in June 1999, formal MWI approval and assignment of all selected staff and management positions within the WRMPD had not been finalized. Senior managers for the Water Resources Monitoring and Water Resources Studies Departments for the new WRMPD organization had been selected but not officially appointed. These managers were performing duties consistent with responsibilities previously exercised under the former WAJ organization for these functions. However, they had not assumed full responsibilities for their positions as described in the planning documents. As yet, a manager for the WIS Department function has not been assigned.

During the period of performance for the EPIQ IQC assignment, other significant changes occurred within MWI. A new Minister was appointed in March 1999 and a new Secretary General for MWI was appointed in February 1999. In late May 1999, new Secretary Generals for WAJ and JVA also were appointed. Throughout most of the period of performance, the overriding issue being addressed by the Ministry had been the ability to deliver water services and supplies to all sectors throughout the country because of the extremely limited precipitation received during the winter of 1998-1999. As a consequence, most of the plans intended to support development of the water

resources management and planning organization did not progress as intended. As a consequence, development toward integrating the water quality monitoring functions (related to water resources as opposed to water delivery systems and distribution networks) or toward decentralizing the organization to improve the efficiency of operations did not occur.

One achievement of note is that all monitoring activities (e.g., surface water, ground water, hydrometeorology) are now managed by a single manager and all studies and related activities are managed by a separate manager. However, further integration of organizations particularly for the monitoring activities has not progressed.

During the EPIQ IQC assignment, SAIC staff worked with key managers of the WRMPD organization to try to promote resolution of formalities and to identify important issues relating to department responsibilities and operational practices. In addition, the staffing requirements and qualifications for the various departments were discussed and recommendations were made to begin assigning responsibilities to staff temporarily appointed to various departments.

2.3.2 Operations

The inability to officially complete the re-organization of the WRMPD also affected development of formal operational programs. Until MWI officially finalizes the organization and management of the WRMPD and has clearly defined responsibilities and authorities, it is not possible to develop and institute operational programs and procedures. At the present time, business is continuing very much as it has in the past.

Water Resources Monitoring Function

The water resources monitoring networks continue to be operated and upgraded as resources allow. This is an improvement over operations conducted in the recent past, but still remains far less than what is required for water resources management and planning and what is possible with existing resources. It is believed that major portions of the ground water resources monitoring networks could be activated immediately if staffing and vehicle resources were available. Substantial effort is required to consolidate and streamline data collection practices to improve efficiency and better utilize available resources. Monitoring technicians could be collecting a variety of data instead of having individual programs collect specific types of data (e.g., ground water level data only).

In brief, as a consequence of these delays, program development has stagnated, responsibilities are not being fully met, and the full capabilities and resources of the organization cannot be used to support long-term MWI objective. In addition, the possibility of fragmentation of the progress achieved to date for this program remains. Coordination between MWI and JVA with respect to surface water resources monitoring in the Jordan River Valley still requires improvement. If program issues remain unresolved, even the currently operational monitoring networks will fall into disrepair and deteriorate to the point of being non-functional.

As yet, the surface and ground water quality monitoring networks developed with support of the WQIC Project have not been activated. These networks are intended to monitor the water quality of natural water resources (e.g., wadis/streams, reservoirs, springs, ground water) throughout Jordan and not drinking water distribution systems or networks. With the continued, on-going changes within the Ministry and uncertainties about the authorities of the different agencies of the Ministry, the water quality monitoring issue likely will remain unresolved. It is believed that MWI should take the lead for instituting the water quality monitoring networks for natural water resources. If staff and related resources are limited, consideration could be given to subcontracting the actual monitoring activities to qualified local firms. The other issue affecting this topic is the availability of capable analytical laboratories. Originally, the intention was for the WAJ Central Laboratory to perform analyses of water quality samples collected from these networks. With events of the past year and the increasing commitment of the WAJ Central Laboratory toward supporting drinking water networks and distribution systems, availability of the WAJ Central Laboratory for this purpose must be revisited.

Water Resources Studies Function

Operations of the water resources studies function of the WRMPD were not addressed during the EPIQ IQC assignment. Earlier discussions held during the WQIC Project indicate that a more structured approach for conducting water resources and water quality studies and analyses by MWI is desirable. Studies and analyses of a routine nature that are required to support water resources management practices must be determined and then instituted. Studies and analyses that would support long-term strategic planning for Jordan's water resources also must be determined and prioritized.

2.4 Laboratory Issues Remaining from WQIC Project

Two (2) issues were identified as requiring support during the EPIQ IQC assignment. The first of these related to delivery and installation of the laboratory information management system (LIMS) software that had been procured by the WQIC Project for the WAJ Central Laboratory. The second of these issues related to further implementation of the quality assurance (QA) and laboratory operations programs developed by the WQIC Project to support the WAJ Central Laboratory.

LIMS Software Procurement and Installation

The LIMS software was finally procured and shipped to Jordan in May 1999. The LIMS software was delivered to MWI in June 1999. At the time of preparation of this final report, the LIMS software was scheduled for installation by the vendor at the WAJ Central Laboratory during the later half of July 1999. The first of three training programs for WAJ Central Laboratory staff also was scheduled to proceed concurrent with the installation process. The LIMS will provide the WAJ Central Laboratory with state-of-the-art information management technology for planning,

tracing, and monitoring the various chemical or microbiological analyses of water quality samples, conducting QA/QC of analytical results, and reporting sample results to their clients. In addition, the LIMS software will make it easier for water quality data to be imported into the water quality related data tables of the WIS Databases.

Further Implementation of Operations and QA Programs

Because of the technical scope and limited resources available through the EPIQ IQC assignment, issues relating to implementation of quality assurance (QA) and operations programs developed by the WQIC Project for the WAJ Central Laboratory could not be supported. These are critically important programs for MWI and Jordan and are worthy of substantial support through future donor projects. The WAJ Central Laboratory has been affected by the Zai water treatment plant problems of 1998 and these important laboratory programs largely have been suspended because of continued focus on the Zai facility. As a consequence of these problems, the Central Laboratory has had three directors and one acting director during this period. In addition, the lack of resources and the limited understanding by senior management of the importance of these programs has affected their implementation.

2.5 MIS Issues Remaining from WQIC Project

Four (4) MIS issues were identified as requiring support during the EPIQ IQC assignment:

- Procurement of "Help Desk" services to support MWI's MIS operations
- Delivery and installation of the proxy server procured by the United States Geological Survey (USGS) under the Regional Water Data Banks Project
- MIS network expansions
- MIS network administration

Because of the technical scope and limited resources available through the EPIQ IQC assignment, issues relating to MIS network expansions and MIS network administration could not be supported. These are critically important programs for MWI and are worthy of substantial support through future donor projects.

Help Desk

Toward the end of the WQIC Project, MWI had decided it would be better to procure "Help Desk" services to support operation and maintenance of MWI's Management of Information System (MIS) than to try to provide these services using in-house staff. Initial attempts were made in the second-half of 1998 to secure local currency monies to procure these services. In late 1998, local currency monies finally were obtained and MWI initiated an RFP (request for proposals) to procure these services. An RFP was released on two occasions; however, MWI received only one proposal in response to the RFP. As a consequence, MWI cancelled the RFP and has been

trying to provide "Help Desk" services using in-house staff supported by EPIQ IQC staff under the current assignment.

The "Help Desk" is a critically important corporate function for administration of an organization's MIS network. The issue must be resolved satisfactorily and soon if MWI's MIS network is to be maintained operational.

Proxy Server

The USGS procured server was delivered and installed in the MIS server room at MWI by the vendor. The server has been brought on-line and has been integrated into MWI's MIS network. However, the server currently is not being used for its intended purpose of functioning as the modem communications link for MWI's operations and offices located throughout Jordan.

3. Recommendations

This document presents a summary of activities supported by SAIC during the period 4 January through 30 June 1999 under the EPIQ IQC assignment to the Jordan Ministry of Water and Irrigation. The primary purpose of SAIC's assistance was to provide continuity to specific critical MWI program elements previously supported by USAID's Water Quality Improvement and Conservation (WQIC) Project. Technical assistance under the EPIQ IQC task was provided to the newly organized Water Resources Management and Planning Directorate of MWI primarily for: (1) water information system databases; (2) upgrade and implementation of water monitoring system networks; and, (3) unified water monitoring system restructuring. Attachment 1 is a listing of action items (activities) undertaken during the period of performance of SAIC's assignment under the EPIQ IQC Task Order.

A number of initiatives for continued support of the MWI programs established during the USAID's WQIC Project and assisted by the EPIQ IQC assignment are recommended. In addition, activities supported by other donor organizations, most notably those of GTZ for the National Water Master Plan, have complemented the work of the WQIC Project. Collectively these efforts have made a substantial contribution to the management and planning of Jordan's water resources.

3.1 Water Information System (WIS)

WIS Databases (ORACLE RDBMS) Design

The WIS Databases will continue to undergo development as new data management requirements of MWI are identified. Of the action items listed in Attachment 1, only activation (programming) of the calculated data fields in several data tables remains to be completed. Several refinements to the basic design of the WIS Databases were identified by the WQIC Project during the database development process. These refinements were not short-term priorities and were not addressed at that time. However, for the long-term development of the database they remain valid and are listed below.

Long-Term Enhancements to WIS Databases

1) **Monitoring_Station_Equipment Table** (data entry) -
- (i) For water resources equipment, only allow selection of monitoring equipment (water resources) appropriate to the specific station type
- (ii) For water quality equipment, only allow selection of monitoring equipment (water quality) appropriate to specific station type

2) **Primary_Values Table** (data entry) -
- (i) For field data form, only allow selection of water quality parameters analyzed in the field
- (ii) For lab data form, only allow selection of water quality parameters analyzed in the lab

3) **Primary_Values Table** (data entry) -
- (i) For field data form, only allow selection of field water quality equipment for parameters analyzed in the field
- (ii) For lab data form, only allow selection of laboratory equipment for water quality parameters analyzed in the lab

4) **QA/QC_Values Table** (data entry) - only allow selection of water quality parameters analyzed in the lab

5) **Spring and Wadi/Stream-Discharge_Measurements Tables** (data entry) - only allow selection of monitoring equipment (water resources) appropriate to the specific station type

6) **Rainfall_Duration Table** (data entry) - only allow selection of statistic codes appropriate to the data of interest

7) **Daily_Climatological Table** (data entry) - only allow selection of statistic codes and water resources parameter codes appropriate to the data of interest

8) **Facility Monitoring Values Tables** (parent and child tables, data entry) -
- (i) For field data form, only allow selection of water quality parameters analyzed in the field
- (ii) For lab data form, only allow selection of water quality parameters analyzed in the lab

9) **Facility Monitoring Values Tables** (parent and child tables, data entry) -
- (i) For field data form, only allow selection of field water quality equipment for water quality parameters analyzed in the field
- (ii) For lab data form, only allow selection of laboratory equipment for water quality parameters analyzed in the lab

10) **Facility QA/QC Values Tables** (parent and child tables, data entry) - only allow selection of water quality parameters analyzed in the lab

Database Administration (DBA) Development

A number of activities still must be completed before the DBA function for the WIS Databases is fully established and able to perform defined responsibilities. The major unresolved DBA issues relate to defining and instituting required DBA procedures and practices, expanding the operational access of the WIS Databases, and developing reporting capabilities for users. In addition, the DBA function will assist in automating the data entry validation process. Issues still requiring development are listed below.

WIS Databases DBA Development

1) Identify and Assign DBA Staff Responsibilities

(i) Identify specific WIS Databases management and administration needs and responsibilities

(ii) Assign responsibilities to appropriate staff

(iii) Remove data entry requirements from DBA staff. Currently DBA staff are expected to support database users for data-query needs as well as perform database administration duties. DBA duties alone are a full-time requirement if the ORACLE RDBMS database is to serve the needs of MWI as intended. Database programmers and DBA administrators are not able also to function as data-entry personnel

2) Conduct ORACLE Training for Users

(i) Data entry for new personnel

(ii) Data entry and query update course for previous trainees

3) Develop WIS Databases Report Formats and Reports

(i) Determine/update the types of reports required and linkages back to WIS Databases menu system

(ii) Define report format guidelines and standards

(iii) Prioritize report preparation activities

(iv) Begin programming and testing of reports

(v) Complete final user training and testing of reports

(vi) Incorporate reports into WIS Databases

Data Entry and Populate Data Tables

Substantial progress has been made in recent months to populate data tables in the WIS Databases. MWI currently is processing time-series data collected from water resources monitoring networks much more rapidly than historic practices (i.e., within weeks rather than years). Progress toward streamlining the data entry process for evaporation data into the Daily_Climatological data table still is warranted. In addition, substantial difficulties still must be overcome in obtaining production data from the appropriate authorities and sources.

Specific data entry and data-entry validation procedures still must be developed, instituted, and enforced to ensure the integrity of data in the WIS Databases. In the case of general information, data security has been satisfied by restricting data entry access to data-entry menus (e.g., general station information). In the case of time-series data, data-entry personnel must adhere to standard procedures. This work must be pursued in cooperation with the WIS Databases programmers and DBAs who will provide substantial assistance in the developmental process.

Data Entry Process and Population of Data Tables

1) **Institute Rigorous Data Entry Validation Procedures** (Futaki report from UNDP)
   - (i) Define data entry process for each type of data
   - (ii) Define QA procedures for entry of each type of data
   - (iii) Prepare written QA and data entry procedure for each type of data
   - (iv) Train technical staff collecting data and data entry staff on data entry procedures (including required WIS Databases procedures)
   - (v) Develop Phase II program for data entry incorporating Futaki's recommendations for data validation before moving to final data table in WIS Databases

2) **Set Data Ranges for Data Fields in WIS Databases Tables** (Futaki report from UNDP)
   - (i) Follow-up with Ali Subah and Ayman Jaber's original work and identify specific data fields which will have a data range (consider global and station specific data ranges)
   - (ii) Finalize data ranges for each data field that will have a data range
   - (iii) Program into WIS Databases each data range and integrate into the data entry process

3) **Complete Data Entry for Production Data**
   - (i) Streamline process for obtaining data
   - (ii) Institute data validation process for these data

4) **Populate WIS Databases with Historic Discharge Data** - Historic surface water daily and unit discharge data should be entered into the WIS Databases as data reliability permits. This is a major project that must be properly scoped and defined.

5) **Populate WIS Database with Historic Water Quality Data** - Historic water quality and wastewater quality data maintained by the WAJ Central Laboratory should be entered into the WIS Databases as data reliability permits. This is a major project that must be properly scoped and defined.

WIS Databases Cleanup

Substantial progress has been made over the past four years toward correcting basic errors in the database records. Many additional errors were identified during migration of the FoxPro data to the ORACLE RDBMS-based WIS Databases. Several data cleanup activities still remain and should be pursued as soon as possible.

WIS Databases Cleanup

1) **Validate Basic Station Data in the WIS Databases** - Basic station data must be validated for each monitoring station. This activity should be conducted in conjunction with labeling of each monitoring station.

2) **Validate Basic Ground Water Data in the WIS Databases** - Ground water well data (lithology, formation, aquifers, aquifer test, well construction, etc.) must be validated for each well. Data in the WIS Databases (ORACLE RDBMS) must be compared against similar data in the FoxPro and GWW databases, and in the BGR report. This activity should be conducted in conjunction with labeling of each ground water well. {NOTE: This is a major project by itself and ultimately must be completed by MWI in order to provide for the most accurate information in the WIS databases.}

3) **Validate Governorate and Village for each WIS Station**

4) **Validate Coordinates and Altitude for each WIS Station (MWI subcontract)**

5) **Update and Activate New Settlement List**

6) **Complete Update of Data Type Records for Ground Water Stations**

7) **Lead Zeros (0) for Decimal Values (e.g., 0.25)**
   (i) Check on appropriateness of lead zeros in ORACLE RDBMS
   (ii) Make corrections to WIS Databases data tables

8) **Calcium + Magnesium (Ca + Mg)** - were specified as a single value in FoxPro for Mg. Now these data are incorrect in ORACLE (much check each station to determine which are wells affected).

WIS Technology Integration and Development

The WQIC Project procured several software applications (e.g., Western Hydrologic System for stream discharge data; Laboratory Information Management System (LIMS) for laboratory analytical data; monitoring instrumentation software) to support more complete and consistent data processing and reporting. These software applications can be integrated with the WIS Databases to promote more efficient and accurate entry of monitoring data into the WIS Databases. In addition, integration of the WIS Databases programmed in ORACLE RDBMS with GIS (ArcInfo/ArcView) has been tested successfully by the WQIC Project and National Water Master Plan (GTZ). These systems should be fully integrated to permit better management of data and to permit better analysis and interpretation of water resources and water quality data.

WIS Technology Integration and Development

1) Develop GIS/WIS Databases Interface and Integrate Systems

(i) Define scope of integration needed and required
(ii) Develop plan of action with priorities of types of integration and data analyses desired
(iii) Program linkages for specific database/GIS analyses
(iv) Conduct testing of linkages
(v) Complete training for system

2) Integrate Ground Water for Windows (GWW) Analytical Packages into WIS

(i) Define scope of integration activities and develop plan of action
(ii) Develop interface between GWW and WIS Databases
(iii) Develop interface between GWW and GIS
(iv) Conduct testing of integrated system
(iv) Complete training for system

3) Integrate Processing of Water Resources Monitoring Data with WIS Databases Data Entry Activities

(i) Integrate Laboratory Information Management System with WIS Databases (as a first step, a plan of action for this activity must be developed)
(ii) Integrate WHS Software with WIS Databases (as a first step, a plan of action for this activity must be developed)

4) Continue development of GIS layers (lead by GTZ)

(i) Develop and add layers (coverages) particularly with respect to geological structures and formations, aquifers and ground water hydrology
(ii) Define, develop, and add other layers that are of importance for water resources studies needs

3.2 Water Resources Monitoring Networks and Instrumentation

Monitoring Station Installation

Construction of the water resources monitoring networks is proceeding slowly (see Section 2.2 of this report). Drilling of the remaining boreholes and installation of the remaining ground water monitoring wells is pending successful resolution of the summer of 1999 water crises. Design and construction of the remaining surface water monitoring stations still is problematic primarily due to MWI subcontracting procedures and difficulties. All construction related activities must be monitored closely and assistance must be provided as necessary to ensure the networks are completed in a reasonable timeframe. After the upgraded monitoring networks are constructed and instrumentation is installed, future actions largely are maintenance driven and oriented. These actions would become the responsibility of MWI's water resources monitoring function.

Monitoring Station Installation

1) Ground Water

(i) Begin drilling boreholes and installing well casing (Phase 2 GW - A4, A2, K, Wadi Araba, Jordan Valley wells)

(ii) Complete installation ground water well casing (WAJ Drilling Dept. - Wadi Mujib, Wadi Hasa, Jafr Basins wells)

(iii) Install new instrumentation boxes at new and rehabilitated stations

2) Surface Water

(i) Complete Phase 1 surface water construction (Yarmouk Basin, some Wadi Mujib Basin stations)

(ii) Complete Phase 2 surface water station design (Wadi Araba, Azraq, Jafr, Dead Sea Phase 2)

(iii) Initiate and complete Phase 2 surface water station installation

(iv) Initiate and complete Phase 3 surface water station design and construction (Jordan River Valley)

(v) Install surface water and ground water monitoring instrumentation pending completion of wells and surface water stations

Monitoring Station Instrumentation

Substantial monitoring instrumentation procured by the WQIC Project still remains to be installed at appropriate monitoring stations. Installation cannot proceed until the monitoring stations have been constructed. MWI has begun installation of the 100 standard precipitation gauges received in June 1999; this process will take some time to complete.

3.3 Water Resources Management Directorate and Program

Tasks completed by the WQIC Project which relate to MWI's Integrated National Water Resources Monitoring System primarily focused on establishing a foundation for functional programs required to support water resources management and planning. Substantial progress was made toward integrating these functional programs within MWI. However, much work remains to be completed both at the institutional level and at the operational level before MWI has effective water resources and planning capabilities and supporting programs.

The Water Monitoring System Long-Term Plan (report 3114-95-1c-05, 1995) prepared by the WQIC Project presents a detailed strategy for assuring that the upgraded water resources/quality monitoring system would remain responsive to the water resources/quality management needs of Jordan. The Long-Term Plan addresses institutional issues such as a unified monitoring organization, centralized water resources database, training, equipment management, and operations which affect the sustainability of the monitoring network and program. The Long-Term Plan also presents detailed recommendations for a water monitoring training program including suggested courses and course content.

WRMPD Operations and Water Resources Monitoring Function

Water resources management and planning responsibilities including water resources monitoring and data collection and water resources studies functions formally were consolidated within the WRMPD of MWI only in 1999. The organizational and management (and staffing) decision processes for MWI's new program still are being addressed and have delayed development and institution of formal operational practices. As a consequence, substantial development of programs supporting operations of the WRMPD still remain to be completed once these decisions are finalized. Development work is required for an equipment management program and a formal staff-training program to improve overall capabilities of the WRMPD and staff as well as efficiency of operations.

As yet, the water quality monitoring networks for Jordan's water resources (e.g., wadis, springs, ground water) developed with the WQIC Project have not been put into practice. These networks and supporting monitoring plans should be implemented as soon as possible. Water quality issues have become of greater importance in the overall water resources management and planning process. Data obtained from these networks will be critical for improved planning and decision-making. Issues still requiring development are listed below.

Water Resources Management and Planning Operations

1) Operational Practices

(i) Develop operations plan and administrative procedures for Directorate and each Division/Department of the Directorate (Details are outlined in the Long-Term Plan, Water Monitoring System Program Plan, and Water Resources Functions and Organizations Assessment Document)

(ii) Develop procedures for coordinating well licensing and permitting process with WAJ

(iii) Institute full water resources monitoring networks; continue to construct and rehabilitate monitoring stations

(iv) Institute full water quality monitoring networks

(v) Institute operations plan and administrative procedures

(vi) Institute proper monitoring programs and procedures including formal QA/QC practices

2) Equipment Management Program (Details are outlined in the Long-Term Plan)

(i) Develop equipment management program plan

(ii) Perform complete inventory of Directorate equipment and resources

(iii) Develop an inventory control system/database for Directorate equipment

(iv) Obtain model numbers and serial numbers for all equipment for inventory control system/database

(v) Institute equipment management program

3) Training Program (Details are outlined in the Long-Term Plan)

(i) Prepare training program plan for Directorate

(ii) Develop training courses

(iii) Institute training program and courses

Water Resources Studies and Analyses Function

Substantial programmatic and operational support must be considered to fully develop the water resources/quality studies/analysis capability of MWI. This function relies on data collected by the water resources monitoring function and provides analyses and assessments of Jordan's water resources. These analyses then become instrumental in developing and re-assessing Jordan's strategic, long-term water resources management planning options.

Water Resources Studies and Analyses	
1)	**Operational Practices**
	(i) Identify studies and analyses which should be conducted on a periodic basis (e.g., weekly, monthly, quarterly, semi-annually annually)
	(ii) Identify and prioritize specific studies and analyses which should be conducted for Jordan

3.4 WAJ's Central Laboratory

The Central Laboratory of WAJ has undergone substantial development since 1994. The WQIC Project provided for major equipment upgrades, several operational and management tools including operational and QA/QC practices, standard analytical procedures, health and safety procedures, a conceptual design for a new laboratory facility, and a Laboratory Information Management System (LIMS). The **Central Laboratory Refurbishment Plan** (1997) outlines a program to maintain the WAJ Central Laboratory at an upgraded level of capability. The Plan also provides detailed recommendations for the continued development of the laboratory ensure that the WAJ Central Laboratory will be continually upgraded, improved, and refurbished and thus will remain responsive to the analytical requirements and demands for which the laboratory is responsible. This includes staffing and training requirements, acquisition of additional instrumentation, chemical and equipment supplies, QA/C audits, health and safety, and other laboratory operations.

During the EPIQ IQC task only limited support was provided to the WAJ Central Laboratory. This support primarily focused on completing procurement and installation and initial training of the laboratory information management system (LIMS). Although the LIMS software finally was delivered to MWI in June 1999, installation and the initial training of staff will not occur until mid-July 1999. Specific recommendations for upgrading of WAJ's Central Laboratory are listed below.

WAJ Central Laboratory

1) Laboratory Information Management System (LIMS)

(i) Recruit experienced LAN/LIMS personnel to operate and manage the LIMS and the Laboratory's computer system
(ii) Continue on-going training through the first year of LIMS operation
(iii) Integrate some PCs and analytical instrumentation at the existing laboratory facility into the LIMS
(iv) Design and install full LIMS in new laboratory facility (in 2000)

2) New Central Laboratory Facility

(i) Complete the internal design of the new laboratory facility
(ii) Procure furnishings for new laboratory facility
(iii) Move laboratory equipment from existing facility to new laboratory facility
(iv) Procure B2 list of instrumentation identified by WQIC Project
(v) Procure equipment/supplies identified in Refurbishment Plan

3) Laboratory Operations and Management

(i) Obtain ISO certification and laboratory accreditation for Central Laboratory
(ii) Recruit required personnel for Central Laboratory (per Refurbishment Plan)
(iii) Institute training program (per Refurbishment Plan)
(iv) Continue to institute laboratory operations, QA/QC program, and analytical procedures

The Central Laboratory needs continued assistance to support implementation of all developed operations and management tools. Strong commitment and support from MIW is required to promote use of and dedication to standard procedures if improvement of water quality data reliability is to be achieved. The lab should be supported, not only in acquiring new equipment and state-of-the-art technology, but also in developing the skills of existing staff and hiring of new staff with qualifications and training commensurate with the acquired technologies and other requirements of a national water quality laboratory.

3.5 Management of Information Systems (MIS) Function

A formal Management of Information Systems (MIS) at MWI didn't exist when the WQIC Project was initiated. At the end of the Project, an MIS local area network (LAN) had been installed in the main Ministry building, the three (3) MWI organizations were operating from the LAN, common LAN operating systems and relational database management systems had been established, and an MIS Directorate had been established. Detailed engineering plans for the MIS for all MWI offices and the MIS operations plan had been developed. Specific recommendations for further developing the MIS function are listed below.

Management of Information Systems (MIS)

1) MIS Network

(i) **Install MIS Networks in Principal MWI Operations in the Amman Area and Link to MIS** - Include WAJ-Amman, Central Laboratory; and JVA-Dirar operations in Jordan Valley

(ii) **Establish Priorities for Installation of Networks in Other MWI Offices** - Initial priorities may include Irbid and Aqaba operations because of potential commercialization of water utility functions in these areas.

(iii) **Install MIS Networks in Other MWI Offices and Link to Amman**

2) Database Development

(i) **Migrate (and Update) Old Databases to ORACLE RDBMS**

(ii) **Assess Needs and Develop New Databases to Support MWI Operations** - Use of the MIS to support MWI operations and data management requirements still is in its infancy. Substantial development effort is required to fully define and integrate MWI's data management systems.

3) MIS Operations

(i) **Formally Institute Unified MIS Organization** - MWI must formally institute all authorities, duties, and responsibilities of the MIS Directorate if the MIS is to properly support overall MWI operations. Operations plans, organizational structure, and duties and responsibilities have been defined in WQIC Project documents. The alternative will be the gradual degradation of the MIS LAN, loss of system security and integrity, loss of data security and integrity, and eventual fragmentation of the MIS into independent LANs.

(ii) **Institute MIS Security Risk Plan Recommendations**

(iii) **Update MIS Concept of Operations Plan**

(iv) **Staff the Unified MIS Organization and Train Staff**

Attachments

Attachment 1

Water Resources Management and Planning Directorate
(January - June 1999 Action Items)

Attachment 2

Borehole_Diameter Data Field Records with Value = "0"

Attachment 3

Casing_Screen_Diameter Data Field Records with Value = "0"

Attachment 4

Water_Level Data Field Records with Value <>"0" (i.e., not equal "0")

Attachment 5

Base_Formation Data Field Records with Value = "0" or "Null"

Attachment 6

Base_Lithologic_Depth Data Field Records with Value = "0" or "Null"

Attachment 7

Correction of Inconsistent FoxPro Aquifer Data Records (Well.Aqpen(x) versus Aquifer.Aqtest Data Field Values)

Attachment 8

Wells Listed in FoxPro Database with Data in WF1 and WF2 Data Fields

Attachment 9

WQIC Project Water Monitoring System Equipment Inventory

Attachment 10

Surface Water Resources Monitoring Stations

Attachment 11

Monitoring Wells in Jordan's Integrated Water Resources Monitoring Program

Attachment 12

Monitoring Wells in Jordan's Integrated Water Quality Monitoring Program